

Introduction:

The measurement setup for data acquisition is described in Section 1. The original measurement results of the laser tracker are saved in CSV files. The ZIP files, e.g. SP1_S1_hvd.zip, contain the measurements of a data set on an instrument standpoint. SP1 means that the laser tracker is on standpoint one. S1 means that this is the first repetition on SP1. Five sets were measured on each SP. hvd means that horizontal angle, vertical angle und distance were measured. In the ZIP files are the CSV files, e.g. 231_1.csv. The first number is the point number (here 231) and the second number is the measuring rate (here 1 Hz). The CSV files are described in Section 2.

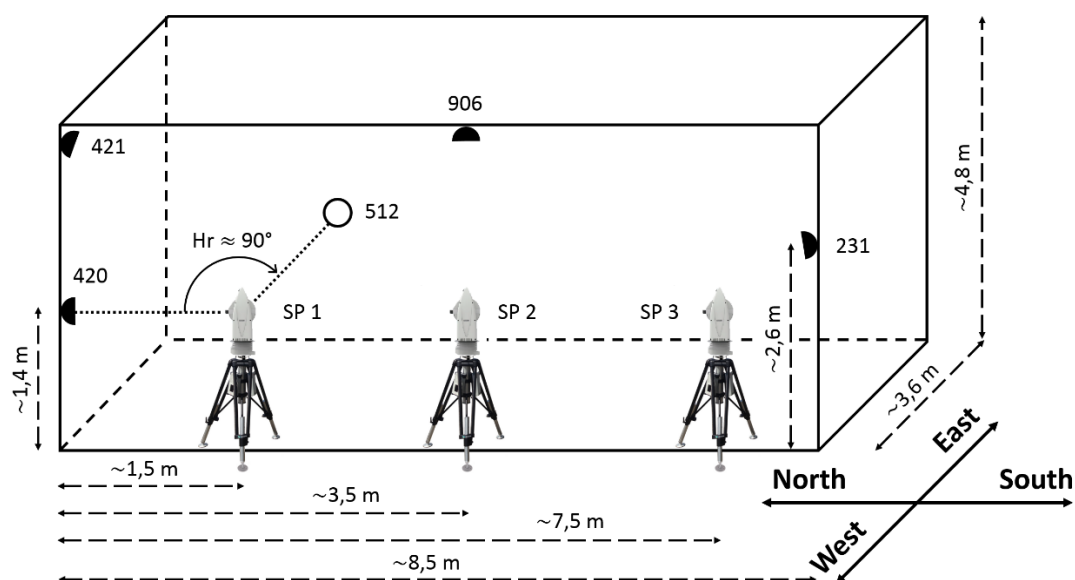
In addition to the original measurement CSV files, the measurement results are provided as MATLAB files. Attention, the MATLAB files has been pre-processed. Detailed information are given in Section 3. Furthermore, plots of the measurement results with the corresponding descriptive statistics are available as downloads (see Section 4.).

1. Description of the measurement setup:

Description of the characteristics of the laboratory:

- The laboratory is located on the ground floor of the Geodetic Institute Hannover.
- The dimension of the laboratory is ca. 8.50 m long, ca. 7.00 m wide and ca. 4.8 m high.
- The walls consist of brick. The floor consists of a concrete. The ceiling is suspended with a wooden construction. Under the laboratory is a cellar. On the northern wall borders an office. A corridor borders on the eastern and southern wall of the laboratory. The wall to the west has windows. Above the laboratory there are 1 ½ floors with offices.

Setup of the measurement:



- Point 420 was mounted on a heavy duty tripod made by Brunson Instrument Co. The distance to the wall is approx. 30 cm.
- All other points are mounted to the walls and ceiling of the laboratory.

- The points were signalled during the experiment with the following Corner Cube reflectors: Point 420 with Leica Red Ring Reflector 1.5"; points 421, 512 and 906 with Leica Break Resistant Reflector 1.5"; point 231 with a ball prism 1.5" from Goecke, Schwelm.
- Windows are darkened with blinds against sunlight. Light was off during measurement.

Measuring procedure:

- Each of the five points was measured on each SP with the measuring rates 1 Hz, 10 Hz, 20 Hz, 100 Hz and 1000 Hz for ten minutes.
- All points were first observed at 1 Hz. The measuring sequence was point 420, 512, 421, 906 and 231. The measurement was then repeated at the next higher measuring rate. The measurement of all points at each measuring rate takes about 4.2 hours.
- After all points were observed, the measurements were repeated 4 times according to the procedure described above. This results in total of five data sets.
- The measurements were performed in the period from Friday afternoon, August 2nd 2019, to Monday morning, August 5th 2019.
- The original measuring elements distance (d), horizontal direction (Hr) and vertical angle (V) were observed. The distance has the decimal places to 10^{-1} μm . The Hr has the decimal places to 10^{-2} milli degrees [m°]. The V has the decimal places to 10^{-3} m°.

Instrument:

The laser tracker Leica AT960-LR was used for the measurement. The instrument was calibrated by the manufacturer immediately before this experiment. An Axis check was performed before the experiment. Temperature and air pressure were recorded over the entire measurement with the AT960-LR. The first speed correction was automatically applied to the distance measurement by the laser tracker. The measurement procedure described above was realized via a C++ implementation using the Leica Metrology Foundation SDK (Version 1.4.0).

2. Description of the original measurement files:

CSV file structure of a line:

```
point number | date | time | temperature | air pressure
231          | 02.08.2019 | 03:40:08.9298498;Continuous Time; | 26.4825; | 1008.014;
```

```
|further atmospheric information |polar measuring elements
```

```
49.700001;45,7731628417969;°C;mBar; 1.3965752;79.66833;7021.0424;Spherical;Millimeter;Degree
```

Description of the line content:

- Date: [day.month.year]
- Time: [hours:minutes:seconds] The time was recorded as a.m. and p.m. The information a.m. and p.m. is missing in the CSV files. The following table shows this information for the first measurement of each SP. The time for the other points on the SP results from the measuring procedure. Or take the times from the document "Descriptive_Statistic.pdf".

SP	Repetition	Point-Nr.	Measuring Rate	Time of day
1	1	420	1	a.m.
2	1	420	1	a.m.
3	1	420	1	a.m.

- Temperature: Degree Celsius [°C]
- Air pressure: [hPa] respectively [mBar]
- Polar measuring elements: [Hr ; V ; d] The angle are in degree and the distance in millimetre.

3. Description of the MATLAB files:

The original CSV measurement files were loaded into MATLAB and saved as structure array for each position of the laser tracker, e.g. Data_SP1.mat. When reading the CSV files, the reflector constant was corrected to the distance measurement. Furthermore, the time of day (a.m. or p.m.) was added. The struct consists of the following fields:

- Standpoint (SP): Position number of the lasertracker.
- Repetition: Number of repetitions on the standpoint.
- PointNr: Number of the point.
- Hz: Measuring rate.
- Date: MATLAB date of the measurement. See MATLAB help: datenum and datestr. Back-transformation to the Julian date with the command: datestr(Data_SP1(1).Date,'dd.mm.yyyy')
- Time: Time in second related to the day in the Date field. For example, 60 seconds means 00:01 a.m.
- Temp: Temperature in [°C].
- mBar: Air pressure is in [hPa] respectively [mBar].
- hvd: Measurement results of the polar coordinates. First column are the horizontal angles in degrees. Second column contains the vertical angles in degrees. The third column contains the distance measurement in [mm].

4. Descriptive overview of the measurement results:

The ZIP file "DescriptiveStatistics.zip" contain PNG figures, an PDF file and an CSV file. The figures show the results of the ten-minute measurement (blue line). The red dash lines represent the mean values of the measuring sets. The dotted red lines are the one σ (standard deviation) confidence interval of the set. The PDF and CSV files contain the mean values and standard deviations of all ten-minute measurements.