POTSDAM

GeoForschungsZentrum SLR – GPS – PRARE

Co-Location Survey Report Summary

Date of Survey: April 2006

Date of Report: July 2012

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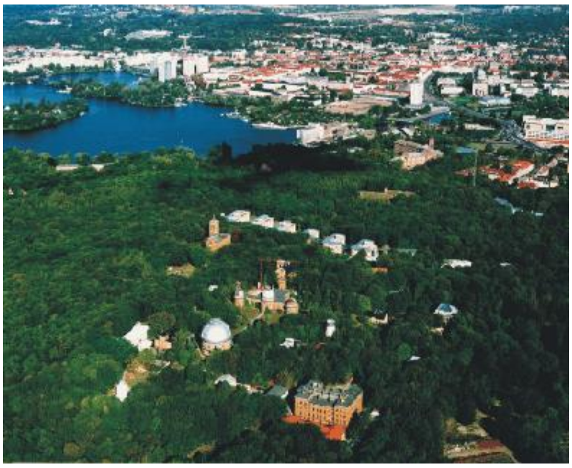
1. Introduction

This report summarizes the results of a co-location survey conducted within the framework of a diploma thesis.

2. Site Description

The space geodesy instruments of the GFZ Potsdam are located within the campus of the science park “Albert Einstein” on top of the Telegrafenberg hill (photo by courtesy of Lutz Hannemann, Potsdam). The Telegrafenberg has an elevation of about 96 meters above sea level and is in wide



parts thickly wooded. There are several scientific institutions located within the campus: the GeoForschungsZentrum (GFZ), the Potsdam Institute for Climate Impact Research (PIK), the Alfred Wegener Institute for Polar and Marine Research (AWI), the Astrophysical Institute Potsdam (AIP) and parts of the German Weather Service.

The wooded and hilly terrain complicates any geodetic survey because the visibility between the single targets is strongly limited and additional auxiliary survey points are required.

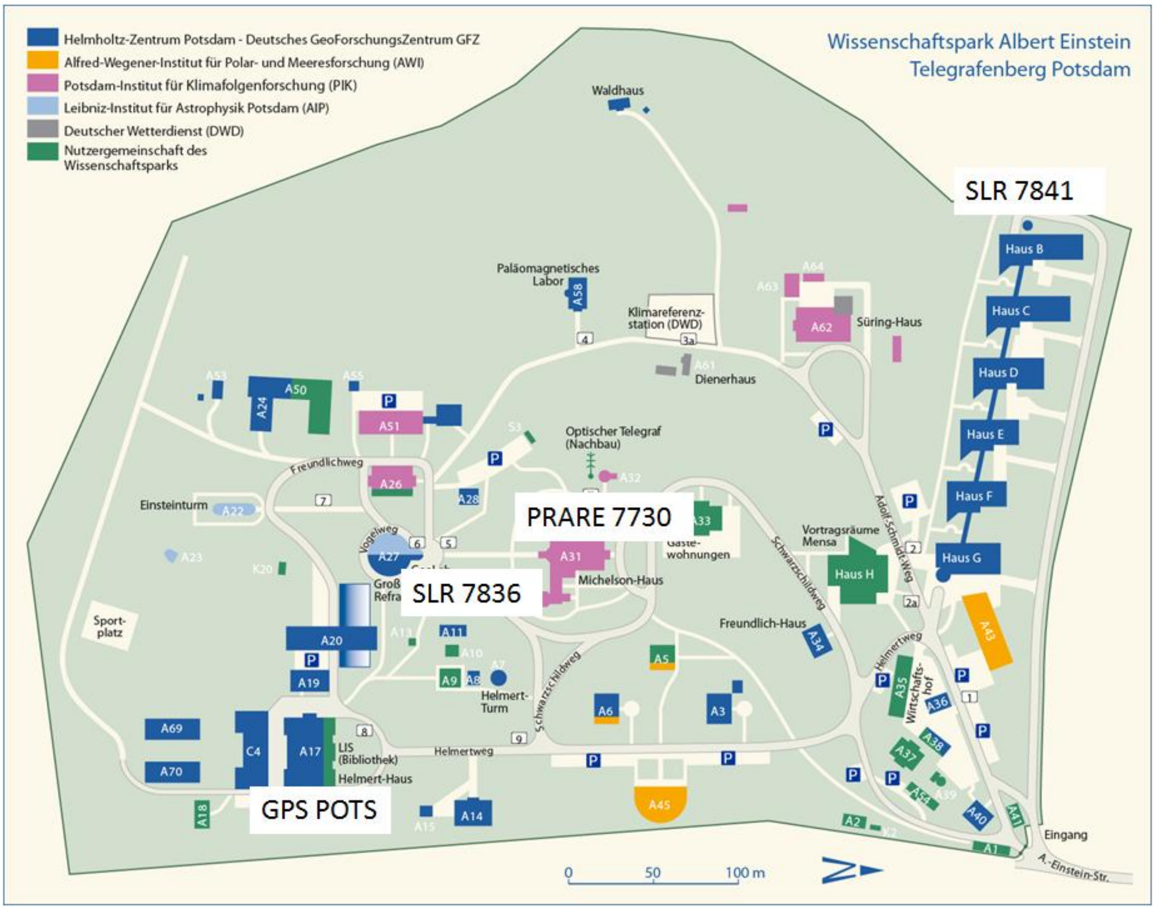
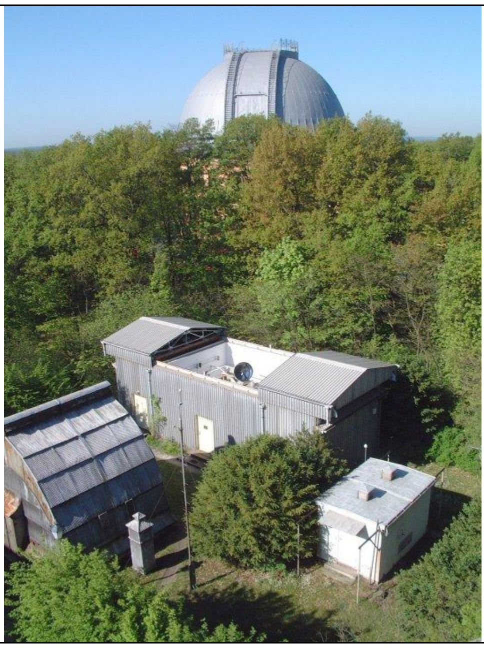


Figure 1 Campus plan with approximate locations of space geodesy instruments

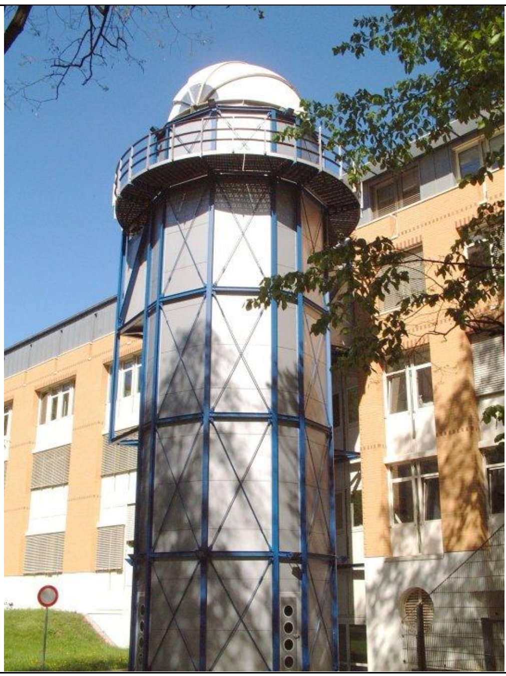
3. Co-located Space Geodesy Instruments

SLR Stations

There are two SLR stations at Potsdam Telegrafenberg:

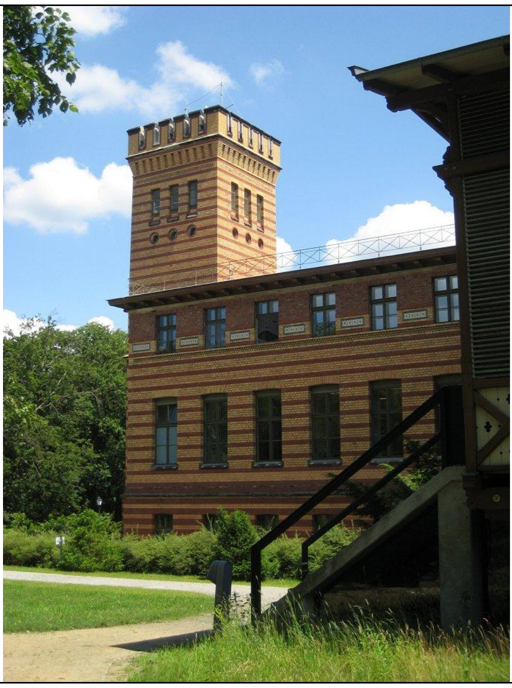
	
SLR 7836 in building A 11	Close-up view of the telescope

The SLR system 7836 (Potsdam-2) was operated between 1992 and 2004. It comprises a 1-m Coudé-Mangin telescope on an alt-azimuthal mount. The reference point of the 7836 system is the intersection between the azimuth and the elevation axis.

	
SLR 7841 telescope tower close to building B of the new GFZ premises	Close-up view of the telescopes (foreground: receiver, background: transmitter)

The SLR system 7841 (Potsdam-3) has been operated continuously since 2002. It features a bistatic approach and comprises a 13 cm refractor as the transmitter telescope and a 40 cm Coudé-Cassegrain mirror as the receiver. Both telescopes display alt-azimuthal mounts. The reference point for each of the 7841 twin telescopes is the intersection between the related azimuth and elevation axes. The invariant point for the complete system is located halfway between both individual reference points.

The former PRARE System



Water tower of the former Astrophysical Institute (former PRARE location)

PRARE system 7730 on top of the fixed tripod (image taken in 1994)

The PRARE system 7730 was located on top of the water tower on the northern side of the former Astrophysical Institute building. It comprised a steerable antenna dish on an alt-azimuthal mount. The geodetic reference point was the intersection of both the azimuth and the elevation axes.

The PRARE system is no longer operational, but the fixed tripod on top of the water tower is maintained and serves as a marker within the local geodetic network.

The IGS Station

	
IGS station POTS on the north-eastern pillar on top of the roof of building A 17	Close-up view of POTS, the yellow cross indicates the system reference point

The permanent GPS station POTS (which is permanently operated within the framework of the IGS) comprises a Javad TRE_G3TH DELTA GPS+GLONASS receiver and a Javad G3T antenna on a choke ring. The system reference point (SRP) is the marker within the pillar. The SRP is located 0.1206 m below the antenna reference point (ARP).

4. Survey Description

Used Instruments

For tacheometric measurements the Zeiss Tachymeter Elta S 10 in connection with the related corner cubes was used. The redundant GPS survey in parts of the network was performed by 5 Trimble receivers 4000 SSE with Trimble 4000 SST L1/L2 and Trimble Permanent L1/L2 antennas, respectively.

Geometric leveling was used to some extent in order to enhance the accuracy of the height components within the complicated terrain. For this purpose a digital level Zeiss DINI 12 was applied.

Description of the Networks

Taking into account the fact that there was no direct visibility between the two SLR systems, it was necessary to introduce intermediate, non-permanent markers and to divide the network into a large and a small one. The small sub-network was set up in the vicinity of the SLR system 7836 .

The following Table gives an overview of the used reference points:

Reference Point	Description	Abbr.	Number (internal)	Comments
Small network, building A 11 (SLR 7836)				
1000	On wall crest, northwest			Center of cemented marker
2000	On wall crest, southwest			Center of cemented marker
3000	On wall crest, northeast			Center of cemented marker
4000	On wall crest, southeast			Center of cemented marker
5000	On wall crest, middle			Center of cemented marker
7836	Telescope axes intersection	LAS	7836	
Large network				
8100	On wall crest within A11			Tripod, temporary
8200	In front of building A 27			Tripod, temporary
8300	Near Helmert sidewalk			Tripod, temporary
8400	On building A 17, west	PW	2053	Measurement pillar, fixed
8500	On water tower of A 31	WTP	2456	Fixed PRARE tripod Position: center/upper edge of drilled reference hole
8600	On GFZ building G			Temporary PRARE tripod
8700	On tower of building A 62			Temporary PRARE tripod
8800	On pillar of SLR 7841	NLT3	2303	Center of cemented marker
8900	On pillar of SLR 7841	NLT4	2304	Center of cemented marker
9000	Reference point of SLR 7841	NLT0		Center between individual SRPs of twin telescopes
8000	Permanent IGS station	PON	2051	Measurement pillar POTS
Leveling references				
1111	South wall of A 11 (SLR 7836)			Cemented height marker
5555	Southwest corner of A 17			Cemented height marker
8888	SLR 7841, bottom of tele-scope tower			Upper edge of lightning conductor

Table 1 Overview of reference points for networks and leveling

Several reference points are shown here in more detail:

Figure 2 Marker 1000 on wall crest in building A 11

Figure 3 Permanent IGS station (8400) and location of marker 8500 in the background

Figure 4 SLR 7841 receiver telescope and location of temporary marker 8700 on top of building A 62 in the background

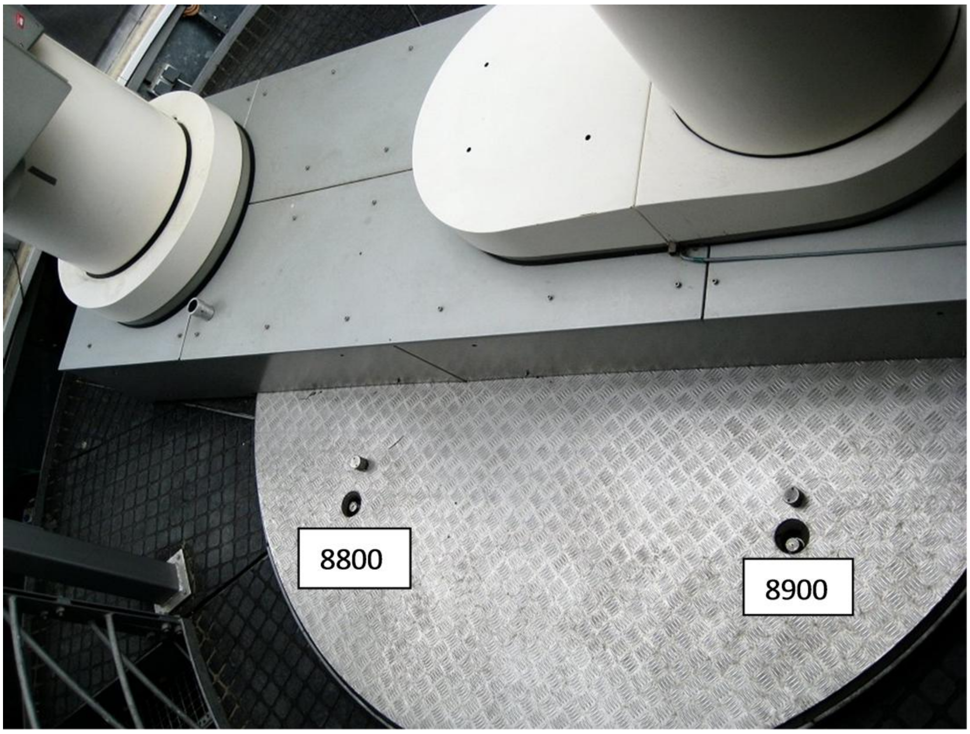


Figure 5 SLR 7841 telescopes and reference markers 8800 and 8900

The following two Figures show the network geometry for the terrestrial survey and the complementary GPS survey, respectively.

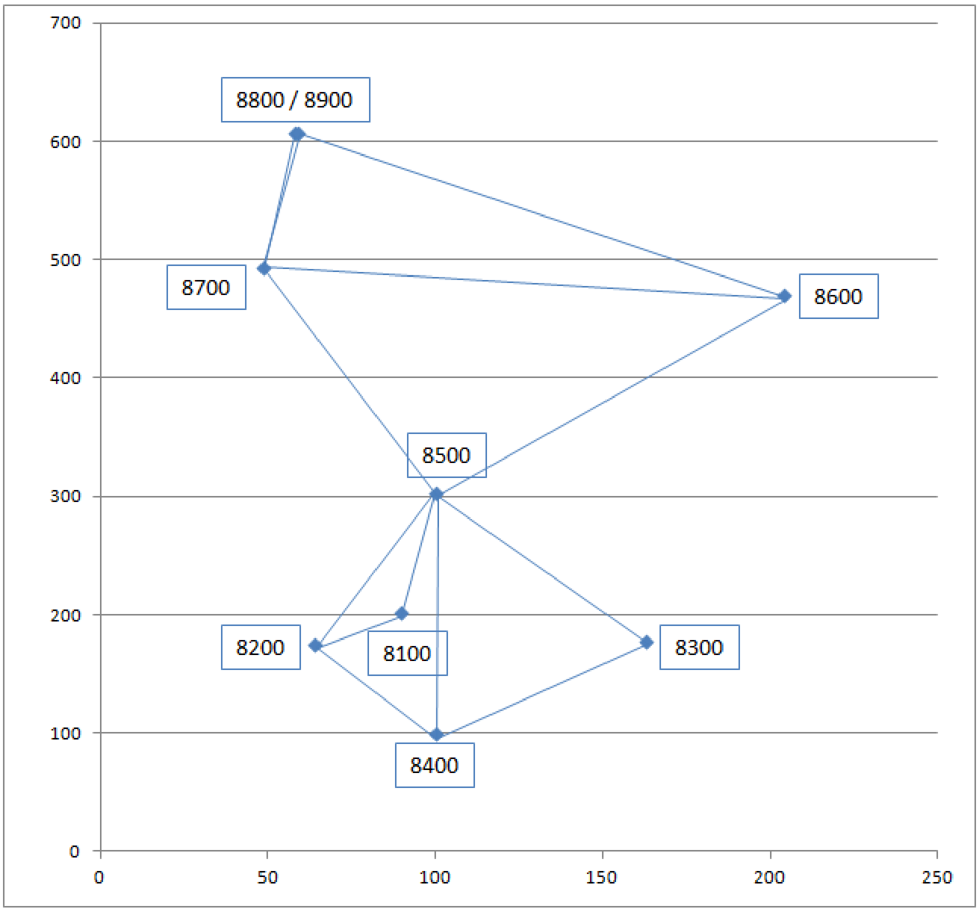


Figure 6 Geometry of the large network (terrestrial survey methods), scales are in meters

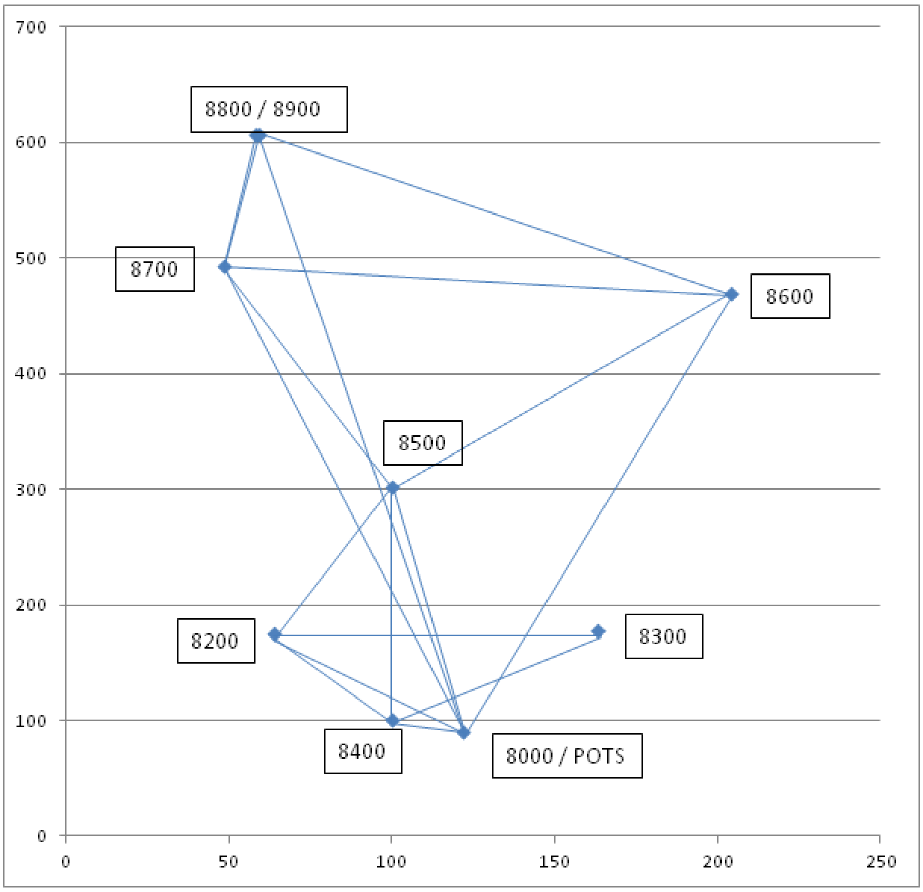


Figure 7 Geometry of the large network (GPS survey), scales in meters

Remarks

The temporary location 8300 was accessible only for one single day, so no joint GPS data with several other markers could be obtained.

SRP of SLR 7836

Because the SRP of the SLR 7836 is not directly accessible, the following method was applied: a small cube corner was attached to the front of the telescope tube. Slope distances to this cube were measured from four locations 1001, 2001, 3001 and 4001 on the wall crest of the station building A 11 which were located close to the network points 1000, 2000, 3000 and 4000, respectively (cf. Fig. 8).

These distance measurements were repeated for various azimuths and elevations of the telescope in order to define sufficient points distributed over part of a sphere which is defined by the movement of the telescope axes about the invariable point. The center of the adjusted sphere is the intersection of the telescope azimuthal axis and elevation axis, the SRP of SLR 7836.

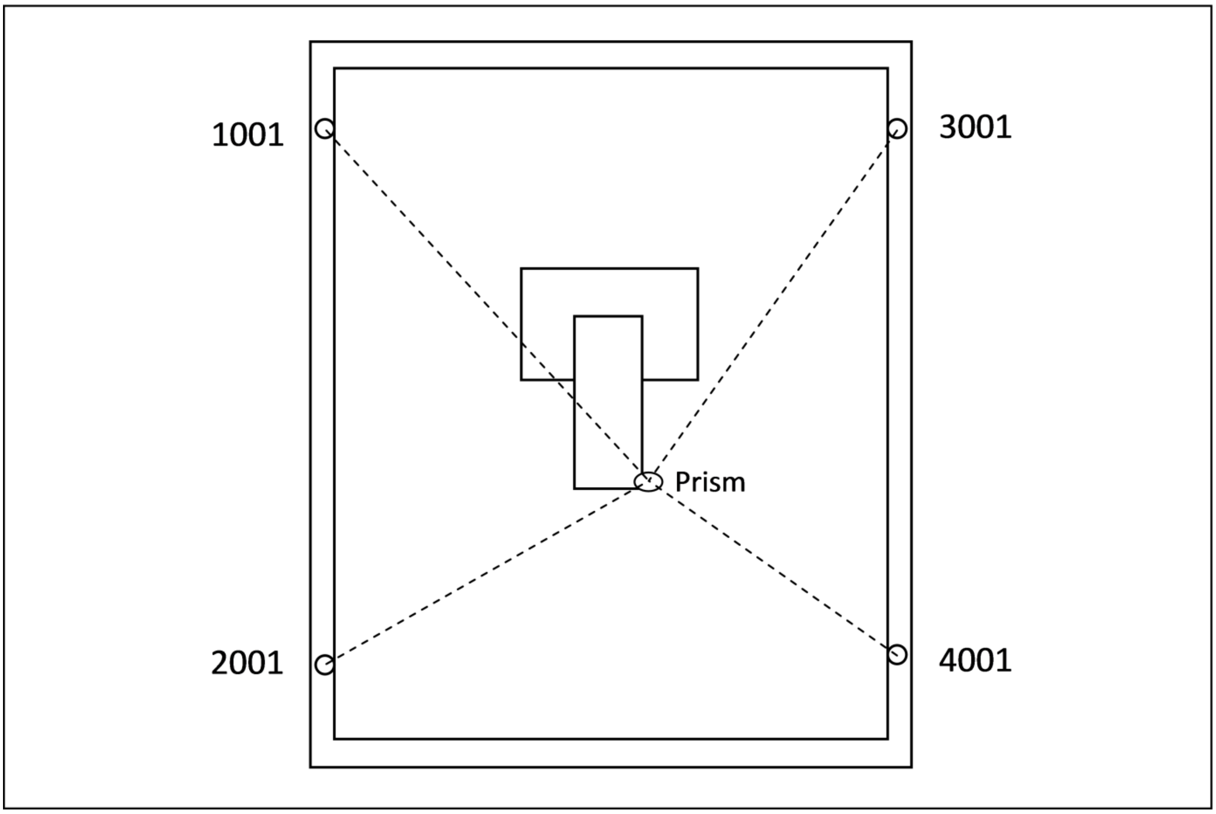


Figure 8 Locations of standpoints for measurements to the reference cube at SLR 7836

SRP of SLR 7841

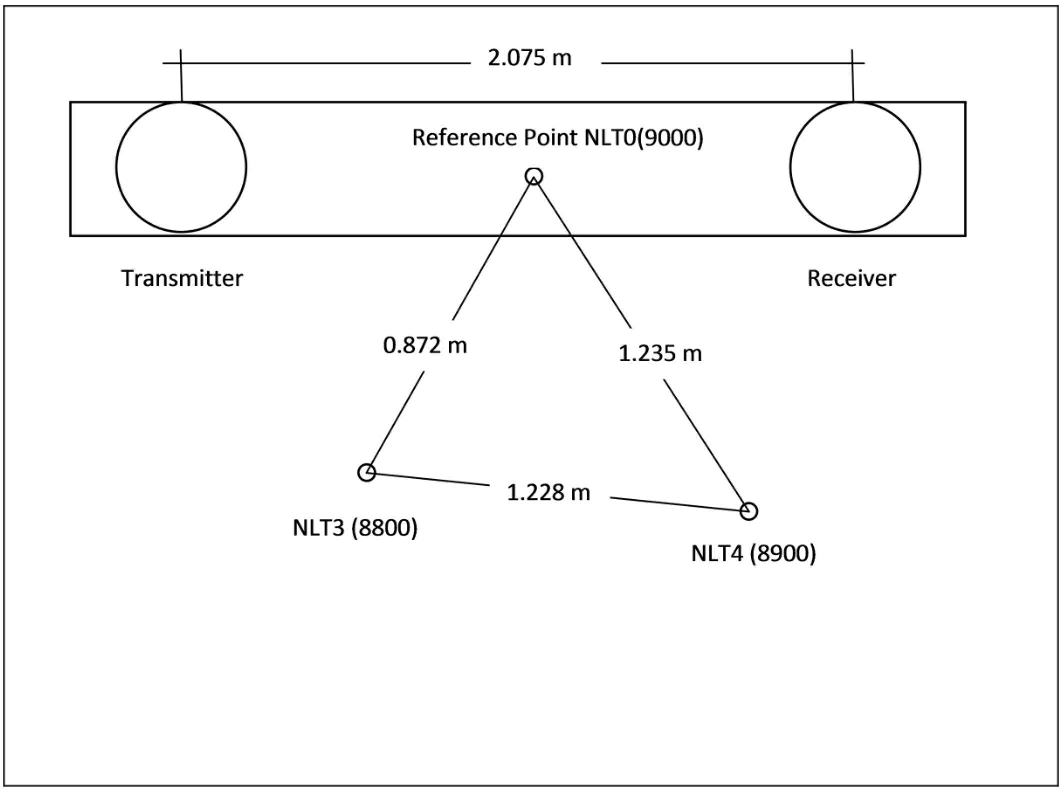


Figure 9 Location of brass markers 8800 and 8900 with respect to SRP of SLR 7841

The system reference point (SRP) of the twin telescopes is defined with respect to the nearby cemented brass markers 8800 and 8900 which are part of the local network. The location of the sub-point of the SRP relative to those markers is shown in Figure 9. The height of the SRP above marker 8800 was measured as 1.370 (+/- 0.5) mm.

5. Survey Results

The network adjustment yielded the following ITRF2000 positions and formal uncertainties for the reference points which are summarized in Table 2:

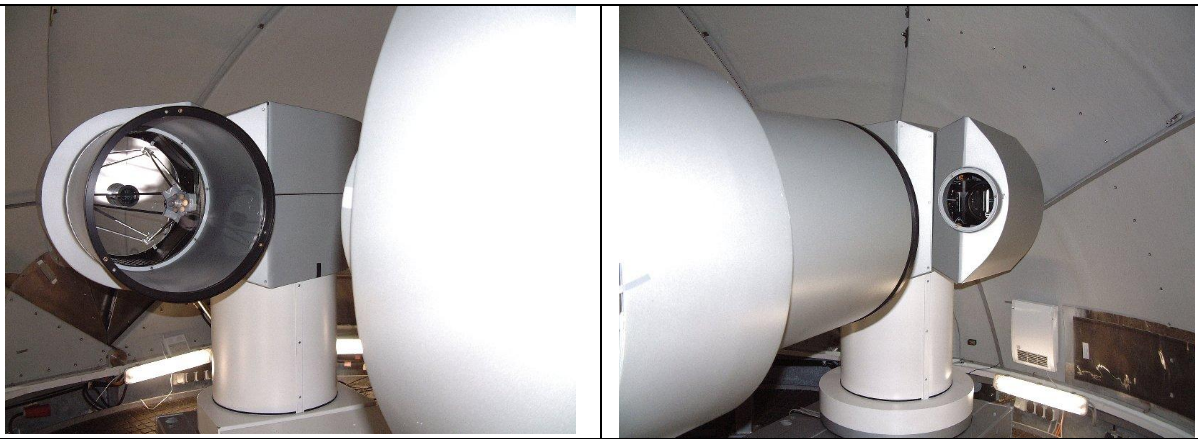
Table 2 ITRF2000 positions oft the surveyed reference points

Reference Point	**X [m]**	**Y [m]**	**Z [m]**	**S_x [mm]**	**S_y [mm]**	**S_z [mm]**	**S_p [mm]**
8200	3800670.010	881977.341	5028808.098	0.4	0.4	0.4	0.7
8300	3800608.030	882049.170	5028836.759	0.7	0.6	0.8	1.2
8400	3800697.373	882049.669	5028789.428	0.4	0.5	0.4	0.7
8500	3800592.169	881924.631	5028903.749	0.3	0.3	0.4	0.5
8600	3800423.356	881889.895	5029003.271	0.6	0.3	0.8	1.0
8700	3800517.305	881761.961	5028988.381	0.4	0.3	0.5	0.7
8800	3800432.195	881691.557	5029028.496	0.5	0.6	0.4	0.9
8900	3800432.001	881692.769	5029028.428	0.6	0.6	0.6	1.1
8000	3800689.768	882077.260	5028791.246	0.6	0.3	0.7	0.9
1000	3800639.242	881979.189	5028833.109	0.3	0.2	0.3	0.5
2000	3800642.627	881979.977	5028830.441	0.4	0.3	0.4	0.6
3000	3800638.068	881984.473	5028833.075	0.3	0.2	0.4	0.6
4000	3800641.519	881985.271	5028830.349	0.3	0.3	0.3	0.6
5000	3800640.326	881979.434	5028832.257	0.4	0.2	0.4	0.6
1001	3800638.914	881978.966	5028833.801	0.3	0.3	0.4	0.6
2001	3800641.648	881979.598	5028831.643	0.3	0.2	0.4	0.5
2003	3800641.763	881979.625	5028831.550	0.3	0.2	0.3	0.5
2005	3800641.421	881979.546	5028831.820	0.3	0.2	0.3	0.5
3001	3800638.861	881984.805	5028832.828	0.4	0.3	0.4	0,6
4001	3800641.741	881985.426	5028830.556	0.4	0.3	0.4	0.6
7836	3800639.682	881982.044	5028831.687	0.3	0.2	0.4	0.5
9000	3800432.317	881691.970	5029030.062	(0.6)	(0.6)	(0.6)	(1.0)

6. Remark concerning SLR 7841 System Calibration

For the bistatic SLR 7841 system, the use of an external target is not feasible due to the fact that the fields of view of both telescopes overlap only at a distance of about 10 km. Consequently, no such external target was included into the co-location survey.

The most simple calibration method is to point the telescopes anti-parallel in a way that the light from the transmitter telescope is directly fed into the receiver telescope. A strong ND filter within the transmitter reduces the amount of illumination of the receiver to single photoelectron level.



Telescopes in calibration position, Tx (right) facing Rx (left)

In the configuration as shown above the (virtual) target distance is equal to half the separation of the reference points of the telescopes and is thus easily obtained via the telescope baseline which is well-defined by design.