Evolution and obtained expertise in reference point determination at the GIK

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Abstract

Since 2002 different strategies have been investigated at the Geodetic Institute of the Universität Karlsruhe to determine the local-tie between the reference points of different geodetic space techniques at co-location stations with high precision. The IVS reference point of a VLBI telescope of azimuth elevation type is defined as the intersection of azimuth axis and elevation axis or if they do not intersect the point on the azimuth axis which is nearest to the elevation axis (Figure 1). Thus, the reference point is independent of any orientation of the telescope.

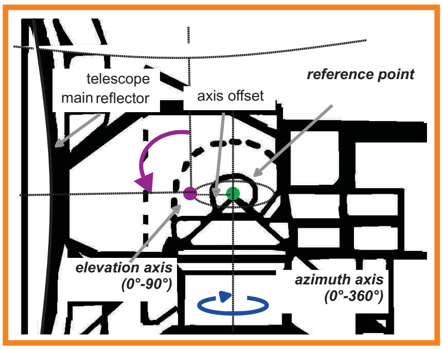

Figure 1: Definition of the IVS reference point

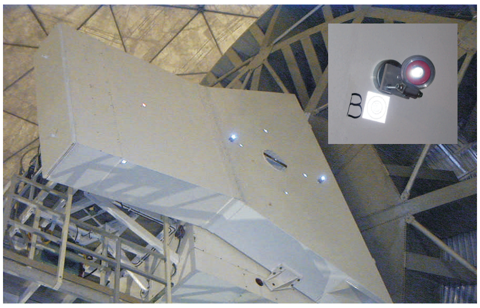

Figure 2: Reflective Tape Targets (2002) and Cat-Eye Reflectors (2008)

Surveying campaigns

Two campaigns took place at the Onsala Space Observatory (OSO) to determine the local-tie between the IGS reference point and the IVS reference point. In both campaigns the IGS reference point was materialised as a steel bolt in the concrete monument below the GPS-antenna and could be measured directly. The 20m radio telescope at OSO is surrounded by a radom and the IVS reference point is an inaccessible point somewhere in the telescope structure. Different equipment and different calculation models were used in the campaigns, implicating modifications of the measurement strategies.

2002

Equipment

Tachymeter for the local network, two theodolites of higher accuracy for the telescope measurements (Figure 3), digital level

Figure 3: Theodolite T2002

Measurements

Local net: horizontal position (horizontal angles and horizontal distances) and height (precise levelling)

IVS reference point measurement: 3-dimensional by the intersection of two simultaneous sightings from pillars in the radom, Reflective Tape Targets at the telescope cabin (Figure 2), telescope movements in strict order

Calculation strategy

Network adjustment: separated adjustments for the local network (split in position and height) and for the telescope measurements providing points at the telescope cabin

IVS reference point: 3-dimensional circle fit combined with restrictions deduced from the telescope structure, error propagation using full covariance matrix

$$f_i^1(\mathbf{x},\tilde{\mathbf{l}}) = (\tilde{X}_i - X_0)^2 + (\tilde{Y}_i - Y_0)^2 + (\tilde{Z}_i - Z_0)^2 - R_0^2 = 0$$

$$f_i^2(\mathbf{x},\tilde{\mathbf{l}}) = A_0\tilde{X}_i + B_0\tilde{Y}_i + C_0\tilde{Z}_i - 1 = 0$$

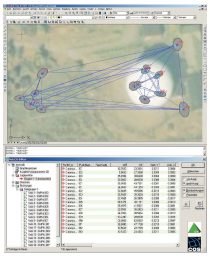

Figure 4: Results of the network adjustment (NetzCG)

Main results

Loca-tie, axis offset

2008

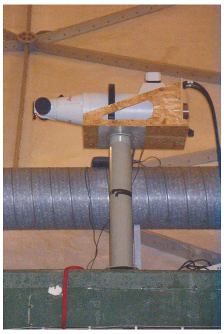

Figure 5: Laser Tracker LTD 840

Equipment

Laser Tracker LTD 840, reflectors with wide field of work (avoidance of laser beam break) or self-orienting reflectors

Measurements

Local net: 3-dimensional by polar measurement (connection of free-stations without relation to the plumb line (Figure 5))

IVS reference point determination: 3-dimensional by polar measurement, Cat-Eye Reflectors at the telescope cabin (Figure 2), telescope orientation angles

Calculation strategy

Network adjustment: adjustment of the measurements of the local network and the telescope measurements in one pour

IVS reference point: transformation between a ground fixed observation system and the telescope system with respect to irregularities of the telescope structure, error propagation using full covariance matrix

Figure 6: Laser Tracker in front of radome

$$P_{Obs} = P_R + R_x(\beta)\cdot R_y(\alpha)\cdot R_z(\mathrm{A}+O_\mathrm{A})\cdot R_y(\gamma)\cdot\left(Ecc + R_x(\mathrm{E}+O_\mathrm{E})\cdot P_{Tel}\right)$$

Main results

Local-tie, axis offset

Comparison

The following table compares the two campaigns. The values of the axis offset and the 3-dimensional distance between the reference points can be given without taking a different geodetic datum in account. Furthermore, pros and cons of the strategies are mentioned.

	2002	2008
3D-Distance [m]	79.5685	79.5678
Axis Offset [m]	-0.0060	-0.0062
Accuracy	Requirement of <1mm fulfilled, full covariance matrix for the local-tie is provided	
Real-time capability	Impossible because of strict order of telescope movements	Possible with synchronised registrations of polar measurements and telescope orientation
Effort	*Local network*: higher effort due to the split of position and height *Telescope measurements*: high effort because of two observation instruments, strict order of telescope movements	*Local network*: reduced effort with Tachymeter, increasing effort in handling with Laser Tracker *Telescope measurements*: fast execution due to automated target recognition

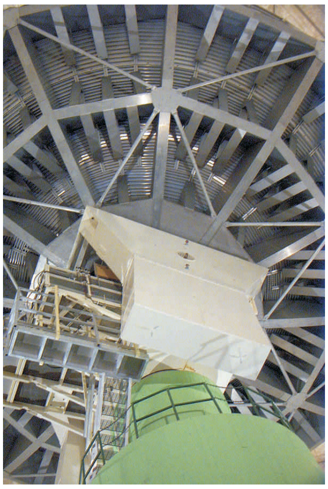

Figure 7: Telescope

Figure 8: Onsala Space Observatory

Further Information

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