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: I am a college student working on my bachelor's degree in Spatial Science (Surveying).

I am interested in photogrammetry, and my study is on drone-based surveys. I have the following questions on the new "ASPRS Positional Accuracy Standards for Digital Geospatial Data":

1. In sections 7.7 and 7.8, when it talks about checkpoint and ground control accuracy being 1/2 RMSEmap, is RMSEmap the desired/intended accuracy class?
2. With GCPs having three times the accuracy of the geospatial data set being tested, does that mean the GCP accuracy will be three times more accurate than the desired/intended accuracy class?
3. Do you use Table D.1 to calculate all the statistics and then use the results to determine the ASPRS accuracy class? Is that the typical workflow? Is there a sample report you can supply?
4. Are there guidelines on what you should aim for regarding the additional statistics discussed on the standards, such as max, min, skew, kurtosis and mean absolute?
5. Can you clarify what it means when you can state "tested to meet" versus "produced to meet"?
6. Can you direct me to a document regarding planning and best practice guidelines?
7. Do the vegetated area ground control points simply go on the bare ground between vegetation?
8. How do you assess seamline mismatch?
9. If an orthophoto fails a column in Table B.3 (e.g. the RMSEr is OK, but the accuracy at 95% CI exceeds the limit), do you select the accuracy class in which your project meets or exceeds all standards in a single row?
10. I note that many drone-based surveys seem to have a mean error much higher than 25% of the RMSE. What does this information tell you about the quality of the project, and how can you correct it?
11. I also noticed that nearly every drone software company reports accuracy as a function of GSD, e.g. heights within three times the GSD. How are these related, and is GSD really related to accuracy in any way? I did a project with a GSD of 1 cm, but I achieved 11 mm RMSE heights and mean of 3 mm.
12. Can you direct me to where I can read more about rigorous total propagated uncertainty regarding photogrammetry?
13. For repeat surveys of the same area, if I use the software to determine the camera calibration via self or automatic calibration, is it best to save it and then use the same calibration for the repeat flights rather than having the software re-calculate the camera calibration each time?

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Dr. Abdullah: In the June 2019 issue, I addressed questions 1 through 6. The remaining questions are addressed below.

Part II

Question 7—*Do the vegetated area ground control points simply go on the bare ground between vegetation?*

Answer: Yes, they should. Ground control points should always be surveyed on a firm ground.

Question 8—*How do you assess seamline mismatch?*

Answer: Evaluating seamline mismatch is usually performed visually to determine whether features in adjacent rectified images are aligned correctly. For standard large-format metric cameras, mosaic cut lines are inserted manually. The technician selects the mosaic cut lines path to avoid buildings, trees and other elevated objects, as well as radiometrically mismatched areas. Those mosaic cut lines are usually saved in a CAD file format such as DGN, DWG or shape file. These CAD files, if they exist, are very

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helpful in evaluating the seamline mismatch quality of the final product, i.e. ortho mosaic. The latest image processing software, such as Pix4D, enables users to visit the mosaic cut lines and allow them to correct or re-route the mosaic cut lines in real time. Once a mismatch is found, it can be quantified and evaluated according to the "ASPRS Positional Accuracy Standards for Digital Geospatial Data," as illustrated in the far-right column of Table 1.

Table 1: ASPRS horizontal accuracy standards and mosaic seamline mismatch.

Horizontal Accuracy Class	$RMSE_x$ and $RMSE_y$ (cm)	RMSEr (cm)	Horizontal Accuracy at 95% Confidence Level (cm)	Orthoimagery Mosaic Seamline Mismatch (cm)
X-cm	≤X	≤1.41*X	≤2.45*X	≤2*X

> **"There is never a situation in which some values of statistical terms meet the given thresholds while other terms fail to meet those thresholds for a given accuracy class."**

Question 9—*If an orthophoto fails a column in Table B.3 (of the ASPRS Standards, see below) (e.g. the RMS-E_r is OK, but the accuracy at 95% CI exceeds the limit), do you select the accuracy class in which your project meets or exceeds all standards in a single row?*

Table B.3 Common Horizontal Accuracy Classes According to the New Standard.

Horizontal Accuracy Class RMSEx and RMSEy(cm)	RMSEr (cm)	Orthoimage Mosaic Seamline Maximum Mismatch (cm)	Horizontal Accuracy at the 95% Confidence Level (cm)
0.63	0.9	1.3	1.5
1.25	1.8	2.5	3.1
2.50	3.5	5.0	6.1
5.00	7.1	10.0	12.2
7.50	10.6	15.0	18.4
10.00	14.1	20.0	24.5
12.50	17.7	25.0	30.6
…..	…..	…..	…..

Answer: There is never a situation in which some values of statistical terms meet the given thresholds while other terms fail to meet those thresholds for a given accuracy class. The derived thresholds for RMSEr and the accuracy at 95% confidence level are all derived using the accuracy class or the RMSE x or y, therefore if the verified RMSE x or y of the product is found to be outside the specified limit, then both RMSEr and the accuracy at 95% should fail to meet the project specifications. Table 2 illustrates two situations of product accuracy verification for a product accuracy class of 10 cm. In CASE 1, the RMSE x or y of 8 cm meets the project specifications; in CASE 2, with RMSE x or y of 13 cm, it fails to meet project specifications. As you notice from the example, once the RMSE x or y value meets the threshold, all other statistical measures derived from that RMSE meet its thresholds. In the same token, once the RMSE x or y value fails the threshold, all statistical measures fail as well.

Table 2: Horizontal Accuracy Examples.

Horizontal Accuracy Class	$RMSE_x$ and $RMSE_y$ (cm)	RMSEr (cm)	Horizontal Accuracy at 95% Confidence Level (cm)
10 cm (specification)	≤10	≤14.1	≤24.5
CASE 1 (actual)	8.0 ≤10 (pass)	11.28 ≤14.1 (pass)	19.6 ≤24.5 (pass)
CASE 2 (actual)	13.0 ≥10 (fail)	18.33 ≥14.1 (fail)	31.85 ≥24.5 (fail)

Question 10—*I note that many drone-based surveys seem to have a mean error much higher than 25% of the RMSE. What does this information tell you about the quality of the project, and how can you correct it?*

Answer: The ASPRS standards states that the exact specification of an acceptable value for mean error may vary by project and should be negotiated between the data provider and the client. It also recommends that the mean error be less than 25% of the specified RMSE value for the project. Mean errors that are greater than 25% of the target RMSE, should be investigated to determine the cause of the errors and to determine what actions, if any, should be taken. Higher value for the mean errors in general indicates biases in the data, especially if the computed standard deviation is low. Biases in the data can be modeled and removed. Examples of such biases in the geospatial products are generated by errors, which can be caused by using the wrong vertical or horizontal datum or if the surveyor forgot to subtract the instrument height when adjusting the network during the ground control surveying or other systematic errors. If the computed standard deviation is low, you can always subtract or add the value of the mean (or average) from the biased quantities to remove the systematic errors, and this will improve the data accuracy.

"The technician selects the mosaic cut lines path to avoid buildings, trees and other elevated objects, as well as radiometrically mismatched areas."

Question 11—*I also noticed that nearly every drone software company reports accuracy as a function of GSD, e.g. heights within three times the GSD. How are these related, and is GSD really related to accuracy in any way? I did a project with a GSD of 1 cm, but I achieved 11 mm RMSE heights and mean of 3 mm.*

Answer: According to the new ASPRS standards, accuracy should not be associated with imagery GSD or scale because today's digital sensors have different configurations and lens design to enable high-resolution imagery from very high altitudes. Table 3 illustrates how these four metric digital cameras can be used to acquire imagery with the same ground resolution of 7.5 cm from drastically varied flying altitudes, from 2,363 feet to 9,937 feet above ground level (AGL). One should expect that the accuracy for products derived from imagery acquired from 9,937 feet AGL should be inferior to the accuracy of products derived from imagery acquired from 2,363 feet AGL. That is why we should not use the GSD as an indicator for product accuracy.

Table 3 Digital Cameras and Flying Altitude Examples

Camera	Focal Length (mm)	Flying Altitude (ft)	Resulting GSD (cm)
ADS80	62.77	2,363	7.5
DMC IIe 230	92.00	4,042	7.5
UltraCAM Falcon Prime	100.00	4,100	7.5
UltraCAM Eagle 210	210.00	9,937	7.5

If the software company is using the GSD as a measurement of length or dimension, then there is no harm in using the GSD to quantify products accuracy because all it means is a quantity. However, if they are using it to associate GSD as indicator or discriminator of product accuracy, then we should not condone this practice.

"There is never a situation in which some values of statistical terms meet the given thresholds while other terms fail to meet those thresholds for a given accuracy class."

Question 12—*Can you direct me to where I can read more about rigorous total propagated uncertainty regarding photogrammetry?*

Answer: As far as I know, there is not a book published on the topic, but you can find several good published papers on the topic, among them are the following:

- *C.A. Rodarmel, M.P. Lee, K.L. Brodie, N.J. Spore and B. Bruder, "Rigorous Error Modeling for sUAS Acquired Image-Derived Point Clouds," April 2019 IEEE Transactions on Geoscience and Remote Sensing.*

"These CAD files, if they exist, are very helpful in evaluating the seamline mismatch quality of the final product, i.e. ortho mosaic."

- H.J. Theiss, "Covariance Propagation from Specific to Generic Model," Proceeding the ASPRS 2010 Annual Conference, San Diego, Calif.

Question 13—*For repeat surveys of the same area, if I use the software to determine the camera calibration via self or automatic calibration, is it best to save it and then use the same calibration for the repeat flights rather than having the software re-calculate the camera calibration each time?*

Answer: It is always beneficial to use accurate camera calibration values in the bundle block adjustment because it minimizes the amount of parameter optimization. That is also how we did it when we used large-format metric cameras. However, because the cameras on board unmanned aircraft systems (UAS) are consumer-grade non-metric cameras, you will always need the help of the camera self-calibration capability of the software for every project, every time you adjust a block. Such non-metric cameras do not maintain their internal calibration geometry, and you will find these internal camera parameters change from one project to another. It is always a good practice to use the adjusted camera parameters from previous projects as initial or approximate values in a new adjustment, as it makes it easier for the software to refine new values to suit your new project.

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