Accuracy and Precision

The "Truth" is equal to one's initial observations plus the corrections discovered through added experience or knowledge.

R. B. Buckner, "Surveying Measurements and their Analysis" 1983, Landmark Enterprises

Accuracy is telling the truth . . . Precision is telling the same story over and over again.

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To many people, accuracy and precision mean the same thing: to someone involved in measurement, the two terms should have very different meanings. In Dr. Ben Buckner's book, he theorizes that in our learning of mathematics, we are taught to count, but not taught to measure. One way in which this distinction is apparent is the difference between a poll (a measurement) and a vote (a count). The result obtained from counting will be an exact result (barring blunder), while the result obtained from measuring will only approach the truth. We are taught how to deal with exact numbers, but are sometimes not aware of the nature of results we obtain from approximated or measured values.

Measurement, by its nature, is inexact; the magnitude of that "inexactness" is the error. This is distinguished from a blunder, which is the introduction of an error that can be traced to its source, and therefore an error that may be detected, quantified and corrected. A blunder is an actual mistake in the application of a measurement, such as misreading a scale or misadjustment of an instrument. Error is inherent in measurement, and incorporates such things as the precision of the measuring tools, their proper adjustment, and competent application. The analysis of the magnitude of probable error is appropriate in examining the suitability of methods or equipment used to obtain, portray and utilize an acceptable result.

Perhaps the easiest way to illustrate the difference between accuracy and precision is to use the analogy of a marksman, to whom the "truth" represents the bullseye.

Precision

the degree of refinement in the performance of an operation, or the degree of perfection in the instruments and methods used to obtain a result. An indication of the uniformity or reproducibility of a result. Precision relates to the quality of an operation by which a result is obtained, and is distinguished from accuracy, which relates to the quality of the result. In Figure 1, the marksman has achieved a uniformity, although it is inaccurate. This uniformity may have been achieved by using a sighting scope, or some sort of

Figure 1: Precision

http://www.flatsurv.com/accuprec.htm
The analysis of precision can be misleading if a certain degree of precision is implied but not actually attained. To overstate an example, suppose someone were to use a vehicle odometer to measure the distance from one town to another, but measure from the last even mile (as indicated on the odometer) with a tape measure. The result could be represented with an implied precision expressed in feet, but the underlying accuracy is no better than the measurement stabilizing device. With the knowledge gained by observation of the results, the marksman can apply a systematic adjustment (aim lower and to the left of his intended target, or have his equipment adjusted) to achieve more accurate results in addition to the precision that his methodology and equipment have already attained.

Accuracy
the degree of conformity with a standard (the "truth"). Accuracy relates to the quality of a result, and is distinguished from precision, which relates to the quality of the operation by which the result is obtained. In Figure 2, the marksman has approached the "truth", although without great precision. It may be that the marksman will need to change the equipment or methodology used to obtain the result if a greater degree of precision is required, as he has reached the limitations associated with his equipment and methodology.

Figure 3 represents results indicating both accuracy and precision. It differs from Figure 1 in that the marksman has probably made one of the systematic adjustments that was indicated by his attainment of precision without accuracy. The degree of precision has not changed greatly, but its conformity with the "truth" has improved over the results obtained in Figure 1.

If the marksman from Figure 2 determines that his results are not adequate for the task at hand, he has no choice but to change his methodology or equipment. He has already performed to the limitations of these.

An additional benefit can be obtained by using a methodology that yields great precision. The analysis of results obtained from techniques yielding a high degree of precision will make the detection of blunders easier. In Figure 4 and Figure 5, we have introduced a blunder into the results associated with accuracy and with precision. Given the degree of precision represented in Figure 4, it is easy to detect the blunder. It would be easy to analyze the results represented in Figure 5, and overlook the blunder. Without a high degree of precision, the blunder may go undetected and uncorrected, thereby affecting the overall accuracy.

The analysis of precision can be misleading if a certain degree of precision is implied but not actually attained. To overstate an example, suppose someone were to use a vehicle odometer to measure the distance from one town to another, but measure from the last even mile (as indicated on the odometer) with a tape measure. The result could be represented with an implied precision expressed in feet, but the underlying accuracy is no better than the measurement
obtained by the least precise method. It is a misleading sense of comfort that is provided when the implied precision expressed is not in agreement with actual methodology used.

In surveying, the need for greater precision usually leads to greater costs. To obtain a higher degree of precision, it may be necessary to use more sophisticated (costly) equipment or a more time-consuming methodology. The surveyor must determine what methodology and resultant precision is needed to achieve the accuracy required for a task at hand.

Related Information

The Nature of Measurement: Part Two: Mistakes and Errors, Dr. Ben Buckner, LS, PE, from Professional Surveyor magazine archives
The Nature of Measurement: Part Three: Dealing With Errors, Dr. Ben Buckner, LS, PE, from Professional Surveyor magazine archives
The Nature of Measurement: Part Four: Precision and Accuracy, Dr. Ben Buckner, LS, PE, from Professional Surveyor magazine archives
The Nature of Measurement: Part Six: Level of Certainty, Dr. Ben Buckner, LS, PE, from Professional Surveyor magazine archives
The Nature of Measurement: Part Seven: Significant Figures in Measurements, Dr. Ben Buckner, LS, PE, from Professional Surveyor magazine archives
The Nature of Measurement: Part Eight: Basic Statistical Analysis of Random Errors, Dr. Ben Buckner, LS, PE, from Professional Surveyor magazine archives
The Nature of Measurement: Part Nine: The Concept of Random Error Propagation, Dr. Ben Buckner, LS, PE, from Professional Surveyor magazine archives
The Nature of Measurement: Part Ten: Achieving Accuracy in Distances, Dr. Ben Buckner, LS, PE, from Professional Surveyor magazine archives
Error, Accuracy and Precision, Kenneth E. Foote and Donald J. Huebner, The Geographer's Craft Project, Department of Geography, University of Colorado at Boulder.
Managing Error, Kenneth E. Foote and Donald J. Huebner, The Geographer's Craft Project, Department of Geography, University of Colorado at Boulder.
National Map Accuracy Standards from the U.S Geological Survey