Current Geodesy/GPS Projects at NMSU

Earl F. Burkholder, PS, PE
Melvin Pyeatt, 2005 graduate
April 2005

Surveying Engineering students at NMSU take a variety of required courses which include, among others, SUR 361 Introduction to Geodesy, and SUR 461, Introduction to Satellite Geodesy. The SUR 361 course looks primarily at the geometrical geodesy relationships of geo-spatial data and the SUR 461 course focuses primarily on GPS surveying. The least squares course, SUR 451, is not a formal prerequisite to the GPS class, but students who have already taken the least squares class find many applications for those concepts in the SUR 461 class.

The SUR 461 class is somewhat special this year because we are using several Topcon HiPer GPS units and processing software loaned to us by Holman's Inc. of Albuquerque, NM. Although the Topcon GPS units are being used in other classes as well, this article summarizes two projects being conducted in the SUR 461 class. The software is being used to reprocess a network of vectors between two HARN stations – "Reilly" and "Crucesair." The dual-frequency Topcon GPS units are also being used in an attempt to bring a high-quality elevation (orthometric height) to the NMSU campus from several nearby first-order benchmarks.

This is being written mid-April and the semester is not quite over. Final results of the two projects are not available yet but this preliminary description is provided to let the surveying community know how the equipment is being used. Final results will be shared in a subsequent issue of Benchmarks. Processes, data, results and a summary of these two projects will also be included in the discussion during the NMPS Llano Estacado Chapter continuing education seminar at Ruidoso in August 2005 – "Integrating GPS and Terrestrial Survey Data."

The first project consists of 7 GPS vectors connecting two HARN stations, "Crucesair" and "Reilly," with 4 additional points on the NMSU campus. Station "Crucesair" is about 16 kilometers west of NMSU at the Las Cruces airport and Station "Reilly" is centrally located on the Horseshoe at NMSU. The four new stations are located at various places on the NMSU campus. Single frequency data were collected at these stations at various times and individual non-trivial vectors were computed using Trimble software. The $\Delta X/\Delta Y/\Delta Z$ components of the vectors were added up and do compare quite nicely with the published differences between the two HARN stations. A least squares solution for the network was computed somewhat routinely. The statistics (standard deviations) for the computed coordinates is the focus of the re-computation. For that, the original Trimble data were converted to RINEX format and both the vectors and the network were reprocessed using Topcon Tools software.

Although a least squares solution is proven to be the best adjustment possible, it has also been said that least squares is dangerous because, depending on how weights are selected, one can get any answer you want. That may be an overstatement, but the point is that a

least squares adjustment depends upon the wisdom and choices of the person making the adjustment. The following four choices are possible options:

1. The simplest case is one in which all observed components are weighted equally. Essentially, that means the weight matrix is an identity matrix.

2. The weights are assigned according to the standard deviation of each observed component. That is, weights are assigned as the reciprocal of each standard deviation squared. The weight matrix is a diagonal matrix and all off-diagonal elements are zero.

3. Weights are computed from the entire covariance matrix of each vector. This includes correlation between components, but does not include correlation between vectors.

4. Finally, the weight matrix includes correlation between components within a given vector and correlation between vectors. Correlation between vectors occurs when two adjacent vectors are observed simultaneously in the same session.

Comprehensive software provided by any vendor should include provision for making a rigorous adjustment for any of the above options selected by a user. Rarely will one see a menu of the four choices listed above but the software is written to use the most rigorous mode possible based upon data as input by the user. But, for learning purposes, each condition described above will be "forced" and a summary of the results will be included in a subsequent analysis. A description of software used will also be included.

The second project is using GPS to establish the elevation (orthometric height) of Station "Reilly" on the NMSU campus. Station "Reilly" was included in the Cooperative Base Network computed by NGS in 2000 and has an A-order horizontal position (1:10,000,000) on it. However, the elevation of Station "Reilly" is only a second-order class-II elevation. In an effort to match or improve on the quality of that elevation, GPS vectors were used to connect with two existing first-order benchmarks located within 2 miles of the NMSU campus – see associated photos. Independent (non-trivial) vectors were used to develop a loop with proven 3-D internal consistency. Then the observed ellipsoid height differences and Geoid 03 height differences were combined and used to compare with the published first-order height differences between the two existing benchmarks. Standard deviations of all quantities and 3-D error propagation were used to judge the quality of the computed elevation. The process, data, and results will be reported in a future issue of Benchmarks.

The Surveying Engineering program at NMSU is very grateful to Holman's for their support in loaning us the GPS equipment and to NMPS for assistance and support in various areas. Go Aggies!!

First-order benchmark A-245 on drainage structure headwall across from Mission Inn Best Western - Las Cruces, NM, April 2005.


At Station “Reilly” looking east to Hadley
Hall Administration building - NMSU
Photo by Melvin Pyeatt - April 2005


GPS antenna on BM A-245
Las Cruces, NM April 2005
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