Some Do's and Don't's in Terrestrial Surveying of Site Excentricities

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Abstract. Surveying tasks at space geodetic stations like eccentricity determinations or stability monitoring have to produce results which meet the one millimeter accuracy requirement of the overall global system. Although surveying procedures seem to be straight forward a number of obstacles have to be taken into account properly in order to achieve the necessary accuracy. In this paper we will address calibrations of instruments and precautions during the surveyings.

1 Motivation

At space geodetic observing stations, especially where two or more techniques are co-located, the surveying tasks related to eccentricity determinations for local ties or stability monitoring have to be considered as equally important as the observations done for the space techniques. Therefore, local surveying is a full technique in its own right and has, thus, to be taken seriously, sometimes requiring some costly investments.

The staff at space geodetic instruments should be well informed about surveying techniques and proper practices before embarking on doing local tie or stability measurements. Good advice can often be acquired from university institutions nearby with technical background like faculties of civil engineering or the like.

Fig. 1: Good example of a surveying pillar at NyAlesund Geodetic Observatory

Fig. 2: Tripod stabilized with stones at NyAlesund Geodetic Observatory

2 Instrumentation

Local surveying should ideally be carried out using fixed monumentation like surveying pillars made of concrete and reinforcement steel with forced centering devices like pillar plates or fixed 3/8" screws and height reference bolts. In order to avoid tilting of the pillar due to temperature gradients in the concrete or sun radiation, the pillar should be imbedded in a shielding either as a separate concrete ring (standard concrete pipe) or as plastic cover with insulation foam (see Fig. 1).

For temporary surveying points it is sometimes sufficient to use stable tripods which should be stabilized with bigger stones. Using tribrachs for exchanging tachymeters, reflectors and target plates is mandatory. It should be made sure that all parts of the surveying equipment are of the same forced centering system.

Tachymeters to be used should be of the highest quality available with uncertainties of at least 3 mm + 3 ppm or better (see Table 1).

Table 1: Tachymeters as of 2003

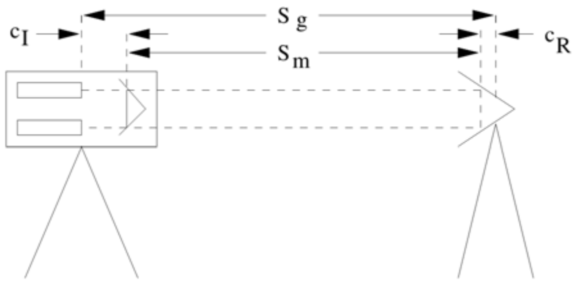
Manufacturer	Model	Display	σ dir. [mGrd[	σ distance [mGrd[	Price
Leica	TC7xx	0.2	0.6	2 mm + 2 ppm	
	TC1103	0.5	1.5	2 mm + 2 ppm	
	TCA 1800	0.1	0.3	1 mm + 2 ppm	EUR 25,000
	TCA 2003	0.01	0.15	1 mm + 1 ppm	EUR 27,000
Sokkia	SET3110 M	0.2	1.0	2 mm + 2 ppm	EUR 17,000
Topcon	GPT 1001	0.2	0.6	3 mm + 2 ppm	EUR 16,000
Trimble	3303	0.2	1.0	3 mm + 3 ppm	
	5601 DR200+	0.1	0.3	3 mm + 3 ppm	EUR 21,000
Wild	TC1600	0.1	1.0	3 mm + 3 ppm	
Zeiss	Elta S10	0.1	0.3	1 mm + 2 ppm	EUR 20,000
	Elta S20	0.1	1.0	2 mm + 2 ppm	EUR 15,500

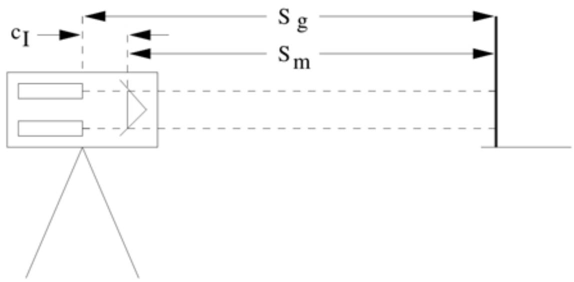
3 Calibration of instruments

Before these instruments can be used they should be checked and calibrated. Most important is that the additive correction is determined for each instrument/prism combination in use. Figures 3 and 4 display the background of the additive corrections for prism and tape reflectors. Table 2 shows which errors may be made if these are not determined properly.

Table 2: Additive corrections of instrument/prism combinations

Prism / Instrument	AGA	Nikon	Pentax	Sokkia	Topcon	Leica	Zeiss
AGA	0	0	0	-30	0	-35	-35
Nikon	0	0	0	-30	0	-35	-35
Pentax	0	0	0	-30	0	-35	-35
Sokkia	+30	+30	+30	0	+30	-5	-5
Topcon	0	0	0	-30	0	-35	-35
Leica	+35	+35	+35	+5	+35	0	0
Zeiss	+35	+35	+35	+5	+35	0	0





Figures 3 and 4 display the background of the additive corrections for prism and tape reflectors.

Table 3 indicates which other errors may be encountered with tachymeters. Cold start and temperature drift effects of additive correction should also be taken into account. This can largely be avoided if the instrument has sufficient time to accommodate to the outside temperature.

Table 3:Instrumental errors

scaled by distance		
modulation frequency		$10^{-6} - 10^{-7}$
refraction/ meteorology		$1\ K \equiv 1 \times 10^{-6}$
		$4\ HPa \equiv 1 \times 10^{-6}$
independent of distance		
integer cycles		free of error
phase	cyclic / inhomogenous	negligible
additive correction		0 – 35 mm

4 Measurements

For the actual measurements one should select a day which is favourable in terms of the weather. It should be stable, i.e. large temperature variations should be avoided. Optimal conditions prevail if the day is hazy with little wind. Rapid changes of sunshine and cloud occultation should be avoided. An umbrella over instrument should be set up in any case and over the reflector if possible.

The handling of the instrument should be given some consideration.

1. Permit acclimatisation of instrument

2. Permit warm-up period

3. Measure temperature at instrument and reflector

4. Measure pressure at instrument (and at reflector if there is a large height difference)

5. Enter meteorological parameters into the instrument only once (apply incremental corrections in data reduction process)

6. Set additive correction in instrument to zero (apply corrections in data reduction process)