

Height Modernization and the Precise Digital Leveling Workshop

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This article gives an overview of Height Modernization in New Mexico and describes the Precise Digital Leveling Workshop held at the Montoya Campus of the Central New Mexico Community College (CNM) in Albuquerque, New Mexico, May 12, 13, and 14, 2009. The workshop is a part of the New Mexico Height Modernization effort and was taught by Curtis Smith, ID and MT Geodetic Advisor and leveling expert with the National Geodetic Survey (NGS). Curt was assisted in the field exercise portion of the workshop by Gregory Hauger of the Texas Spatial Reference Center; our own NM Geodetic Advisor, Bill Stone, and Earl F. Burkholder, NMSU Surveying Professor. Day-1 and Day-2 focused on discussion of background/theory and included actual leveling observations on four temporary bench marks established for that purpose. The third day was devoted to blue-booking the leveling data to NGS format/specifications. Approximately 30 persons attended the workshop, although not everyone attended all three days.

Height modernization is an umbrella term describing activities devoted to improving the vertical component of the National Spatial Reference System. In the big picture:

1. Geodetic leveling has been refined to a high degree and has been implemented successfully for more than 100 years.
2. The North American Vertical Datum of 1988 (NAVD88) is the official vertical datum used in the United States. Elevations on first- and second-order benchmarks are very precise and the benchmark monuments deserve lots of respect/protection.
3. Local users have access to thousands of benchmarks that are part of the NAVD88 network. However, over the years, many benchmarks have been destroyed for various reasons - most by construction, some by lack of awareness, and a few by vandalism. Benchmarks located in areas of known subsidence also lose their value.
4. With infrastructure development (such as subdivisions, transportation and pipeline projects, and irrigation systems), FEMA flood plain maps, and other applications, there is an increasing demand for reliable benchmarks.
5. Replacing destroyed bench marks or establishing new elevations using traditional precise geodetic levels is costly and time consuming.
6. The goals of Height Modernization in New Mexico are to:
 - a. Use new technology (GPS, geoid modeling, and digital leveling) to establish reliable elevations on permanent benchmarks:
 - i) More economically and to
 - ii) Federal standards.
 - b. Increase awareness of the importance of high-quality elevations among:
 - i) Spatial data users and surveying professionals, and
 - ii) Public policy administrators at all levels (no pun intended).
 - c. Support establishment of benchmark elevations in areas most needed.

7. Digital levels and corresponding bar scale rods have been proven to be as accurate and cost effective as optical instruments paired with traditional invar rods.(I am not aware of increased accuracy but I may be wrong. My interest in digital levels increased when I saw the latest digital level designs could operate on a par with the optical systems. I still believe the optical system can be observed faster than digital ultimately making the traditional level more cost effective – personal views.)
8. With appropriate leadership and development of a vision, I suggest the surveying profession can and should embrace the challenge of establishing needed benchmarks and elevations throughout our communities. Can we do it? I believe we can.

Additional information on Height Modernization can be found at the NGS web site - www.ngs.noaa.gov/heightmod/. Briefly, Height Modernization started in California about 10 years ago as an earmark program to address the challenges of stable reliable elevations in an area of known crustal movement (earthquakes etc). By 2007 Height Modernization earmark programs had expanded to include 10 states with overall expenditures of nearly \$10M per year. However, politics and earmarks being what they are, NGS began pushing for a line-item in the agency budget for a National Height Modernization Program (NHMP). The line-item has been established but the level of funding for the NHMP is significantly less than was allocated to Height Modernization under earmark funding. NGS is working diligently, and needs help from the surveying community, to increase the level of funding in that line-item.

In May 2007 NGS and the Texas Spatial Reference Center (TSRC) presented two Height Modernization Forums here in New Mexico – one in Las Cruces and one in Albuquerque. In June 2007, the TSRC presented a GPS leveling workshop in El Paso, Texas, and, along with NGS, supported a 2-day digital leveling workshop at NMSU in September 2007. Attendance at the NMSU workshop was good but blue-booking was not a part of it. Even then, folks from Albuquerque suggested that a repeat workshop in Albuquerque would be worthwhile – especially if blue-booking were included.

Administrative regionalization became a part of the on-going efforts by NGS to build the NHMP and late in 2007 New Mexico was invited to submit a joint Height Modernization proposal with the TSRC at Texas A&M in Corpus Christi. The TSRC had previously received Height Modernization earmark funds but, as a regional leader in the “new” NHMP, extended an invitation for us to participate in a joint proposal. An ambitious effort was proposed but had to be scaled back. We were successful in getting a modest level of support for 1 year that includes outreach, continued promotion of Height Modernization, and installation of two NGS CORS stations – one at NMSU and another location selected to fill a gap in the existing coverage.

Our first joint proposal was funded for the current FY ending September 30, 2009. A second proposal for the FY beginning October 1, 2009, was submitted jointly with the TSRC in September 2008. But, due to anticipated budgetary uncertainties at the time, the monetary amount requested for the next FY was capped at the level of funding for the current FY. Since then, the current economic meltdown changed governmental funding priorities and, regretfully, the NHMP did not fair well in stimulus funding allocations. Hopefully, the New Mexico Height Modernization effort will receive some funding for continued outreach, on-going promotion of Height Modernization, and capacity building during the next FY. In the meantime, we in the surveying profession and other interested parties need to continue building support for Height Modernization. Success will be determined, in part, by raising public awareness to the overall benefits of having access to stable bench marks and corresponding reliable elevations.

Now, back to the Digital Leveling Workshop. Amy Ballard, GIS instructor at CNM, and Bill Stone collaborated to arrange use of the facilities at the Montoya Campus of CNM. It worked out great. The location seemed to be convenient, the lecture hall was roomy with high ceilings (for 3 meter rods), parking was free, vending machines for snacks were nearby (there was no registration fee and no snacks were provided), and the outside leveling course was only a short walk away. The first morning included lecture, power point presentation, and an overall discussion on geodetic leveling. Following lunch, Professor Burkholder described his experience with the transition from analog to digital precise leveling on a monitoring project he worked on in Oregon in the 1990's. Many of the concepts apply to both analog (optical) and digital (electronic bar scale) precise leveling but there are significant differences between working on a local site and designing procedures to be used on long lines of levels such as encountered in a state wide or national campaign. Several attendees expressed appreciation for the transition discussion.

Then the entire workshop gathered in the field for a demonstration of the digital leveling process. Prior to going out, Curt Smith gave everyone a take home test to be turned in the next day. Answers on the test consisted of recording the meta data associated with our field leveling efforts. We used 4 instruments/observers and 2 pairs of calibrated bar scale rods (in each case, two crews/instruments used the same pair of rods). One set of rods was a 2-meter set; the other was a 3-meter set. (Note - before the workshop was over, everyone agreed that the 3-meters rods were preferred if there was much slope at all in the level line. Keeping the cross hairs on the face of the 2-meter rods required shorter set-ups. But the logistics of handling and transporting a pair of 3-meter rods is more of a challenge).

The first part of the field exercise was a collimation test to determine the inclination of the line-of-sight for each instrument. Call it an elaborate peg test but documenting the performance of each instrument is critical. With practice, the collimation test can be conducted in two short set-ups in about 5 minutes. Of course, we asked questions and took somewhat longer. But we got good results in each of the 4 instruments. By starting at opposite ends of our field loop, all persons attending were able to observe closely, ask questions, write notes, and relate procedures to the lecture. The course that we used contained 4 temporary bench marks and the total length of the sections totaled about 0.54 km. Collectively we completed a single forward run of the loop on day-1. The following morning we were informed that the loop misclosure amounted to 0.16 mm – well within the specifications for First-Order, Class II levels.

On the second day, we actually formed two separate crews and ran the loop backward. This time, attendees were responsible for each part of the observations. We traded off observer, recorder, rod persons etc and everyone had an opportunity to perform the various tasks. And, yes, there was some competition between the crews with the 3-meter rods and the crews using the 2-meter rods. It was an excellent learning exercise. It was interesting to note that all four sections observed over the 2 days by the different crews and equipment checked forward and backward runnings of less than 1-mm each – a testimonial to equipment and procedures.

Of the many details that could be described - the sequence of pushing buttons, holding the rods plumb, counting paces to balance backsights/foresights, and recording temperatures at each setup – Greg Hauger had a prototype PDA device (being developed at the TSRC) that was programmed to communicate with the level instrument via blue-tooth. Using that device, all inputs are prompted on the screen and the instrument is operated remotely. More information on that development is at the TSRC web site

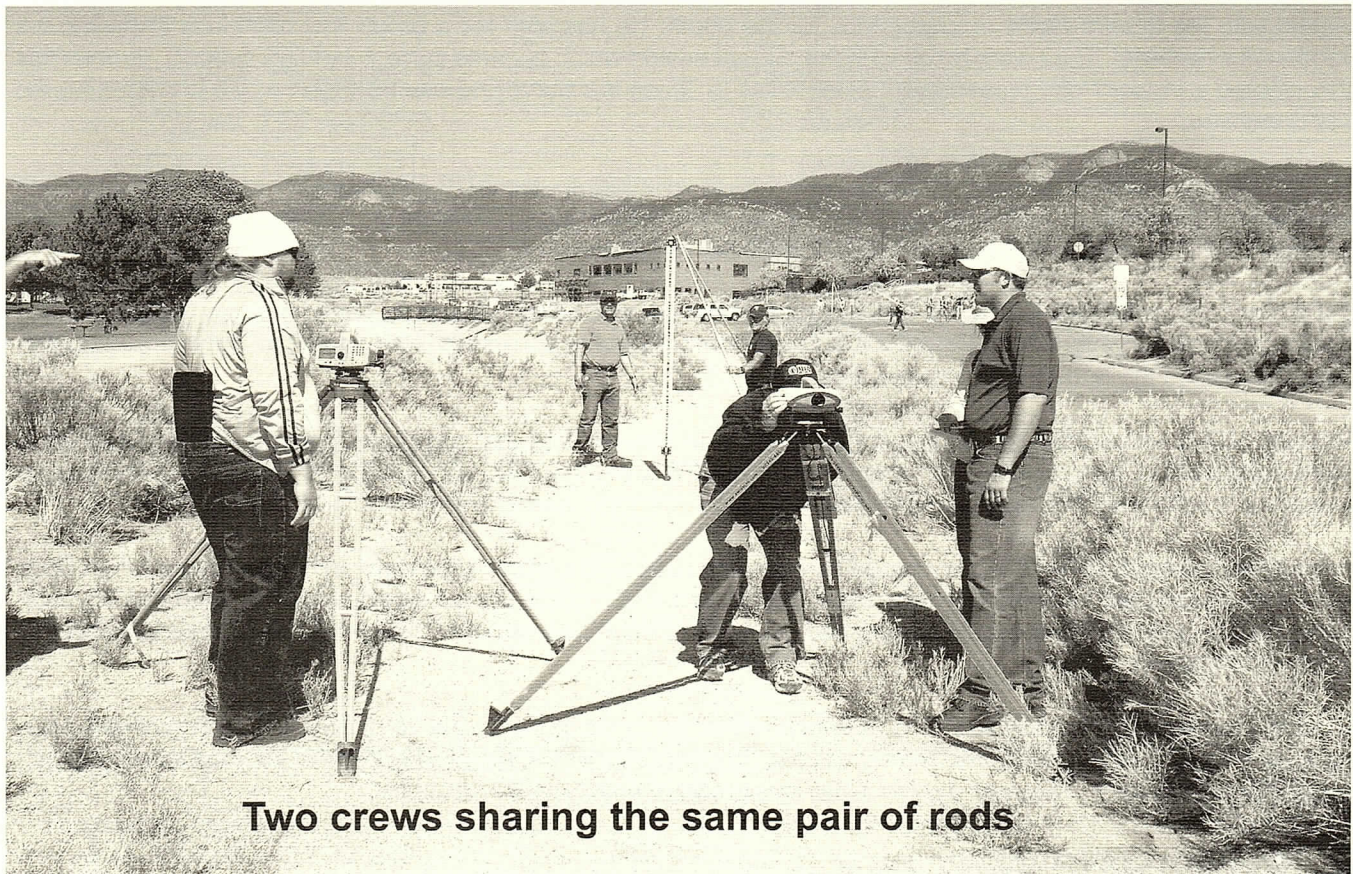
<http://tsrc.cbi.tamucc.edu/TSRC/THMLevelTool-DigitalLevelingSoftware>.

Day-3 started off by discussing the concepts/procedures and answering questions related to the work done on day-2. Following that, Curt discussed two NGS (free) programs that can be used for organizing and processing the digital leveling data – Translev and WinDesc. Both programs are available from the following NGS web site. http://www.ngs.noaa.gov/PC_PROD/pc_prod.shtml.

In the past, blue-booking was an elaborate procedure for defining each and every field of input for data submission to NGS. The two programs facilitate and shorten the process significantly and, with practice, can significantly shorten the effort between data collection and data submission. However, as with learning to use any new software, the learning curve is faster for some than others but NGS is committed to helping the user community do a better job by automating the process as much as possible.

Following the workshop, one attendee in particular emailed back enthusiastically describing applications of lessons learned. Bill Stone and Garry Nielsen are planning to do an actual small leveling project in Santa Fe and members of the Southern Rio Grande Chapter have expressed interest in doing a real live project here in preparation for incorporating the digital level and bar scale reading rods into the Control Surveying class that I get to teach at NMSU this fall. It is quite selfish of me but my proposal is to “prove” the elevation of Station Reilly on the NMSU campus – the GPS version of that project is described at <http://www.globalcogo.com/ReilElev.pdf>.

Stay tuned for on-going developments – or better yet, create your own. Just be sure to share your success stories with others. §



Two crews sharing the same pair of rods