New Technologies for the Real 3D Reference Point Determination

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Fig. 1: Laser tracker LTD 500

3D reference point determination

Problems:

1. *Reference point is inaccessible*
2. *Reference point is non-material*
3. *No connection to other space geodetic reference points*

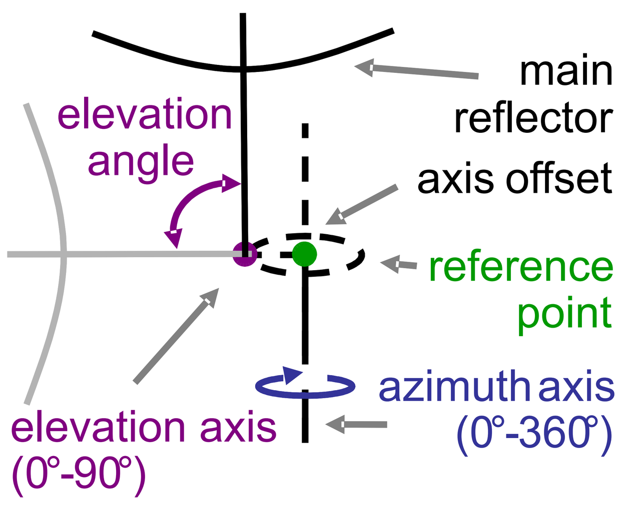

Fig. 2: Definition of telescope reference point

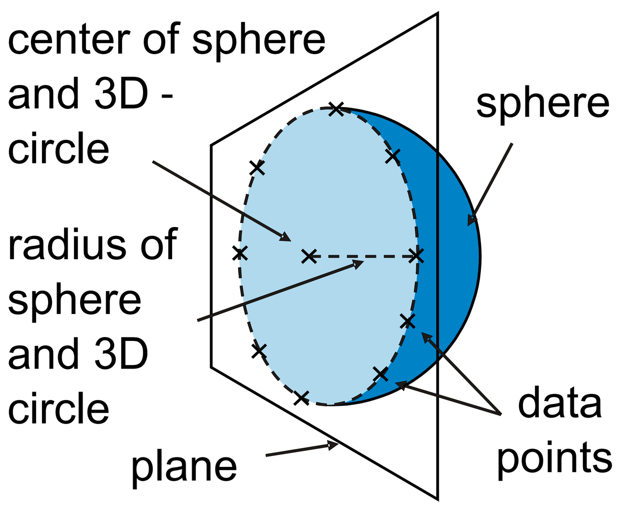

Fig. 3: Adjustment model of the real 3D circle software [Eschelbach, 2002]

Solution in general:

Generation of the virtual reference point *(Fig. 2)* by

1. Placing markers at both ends of the elevation axis
2. Varying the antenna in elevation to produce elevation circles by markers
3. Calculating elevation axis by interconnecting elevation circle centers
4. Repeating 2. and 3. at different azimuth positions of the antenna to generate the azimuth axis
5. Calculating the reference point from the azimuth axis and the elevation axis

Determination of marker coordinates using

1. Angular method or
2. Polar method

Calculation of circle centers by real 3D circle software *(Fig. 3)* [Eschelbach, 2002]

Generation of local tie by a conventional geodetic network

Solution in particular:

Angular method:

Field-tested at the Onsala Space Observatory

Electronic high precision theodolites

600 points observed, generating 60 elevation circles and 4 azimuth circles

Estimated accuracy for the reference point in the local frame: ± 0.1 mm horizontal
± 0.1 mm vertical

Estimated accuracy for axis offset: ± 0.4 mm

Survey time (= telescope downtime): 6 days

Modified method:

Visual adjustment of marker positions at elevation axis

Accuracy for the reference point: ± 0.1 mm horizontal
± 0.3 mm vertical

Survey time (= telescope downtime): 1 ½ days

Solution aspired:

Polar method:

Using laser tracker, e.g. Leica LTD 500 *(Fig. 1)*

Accuracy: ± 0.05 mm for single point static use; < ± 0.01 mm for circle center (measured during telescope motion, depending on reflector orientation compensation)

Measurement during telescope operation possible, LTD 800 with embedded system control enables survey data acquisition by telescope operating software

Survey time (aspired): 5 min each for 5 to 10 stations + reflector mounting time

Modified method:

High precision robot tacheometer, e.g. Leica TCA 5005

Accuracy: ± 0.3 mm (1 point), < ± 0.1 mm for circle center (aspired, depending on reflector orientation compensation)

Survey time (aspired): about 4 h + reflector mounting time

Telescope deformation determination

Fig. 4: Laser radar LR 200

Problems:

1. *Deformation of the antenna support due to thermal effects*
2. *Deformation of the main reflector of the telescope due to thermal and gravitational effects*

Solution in general:

Ad 1.:

Fast 3D reference point method is capable to generate model of $(x,y,z)_{RefPoint} = f(T)$ with T = temperature of support

Ad 2:

Determine shape, position and orientation of the main reflector surface by fast high precision scanning

Fast high precision scanning:

Specifications of laser radar Leica LR 200 *(Fig. 4)*:

Accuracy @ inclination angle < 45°:

Point: ± 10 µm @ 2 points/s,
± 0.3 mm @ 1000 points/s,
Surface patch: ± 0.1 mm in 1 s,
Regardless of orientation of sensor

Range: 1m … 10 m (option: up to 60 m)

Weight: 40 kg (sensor head)

Therefore:

Capable to install near sub-reflector

So: inclination angle restriction is met for the whole main reflector surface

Lit.:
Eschelbach, C. [2002]: *"Determination of the IVS reference point at the Onsala Space Observatory in a local reference frame"*. Diploma thesis. Geodetic Institute, University of Karlsruhe. (Unpublished)

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