Mapping Matters

By Qassim A. Abdullah, Ph.D., PLS, CP

Your Questions Answered

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

Q: What is the best method to determine and verify the accuracy of orthophotos or digital elevation models before sending them to our clients, and what is the best map accuracy standard to consider in such verification?

Anonymous, Frederick, Maryland

Dr. Abdullah: The quality of geospatial products can be assessed in several ways depending on the producer's practices and available means. Having an independent set of ground control is essential to any technically sound approach. Production practices play major roles in achieving and guaranteeing the high quality every client expects from a spatial data provider. Assuring high quality production practices followed by thorough quality controls will not only result in the desired accuracy, but it will help the bottom line as it saves long rework hours. The following are some of the main technical reviews and practices that must be followed if accurate products are expected:

1. Project planning stage: Whatever your collection sensor is, make sure that you follow the manufacturer's recommendation on the limiting acquisition parameters. Whether you are flying film, digital, lidar, or IFSAR, give attention to the optimum performance environment for any of the sensors or auxiliary components that make up the acquisition system. Flight line length or flying time on the line, flying altitude, ground control number and configuration, quality of the GPS receiver, grade of the inertial measurement unit (IMU) used for sensor position and orientation determination, and softcopy measuring device and software, if any, are all to be considered carefully in deciding on the resulting accuracy.

> "... To follow a scientifically sound approach, I recommend that you adopt the RMSE values that are given by the ASPRS standard for use with the NSSDA. In this case you satisfy both group of map standard users, the ASPRS, which is widely used among large scale clients and the new NSSDA, which is strongly recommended by the Federal Geographic Data Committee (FGDC)."

2. Sensor orientation determination stage: The exterior orientation parameter determination of the aerial sensor affects directly the accuracy of the ground mapping. Aerial triangulation for, example, should be conducted with surgical precision and no compromise in these efforts should be allowed in order to cut corners or reduce costs. Sigma of the image measurements should meet sub-pixel accuracy, the residual of the ground controls should meet the criteria of 1/10,000 the flying height as root mean squares error (RMSE) as much as possible. Finally, budgeting extra control points to be utilized as blind check points for the bundle block adjustment solution is an excellent tool for non-bias estimate for the final accuracy of the aerial triangulation. In the case of lidar sensor orientation determination, accurate bore-sighting of the IMU, flying at the correct altitude and flying speed, distance from the GCP base station, calibration of the internal mechanical parts, such as galvanometer and mirror motion, all contribute to the final accuracy of the ground height determination.
3. Height bias determination: Modern technologies associated with the GPS, IMU, laser, and microwave scanning provide means of direct measurement of ground positioning without the rigorous photogrammetric model that provide means to discover and correct biases. Therefore, all geospatial data collected by non-conventional photogrammetric means, such as lidar or IFSAR, should be subject to height or planimetric bias determination after the processing of the data and prior to its delivery to the client. Ground check or control points are the most reliable means to determine and then remove such bias.

As for the best method of determining the accuracy of a mapping product, correct practices by the map producers, as listed above, are the safest ways to assure and attain desired accuracy. Often times map producers limit their accuracy verification to their office activities and seldom send the map to the field for verification. This makes sense as the producer is the one who knows what went into the production of the map backed by a check list for all the correct practices mentioned earlier. I just want to point out additional measures that the map producer can take for extra assurance. Existing reliable geospatial data is an excellent and inexpensive means to check a map. In addition, the map producer can use automated and manual routines to verify tile to tile edge matching.

In the United States, three different map standards or guidelines are used to determine the accuracy of the geospatial products. Those are: the National Maps Accuracy Standard (NMAS), the American Society for Photogrammetry and Remote Sensing (ASPRS) standard, and finally, the National Standard for Spatial Data Accuracy (NSSDA). The three different standards employ the same philosophy of utilizing an independent and more accurate survey technique to assess the measurement made from the map product. However, they differ in their ways of limiting the accuracy figure and the confidence level. In general, at least 20 points well-distributed throughout the project area and visible on the map are to be accurately surveyed, and the map-derived positions are compared to the field survey values and statistically analyzed to come up with the right accuracy figure.

It is recommended to use the latest guidelines for the map accuracy standard or the NSSDA as most government agencies have endorsed it and have started to use it. However, the NSSDA is not a standard in the same meaning a NMAS and ASPRS. It is more of a guideline to safeguard the statistical map accuracy checking practices. The NSSDA is based on a 95% confidence level using the Root Mean Square Errors (RMSE) as its variable. The NSSDA did not specify the values for the RMSE that need to be used for each map scale but left it to be agreed upon between the producer and the client. To follow a scientifically sound approach, I recommend that you adopt the RMSE values that are given by the ASPRS standard for use with the NSSDA. In this case you satisfy both groups of map standard users; the ASPRS, which is widely used among large scale clients, and the new NSSDA, which is strongly recommended by the Federal Geographic Data Committee

continued on page 876

continued from page 875

Mapping Matters, *continued from page 871*

(FGDC). To give you a numerical example for the above argument, let us assume that you are providing ortho photo products with a map scale of 1"-100' (or 1:1,200) and a lidar-derived digital terrain model meeting the accuracy of 2' contour interval. Assume that your client is endorsing the NSSDA standard for both horizontal and vertical accuracy. According to the ASPRS standard, the two products should meet the following horizontal and vertical accuracies:

1- Horizontal accuracy: RMSE = 1 ft or 30 cm,

2. Vertical accuracy: RMSE = 1/3 x 2.0 = 0.67 ft or about 20 cm.

According to the NSSDA standard, the two products shall satisfy the following criteria:

1) Horizontal $Accuracy_r$ = 2.4477 x $RMSE_x$ = 2.4477 x $RMSE_y$

= 2.4477 x $RMSE_r$ /1.4142

= 1.7308 x $RMSE_r$

2) Vertical accuracy: 95% of the checked elevation should be within 1.96 $RMSE_v$

If we adopt the RMSE that is given by ASPRS, the two accuracy figures according to NSSDA will be:

Horizontal ortho $Accuracy_r$ = 2.45 ft

Vertical accuracy of lidar DEM = 1.96 x 0.67 = 1.3 ft or 40 cm

Here you may noticed that I totally ignored the vertical accuracy requirements for the spot height called for by the ASPRS standards, as it is not applicable with lidar data as I discussed it in an earlier issue of "Mapping Matters."

Please send your question to Mapping_Matters@asprs.org and indicate whether you want your name to be blocked from publishing.

Answers for all questions that are not published in *PE&RS* can be found on line at www.asprs.org/Mapping Matters.

Dr. Abdullah is the Chief Scientist at Fugro EarthData, Inc, Frederick, MD.