LOCAL SURVEYS AT GREENBELT

James Long, Nagendra Paudel
NASA SLR/VLBI Program
Honeywell Technology Solutions, Inc.
Honeywell International
Lanham, MD 20706 USA

Fig. 1 SLR - ILRS Station 7105 NASA MOBLAS 7

Fig. 5 GPS - IGS Station GODE

Fig. 6 VLBI - IVS Station MV3

Fig. 2 Survey Target on MOBLAS 7 Mount

Fig. 3 Translation Stage and Target

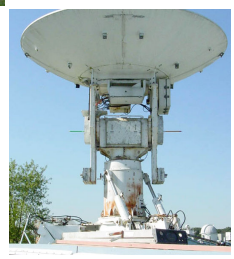

Fig. 7 Survey targets on antenna elevation axis

Fig. 4 DORIS - IDS Station GREB

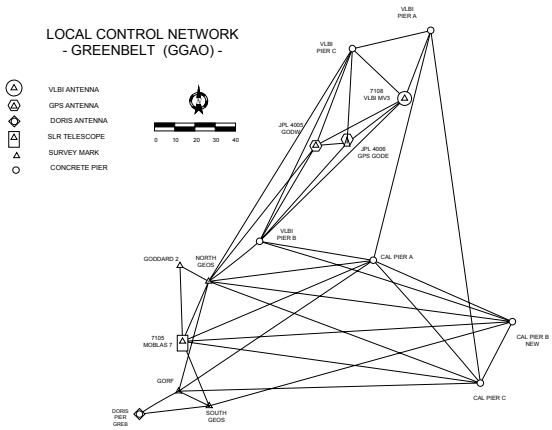

Fig. 8 SLR Calibration Pier C

Introduction

The space geodesy data collected at the Greenbelt station , also known as the Goddard Geophysical and Astronomic Observatory (GGAO), fills a very important role in the realization of the International Terrestrial Reference Frame (ITRF) because of the four collocated techniques. The four space geodesy techniques collocated at Greenbelt are SLR, VLBI, GPS, and DORIS. Precise local survey ties, which determine the relative positions of the collocated space techniques, are critical to the combination of the different techniques in the ITRF solutions.

Local surveys at Greenbelt, also provide spatial data to establish and monitor the operational calibration ranges for the SLR systems, such as ILRS Station 7105 (NASA MOBLAS 7).

Local surveys at Greenbelt to maintain and monitor the stability of the control network are a continuous task.

Local Survey Control Network

The local survey control network at Greenbelt consists of number of inter-visible concrete pillars or piers and ground markers. These survey control points have been installed over a period of 40 years, by different government agencies and organizations for a variety of projects.

Generally, the dimensions of the concrete piers are approximately 0.3 meters (m) in diameter and vary from 1.2 to 1.8 m tall (above the ground surface) and are constructed of reinforced concrete. The piers extend below the ground surface approximately 2.5 to 3.0 m deep. At the top of each pier is a forced-centering fixture with a threaded stud (5/8"-11) to accept a standard survey tribrach.

The ground markers are buried concrete monoliths with a standard brass survey disk imbedded in the top. The ground markers are typically 0.3 m in diameter at the top and extend 1.0 m deep below the ground surface. A tripod is used to set up survey instruments over these points.

The primary survey control points in the Greenbelt network are 7105, North GEOS, and South GEOS. These three survey points are known to be very stable.

The local survey control network can be considered to include: two GPS monuments, one DORIS pier, and the reference points of the SLR telescope and the VLBI antenna.

Local Survey Methods and Equipment

The spatial relationships of the survey control network is established using the conventional survey methods of triangulation, trilateration, direct differential leveling, and trigonometric leveling . These conventional methods are supplemented with the more modern GPS methods.

A theodolite is used to measure horizontal directions and vertical angles. Most distances are measured with electro-optical distance measuring equipment (EDM), with some very short distances measured with a steel tape. For direct differential leveling, a level instrument with a line of sight referenced to local gravity is used. To help ensure an accurate survey, it is most important to utilize the highest-quality, most precise survey instruments that can be made available. GPS equipment are used to measure distances and provide a tie between the local topocentric reference system and the geocentric reference system.

The following is a list of the equipment utilized on the Greenbelt local surveys:

Directions and Vertical Angles:	Wild T2000 and Wild T3000 electronic theodolites
Distances:	Wild DI2000 and Wild DI2002 EDM
Leveling:	Leica NA 2000 and 3003 electronic digital level with precise bar code staffs
GPS:	Trimble 4000SSE

GPS and DORIS Reference Points

The reference point of the GPS choke ring antenna is base of the amplifier housing. The vertical offset to the antenna phase center is given by the manufacturer. The reference point of the DORIS antenna is marked by a red line approximately half-way up the length of the antenna.

Determination of SLR and VLBI Reference Points

The reference point of a azimuth-elevation tracking telescope is the point where the rotation axes intersect. Often times this point is not an actual physical point or it is inaccessible. In this case, indirect methods are used to define the reference point.

For the SLR telescope at Greenbelt, the following method is used to determine the vertical (azimuth) axis of rotation. Previously, a forced-centering plate was mounted on the bottom of the telescope housing, close to the location of the vertical axis of rotation. During set up, the telescope is rotated plunged and leveled with a carpenters level. The survey target with a translation stage fixture is placed on the forced-centering plate. Then the telescope mount is rotated to different azimuth positions, and a distance is measured to the target prism with an EDM set on a nearby tripod. The translation stage is carefully adjusted until the measurements agree to less than 1 mm, throughout a full circle of mount rotation. This location of the target defines the vertical axis of rotation. The height from the center of the elevation axis to the top of the forced-centering plate is measured by direct leveling.

For the 5-meter, VLBI radio telescope, a similar method is utilized. Two special target rods are installed at each end of the elevation axis. As the telescope is rotated to different azimuth positions, the end points of the target rods are located by horizontal and vertical angles from the adjacent survey control points. Each end point of the target rod describes a circle, as the telescope is rotated through 360 degrees in azimuth.

Survey Results

Each of the survey measurement observations are reduced and checked. EDM measured distances are corrected for air temperature, air pressure, and humidity.

A network adjustment, utilizing the least-squares software HAVAGO, is completed, resulting in 3-dimensional coordinates for all survey points. The adjusted 3-dimensional positions of the VLBI target end points are used to compute the VLBI reference point by best-fitting a circle and computing the center. Standard errors in the adjustment are on the level of 2 mm or less.

Table 1. and Table 2.

Coordinates relative to 7105 from network adjustment, ITRF97 epoch 1997.0
Coordinates relative to 7105 computed from ITRF97 solution
Coordinates relative to 7105 computed from ITRF 2000 solution

Table 1.

	ΔX [m]	ΔY [m]	ΔZ [m]
7108	75.125	116.762	110.509
7108	75.131	116.767	110.510
residual	+0.006	+0.005	+0.001
7108	75.129	116.765	110.508
residual	+0.004	+0.003	-0.001

Table 2.

	ΔX [m]	ΔY [m]	ΔZ [m]
GODE	54.230	97.009	93.863
GODE	54.235	97.001	93.863
residual	+0.005	-0.008	0.000
GODE	54.235	96.994	93.870
residual	+0.005	-0.015	+0.007