ASPRS Positional Accuracy Standards for Digital Geospatial Data

(EDITION 2, VERSION 1.0 - AUGUST 2023)

Foreword

Edition 1 of the ASPRS Positional Accuracy Standards for Digital Geospatial Data was published in November 2014. In the years since, users expressed concerns and suggested revisions based on their experience applying the Standards in real-world situations. In addition, technologies have evolved in such a way as to challenge the assumptions upon which Edition 1 was based.

In 2022, ASPRS established a formal Positional Accuracy Standards Working Group under the Standards Committee to evaluate user comments, consider technology advancements, and implement appropriate changes to the Standards. The following individuals were appointed to the Positional Accuracy Standards Working Group:

Chair: Dr. Qassim Abdullah, Vice President and Chief Scientist, Woolpert, Inc.

Members:

- Dr. Riadh Munjy, Professor of Geomatics Engineering, California State University, Fresno
- Josh Nimetz, Senior Elevation Project Lead, U.S. Geological Survey
- Michael Zoltek, National Geospatial Programs Director, GPI Geospatial, Inc.
- Colin Lee, Photogrammetrist, Minnesota Department of Transportation

The ASPRS Positional Accuracy Standards for Digital Geospatial Data are designed to be modular in nature, such that revisions could be made and additional sections added as geospatial technologies and methods evolve. Additionally, the Standards are designed to recommend best practices, methods, and guidelines for the use of emerging technologies to achieve the goals and requirements set forth in the Standards. With support from the ASPRS Technical Divisions, the primary Working Group established subordinate Working Groups to author Addenda for best practices and guidelines for photogrammetry, lidar, UAS, and field surveying. The subordinate Working Group members and contributors are credited in each Addendum, as appropriate.

Summary of Changes in Edition 2

Important changes adopted in Edition 2 of the Standards are as follows:

1. **Eliminated references to the 95% confidence level as an accuracy measure.**
   - **Reason for the change:** The 95% confidence measure of accuracy for geospatial data was introduced in the National Standard for Spatial Data Accuracy (NSSDA) published by the Federal Geographic Data Committee in 1998. This measure was carried forward in the ASPRS Guidelines for Vertical Accuracy Reporting for Lidar Data published in 2004, as well as in Edition 1 of the ASPRS Positional Accuracy Standards for Digital Geospatial Data published in 2014. However, RMSE is also a way to express data accuracy, and it is typically reported alongside the 95% confidence level because the two are derived from the same error distribution. As a matter of fact, users need to compute RMSE first in order to obtain the 95% confidence measure. The reporting of two quantities representing the same accuracy at different confidence levels has created confusion for users and data producers alike.
   - **Justification for the change:** The RMSE is a reliable statistical term that is sufficient to express product accuracy, and it is well understood by users. Experience has shown that the use of both RMSE and the 95% confidence level leads to confusion and misinterpretation.
2. **Relaxed the accuracy requirement for ground control and checkpoints.**
   - **Reason for the change:** Edition 1 called for ground control points of four times the accuracy of the intended final product, and ground checkpoints of three times the accuracy of the intended final product. With goals for final product accuracies approaching a few centimeters in both the horizontal and vertical, it becomes difficult, if not impossible, to use RTK methods for control and checkpoint surveys, introducing a significant burden of cost for many high-accuracy projects.

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- **Justification for the change:** As the demand for higher-accuracy geospatial products grows, accuracy requirements for the surveyed ground control and checkpoints set forth in Edition 1 exceed those that can be achieved in a cost-effective manner, even with high-accuracy GPS. Furthermore, today's sensors, software, and processing methods have become very precise, diminishing the errors introduced in data acquisition and processing. If best practices are followed, safety factors of three and four times the intended product accuracy are no longer needed.

3. **Required the inclusion of survey checkpoint accuracy when computing the accuracy of the final product.**
   - **Reason for the change:** Since checkpoints will no longer need to meet the three-times-intended-product accuracy requirement (see item 2 above), the error in the checkpoints survey may no longer be ignored when reporting the final product accuracy. This is especially important, given the increasing demand for highly accurate products—which, in some cases, approach the same order of magnitude as the survey accuracy of the checkpoints. Therefore, checkpoint error should be factored into the final product accuracy assessment that is used to communicate the reliability of resulting final products.
   - **Justification for the change:** Errors in the survey checkpoints used to assess final product accuracy, although small, can no longer be neglected. As product accuracy increases, the impact of error in checkpoints on the computed product accuracy increases. When final products are used for further measurements, calculations, or decision making, the reliability of these subsequent measurements can be better estimated if the uncertainty associated with the checkpoints is factored in.

4. **Removed the pass/fail requirement for Vegetated Vertical Accuracy (VVA) for lidar data.**
   - **Reason for the change:** Data producers and data users have reported that they are challenged in situations where Non-Vegetated Vertical Accuracy (NVA) is well within contract specifications, but VVA is not. As explained below, factors affecting VVA are not a function of the lidar system accuracy; therefore, only NVA should be used when making a pass/fail decision for the overall project. VVA should be evaluated and reported, but should not be used as a criterion for acceptance.
   - **Justification for the change:** Where lidar can penetrate to bare ground under trees, the accuracy of the points, as a function of system accuracy, should be comparable to lidar points in open areas. However, the accuracy and the quality of lidar-derived surface under trees is affected by:
     1. the type of vegetation where it affects the ability of lidar pulse to reach the ground,
     2. the density of lidar points reaching the ground,
     3. and the performance of the algorithms used to separate ground and above-ground points in these areas.

     Furthermore, the accuracy of the ground checkpoints acquired with GPS surveying techniques in vegetated areas is affected by restricted satellite visibility. As a result, accuracies computed from the lidar-derived surface in vegetated areas are not valid measures of lidar system accuracy.

5. **Increased the minimum number of checkpoints required for product accuracy assessment from 20 to 30.**
   - **Reason for the change:** In Edition 1, a minimum of 20 checkpoints are required for testing positional accuracy of the final mapping products. This minimum number is not based on rigorous science or statistical theory; rather, it is a holdover from legacy Standards and can be traced back to the National Map Accuracy Standards published by the U.S. Bureau of the Budget in 1947.
   - **Justification for the change:** The Central Limit Theorem calls for at least 30 samples to calculate statistics such as mean, standard deviation, and skew. These statistics are relied upon in positional accuracy assessments. According to The Central Limit Theorem, regardless of the distribution of the population, if the sample size is sufficiently large ($n \geq 30$), then the sample mean is approximately normally distributed, and the normal probability model can be used to quantify uncertainty when making inferences about a population based on the sample mean. Therefore, in Edition 2, a product accuracy assessment must have a minimum number of 30 checkpoints in order to be considered fully compliant.

6. **Limited the maximum number of checkpoints for large projects to 120.**
   - **Reason for the change:** Since these Standards recognize the Central Limit Theorem as the basis for statistical testing, there is insufficient evidence for the need to increase the number of checkpoints indefinitely as the project area increases. The new maximum number of checkpoints is equal to four times the number called by the Central Limit Theorem.
   - **Justification for the change:** According to the old guidelines, large projects require hundreds, sometimes thousands of checkpoints to assess product accuracy. Such numbers have proven to be unrealistic for the industry, as it inflates project budget and, in some cases, hinders project executions, especially for projects taking place in remote or difficult-to-access areas.

7. **Introduced a new accuracy term: "three-dimensional positional accuracy."**
   - **Reason for the change:** Three-dimensional models require consideration of three-dimensional accuracy,

rather than separate horizontal and vertical accuracies. Edition 2 endorses the use of the following three terms:
  - Horizontal positional accuracy
  - Vertical positional accuracy
  - Three-dimensional (3D) positional accuracy
- **Justification for the change:** Three-dimensional models and digital twins are gaining acceptance in many engineering and planning applications. Many future geospatial data sets will be in true three-dimensional form; therefore, a method for assessing positional accuracy of a point or feature within the 3D model is needed to support future innovation and product specifications.

8. Added Best Practices and Guidelines Addenda for:

- General Best Practices and Guidelines
- Field Surveying of Ground Control and Checkpoints
- Mapping with Photogrammetry
- Mapping with Lidar
- Mapping with UAS

This summarizes the most significant changes implemented in Edition 2 of the ASPRS Positional Accuracy Standards for Digital Geospatial Data. Other minor changes will be noted throughout.

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