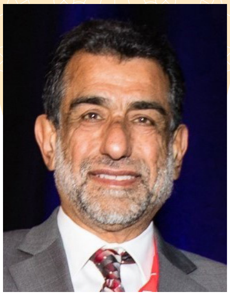

MAPPINGMATTERS

YOUR QUESTIONS ANSWERED

The layman's perspective on technical theory and practical applications of mapping and GIS

BY Qassim A. Abdullah, Ph.D., PLS, CP**

QUESTION:

Question: Like everyone else around the world, we in St. Petersburg, Russia, are working with outdated manuals and standards for geospatial data production. There are tremendous difficulties in finding recommendations for acquiring and processing geospatial data when the only guidelines on photogrammetric processes in our country were published in 2002. It is extremely difficult to apply old specifications to products from today's digital sensors, especially when working with lidar and unmanned aircraft systems (UAS). I went on the internet looking for any appropriate documents on the subject and discovered the ASPRS Positional Accuracy Standards for Digital Geospatial Data of 2014. These are good standards for today's mapping operations. In the standards, I noticed there are requirements for the accuracy of aerial triangulation, number of checkpoints and examples of how to assess your data accuracy. However, most accuracy examples seem to be applicable to products from large- and medium-format metric cameras. Most of our operations today use UAS with a dual-frequency GNSS receiver and Sony RX1 camera. Unfortunately, this camera is not a metric camera. Thus, I have the following questions:

1. Can we use the ASPRS Accuracy Standards for Digital Geospatial Data in our practice? Are there official guidelines and standards for situations in which small-format, non-metric cameras and UAS are used?
2. I also found your presentation, "Understanding The new ASPRS Positional Accuracy Standards for Digital Geospatial Data,"[1] from a NOAA's National Geodetic Survey (NGS) event, The National Spatial Reference System (NSRS) Modernization Industry Workshop, on May 7-8, 2018. Slide 20 of the presentation lists 4cm as the highest affordable accuracy that one can achieve with UAS. What other conditions and practices should be observed to achieve this accuracy?
3. I also read your white paper that Woolpert published on "The New Standards of Map Accuracy."[2] In Table 3 on Page 5 of that white paper lists the "Horizontal Accuracy Standards for Digital Planimetric Data," in which you multiply map scale factor by 1.25%, 1.5% or 2% to calculate RMSEx and RMSEy (cm). I don't understand what this multiplier means. Is it something like the National Map Accuracy Standards (NMAS), where the horizontal accuracy standard requires that the positions of 90% of all points tested must be accurate within 1/50th of an inch (0.05cm) on the map? Is it something that describes how accurately a user can measure a line on the map with a ruler?

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1 https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=7&ved=2ahUKEwjQyYa97ZrhAhXa8qYKHTyDCr8QFjAGegQIBBAC&url=https%3A%2F%2Fwww.ngs.noaa.gov%2Fdatums%2Fnewdatums%2Findustry-workshop-presentations%2FASPRS_Accuracy_Standards.pptx&usg=AOvVaw3lIlKirs8s4q8FwU7Ex7GP.

2 https://woolpert.com/wp-content/uploads/2017/05/The-New-Standard-of-Map-Accuracy.pdf.

Dr. Abdullah: I am going to address your questions in the same order as your message.

1. Your observations on the new ASPRS Positional Accuracy Standards for Digital Geospatial Data are accurate. These are the only standards that exist today that are solely designed for today's geospatial sensors and technologies. These standards provide guidance on process control throughout the product-generation phases. They define the requirement for ground control accuracy, aerial triangulation accuracy and final product accuracy, and contain guidelines on checkpoints. While some examples are based on large-format metric cameras, the new standards are designed to be sensor agnostic and data driven. These standards are suitable for current and future technologies, no matter how accurate the products are. You can use it for satellite imagery-derived products, aerial sensors, UAS-based sensors, and mobile mapping lidar and terrestrial lidar sensors. You can use it to evaluate and express products from UAS the same way you use it for products from manned aircraft. The strength of the new

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standards is that they endorse unlimited accuracy classes. The accuracy class is not based on a preset accuracy number nor does it depend on imagery resolution, contour interval or a map scale, as all these terms are associated with the old generation of mapping practices. Take, for example, ortho accuracy produced from imagery acquired with 5cm resolution. This imagery can be produced with 5cm, 10cm or even 100cm accuracy, depending on how stringent the workflow used during the production process is or the number and quality of the ground control points. With today's various configurations of digital cameras and focal length, such imagery can be acquired from less than 100m (the case of UAS) or by using manned aircraft from an altitude of 1,000m or even higher using cameras with a longer focal length. That is the reason we designed the new standards to be sensor agnostic, focusing on the merit of the final products produced from the sensor. Users can order 5cm orthorectified imagery that has an accuracy of 5cm, if the application requires it and the user is willing to pay extra, or they can order that imagery with an accuracy of 15cm if that will satisfy the project requirements. That is exactly what the new standard is based on. Users or producers can label any level of product accuracy, regardless of the pixel resolution. That is why the new standards provide an unlimited number of accuracy classes. Such flexibility allows the use of metric and non-metric cameras, including the consumer-grade cameras flown on board a UAS. However, users and producers should understand the difference between the two types of camera classes, so they do not oversell products from non-metric cameras. The only complaint I receive from the UAS community about using the new standards for their UAS projects is the number of checkpoints required for accuracy evaluation. The standards call for a minimum of 25 checkpoints to verify the horizontal and vertical accuracy of a project area of no larger than 500 square kilometers. Projects flown by UAS are nowhere near 500 square kilometers, so having the requirement of 25 checkpoints is not practical nor affordable for these small projects. Although this complaint is valid, the ASPRS standards adopted this number to satisfy its statistical sampling theories. To perform a statistically valid test, you need the sample (represented by the areas around the checkpoints) to accurately represent population (represented by the map of the entire project test). Therefore, the larger the sample, the more accurate the test. The National Standard for Spatial Data Accuracy (NSSDA) published by the Federal Geographic Data Committee (FGDC) calls

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for a minimum of 20 checkpoints. Reducing the number of checkpoints to fewer than 20 or even fewer than 25 may result in skewed results that do not represent a random distribution of errors. Imagine that you are running a test using only 3 checkpoints and found that the errors in one of these 3 checkpoints vastly exceeded the accuracy tolerance expected from this test. These results would mean that 33% of the samples failed the test, and you would have no choice but to reject the tested data. But if you have 25 points, one outlier represents only 4% of the samples failed, which allows for better confidence in the data. My advice to members of the UAS community who are planning to evaluate the accuracy of UAS-derived products is to plan on having 20-25 checkpoints if the project budget allows for it. If not, then the fewer checkpoints available for the test is better than not performing any accuracy evaluation. However, I cannot advise you on using fewer checkpoints routinely, as this method does not yield a statistically valid sample.

2. As for the slide in my presentation, I am listing it here (Figure 1) for the benefit of the readers:

Can ASPRS Standards be used for UAS products?

Required accuracy for the products:
Ortho Accuracy: 4 cm (RMSEx or y)
DSM Accuracy: 4 cm (RMSEz)

ASPRS Standards Requires:
$RMSE_x$, $RMSE_y$ or $RMSE_z$ (ground control)= $^1/_4$ * $RMSE_{x(Map)}$, $RMSE_{y(Map)}$ or $RMSE_{z(DEM)}$

Ground Control for AT accuracy = 1 cm (RMSEx, y, z)
Check points for QC accuracy = 1.33 cm

Figure 1: UAS products and ASPRS standards.

In that slide, I tried to emphasize the false claims made by many UAS-operators-turned-mappers. Many in the UAS business claim that they are meeting sub-centimeter accuracy on a regular basis. Such a claim has no merit when you discuss it in the context of standard photogrammetric and surveying practices. Everyone knows that if you are testing a mapping product, the reference agent you use to produce the map, which are the ground control points—or, for accuracy evaluation, the checkpoints—need to be of higher fidelity than the produced or tested map. The new ASPRS standards call for the ground control points used in the aerial triangulation process to be FOUR times more accurate than the generated products noted in the above slide. The standards also call for the checkpoints used to verify product accuracy to be three times more accurate than the tested map. Accordingly, when someone claims that the ortho-rectified mosaic produced from a UAS mission is accurate to 4cm (as RMSE), they need to realize that the ground control points used in processing the data need to be accurate to 1cm (as RMSE). While it's possible to survey ground control points with accuracy of 1cm using traditional surveying techniques, it is not possible to produce this accuracy from RTK surveying practices that are commonly used for surveying ground control points for mapping. Besides not meeting the ground control point accuracy used in the production process, their claim of product accuracy should be based on independent testing using independent checkpoints that are three times more accurate than the tested products and that were not used in the aerial triangulation process. Many of these producers base their accuracy conclusions on the fit of the ground control points in the aerial triangulation process. Again, basing the product accuracy on the aerial triangulation results is not correct because the ground controls used in the processing do not equate to independent checkpoints. It is well known that RTK-based field surveying techniques, which are used to support the majority of mapping projects, result in no better than 2cm accuracy. Therefore, according to the new ASPRS standards, such RTK-based survey can only be used to produce products that are no more accurate than 8cm (or 0.26 feet) or to verify the accuracy of mapping products that are no more accurate than 6cm (or 0.20 feet). That is the reason I question any claim that a UAS-derived product is more accurate than 8cm, unless traditional surveying techniques and differential leveling practices were used to survey the ground control points. Data providers need to educate themselves on photogrammetry and surveying best practices if they want to join the geospatial mapping community. This education can be pursued through participation in the training program that ASPRS offers at its annual conference or through pursuing an ASPRS certification.

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3. As for the white paper, the accuracy thresholds were based on an earlier version of the ASPRS standards before the final version of the standards were published in 2014. The drafting of the standards lasted three years during which we, the drafting committee, considered different approaches for accuracy classes. The white paper represents the period when the drafting committee considered adopting the same approach as the previous version of the legacy ASPRS standards of 1990, in which there are three accuracy classes: I, II and III. Later in the drafting process, the committee realized that limiting the accuracy to three classes that are fixed to certain accuracy numbers is the wrong approach, since mapping technologies are evolving rapidly, and future technologies may enable us to obtain accuracies that far exceed the thresholds we have today. In addition, we wanted the new standards to be sensor agnostic to apply to all mapping technologies, including the most accurate terrestrial and mobile lidar systems. As for your question on the approach followed in the white paper by assigning 1.25%, 1.5% or 2.0% scale factor, I do not encourage anyone to follow this approach anymore because the drafting committee has since abandoned the use of map scale, contour interval, pixel size, etc., as an accuracy measure. Scale was created to help the mapping process at a time when the only way to produce a map was on paper. This is also true of the use of the old concept of contours and contours interval. I hope users will embrace the new standards and get used to the idea of assigning an accuracy class to the data that suits their needs regardless of the imagery resolution or lidar data quality. We need to start expressing the accuracy for orthorectified imagery as a 15cm or 5cm accuracy class, regardless of the image resolution from which it was produced. This approach is already used by the industry when dealing with lidar data. Of course, best practices should be followed by the data producers and end users when contracting projects. Both should agree on reasonable acquisition parameters of imagery or lidar and the production process to assure that 5cm, 10cm or any other accuracy classes are achievable.

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However, although I do not recommend using this approach, I also would like to answer your question on the formulas I used in the white paper as I know some agencies are still using map scale and associated accuracy figures. If you look at Table 1 (also Table 1 in the white paper), which lists the horizontal accuracy classes for orthophoto, you notice that we were going to use Class I with the accuracy of 1 pixel of the orthophoto, Class II with 1.5 pixel accuracy, and Class III with 2.0 pixel accuracy.

Table 1 Horizontal accuracy classes for ortho imagery.

Horizontal Data Accuracy Class	RMSEx and RMSEy	Orthophoto Mosaic Seamline Maximum Mismatch
I	Pixel size x 1.0	Pixel size x 2.0
II	Pixel size x 1.5	Pixel size x 3.0
III	Pixel size x 2.0	Pixel size x 4.0

To apply these accuracy classes to planimetric paper maps with certain scales, I followed our common practice of associating the 15cm imagery to produce 1:1,200-scale map. Then I used the accuracy figures from Table 1 for 15cm orthophoto, which is 15cm to derive the following relationship to associate the map scale with the map accuracy:

Accuracy (cm) = (15cm/1,200) x 100 x 1,200 = 1.25% x Map Scale Factor = 0.0125 x Map Scale Factor.

I hope I addressed all your questions and concerns.

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