# Recent GPS Results at SLAC

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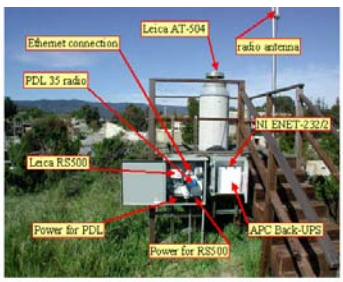
## GPS Base Station

The Alignment Engineering Group (AEG) makes use of GPS technology for fulfilling part of its above ground surveying tasks at SLAC since early 2002. A base station (SLAC M40) has been set up at a central location of the SLAC campus serving both as master station for real-time kinematic (RTK) operations and as datum point for local GPS campaigns.




The Leica RS500 system is running continuously and the GPS data are collected both externally (logging PC) and internally (receiver flashcard). The external logging is facilitated by a serial to Ethernet converter and an Ethernet connection at the station. Internal logging (ring buffer) is done for data security purposes.

The weatherproof boxes for the instrumentation are excellent shelters against rain and wind, but do heat up considerably in sun light. Whereas the GPS receiver showed no problems, the Pacific Crest PDL 35 radio shut down several times due to overheating disrupting the RTK operations. In order to prevent heat-induced shutdowns, a protection against direct sun exposure (**shading**)

and a constant air circulation system (**ventilation**) were installed.


As no further shutdowns have occurred so far, it appears that the two measures successfully mended the heat problem.

## Coordinates and Velocities

The GPS data are permanently recorded and organized in 24 h batches. Together with data from seven IGS stations a regional network is formed and adjusted with the **Bernese** GPS Software Version 4.2 resulting in 24 h coordinate solutions. An overall solution for the position and its change over time can be obtained by either stacking the normal equations (Bernese program ADDNEQ) or by analyzing the time series of the daily coordinate files.

**• Stacking of normal equations**

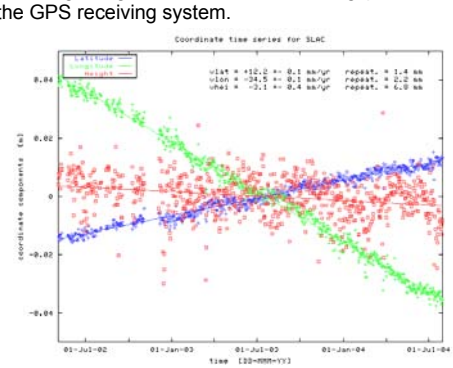
By stacking the normal equations of 411 days (day 124 of 2002 to day 170 of 2003) the "official coordinates" for SLAC M40 have been determined using program ADDNEQ. The reference epoch is **2002.90** (26-NOV-2002) which is the middle of the analyzed time span. The NAD83 coordinates of SLAC M40 at epoch 2002.90 can be considered the "SLAC reference datum".

| | ITRF2000 | NAD83 |
|---|---|---|
| φ | N 37°24′59.45851″ ±0.6 mm | N 37°24′59.44353″ |
| λ | W122°12′15.34051″ ±0.4 mm | W122°12′15.28996″ |
| h | 63.689 m ±2.0 mm | 64.231 m |
| $V_n$ | **11.6** mm/a **±1.4** mm/a | **26.1** mm/a |
| $V_e$ | **-34.2** mm/a **±1.2** mm/a | **-20.7** mm/a |
| $V_u$ | **0.0** mm/a **±5.5** mm/a | **-0.6** mm/a |

In order to avoid the co-existence of several SLAC datums (and its inherent chances for confusion), this coordinate set will not be updated, even when a more accurate estimate could be determined with a longer time series.

**• Time series analysis**

Velocity estimates have been derived from the time series of the daily solutions, at the same time checking for gross errors and detecting problems in the GPS receiving system.



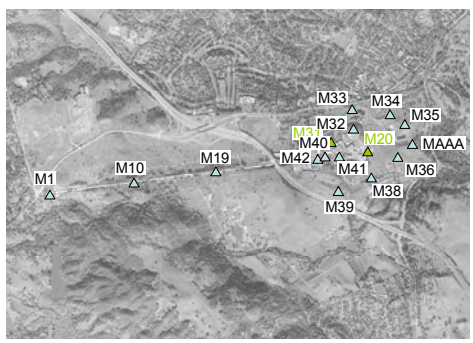
The daily solutions of the regional network were transformed onto the ITRF2000 reference frame by means of a six-parameter Helmert transformation (no significant scale parameter). The velocities of the 3 coordinate components latitude, longitude, and height are estimated by fitting a linear trend to the data.

The standard deviations for the velocity estimates as derived from the time series are generally considered to be too optimistic. A better indication of the quality of the velocity determination is the repeatability of the coordinates after the velocity part (trend) has been removed.

## SLC Local GPS Network

For the Linac Coherent Light Source (LCLS), which is to be constructed at the east end of the Linac, the chosen design coordinate system is the Stanford Linear Collider (SLC) system. The SLC system was set up in the middle of the 1980s by classical methods as well as GPS.

Of the 16 original SLC network stations all but 2 (M20 and M31) are still usable for geodetic purposes. With station SLAC M40 already occupied by a permanent GPS station, the SLC network lends itself to be reused in the LCLS project. Thus, a local GPS campaign was conducted to verify the positions of the 14 remaining SLC stations.




24-hour sessions have been observed on the SLC stations using Leica SR530 receivers and Leica AT-503 antennas. The 4 Linac penetration points (M1, M10, M19, and M42) were set up on translation stages with the AT-503 centered over the ground point by means of a nadir plummet. For these stations no height reference was established.

The GPS data have been adjusted with the Bernese software package. Applying a recommended scaling factor of 4 to the formal error estimates yields the following 1-σ standard deviations:

• **horizontal** components: **±0.5 mm**,

• **vertical** components: **±1.5 mm**.

The consistency of the 1984 and 2004 results is checked by applying a 7-parameter **Helmert transformation** between the geocentrical XYZ data sets. The a posteriori standard deviation of the unit weight amounts to $\sigma_o$**= 4.5 mm** (the 4 penetration points excluded). This appears to be a reasonable value, taking the relative accuracies of GPS1984 (2.0 mm) and of GPS2004 (1.0 mm) as well as possible point instabilities over the time span of twenty years into account.

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