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ACCURACY AND RELIABILITY

Technological, economic and circumstantial factors interact in a complicated fashion in designing and performing a project. Certain fundamental technical considerations are necessary in designing and evaluating any project relating to the extraction of quantitative data. In EM applications, comparative (or relative) results from different specimens are often more important than absolute accuracy. The variability between specimens sometimes far outweighs the importance of some accuracies in individual results. This leads to a general reluctance to consider accuracy related aspects. Nonetheless, they are important considerations and are, therefore, briefly presented here. Ideas are drawn from the domains of topographical and engineering mapping, which are standard jobs in menstrual data handling. Standard accuracy specifications and evaluation (testing) criteria are usually established for standard jobs. For elaborated ideas on these, the reader may benefit from various publications on Adjustment Computations (e.g. Wolf and Ghilani, 1997).

A. Accuracy

In general discussion on *Accuracy*, we must specify both, a range of values within which we expect the output to lie and the probability that will occur. There are two other terms used in this regard, viz., *Bias* and *Precision*. *Bias* is the difference between the input and the mean (accepted as correct) value of the output. *Precision* is the degree of mutual agreement among individual measurements (made under prescribed like conditions), thus it describes the repeatibility issue also. In this light, *Accuracy* is defined as the degree of agreement of individual measurement with an accepted reference value. There is general agreement on the desirability of using the term, *Standard Deviation*, *Standard Error*, or *Root-mean-square-error*, to express accuracy directly or indirectly. Depending on the circumstances, however, the concept must be considered in terms of the following five possibilities in EM applications, for which the following notations are used ("*i*" refers to individual observations):

$t_1, t_2, \ldots, t_n$	observations; n is the number of measurements;
$x, y, z, \ldots$	unknowns; u is the number of unknowns;
$v_i = x - t_i$	corrections in direct observations;

$v_i = f(x, y, z, \ldots) - t_i$	corrections where unknowns are related by functions (linear or nonlinear);
$m_x, m_y, m_z, \ldots$	standard errors (deviations) of unknowns;
m and m_0	standard errors of one observation and one observation of unit weight, respectively;
p	weight of one measurement.

Possibility 1. Adjustment of Direct Observations of Identical Accuracy

In this case, $p = 1$; $x = (1/n)(t_1 + t_2 + \ldots + t_n) = [t]/n$ and $[v] = 0$ are assumed. These give, from basic statistical principles,

$$m = \pm\sqrt{[vv]/(n-1)} \quad \text{and} \quad m_x = \pm m/\sqrt{n} \qquad \text{Eq. (22)}$$

Possibility 2. Adjustment of Direct Observations of Different Accuracy

In this case, one assumes

$$p = m_0^2/m_i^2; \quad [vp] = 0$$

and

$$x = \frac{t_1 p_1 + t_2 p_2 + \ldots + t_n p_n}{p_1 + p_2 + \ldots + p_n} = [tp]/[p]$$

These give

$$m_0 = \pm\sqrt{[vvp]/(n-1)} \qquad m_i = \pm m_0/\sqrt{p_i} \qquad m_x = \pm m_0/\sqrt{[p]} \qquad \text{Eq. (23)}$$

Possibility 3. Adjustment of Linear Functions (in View of the Law of Error Propagation)

One assumes $x = a_1 t_1 + a_2 t_2 + \ldots + a_n t_n$, the a's being certain constants.
These gives

$$m_x^2 = a_1^2 m_1^2 + a_2^2 m_2^2 + \ldots + a_n^2 m_n^2 \qquad \text{Eq. (24)}$$

Possibility 4. Adjustment of Nonlinear Functions (in View of the Law of Error Propagation)

One assumes $x = f(t_1, t_2, \ldots, t_n)$. This gives

$$m_x^2 = \left(\frac{\partial f}{\partial t_1}\right)^2 m_1^2 + \left(\frac{\partial f}{\partial t_2}\right)^2 m_2^2 + \ldots + \left(\frac{\partial f}{\partial t_n}\right)^2 m_n^2 \qquad \text{Eq. (25)}$$

Possibility 5. Adjustment of Intermediate Observations (in View of the Law of Error Propagation)

The original error equation can be set up in the form

$$T_i + v_i = f_i(x, y, z, \ldots) \quad \text{with weights, } p_i = m_0^2/m_i^2$$