INNOVATIVE AND COST EFFECTIVE SPATIAL POSITIONING

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FIG Commission 5 „Positioning and Measurement“

FIG Working Week 2013
Abuja, Nigeria, 06 - 10 May, 2013

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Introduction

- Positional infrastructure is a key technology for the economy of any country: Reference Frames, Continuous Operating Reference Stations (CORS), etc.
- Positioning is in general realized by surveyors/geodesists.
- Instruments are highly accurate and therefore often expensive; this is valid for new instruments for spatial data acquisition too (e.g., Terrestrial Laser Scanning).
- Alternative: Low-Cost Instruments

Measure as accurate as needed not as accurate as possible.

Cost-Effective Positioning is the aim!

Surveying Instruments

Low Accuracy Level
- Total Station: ca. 8,000 €
- Level Instrument: ca. 2,000 €
- GNSS Receiver: ca. 8,000 €

High Accuracy Level
- Total Station: ca. 30,000 €
- Level Instrument: ca. 10,000 €
- GNSS Receiver: ca. 20,000 €
New Development: Spatial Data Acquisition

- Terrestrial Laser Scanning (TLS)
- Ground Based Radar
- Terrestrial Photogrammetry

**Investment Costs TLS**
30,000 € to 100,000 €

*Exemplary Laserscanners: Faro Focus 3D, Riegl VZ 100, Zöller & Fröhlich*

Kinematic Spatial Data Acquisition / Mobile Mapping
Multi-Sensor-Systems; mainly by specialized companies. Investment costs: even higher!

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Low-Cost Instruments

- GNSS receivers (mass market receivers): **yes**
- Level instruments and total stations: **no**

Accurcay: Comparable to survey grade receivers for short baselines
Costs: 1,000 to 2,000 € (complete system)

Alternative:
Positioning by mobile / smart phones (GNSS or mobile phone positioning)
Accuracy: some m to some km
Costs: 0 to 700 € (complete system)
Positional Infrastructure

GNSS CORS networks improve accuracy and reliability and economize one receiver!

CORS station within Swepos network

Positional Infrastructure

Mobile phone networks are important
- for data real time transfer of GNSS networks
- to support of GNSS positioning (A-GNSS)
- for positioning by mobile phones

Mobile phone network in Karlsruhe, Germany
### Cost-Effective Positioning

**Simple decision table**
for the case that personnel and any other cost have no influence or are the same for all instruments compared.
*Only investment costs and accuracy (quality) are counting!*

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Max. Accuracy</th>
<th>Investment</th>
<th>Invest per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type A</td>
<td>1 cm</td>
<td>8 000 €</td>
<td>1 600 €</td>
</tr>
<tr>
<td>Type B</td>
<td>0.5 cm</td>
<td>15 000 €</td>
<td>3 000 €</td>
</tr>
<tr>
<td>Type C</td>
<td>1 mm</td>
<td>25 000 €</td>
<td>5 000 €</td>
</tr>
</tbody>
</table>

*Measure as accurate as needed not as accurate as possible.*

### Cost-Effective Positioning

**Complex decision table**
Influences: personnel, investment and additional costs.
Important: personnel costs per hour / day / year.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Max. Accuracy</th>
<th>Invest per year</th>
<th>Personnel per year / (1 €)</th>
<th>Personnel per year / (70 €)</th>
<th>Fees / Communication per year</th>
<th>Overall costs (1 €)</th>
<th>Overall costs (70 €)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Station</td>
<td>1 mm</td>
<td>5 000 €</td>
<td>4 000 €</td>
<td>270 000 €</td>
<td>-</td>
<td>9 000 €</td>
<td>275 000 €</td>
</tr>
<tr>
<td>Robotic Total Station</td>
<td>1 mm</td>
<td>6 000 €</td>
<td>2 000 €</td>
<td>135 000 €</td>
<td>-</td>
<td>8 000 €</td>
<td>141 000 €</td>
</tr>
<tr>
<td>Low-Cost GNSS / CORS</td>
<td>5 mm</td>
<td>500 €</td>
<td>2 000 €</td>
<td>135 000 €</td>
<td>1 000 €</td>
<td>3 500 €</td>
<td>138 000 €</td>
</tr>
</tbody>
</table>

*Developed Countries: Automation and positional infrastructure important.*

*Developing Countries: Low-Cost instruments and positional infrastructure important.*
## Cost-Effective Positioning

### Decision table for huge data amounts

**Example: 500 m street & facades**

<table>
<thead>
<tr>
<th>Method</th>
<th>Max. Accuracy</th>
<th>Invest</th>
<th>Personnel (70 €): field / office</th>
<th>Personnel (1 €): field / office</th>
<th>Assignment costs</th>
<th>Overall costs (1 €)</th>
<th>Overall costs (70 €)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robotic Total Station</td>
<td>1 mm</td>
<td>2 000 €</td>
<td>56 € / 5 €; 8 days / 1 day</td>
<td>5 000 € / 500 €; 8 days / 1 day</td>
<td>1 072 €</td>
<td>4 568 €</td>
<td>6 040 €</td>
</tr>
<tr>
<td>TLS</td>
<td>2 mm</td>
<td>830 €</td>
<td>16 € / 40 €; 2 days / 5 days</td>
<td>1120 € / 3 000 €; 2 days / 5 days</td>
<td>4 750 €</td>
<td>11 200 €</td>
<td></td>
</tr>
<tr>
<td>Mobile Mapping</td>
<td>2 mm</td>
<td>10 000 €</td>
<td></td>
<td>10 000 €</td>
<td>10 000 €</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

 TLS cost-effective although investment costs higher.

### Summary

- Presentation of well-known geodetic techniques and low-cost alternatives as well as new developments for spatial data acquisition
- Importance of positional infrastructure is highlighted
- **Cost-Effectiveness** means
  - using the quality level required,
  - using the automation level required,
  - using positional infrastructure,
  - taking into account all costs, and decide for the survey instrument and procedure delivering the required quality with minimal financial effort!
Thank you very much for your attention!

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