# External reliability analysis of a GPS/Acoustic experiment from a towed buoy

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Combined GPS/Acoustic data for seafloor geodesy are analyzed by least-squares adjustment of seafloor transponder coordinates. Observations of travel time are accumulated by a survey vessel after first transmitting an acoustic signal to at least three seafloor transponders. Each transmit/receive cycle may be thought of as an 'epoch' of data. There may be either one, two, or three observations made each epoch. In this approach, the survey vessel position at every epoch is taken to be known from GPS to a certain precision. One may construct so-called 'epoch observation equations' which consist of the differences between the observed travel times and calculated values (using an initial guess for the transponder coordinates and some model of the sound speed).

We seek to minimize these differences in a least-squares sense by adjusting the transponder coordinates. This is accomplished through inversion of the so-called 'normal' matrix, which is constructed from the partial derivatives of all of the epoch observation equations with respect to the transponder coordinates and the data weights. The data weights are themselves constructed from the uncertainties in each travel time measurement. Additionally, the normal matrix includes external constraints that are placed on the transponder array geometry and orientation. The inverse of the normal matrix is used to update the initial guess for the transponder coordinates. The calculated travel times are then updated as well, and the procedure is iterated until the change to the transponder coordinates is less then a prescribed tolerance (typically, 1 mm).

The size of the travel time residuals give an indication of the precision of the transponder coordinate estimates, as long as there is sufficient redundancy in the data. If there is insufficient redundancy in the observations, then the estimate of the transponder coordinates may be sensitive to marginally detectable blunders in the data. I will discuss the least-squares adjustment, the data redundancy, and the sensitivity to marginally detectable blunders in the context of travel time observations that were accumulated from a buoy in August 2003.