

SELECTION OF SURVEYING METHODS

by

ROBERT JAMES HARRIS

B.S., Kansas State University, 1969

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Geology

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1975

Approved by:

Page C. Furr
Major Professor

LD
2668
T4
1975
H37
C.2

C O N T E N T S

Document

	Page
Introduction.....	1
Purpose.....	1
Applications.....	2
Other investigations.....	3
Methods of investigation.....	4
Determination of appropriate procedures.....	7
Accuracy goals and instrument precision.....	7
Tentative plan.....	7
Site examination.....	7
Control.....	8
Tentative traverse plan.....	8
Horizontal measurements.....	9
Statistical parameters.....	9
Error charts.....	11
Vertical measurements.....	14
Statistical parameters.....	14
Error Charts.....	14
Selection from among appropriate procedures.....	18
Immediate availability and costs.....	19
Systematic errors.....	19
Operator convenience and speed.....	20
Practical examples.....	21
Yarrow and Schmidt.....	21
Bell.....	23
Hypothetical example 1.....	25
Hypothetical example 2.....	27
Hypothetical example 3.....	30

	Page
Conclusions.....	30
Acknowledgements.....	32
Selected References.....	34
Appendices.....	43
Short subject index to selected references.....	43
National Map Accuracy Standards.....	45
Description of experiments conducted by the author.....	46
Summary of errors in horizontal measurements.....	65
Summary of errors in vertical measurements.....	71

I L L U S T R A T I O N S

	Page
Figure 1. Errors in stadia distance measurements.....	12
2. Errors in horizontal measurements.....	13
3. Errors in elevations, standard alidade (13x telescope) and Beaman method.....	15
4. Errors in elevations, Wild self-reducing tacheometers RDS, RK-1.....	16
5. Errors in vertical measurements.....	17
6. Structure contour map on top of Americus Limestone in Pottawatomie, Riley, and Wabaunsee Counties, Kansas (Yarrow 1974).....	22
7. Water table map showing ground-water flow (Bell 1974).....	24
8. Section of Geodetic Control Diagram Manhattan, Kansas (NJ 14-3), 1967.....	26
9. Tentative routes of control level survey for hypothetical example 2.....	28
10. Plan view of fault study, hypothetical example 3.....	31
11. Observed errors, K & E alidade.....	53
12. Observed errors, Wild RK-1 alidade.....	54
13. Results of USGS level tests, Ni-2 and N-3 levels.....	55
14. Observed errors and Princeton Test values, RK-1 alidade.....	57
15. Calculated estimation errors.....	60

T A B L E S

	Page
Table 1. Status of data on errors in surveying methods.....	5
2. Probability level conversion factors.....	10
3. Expected elevation error in $1\frac{1}{2}$ miles of traverse.....	23
4. Expected elevation error in 3 miles of leveling.....	25
5. Expected elevation error in 3 miles of traverse.....	25
6. Expected error for level lines of 15, 20, and 35 miles.....	29
7. Minimum detectable displacements for several measurement devices.....	31
8. Princeton Test results, Wild Na-2 automatic level.....	49
9. Error equations for the K & E and Wild RK-1 alidades.....	61
10. Errors in aligning alidades with previously plotted points....	63
11. Examples of Collimation errors, six K & E alidades.....	63
12. Tape correction equations.....	68
13. Errors for electronic distance measurement.....	69
14. Observed errors in barometric leveling.....	73
15. Princeton Test results, USGS level tests.....	74

INTRODUCTION

Purpose

This investigation provides a means for judging the adequacy of the commonly available plane-surveying techniques and instruments in meeting pre-determined accuracy goals. These methods and instruments include:

1) plane table and alidade; 2) elevations by differential leveling, vertical angles, and altimetry; and 3) locations by traverse with distances by tacheometry, taping, and electronic devices, and directions by vernier transits, optical transits, and theodolites.

Because most systematic errors can be corrected or compensated for, the several sources of accidental error limit the attainable accuracy of each method or instrument. By determining, for each of the methods, the magnitude of these errors as a function of different conditions and instrument design, it should be possible to estimate the error in any future measurement. The Theory of Errors, which predicts the resultant of a series of independent accidental errors, could then be used to estimate the error for any measured point in a survey.

This is a study and tabulation of the errors in the methods; the determination of required precision rests with the user. Therefore, though the illustrations are drawn from geology, the principles and data have general application. The methods and their appropriate field procedures are well documented in existing texts and will not be described here. Similarly, though photogrammetry is the optimal method for mapping any substantial area when the measured points can be identified on photographs, there already exists a substantial body of literature on the errors of these methods and selection has been treated by others (Aguilar 1967, 1969).