Some do’s and don’t’s in terrestrial surveying of site excentricities

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### Characteristics of Electronic Tachymeters

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Model</th>
<th>Display mGrd</th>
<th>$\sigma$ dir. mGrd</th>
<th>$\sigma$ distance</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leica</td>
<td>TC110</td>
<td>0.5</td>
<td>3.0</td>
<td>5 mm + 3 ppm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TC7xx</td>
<td>0.2</td>
<td>0.6</td>
<td>2 mm + 2 ppm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TC1103</td>
<td>0.5</td>
<td>1.5</td>
<td>2 mm + 2 ppm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TCA 1800</td>
<td>0.1</td>
<td>0.3</td>
<td>1 mm + 2 ppm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TCA 2003</td>
<td>0.01</td>
<td>0.15</td>
<td>1 mm + 1 ppm</td>
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</tr>
<tr>
<td>Sokkia</td>
<td>SET3110 M</td>
<td>0.2</td>
<td>1.0</td>
<td>2 mm + 2 ppm</td>
<td>EUR 17,000</td>
</tr>
<tr>
<td>Topcon</td>
<td>GPT 1001</td>
<td>0.2</td>
<td>0.6</td>
<td>3 mm + 2 ppm</td>
<td>EUR 16,000</td>
</tr>
<tr>
<td>Trimble</td>
<td>3303</td>
<td>0.2</td>
<td>1.0</td>
<td>3 mm + 3 ppm</td>
<td>EUR 21,000</td>
</tr>
<tr>
<td></td>
<td>5601 DR200+</td>
<td>0.1</td>
<td>0.3</td>
<td>3 mm + 3 ppm</td>
<td>EUR 21,000</td>
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<tr>
<td>Wild</td>
<td>TC1600</td>
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<td>1.0</td>
<td>3 mm + 3 ppm</td>
<td>EUR 21,000</td>
</tr>
<tr>
<td>Zeiss</td>
<td>Elta S10</td>
<td>0.1</td>
<td>0.3</td>
<td>1 mm + 2 ppm</td>
<td>EUR 20,000</td>
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<tr>
<td></td>
<td>Elta S20</td>
<td>0.1</td>
<td>1.0</td>
<td>2 mm + 2 ppm</td>
<td>EUR 15,500</td>
</tr>
</tbody>
</table>
Instrumental errors

**scaled by distance**
- modulation frequency
- refraction/ meteorology

\[ 10^{-6} - 10^{-7} \]
\[ 1 \text{ K} \equiv 1 \times 10^{-6} \]
\[ 4 \text{ HPa} \equiv 1 \times 10^{-6} \]

**independent of distance**
- integer cycles
  - free of error
- phase
  - cyclic / inhomogenous
  - negligible
- additive correction
  - 0 - 35 mm

Cold start and temperature drift effects of additive correction
Additive corrections of instrument – prism combinations
### Additive corrections of instrument – prism combinations

<table>
<thead>
<tr>
<th>Prism / Instrument</th>
<th>AGA</th>
<th>Nikon</th>
<th>Pentax</th>
<th>Sokkia</th>
<th>Topcon</th>
<th>Leica</th>
<th>Zeiss</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGA</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-30</td>
<td>0</td>
<td>-35</td>
<td>-35</td>
</tr>
<tr>
<td>Nikon</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-30</td>
<td>0</td>
<td>-35</td>
<td>-35</td>
</tr>
<tr>
<td>Pentax</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-30</td>
<td>0</td>
<td>-35</td>
<td>-35</td>
</tr>
<tr>
<td>Sokkia</td>
<td>+30</td>
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<td>+30</td>
<td>0</td>
<td>+30</td>
<td>-5</td>
<td>-5</td>
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<tr>
<td>Topcon</td>
<td>0</td>
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<td>0</td>
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<td>-35</td>
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<tr>
<td>Leica</td>
<td>+35</td>
<td>+35</td>
<td>+35</td>
<td>+5</td>
<td>+35</td>
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<td>0</td>
</tr>
<tr>
<td>Zeiss</td>
<td>+35</td>
<td>+35</td>
<td>+35</td>
<td>+5</td>
<td>+35</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Setup of EDM calibration procedure
Results of EDM calibration procedure I

TC 1600 Tachymat, Ser.-Nr. 1

Soll-lst [mm]

-15,00
-13,75
-12,50
-11,25
-10,00
-9,75
-9,50
-9,25
-9,00
-8,75
-8,50
-8,25
-8,00
-7,75
-7,50
-7,25
-7,00
-6,25
-5,00

200 400 600
Results of EDM calibration procedure II

Trimble 5600 DR 200+  25/08/03

Some do's and don't's
Some do’s and don’ts

Temperature variations during EDM calibration procedure

[Graph showing temperature variations over Satz Nr. 2 to 20, with a peak at Satz Nr. 8 and a general trend of temperature changes on 25/08/03 - Temperatur.]
Distance dependence of additive constant

![Graph showing the relationship between Entfernung [m] and Additionskorrektur [mm].]
Some do's and don’t’s

**Precautions**

- **Weather**
  - Select stable weather (avoid temperature variations)
  - Optimal: Hazy (moist) weather with little wind
  - Avoid: Rapid change of sunshine and cloud occultation

- **Cover**
  - Use umbrella over instrument and reflector

- **Handling of instrument**
  - Permit acclimatisation of instrument
  - Permit warm-up period
  - Measure temperature at instrument and reflector
  - Measure pressure at instrument (and at reflector if large height difference)
  - Enter meteorological parameters only once (apply corrections in data reduction process)
  - Set additive correction to zero (apply corrections in data reduction process)
Correlations between parameters of adjustment of circle I

<table>
<thead>
<tr>
<th>$X_M$</th>
<th>$Y_M$</th>
<th>$R$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.89</td>
<td>0.96</td>
</tr>
<tr>
<td>0.89</td>
<td>1</td>
<td>0.96</td>
</tr>
<tr>
<td>0.96</td>
<td>0.96</td>
<td>1</td>
</tr>
</tbody>
</table>
Some do's and don't's

Correlations between parameters of adjustment of circle II

![Diagram](image)

<table>
<thead>
<tr>
<th>$X_M$</th>
<th>$Y_M$</th>
<th>$R$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0.99</td>
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<tr>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>0.99</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
Correlations between parameters of adjustment of circle III

\[ \begin{array}{cccc}
X_M & Y_M & R_1 & R_2 \\
1 & 0.24 & -0.99 & 0.97 \\
0.24 & 1 & -0.23 & 0.33 \\
-0.93 & -0.23 & 1 & -0.96 \\
0.97 & 0.33 & -0.96 & 1 \\
\end{array} \]
Some do’s and don’t’s

Correlations between parameters of adjustment of circle IV

\[ \begin{array}{ccc}
X_M & Y_M & R \\
1 & 0 & 0 \\
0 & 1 & 0 \\
0 & 0 & 1 \\
\end{array} \]