AMENDED

UNIVERSITY OF NEW SOUTH WALES

SCHOOL OF SURVEYING

29.103 SURVEYING III

FULL TIME COURSE 1977

FIELD EXERCISE: EDM CALIBRATION (ZERO, CYCLIC- AND SCALE ERROR)

1. AIM

To familiarize students with two methods of zero error determination (using redundant observations and least-squares adjustments) and methods of cyclic error and scale error testing of edm instruments.

2. INTRODUCTION

The *additive constant* (or *zero error*) of a combination of an individual edm instrument and a type of reflector is that small amount, which has to be added to every distance measured with a edm instrument, because the origin of the edm does not lie in the vertical axis of the instrument and the prism corner not in the vertical axis of the reflector. The *cyclic error* of an edm instrument is caused by electronic and optical crosstalk between transmitter and receiver. The wave length of a HP 3800B and HP 3805A cyclic error is 10 m. The *scale error* is mainly caused by an error in the modulation frequency. It can be determined by frequency measurement or by comparison with accurate, known distances.

3. EQUIPMENT

Per group:

1 Scale Reading Theodolite Wild T16 (with tribrach)
1 100 m steel band (with reader graduated to mm) which was standardized by your group in a previous field work.
1 Thermometer
1 Spring Balance
1 Clip Board
1 3 m pocket tape
5 Tripods Wild GST20 or Wild GST10 or Wild IIIb or Wild 16b or Shokkisha
1 New Wild Target (Z21 or GST1/GZR2) with tribrach (Wild GDF6)
1 EDM instrument HP3800 or HP3805
(ask for exactly the same instrument you used in the first edm fieldwork!)
with
- 1 Battery Pack (charged) + cables
- 1 Tribrach (Wild GDF6)
- 1 Transmitter Lens Attenuator Cap

1 Single-Prism AGA or HP Reflector (ask for the same type of reflector you used in the first edm fieldwork)
with
- 1 Tribrach (Wild GDF6)
- 1 Revolving swivel base

1 Additional tribrach Wild GDF6
1 Barometer (small survey Aneroid "Dobbie")
7 Wooden pegs
1 Hammer

Demonstrator:

1 Wild Tripod GST20
2 Wild Tribrachs GDF6
1 30 m Steel Tape "Lufkin" (in proper conditions)
1 Spring Balance with hook
1 5 kg weight
Rags
1 Pocket tape
1 HP Red-and-white Target
1 Survey Umbrella with steel rod
1 Hammer

4. FIRST PART OF EXERCISE
(See paragraph 6 for organisation details)

4.1 Set out along the main walkway between Anzac main gate and Science Road a row of five pegs. All pegs must be exactly on line (±1 cm). The distances between the first peg and the others should be (±5 cm): 30 m, 120 m, 170 m, 180 m. The intermediate distances are therefore: 30 m, 90 m, 50 m, 10 m. The centre of the pegs must be marked with a pencil cross. Use theodolite (over peg 1) for alignment, level it carefully, and centre it to better than ±1 mm. Set up a tripod with the traverse target in such a way at a distance of about 180 m, that the line theodolite-target is parallel to the main walkway. Clamp alidade. Set out first the 30 m peg, then the 120 m peg, the 170 m peg and finally the exact 180 m peg, using theodolite and band. Draw locality sketch of baseline in your field book. Number pegs with 1, 2, 3, 4, 5.

4.2 Set up tripods over the four other pegs, attach tribrachs, level them and centre to better than ±1 mm, using the optical plummet.

4.3 Fix the traversing target alternatively in the tribrachs over peg 2, 3, 4 and 5 and measure one zenith distance (in both faces) in each position. Measure heights of theodolite and targets to mm and to top of peg. Book on edm field form.

4.4 Replace theodolite by edm instrument over peg 1, using the constrained centring system. Set the Environmental Correction Dial of your distance meter to the neutral position (= zero) and leave it like that during whole field work. Measure height of edm instrument (to mm) and book it. Fix and orientate reflector alternatively at stations 2, 3, 4 and 5. For each reflector position:

(1) measure height of reflector (centre of prism) to mm and to top of peg and book,
(2) measure the distance twice, repeating the pointing in between. The so called "Transmitter Lens Attenuator Cap" will have to be used usually on short distances, to reduce the signal strength. Book, if the cap was used or not.
Record temperature (in the shade) and pressure.
Book all observations on edm field form.

4.5 Move edm instrument and theodolite to station 2 and measure distances resp. zenith distances to reflector resp. target on stations 3, 4, 5. Take notice of instructions 4.3 and 4.4.

4.6 Move edm instrument and theodolite to station 3 and measure distances and zenith distances to stations 4 and 5. Take notice of instructions 4.3 and 4.4.

4.7 Move edm instrument and theodolite to station 4 and measure distance and zenith distance to station 5.

4.8 Measure the distances 1-2, 1-3, 1-4, 1-5, 2-3, 2-4, 2-5, 3-4, 3-5, 4-5 twice each, with your standardized steel band, fully supported and with standard tension (70N?). Record temperature. Book in field book. Distances exceeding 100 m should be measured in two sections of equal length, using an auxiliary peg in the midpoint.

5. SECOND PART OF EXERCISE

5.1 Proceed to the SW corner of the new MEE Building. Take the following equipment with you:

- edm instrument with battery pack, cables and attenuater cap, without tribrach
- reflector with swivel base but without tribrach
- thermometer
- barometer
- clip board
- pocket tape

5.2 Put your instrument into the prepared tribrach, and measure a first distance to the reflector on tape mark 0.25 m. Follow the instructions given by your demonstrator.

5.3 Move reflector along tape in 0.5 m intervals, taking an edm observation each, up to 10.25 m mark. Measure height of instrument. Measure temperature and pressure periodically. Book all observations on edm field form.

5.4 Repeat the observation programme 5.3 by moving reflector from mark 10.25 m to tape mark 0.25 m.

6. ORGANIZATION

6.1 It takes about one hour to complete the second part. Because there is only one cyclic error test line available, the first group has to start immediately with the second part of the exercise. The second group interrupts its work on the first part of the exercise and starts the second one as soon as the first group has finished its cyclic error test. Other groups follow.

6.2 Get field forms and field books signed by demonstrator after both parts of the exercise are completed.

6.3 Remove pegs and return the equipment to the Survey Store.

7. REPORT

Individual reports are required. Submission: Three weeks after field session, together with field books and field forms.

REPORT ON FIRST PART OF EXERCISE

7.1 Draw edm baseline, showing locality and point numbers.

7.2 Reduce all band measurements on the edm baseline for temperature and slope, using the standard temperature of your band, which was determined in a previous fieldwork. Make all reductions with the mean of the two original observations. The horizontal distances may be obtained as follows:

$$S_{hor} = (S_{Band} + (h_T - h_{TH}) \cos Z_{TH} - \frac{(h_T - h_{TH})^2}{2\, S_{Band}}) \sin Z_{TH}$$

where S_{hor} = horizontal band distance (on local height)

Z_{TH} = zenith distance measured with theodolite to target

S_{Band} = measured band distance (fully supported), corrected for temperature and tension

h_T = height of target above top of peg

h_{TH} = height of theodolite above top of peg.

See handout "Field Exercise: EDM Traverse" for reference.

7.3 Execute a least square adjustment with all ten band measurements using an approach described on page 183/184 of reference [1]. The observations are assumed to be of equal precision. Compute the unknowns C, $\bar{S}_{12}$, $\bar{S}_{13}$, $\bar{S}_{14}$, $\bar{S}_{15}$ in a first step, assuming that a zero error C may occur at the joint between reader and band. In a second step, determine all residuals according to reference [1], p. 184 and compute the standard deviation of one band measurement (mean of two observations). List the adjusted values of all ten distances. Discuss magnitude of residuals and standard deviation.

7.4 Correct edm distances (mean of double measurement) for temperature, pressure and for slope. See formulae in first edm fieldwork handout.

7.5 Compute the zero error, the scale error, and standard deviations from linear regression (least square adjustment with 2 unknowns and 8 redundant observations):

$$\bar{y} = a + b\,x \qquad \text{Zero Error } C = -a$$

y = edm distances (S_{hor}) (according to 7.4)

x = horizontal steelband distances (adjusted values according to 7.3)

$\bar{y}$ = adjusted measured distance for a given x

Use ten corresponding pairs y_i, x_i to compute a, b, s_o, s_c, s_b, according to table 4 in reference [1], p. 183. Compute all residuals

$$v = a + b\,x - y$$

and plot them in function of distance. See figures 7 in reference [1], p. 185.

7.6 The scale corrections may be obtained from 7.5 as follows:

$$S_{corr} = \frac{1}{b}\,S_{meas} \quad \text{(See page 183 of reference [1])}$$

The scale corrections may also be obtained from frequency measurements (see page 187, reference [1]):

$$S_{corr} = \frac{f_{nom}}{f_{act}} \cdot S_{meas}$$

The actual and ~~normal~~ nominal frequency values of your edm meter are displayed on a notice board on the 6th floor, MEE. Discuss the difference between both ~~values of the~~ scale ~~correction~~ factors $\frac{1}{b}$ and $\frac{f_{nom}}{f_{act}}$. Which scale factor should be adopted subsequently?

7.7 Compute zero error C, adjusted distances $\bar{S}$, residuals v and standard deviations s_o and s_c from edm distances only, based on a least squares adjustment with 5 unknowns and 5 redundant observations. The necessary formulae are listed on pages 183 and 184 of reference [1]. Plot residuals in function of distance into the graph used in 7.5.

7.8 Compare zero error, C, standard deviation s_o, 95% confidence interval of C (see page 179 and 180 of reference [1]) and plot of v versus d from 7.5 and 7.7. Comment agreement or disagreement of the above values or graphs. Compare standard deviations s_o also with the manufacturers specifications for the accuracy of one distance observation:

HP3800B	± (5 mm + 7 ppm)
HP3805A	± (7 mm + 10 ppm)

Which zero error should be adopted subsequently? Why? How could both methods be improved?

REPORT ON SECOND PART OF EXERCISE

7.9 No slope corrections are necessary because the steel tape axis is parallel to the line from edm instrument to the reflector. See figure 10 in reference [1]. No corrections for temperature and pressure need to be applied, as long as they have remained constant during the cyclic error test. If small differences in temperature did occur, their effect onto the distances should be checked. Correct distances if necessary.

7.10 Reduce all S to the 0.25 m mark on the tape. That means, that you have to subtract e.g. 6 m exactly from the edm distance to the 6.25 m mark etc. You get this way 42 values S*, of about 82 m. The tape is assumed to be at standard temperature and at standard tension. See table 5 on page 186 in reference [1].

7.11 Plot S* in function of S. Scale of y-axis (S*) = 1:1. Range of y-axis:from lowest to highest S* value only. Scale of x-axis (S) = 1:100, range: 82 m to 93 m. See figure 11, p. 187 of reference [1].

7.12 Draw a sine - curve of best fit, if the 42 dots show any cyclic error of 10 m wavelength.

7.13 Compute the mean of all S* and the standard deviation of one observation and the mean. Mark the mean on the plot by a parallel line to the x-axis (S^*_{mean}). Compare the standard deviation of one observation with values obtained during zero error calibration in 7.5 and 7.7 and with manufacturers specifications (see 7.8).

7.14 If you can draw no sine-curve, correct your traverse distances from your first edm field work for zero error (see 7.8) and for scale error (see 7.6) and recalculate the traverse (horizontal position, only!). Discuss new misclosures and new coordinates.

7.15 If you were able to draw a sine-surve, which does cross the line of the mean of all S* more or less over S = 90 m, your zero error from 7.8 is still valid. Correct traverse distances for zero error, for scale error and for cyclic error, recalculate traverse and discuss new misclosure.

The correction for cyclic error (= C_y) is obtained by entering the fractions of 10 m of the traverse distance onto the x-axis, regarding the fractions of 10 m of S here, too, and by measuring the distance between sine-surve and line of mean S* above. Sign of cyclic error correction C_y: positive if curve below mean-line; negative, if sine-surve above line of S^*_{mean}. See page 187 of reference [1].

7.16 If your sine-surve is not crossing the line of mean S* over an exact multiple of 10 m (90 m in this case), the zero error determined in 7.8 must be modified, before it can be applied to the distances measured in the first edm field work:

$$C_{tot} = c + dc$$

See reference [1], page 187, for an example.

Correct then traverse distances for total zero error (C_{tot}), for scale error and for cyclic error (C_y) and recalculate coordinates of traverse stations. Discuss new misclosures.

8. REFERENCE:

[1] J.M. RUEGER: Design and Use of Baselines for the Calibration of EDM-Instruments. Technical Paper No. 14, 20th Australian Survey Congress, Darwin, May 1977.

J.M. RUEGER
Lecturer
June 1977

13/6/77/JMR/120