Viewing Multibeam Uncertainty in HYPACK®

by Pat Sanders

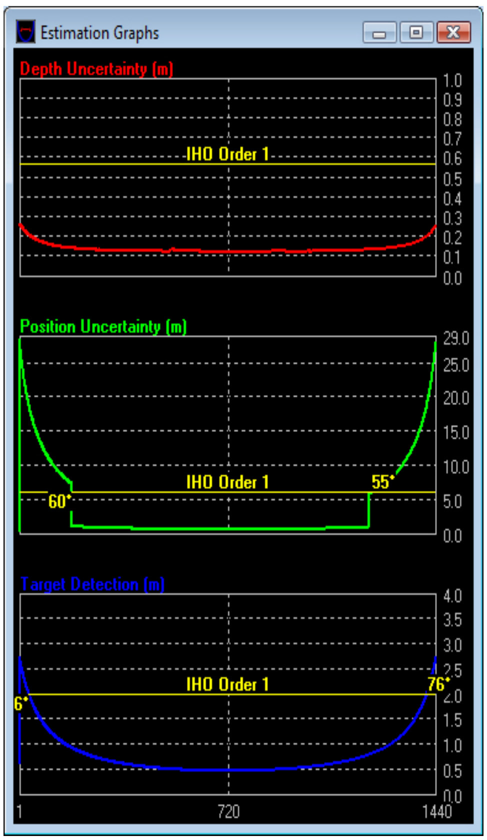
More and more of our users are starting to pay attention to the 'uncertainty' of their soundings. This probably started with the introduction of the Total Propagated Uncertainty Editor (TPU Editor) a couple of years ago and the ability to display uncertainty in some of the multibeam processing programs.

For the uninitiated, let's start off with a definition:

Uncertainty: *The range about a depth measurement that should contain the true value at a certain confidence level (usually 95%).*

If a depth measurement of 20' has an uncertainty of 0.2', there is a 95% chance (19 out of 20 times) that the true depth lies between 19.8 and 20.2. Obviously, the smaller the uncertainty value, the more confident you are with your final result.

Determining Uncertainty: According to one of my old Statistics text books, "*uncertainty can be based upon either limitations of the measuring instruments or from statistical fluctuations in the quantity being measured*".



The concept of **Total Propagated Uncertainty (TPU)** is based upon determining the limitations of your survey equipment and extrapolating those limitations across the entire system. For example, the accuracy of your roll measurement by your MRU will affect the launch angle of your multibeam system, which affects the ray-bending results when determining the final location of your soundings. **TPU** can be subdivided into **TVU** (Total Vertical Uncertainty) and **THU** (Total Horizontal Uncertainty). Before they received their fancy names, we referred to them in HYPACK® as Depth Uncertainty and Position Uncertainty. (Leave it to academia to muddle things up with lingo that makes it seem even more complicated…)

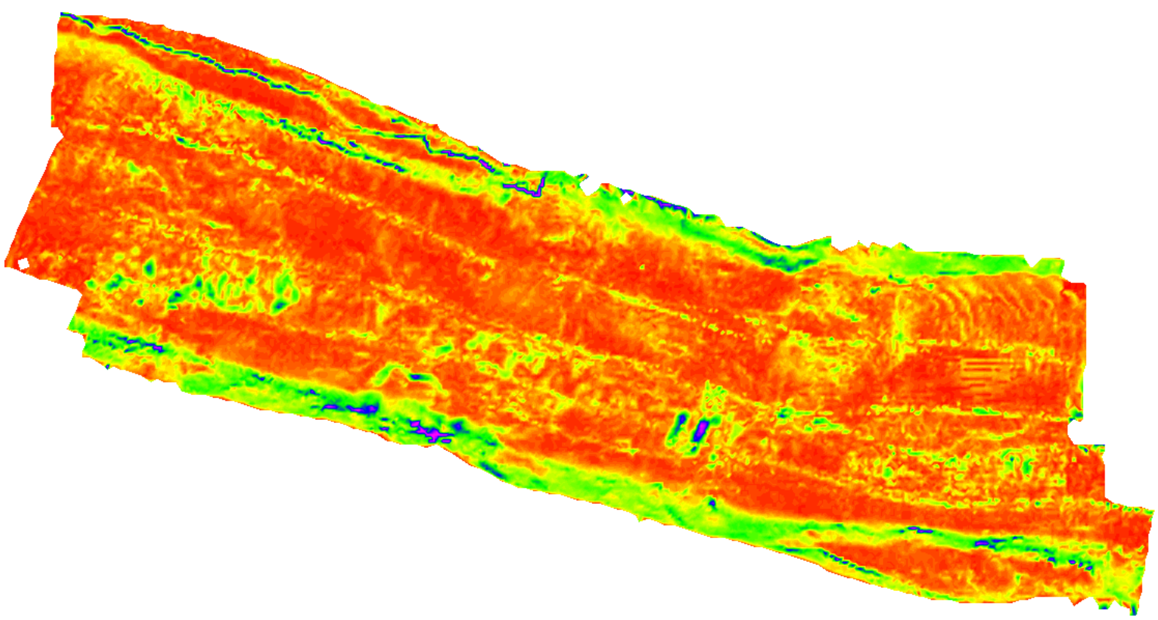
The TPU calculations can be used as a predictive tool to estimate which of your beams can meet IHO or USACE standards. It can also be computed in real time, or in post-processing. The advantage to computing it in real time or in post-processing is that actual values can sometimes be substituted for estimates used when predicting values.

Hydrographers should remember that TPU is just one tool used in determining the quality of their soundings. My beef with the over-reliance of TPU is that many of the important parameters used in computing TPU are unknown. For example, how accurately you can measure the tide at your tide station. Then, how accurately do the results at your tide station apply to your actual survey area? I don't know many hydrographers who can take the time to do a full-blown tide study of their survey area. Most of them just use the default values in the TPU EDITOR and then make decisions to keep or kill soundings based on the resultant values. That just seems wrong to me.

Statistical Methods: According to our definition, uncertainty can also be determined based on the statistical fluctuations of the quantity being measured. MBMAX-64 (Multibeam Editor), CUBE and MAPPER can all generate uncertainty calculations, based upon the variation of z-values of soundings grouped in a matrix cell. The computed uncertainty reflects the **repeatability** of your soundings, not the **accuracy** of your soundings.

It might be argued that our statistical approach is not a 'true' uncertainty. To compute a true uncertainty, you would repeat the measurement of the same quantity over and over again. For example, measure the distance between Point A and Point B 100 times and then generate the statistical uncertainty. In hydrography, this is impossible, as we could never get our survey vessel over the same point with the same dynamics two times in a row. Instead, we group soundings together using a matrix cell and then compute uncertainty with the assumption that all soundings in the cell are measuring the same value (… a flat bottom).

FIGURE 1. *Uncertainties Generated in CUBE Displayed in TIN MODEL. Red = low; Green = medium; Blue = high*



By computing uncertainty in this method, all soundings within a matrix cell receive the same uncertainty. This is true, even though some of the measurements might have been made with a beam angle of 10˚ from nadir and others made with a beam angle of 70˚ from nadir. (Special applications, such as the Performance Test in MBMAX groups beams in 5˚ groups and computes the uncertainty for each group.)

To be the devil's advocate, let's say that every sounding you measured with your multibeam system was equal to the true sounding. On a perfectly flat bottom, every sounding in the matrix cell would have the same value and your uncertainty would be 0.00. However, in a matrix cell that was on a side slope, even though all of your soundings were absolutely correct, you would wind up with an uncertainty that was proportional to the steepness of the side slope. This would be due to the variation in z-values in the cell. They are all correct, but there is a lot of difference in those values that winds up generating an uncertainty.

So, in summary:

- The uncertainties computed by Total Propagated Uncertainty are reflections of the **accuracy** of your results.
  - Most hydrographers don't have a clue as to what many of the different parameters should be.
- The uncertainties computed by statistical methods are reflections of the **repeatability** of your data.
  - Uncertainties computed over flat areas will usually be less than uncertainties computed over sloping bottoms.