

Volume 32: Issue 2  
April, 2021



# LINES & POINTS

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the Challenge



*Lucy T. Perry L.S.*  
2003



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On The Cover

The Challenge  
by Larry Perry

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For more information please contact Jack Studley.

PLSW (Professional Land Surveyors of Wyoming; PO Box 8, Cheyenne, WY 82003) is a statewide organization of Land Surveyors registered to practice in the Equality State of Wyoming. PLSW is dedicated to improving the technical, legal, and business aspects of surveying in the State of Wyoming. PLSW is affiliated with the National Society of Professional Surveyors (NSPS) and the Western Federation of Professional Land Surveyors (WestFed).

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## PRESIDENT'S MESSAGE

Hello everyone,

What a spring so far for many areas of the State we have had record snow storms, record highs and fires all in the last few months. I think the groundhog is a bit confused this year. Well with that I did see a Meadowlark the other day which would indicate that spring is here and although we might get a little snow it wont stay around long.

We are starting to look at the format of the Fall Tech Session already and with the break in the COVID restrictions and the feedback from the chapters we are looking at an in-person conference this year. We are however approaching this with caution and more detail will come out as we get closer to November.

I hope everyone has a great spring!

Brad Neumiller, PLS

President - Professional Land Surveyors of Wyoming

## ATTENTION!

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## BLM NEWS

This letter is to inform you of the official cadastral surveys that were approved in Wyoming in 2020 and have been published to BLM Wyoming's Cadastral Survey website. Copies of the surveys can be viewed and/or printed from this website: <http://www.wy.blm.gov/cadastral/plats20.htm>

Township and Range	Type of Survey	Meridian	Accepted
T. 52 N., R. 66 W.	Dep. Res. & Survey	6 P.M.	03/25/2020
T. 20 N., R. 109 W.	Dep. Res. & Survey	6 P.M.	03/25/2020
T. 16 N., R. 86 W.	Dep. Res. & Survey	6 P.M.	03/25/2020
T. 18 N., R. 78 W.	Dep. Res. & Survey	6 P.M.	03/25/2020
T. 44 N., R. 66 W.	Dependent Resurvey	6 P.M.	03/25/2020
T. 48 N., R. 63 W.	Dep. Res. & Survey	6 P.M.	03/25/2020
T. 45 N., R. 77 W.	Corr. Dep. Resurvey	6 P.M.	03/25/2020
T. 46 N., R. 78 W.	Corr. Dep. Resurvey	6 P.M.	03/25/2020
T. 40 N., R. 117 W.	Dep. Res & Corr. Dep. Res.	6 P.M.	03/25/2020
T. 50 N., R. 105 W.	Supplemental Plat	6 P.M.	03/25/2020
T. 49 N., R. 105 W.	Supplemental Plat	6 P.M.	03/25/2020
T. 30 N., R. 111 W.	Supplemental Plat	6 P.M.	03/25/2020
T. 12 N., R. 69 W.	Remonumentation	6 P.M.	03/25/2020
T. 45 N., R. 101 W.	Dep. Res. & Survey	6 P.M.	08/26/2020
T. 50 N., R. 83 W.	Dep. Res. & Survey	6 P.M.	08/26/2020
T. 48 N., R. 65 W.	Dep. Res. & Survey	6 P.M.	08/26/2020
T. 30 N., R. 79 W.	Dep. Res. & Survey	6 P.M.	08/26/2020
T. 30 N., R. 80 W.	Dep. Res. & Survey	6 P.M.	08/26/2020
T. 15 N., R. 75 W.	Dependent Resurvey	6 P.M.	08/26/2020
T. 49 N., R. 77 W.	Dependent Resurvey	6 P.M.	08/26/2020
T. 31 N., R. 83 W.	Dep. Res. & Survey	6 P.M.	08/26/2020
T. 29 N., R. 109 W.	Corr. Dep. Resurvey	6 P.M.	08/26/2020
T. 35 N., R. 109 W.	Corr. Dep. Resurvey	6 P.M.	08/26/2020

## ANNOUNCEMENTS

### CONGRATULATIONS!

The members of the Professional Land Surveyors of Wyoming would like to recognize the achievement of the following new Wyoming registrants:

LS	18333	Simon Kiefer
LS	18334	Randall Peppersack
PELS	13346	Paul Heintz



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### LINEs AND POINTS ARTICLE ROTATION SUBMISSION SCHEDULE BY CHAPTER

Responsible Chapter	First Call Date	Last Call Date	Publication Date
Southeast Chapter	THANK YOU!! (SEE "EXCERPTS FROM NOAA WEBINARS" IN THIS ISSUE)		
Upper Platte Chapter	June 1	June 15	July 1, 2021
Southwest Chapter	September 1	September 15	October 1, 2021
Northeast Chapter	December 1	December 15, 2021	January 1, 2022
West Chapter	March 1	March 15	April 1, 2022
Central Chapter	June 1	June 15	July 1, 2022
South Central Chapter	September 1	September 15	October 1, 2022
Southeast Chapter	December 1	December 15, 2022	January 1, 2023



**Granted**  
**Honorary Membership**  
**Professional Land Surveyors of Wyoming**  
Herbert W. Stoughton, Ph.D., P.E., P.L.S., C.P.  
Geodetic Engineer



At the 2020 Fall Technical Session of the Professional Land Surveyors of Wyoming (PLSW), Herbert W. Stoughton (Dr. Herb) was bestowed PLSW Honorary Membership for his nearly four decades of service to PLSW and five decades to the surveying profession. Dr. Herb has worked tirelessly to bring a high standard to the profession of land surveying and the PLSW. He has been an appreciated and thorough reviewer and proof reader of the journal *Lines & Points*, proposed legislation/regulations, and professional papers. For over three decades he served as a technical article reviewer/editor for the professional journals of ACSM, AAGS, ASCE, and PLSW, receiving appreciation from several authors for his efforts, insights, comments, and recommendations.

Dr. Herb has an impressive curriculum vitae of education and professional activities. He graduated from high school (in central New York State) in 1958, and enrolled in the University of Michigan. He obtained his Ph.D. from the same institution in 1980. His first employment as a surveyor took place in the summer of 1960. During college he worked three seasons for the Topographic Division of the USGS. He has received numerous professional awards, and holds thirteen different professional registrations and credentials, including professional land surveyor in eight states and professional engineer in three states. At the age of 34, Dr. Stoughton was appointed by the New York State Board of Regents as a Land Surveyor Member for the New York State Board for Engineering and Surveying.

Immediately after completing his baccalaureate degree, Stoughton worked for consulting engineering and surveying firms in Michigan and New York. At the latter organization he researched title and wrote nearly 350 easement descriptions! He then crossed the U.S. to Los Angeles where he worked for the Metropolitan Water District of Southern California. There his assignments included designing surveying computer programs, overseeing engineering surveys, and developing specialized geodetic surveys to monitor structural deformation (aqueducts/pipelines, dams, and reservoirs) and

earthquake/subsidence monitoring. Between 1980 and 1993, Dr. Herb worked as a geodesist for the US DoD Defense Mapping Agency here in Wyoming (F.E. Warren AFB), assigned to geodetic and geophysical surveying supporting strategic and tactical weapon systems worldwide. Besides holding supervisory or management positions (preparing staffing documents for program appropriations), he worked in project management and developing new procedures and survey instrumentation for precise astronomic positioning, absolute and relative gravimetry, early GPS development, geodetic computing, and map projections. He oversaw several GPS HARN type surveys outside the United States in 1992 and 1993.

While much of his professional work during the first three decades of his career was on main frame computers, developing field survey data reduction and office survey computation/adjustment computer programs, Dr. Herb currently performs his extensive calculations by hand employing hand-held scientific calculators/computers. It was amazing to this writer to witness his fingers “dance” over the calculator’s key board producing highly complex numerical solutions. The sample/example computations produced in the PLSW-Wyoming NAD 1927/1983 state plane coordinate manual were completed on scientific calculators!

In 1996, Dr. Herb was appointed Professor of Surveying at the Metropolitan State College of Denver. During his twelve year tenure, he taught, tutored, and was mentor to numerous surveying students, who came away with an in depth understanding of important elements of the surveying profession. Each fall, Dr. Stoughton invited this writer and two other professional land surveyors from Colorado to spend a full day in the surveying laboratory performing real world (compared to academic) survey problems. The students appreciated the melding of Dr. Herb’s academic course work with practical applications. During his tenure at that institution, Dr. Herb wrote, filmed, and conducted one dozen professional level distance learning surveying courses. It is important to note that Professor Stoughton educated surveyors, not to be just “button pushers” in an increasingly technological society. When the students completed their

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course work, they had a good understanding of the principles needed for making the decisions that they would have to make during their professional career.

Dr. Herb’s vitae contains eight pages of published professional papers and literature reviews (83 book reviews in less than a decade). His writings have been published in the U.S., Canada, Great Britain, Australia, Papua New Guinea, and the Netherlands. He is currently writing a two volume book set addressing surveying and mapping computations entitled: The Handbook of Surveying Mathematics and Computations: Volume 1: Plane Surveying and Volume 2: Route Surveying (each volume over 1,000 pages!), and he recently completed Documents and Papers Pertaining to Plane Coordinate Systems Used in the United States (436 pages) (in 2020).

Dr. Herb married Catherine W. Dolan at the Mission San Fernando Rey de Espana (Los Angeles) in May 1970. The couple quietly celebrated their fiftieth wedding anniversary last summer, with their son, Sean (a professional civil engineer in construction management), daughter-in-law, and four grand children. Although Dr. Stoughton continues to address PLSW and surveying issues, he also serves as the Chairman of the Building Commission for the Catholic Diocese of Cheyenne (covering the State of Wyoming). He recommends to the bishop pertaining to matters concerning new construction and remodeling of existing church structures. For his efforts, he was made an Honorary Member of the Catholic Council for Facility Management.



## HINTS TO AUTHORS

Dear Readers:

The editors of Lines & Points wish to convey our gratitude to the numerous authors who have contributed photographs, technical and professional articles, and other information to be incorporated into the quarterly journal. In recent years, the assembly and redaction of the submitted materials has taken on considerable technical application of the various English language compilers, office suites, and "publishing suites". This means that the communication and transfer of information and materials arrive at the editors' desktops in a multitude of formats and styles, which sometimes are not compatible with the PLSW personal computers.

We, the editors, are setting forth some simple rules for submitting materials which, hopefully will simplify your efforts and make the transition to the published version simpler and less time consuming.

1. If you have any questions or comments, please contact S. Dennis Dawson, Publications Comm. Chm., (dennieandbarb@gmail.com) or Michael A. Flaim, Editor-in-Chief (mike.flaim@bresnan.net).

2. If an article contains any illustrations, photographs, graphs, or other graphics, please transmit them as separate individual files. You may also include the illustrations within your manuscript, but the image integrity/quality is degraded seriously when attempting to extract them from the manuscript to create a published digital image. The Editor-in-Chief states that a much better digital resolution is obtained from the separate, individual illustrations submitted.


3. All submissions (electronic and snail mail) should be sent to S. Dennis Dawson (4005 Snyder Avenue; Cheyenne 82001). It is recommended a second copy be sent to Mike Flaim (1212 Southwest Drive; Cheyenne 82007).

4. It is strongly recommended that all submissions be transmitted six weeks prior to the publication deadline. The publication deadlines are: 1 January; 1 April; 1 July; and 1 October, annually.

5. Lines & Points is the official publication for the Professional Land Surveyors of Wyoming. Therefore, hence forth there will be incorporated in the publication all formal announcements pertaining to official business of the organization and other announcements. This includes announcements for the Annual Meeting; state-wide membership meetings; seminars; and the Fall Technical Session. These announcements are to be submitted to the PLSW Secretary/Treasurer John J. Studley (PLSW; Attn.: Mr. Jack Studley; P.O. Box No. 8; Cheyenne 82003) (jklz0318@gmail.com), at least four weeks prior to the publication deadline in which the announcement will appear. The PLSW Secretary/Treasurer will circulate the announcements to the Publication Comm. Chm.; the Editor-in-Chief; and the PLSW Board of Directors.

6. Advertisers and prospective advertisers should communicate directly with PLSW Secretary/Treasurer Studley about any advertisements and modifications.

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## *In Memoriam*

Larry Thomas Perry, P.L.S.

22 February 1940 - 5 February 2021

Larry Thomas Perry, of Cheyenne, passed away on Friday, 5 February 2021 in Cheyenne.

Larry Perry was born 22 February 1940 in McKeesport, Alleghany County, Pennsylvania, to Tom L. and Edna Lillian (O'Neil) Perry. He was graduated from Annandale High School (Annandale, Fairfax County, Virginia) on 5 June 1959. In 1966, he graduated from the Asheville Buncombe Technical Institute (Asheville, North Carolina). Also, Larry completed engineering and land surveying courses at the University of Wyoming, but earned no degrees.

Larry met and married Lucille (Vaillancourt) Perry in South Carolina in 1962. They were happily married for 59 years.

Larry was preceded in death by his parents, his brother Harvey, his son Carter, and his daughter Loretta. Larry is survived by his wife, Lucille Perry, their son Steve Perry and daughter-in-law Janyce (Auker) Perry of Atlanta, Georgia; his sister Donna Kerns of South Carolina; his brother Roy Perry of Virginia; two grandsons; two great-grandchildren; and numerous nieces and nephews.

Larry was a veteran of the US Army. During his professional career, he worked on many challenging projects. These included layout and development of Brimmer Park (Cheyenne); worked on numerous handicap access projects; taught part-time at Laramie County Community College; and assisted in the construction of All Saints Anglican Church (Cheyenne).

Larry was part of the US Geodetic Squadron that surveyed Wyoming, Nebraska, South Dakota, and Colorado in preparation for design and construction of the Minute Man Missile system. Larry worked as a surveyor on the Gray Rocks Dam near Guernsey Wyoming. Larry was an artist, particularly in the art of survey mapping. Larry's maps were masterpieces showing many aspects of western lore. Each of his maps would show a scene that one might expect in the country that he surveyed. Many of his maps are available in the records of the Laramie County Clerk's office.

His professional career included assignments as an engineering aide; a draftsman; an engineering technician; a survey party chief; a mechanical

engineering aide; and a surveyor and field engineer. One of Larry's coworkers in the 1970, was PLSW Honorary Member Rick Hudson. When I learned of Larry's passing I contacted Rick and requested an anecdote about Larry. Here is Rick's response:

### *Remembering Larry*

I knew Larry T. Perry, L.S., during the 1970's in Cheyenne, and we kept in touch sporadically until a few years ago. His letterhead read "Your Friendly Neighborhood Surveyor", and I found that to be somewhat of an understatement for both the southern gentleman, and the good 'ol boy he was. An accomplished artist and calligrapher, an historian, and a mentor to those entering his profession. Both he and I were old school 'vey ors, having learned land surveying in the early 1960's from our mentors and through self study. I feel honored to have known as a fellow Army veteran, as a fellow Land Surveyor, and as a friend. Larry - you'all left a legacy that will endure long into the future. Thank you.

Working with Larry on field surveys could prove interesting. Larry had numerous contacts with the Laramie County officials and employees, through his land surveying practice and working with the Laramie County Conservation District. Several times the undersigned accompanied Larry on rural surveys, and invariably employees of the County Road Department, the sheriff's office, other county and municipal employees; and local residents would pause in their journeys to greet Larry and exchange news and information. Everyone seemed to recognize Larry's brilliant, yellow utility pickup survey truck. (That yellow color would shame a NYC yellow cab!) On one of his projects, Larry had recovered several miles of section lines and the original monuments, but one corner (the required corner!) eluded his efforts. It was thought that the monument was at the intersection of two unpaved county roads east of Cheyenne. At Larry's request, the undersigned accompanied him on the survey. When we arrived at the site, we encountered a mound of blow sand at the northeast corner of the intersection which had eroded into the intersection. After a brief inspection of the site, no evidence of the monument or any accessories were found. Then, a county

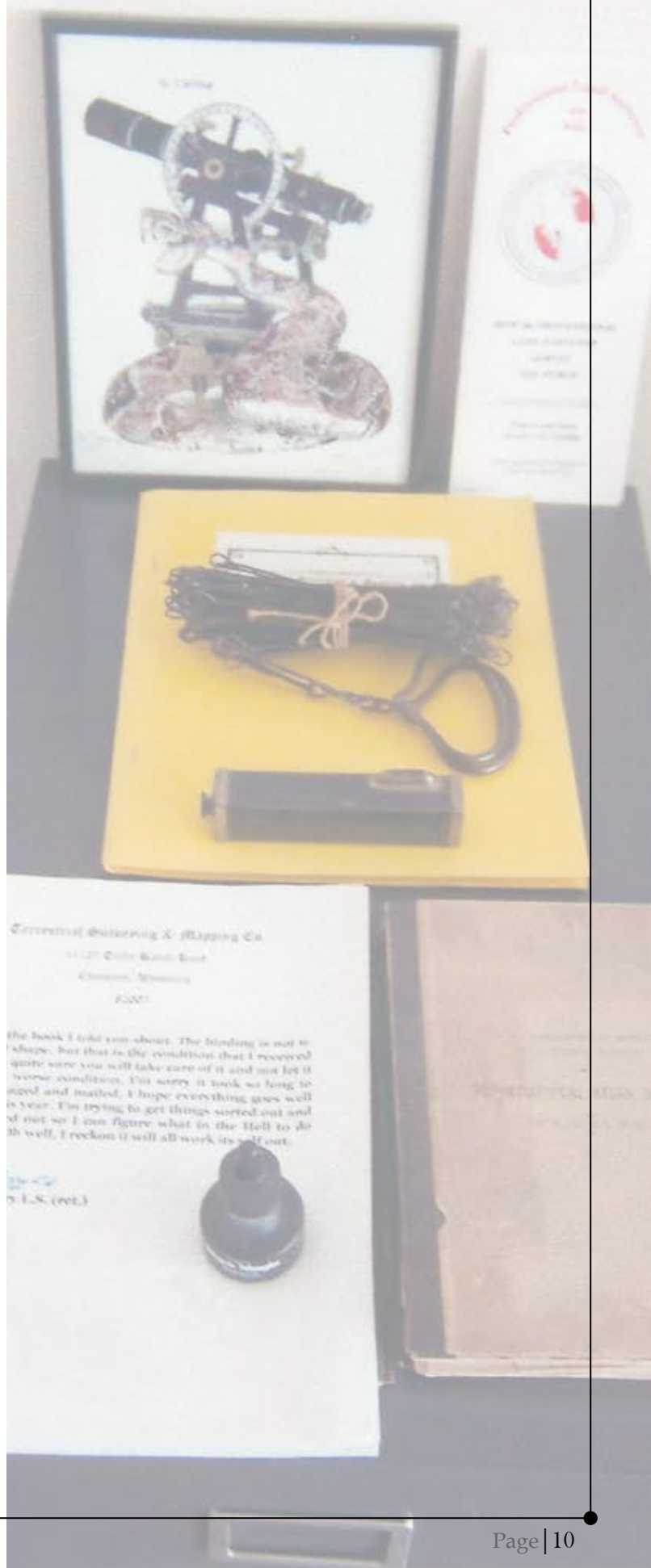


road maintenance crew (a grader and dump truck) drove up. After exchanging amenities and friendly banter, the grader operator proceeded to grade the site and remove the blow sand out of the right-of-way. We unearthed the original monument under over three feet of material; Larry completed the survey; and the County was provided additional right-of-way survey monumentation around the intersection. After the monument had been found the county crew proceeded to perform their normal assignment on the two county roads at the survey site. Later, I asked Larry if he had arranged for the county road crew. Larry, smiled, and said that he knew that a county road maintenance crew was regrading in that area; was scheduled to be working on those county roads on that day; and were desirous to have right-of-way monumentation in the area. That was Larry and his "old boys' network".

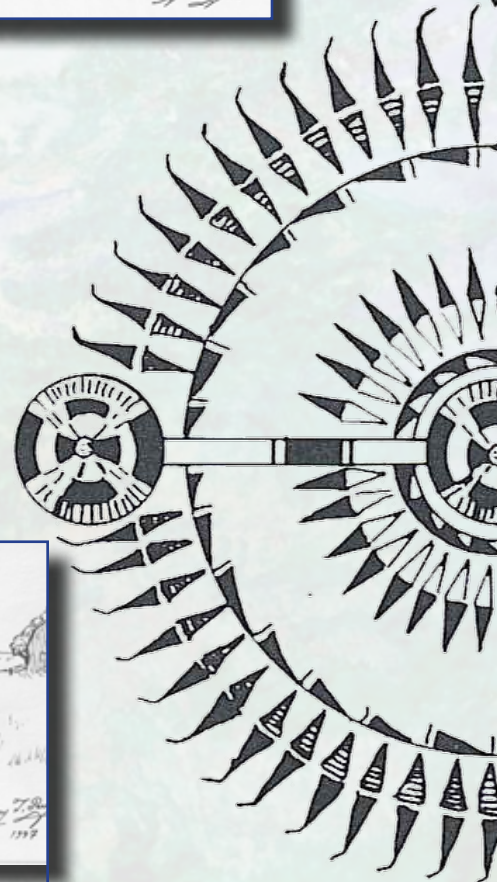
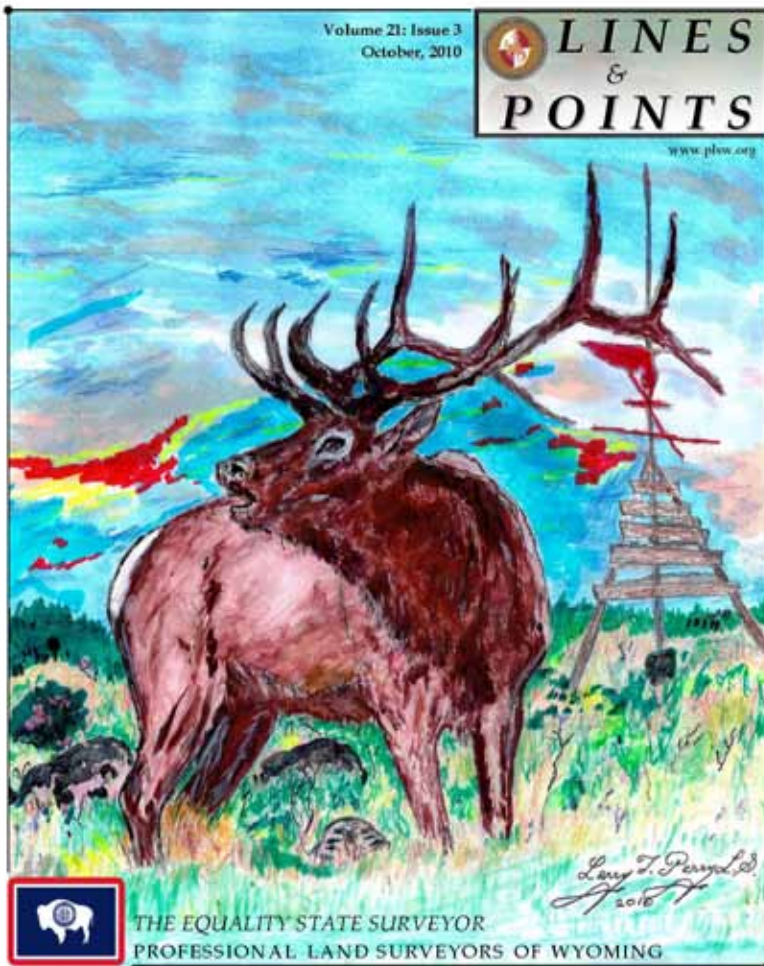
Larry's professional affiliations included the American Congress on Surveying and Mapping (1976); American Society of Photogrammetry (1976); National Association of Archivist (1977) Wyoming Engineering Society (1972); Cheyenne Engineer's Club (1966); and Professional Land Surveyors of Wyoming (c. 1981). Larry actively contributed and participated on programs and projects of the PLSW and the Southeast Chapter of PLSW. He was an accomplished artist. Ten of his artworks were featured as covers for Lines & Points. Many of his survey plats contained art work. He drew the place mat for the PLSW Centennial Acres and the associated surveyor's plat. He worked on legislation and wandered the halls of the Wyoming Legislature (as a lobbyist) when they were in session. One of the least noticed of his activities was heading the PLSW Publicity Committee. He regularly attended the PLSW Board of Directors' meetings, the Annual Meetings, and the Southeast Chapter meetings, where he gathered information, located background materials, and wrote news items and announcements. About five years ago, the PLSW Southeast Chapter awarded its first Chapter Honorary Member to Larry.

Funeral services with Military Honors by the American Legion Honor Guard and the Patriot Guard Riders were conducted at the Wiederspahn-Radomsky Chapel of the Chimes with internment at Cheyenne Memorial Gardens.

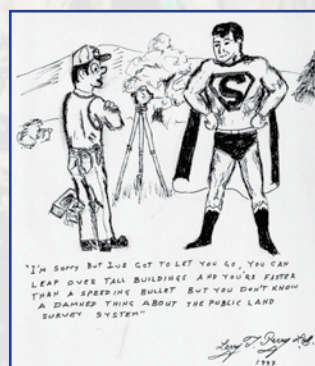
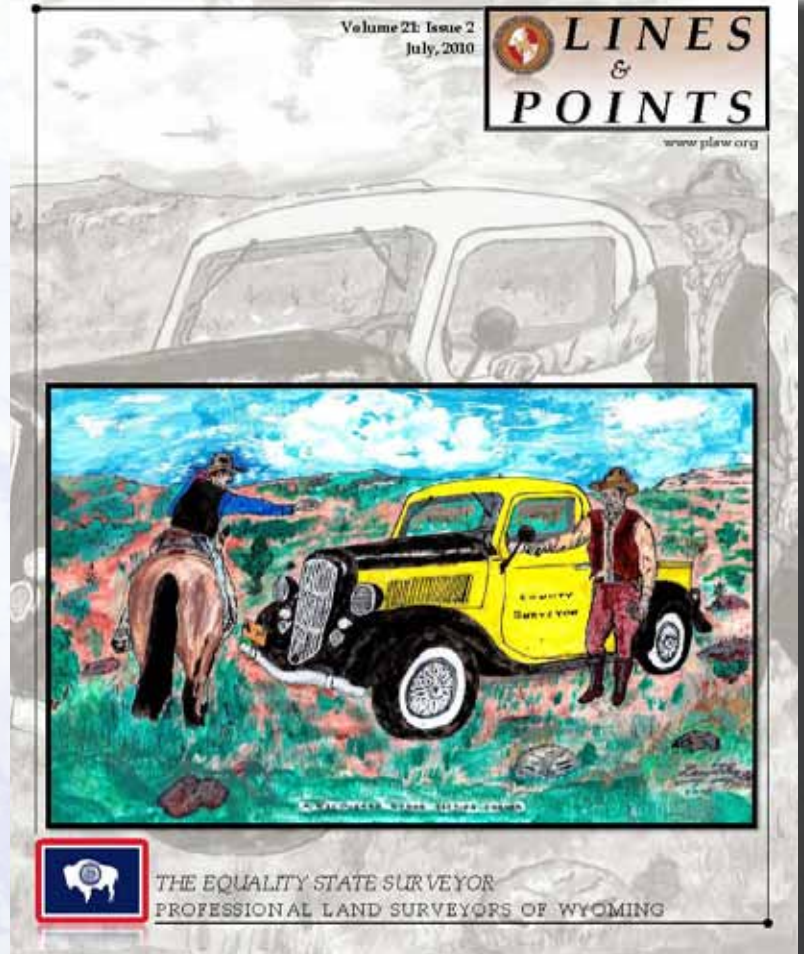
Herbert W. Stoughton, Ph.D., P.E., P.L.S., C.P.











## EXCERPTS FROM THE NOAA WEBINAR:

### *Overview of the NGS Online User Service - Where We Are and Where We're Going*

OPUS User Forum of February 3, 2021

Compiled by Herbert W. Stoughton, Ph.D., P.E., P.L.S., C.P.

On 3 February 2021 panelists Joe Evjen, Dan Gillins, Dave Zenk, and Galen Scott took questions from the attendees (reported to be several hundred individuals) concerning current and future developments for OPUS. An email containing 71 questions and the panelists' response was published (11 February 2021). Below is a sample of some of the questions with the panelists' responses. For a copy containing all the questions and responses please see: <https://geodesy.noaa.gov/sitemsgs/OPUS/QAfromOPUSForum.html>.

**Q: Will the upcoming new datums affect how I use OPUS?**

A: Yes, for the better hopefully. New datums will allow simplifications to OPUS options and should usher in new functionality, as new frames and tools are built around OPUS works. Fundamentally, OPUS won't change, it will still process your data in the ITRF reference frame, and convert that to regional frames for reporting and other options.

**Q: What is the minimum occupation time for a static survey to be successfully submitted in OPUS?**

A: For now, two hours is the shortest data file that OPUS-S will accept. Longer data files, 4 - 5 hours, provide better results. We are actively testing the new GNSS processing engine, and may lower this limit if experiments prove it wise.

**Q: How significant is it to process your OPUS solution 24 hours after collection?**

A: It Depends. OPUS will use the best CORS and orbits available at the time you upload your data. While most CORS are archived within 30-minutes past the hour, some aren't available until the next day. If you process your data in less than 24 hours after collection, OPUS will use Ultra-Rapid orbits. Rapid orbits, available at 17:00 UTC the next day, will offer a slight improvement in your accuracy. Final orbits, available weeks later, offer only slight benefit to solutions in areas with usable CORS nearby.

**Q: I would like to submit several hundred datasets through OPUS every evening. Is there a limit to the number of datasets you like an organization to submit to OPUS on a daily basis?**

A: No, OPUS currently has no usage limits, and does have techniques for managing heavy users. We are investigating ways to make OPUS more usable for users with many files per day; the resulting product should be easier to use, but this may invoke usage caps, if popularity causes the tool to slow down.

**Q: Would it be possible to read the RINEX header for initial form filling in the antenna model and height fields?**

A: Yes, in future versions OPUS will use metadata properly recorded in the RINEX header as default values, replacing NONE antenna @ 0.0 meter height. Users can elect to override these new defaults with optional, manual entries or user profiles.

**Q: Could an updated OPUS solution include State Plane Coordinates in International feet rather than meters?**

A: Yes, simply select the upload option>forms>extended format to see state-selected foot units. As this has been a popular suggestion, NGS may consider making feet more prominent when we redesign OPUS output for the new reference frames.

**Q: What is the man machine interface? Is that the touch panel?**

A: Yes, MMI is the side of the antenna with the user interface, one of several possible North Reference Points (NRP) described at [ANTCAL/#faq5](#)

**Q: Did he say that the antenna needed to be pointed to the north**



A: Yes, NGS recommends that when conducting a GNSS survey, your antenna's North Reference Point (NRP) should be oriented to true north. See Antenna Calibrations to look up your antenna's ARP and NRP.

**Q: Why turn the Antenna to the North while collecting data?**

A: This allows the antenna calibration to properly account for your antenna's azimuthal bias, if any.

**Q: How accurate does the north orientation need to be?**

A: It depends on how much azimuthal bias exists in your antenna calibration. Many manufacturers design their antennas to have only small biases, in which case it shouldn't matter much, but if you are building a CORS, guidelines ask you to look up your magnetic declination, so that you can use a magnetic compass and account for the small difference from true north. You can look up your antenna's azimuthal bias from the Antenna Calibration website.

**Q: Is Antenna model or Code included in the data file? If the antenna type is included in the data file, why do we need to provide it separately in OPUS?**

A: Good point, the future versions of OPUS will use metadata properly recorded in the RINEX header as default values, replacing NONE antenna @ 0.0 meter height. Users can still elect to override these new defaults with optional, manual entries or user profiles, but this should simplify data upload for many of them.

**Q: The RINEX program I use removes all constellations except GPS. Can we use through RINEX all possible constellations?**

A: Yes, RINEX3 was developed to support many GNSS constellations, whereas RINEX2 supports only GPS and GLONASS.

**Q: With the new multi-constellation OPUS will we be able to specify what constellations are used?**

A: Yes, an upload option will allow you to exclude constellations. You can also manually  
(Continued on Page 19)

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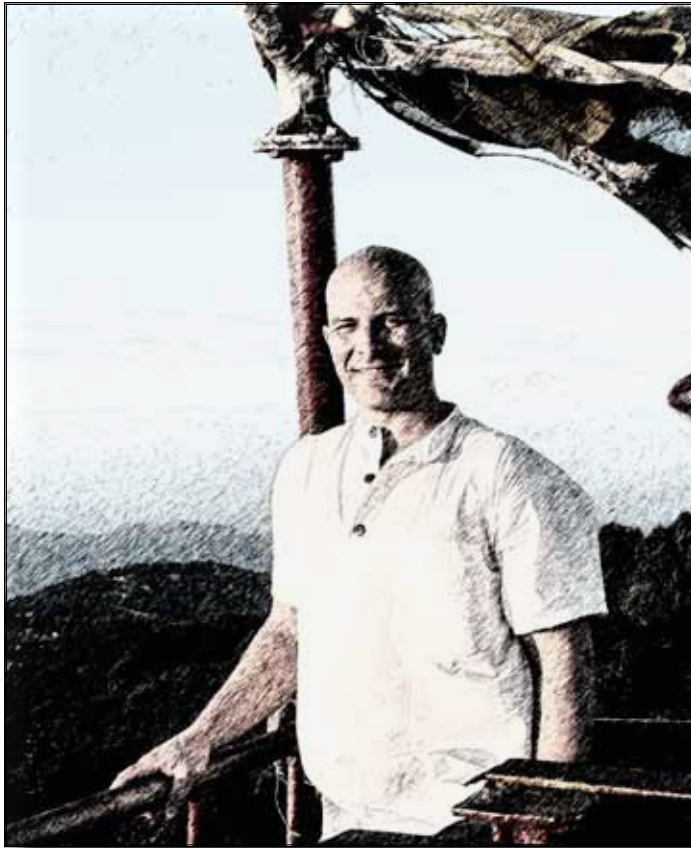
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## NSRS Modernization

By Brian Shaw, NGS Rocky Mountain Regional Advisor ([brian.shaw@noaa.gov](mailto:brian.shaw@noaa.gov))

### BACKGROUND

NOAA's National Geodetic Survey (NGS) has been planning to modernize the National Spatial Reference System (NSRS) since 2007. The NSRS is a consistent coordinate system that defines latitude, longitude, height, scale, gravity, orientation, and shoreline for the United States and its territories. The NSRS includes such things as datums, geoid models, gravity models, survey data, transformation tools and more. Modernizing the NSRS will be composed of many things but the primary updates will be replacing the North American Datum of 1983 (NAD 83), the North American Vertical Datum of 1988 (NAVD 88) and the State Plane Coordinate System of 1983 (SPCS83).

Datums and reference frames are an essential component for spatial data, serving as the foundation for aligning geospatial data from disparate sources. When performing analysis with geospatial data, using a consistent datum or reference frame assures that different datasets are correctly referenced to one another helping assure that any decisions made from this analysis are accurate. Similar to how the concrete foundation helps keep the frame of a house in place, datums and reference frames help to keep geospatial data properly aligned.

Since the introduction of NAD 83 and NAVD 88 science and technology have progressed at a rate never before seen which continues to accelerate with each passing year. With this progression our understanding of Positioning, Navigation and Timing (PNT) have greatly improved making it possible to collect geospatial data to a precision and accuracy never before done. Thanks to this technology we can see how the tectonic plates are moving in different ways relative to each other, as well as see land changing vertically and horizontally due to various factors like ground fluid withdrawal or glacial isostatic adjustment. With these advancements we are able to track changes in our environment to a level that requires an improved NSRS that can provide a framework for these measurements.

One of the main components to the NSRS Modernization is collecting new gravity data for the entire United States to be used to create the North American-Pacific Geopotential Datum of 2022 (NAPGD2022) which will replace NAVD 88. In 2007 the Gravity for the Redefinition of the American Vertical Datum (GRAV-D) project was first created. NGS had the ambitious goal to collect airborne gravity measurements across the vast majority of the US lands to help develop a geoid model with differential accuracies of 1 cm across any distance. NGS was unsure how much time would be needed to collect the data for the Aleutian Islands, Hawaii and the Pacific territories, but original estimates (since updated) were at least 11 years.

The first GRAV-D survey was conducted out of Montgomery, Alabama in early 2008 and would fly out over the Gulf of Mexico continental shelf, known as block CS01. I had the honor to be one of two gravimeter operators on this maiden survey which provided me an amazing experience. We performed flights at three different altitudes as well as varying speeds to identify the optimal spacing, speed and



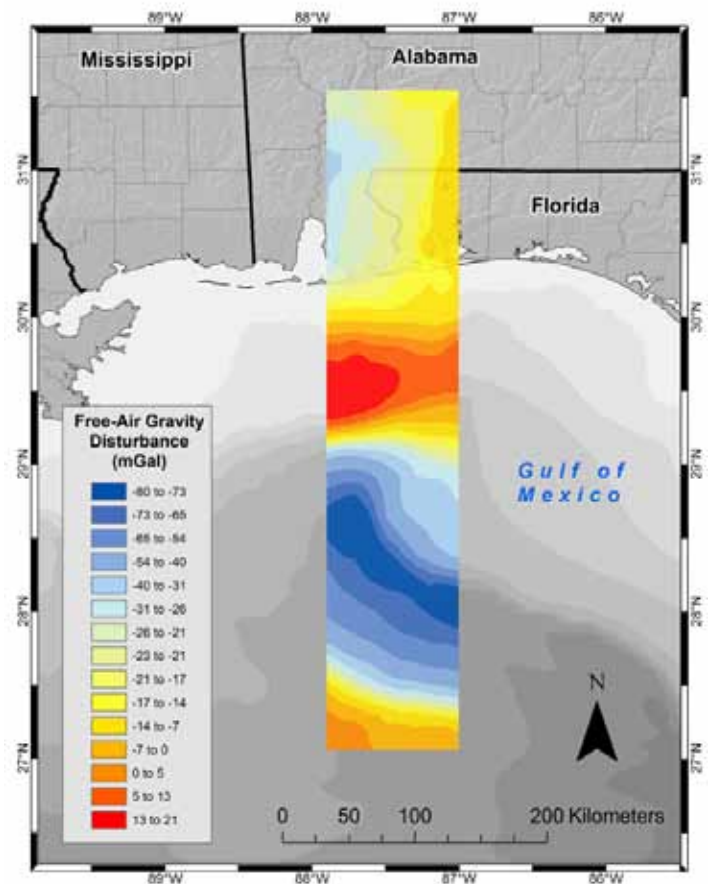
altitude that the data should be collected. Over the next 5-10 years the process was streamlined, collecting data across the US, and updated planning indicated that the data collection would be complete by the end of 2022. Unfortunately due to various factors NGS realized that this would not be possible and in June of 2020 we officially delayed the rollout of NSRS Modernization.

### NSRS MODERNIZATION DELAY MESSAGE

Here is part of the official NSRS delay message<sup>2</sup>:

*Since 2017, operational, workforce, and other issues have arisen and compounded, causing NGS to recently re-evaluate whether a successful roll-out by 2022 is possible. The most significant impacts have been in workforce hiring and retention, and in meeting GRAV-D data collection milestones, which underpin the NSRS modernization efforts.*

*NGS is currently conducting a comprehensive analysis of ongoing projects, programs, and resources required to complete NSRS modernization and will continue to provide regular updates on our progress. To get the latest news on NSRS modernization and track our progress, subscribe to NGS News<sup>3</sup> or visit our "New Datums" web pages<sup>4</sup>.*



Map of GRAV-D block CS01 <sup>1</sup>

### WORKING IN THE MODERNIZED NSRS

In this section I would like to highlight some of the key components and concepts of working in the Modernized NSRS. For more details please reference the NOAA Technical Report, Blueprint for 2022, Part 3: Working in the Modernized NSRS<sup>5</sup> which has recently been updated from the original publication. On March 11, 2021 there was a webinar on this document which was recorded and available here<sup>6</sup>.

Today in Colorado/Wyoming/Montana we work in NAD 83 (2011) and NAVD 88 but this will be changing with NSRS modernization. In the future NAD 83 (2011) will be replaced by four plate fixed Terrestrial Reference Frames (TRFs) of which the North American Terrestrial Reference Frame of 2022 (NATRF2022) will be the most likely candidate for use in this region. NATRF2022 and the other three TRFs will be mathematically defined relative to the International Terrestrial Reference Frame of 2020 (ITRF2020). In fact, all geometric NGS products and services will operate in ITRF2020, and only after computations are complete will NATRF2022 (et al) coordinates be available.

NAVD 88 will be replaced by NAPGD2022 which will include GEOID2022, GRAV2022 and more. Today we understand that all tectonic plates are moving in different ways relative to each other and to help model this plate movement NGS will develop Euler Pole Parameters (EPPs) for each of the four tectonic plates upon which some 99% of U.S. states and territories are located -- Caribbean, Mariana, North American, and Pacific. When the modernized NSRS is released all the TRFs will be identical to ITRF2020 at epoch 2020.00. The EPPs will be used to convert between NATRF2022 (et al) and ITRF2020 at any other epoch besides 2020.00. There will also be another model currently called the Intra-frame velocity model of 2022 (IFVM2022, the name might change) that will be a 3D model of mark motion through time (using surface motion as a proxy) used to account for residual motion within each frame to estimate coordinate changes through time. Figure 2 shows the North American plate Euler pole as well as the velocities of continuously operating reference stations (CORSs) on the Caribbean, North American and Pacific Plates.

In the future the primary way to access the NSRS will be through GNSS observations that are processed relative to the NOAA CORS network (NCN) and/or the IGS network. Most surveys will have GNSS involved, for example when performing leveling there will be procedures to assure that some marks have GNSS observations used to constrain the leveling survey to those coordinates/heights (some exceptions will exist, but using GNSS will be the most accurate, preferred way to ensure leveling-derived orthometric heights are up to date).

New types of coordinates on geodetic control will be coming with the modernized NSRS and these new coordinates will be called reference epoch coordinates (RECs), survey epoch coordinates (SECs), online positioning user service (OPUS) coordinates and reported coordinates. RECs will be coordinates computed by NGS using data submitted to NGS and processed by NGS an adjustment project to estimate the coordinates at a specific reference epoch. Reference epochs will be determined by NGS and are currently planned every five or ten years, starting at epoch 2020.00. SECs will be coordinates computed by NGS using submitted data, but estimated at (or near) the date of the actual data collection, called the "survey epoch". Each survey epoch will be the center of an "adjustment window", inside of which all data collected in that window will be part of the SEC adjustment project. Currently the time of an adjustment window has not been determined but the leading candidate for GNSS surveys is four weeks, and one year for leveling surveys. RECs and SECs will be computed by NGS and once adjusted these coordinates on passive control will be considered "part of the NSRS", similar to how datasheet coordinates are used as geodetic control today.

OPUS coordinates will be any coordinates that are provided from using OPUS. Any coordinates computed using "OPUS recommendations" will be considered "tied to the NSRS". These coordinates will be observations from GNSS, leveling, total stations and more that are processed using the future OPUS 6.0 nicknamed "OPUS for Everything". One other set of coordinates will be called reported coordinates and these will be any coordinates reported to NGS without the data necessary to replicate

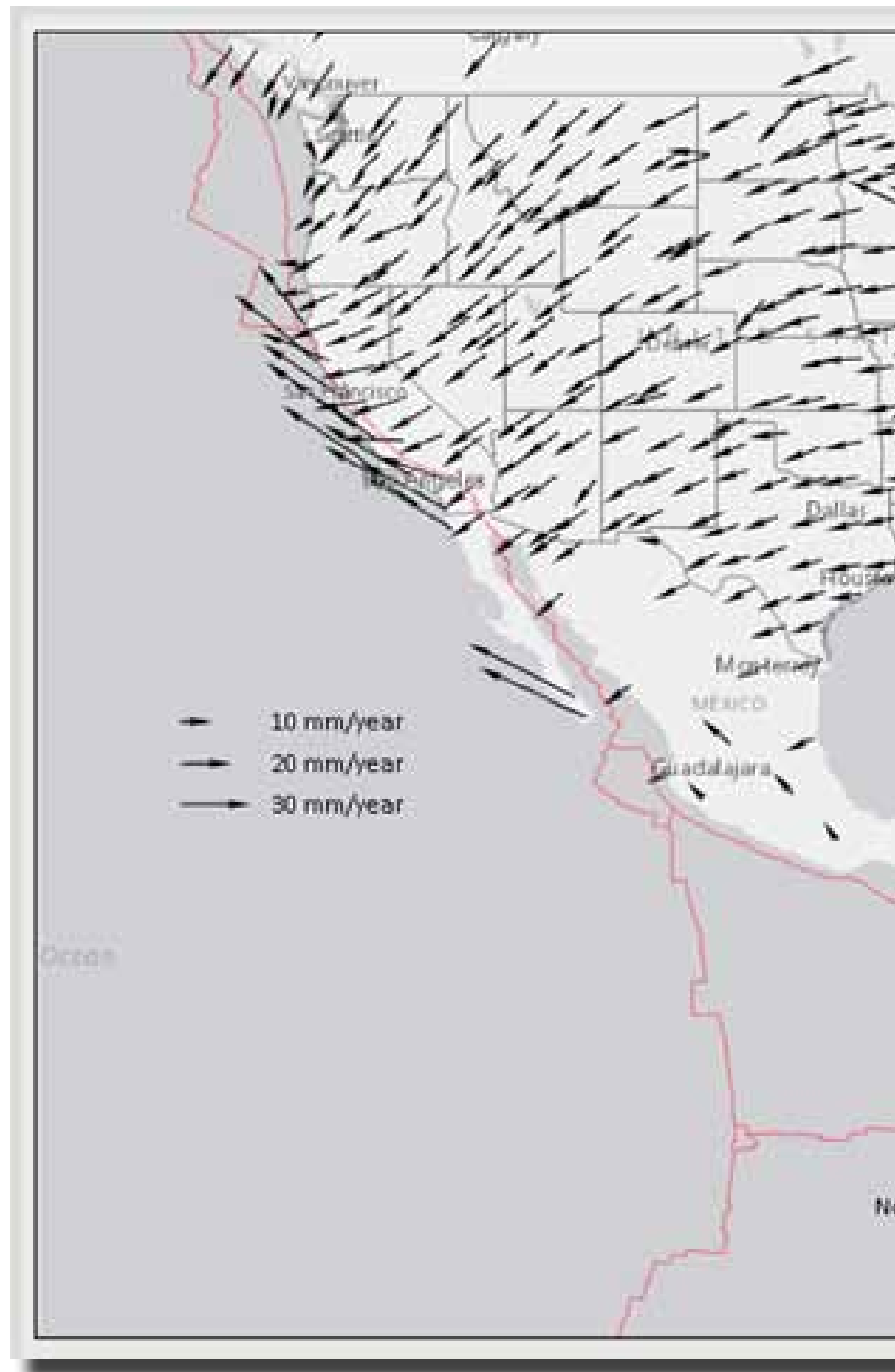


FIGURE 2: VECTORS OF HORIZONTAL VELOCITY AT SELECT





CORS AND THE NORTH AMERICAN PLATE EULER POLE.

or evaluate them. These coordinates will also include any coordinates that are transformed between datums. A final type of coordinate--actually a coordinate function through time--will be active coordinates (ACs), but these will only be available at active control stations, such as CORSs.

The best way for users to determine coordinates in the modernized NSRS will be:

1. Resurvey: return to the field and collect new observations at geodetic control of interest.
2. Readjust: adjust existing observations in the modernized NSRS using OPUS
3. Transform: Use transformation software to transform finished products in the old NSRS to the new NSRS.

These three methods go from the most expensive and accurate way of determining coordinates in the modernized NSRS to the least expensive and least accurate. Each organization will need to determine accuracy requirement needs for their geospatial data. Note that any data submitted to NGS today through bluebooking or OPUS Share will be included when the RECs and SECs are adjusted so if you submit your data to NGS today then readjustment results will be available when the modernized NSRS is released. You can learn more about the GPS on benchmarks campaign<sup>1</sup> as well as learn about how to share your observations with OPUS<sup>2</sup>.

<sup>1</sup>[https://geodesy.noaa.gov/GRAV-D/data\\_cs01.shtml](https://geodesy.noaa.gov/GRAV-D/data_cs01.shtml)

<sup>2</sup><https://geodesy.noaa.gov/datums/newdatums/delayed-release.shtml>

<sup>3</sup><https://geodesy.noaa.gov/INFO/subscribe.shtml>

<sup>4</sup><https://geodesy.noaa.gov/datums/newdatums/index.shtml>

<sup>5</sup>[https://geodesy.noaa.gov/PUBS\\_LIB/NOAA\\_TR\\_NOS\\_NGS\\_0067.pdf](https://geodesy.noaa.gov/PUBS_LIB/NOAA_TR_NOS_NGS_0067.pdf)

<sup>6</sup>[https://geodesy.noaa.gov/web/science\\_edu/webinar\\_series/working-in-modernized-nsrs.shtml](https://geodesy.noaa.gov/web/science_edu/webinar_series/working-in-modernized-nsrs.shtml)

<sup>7</sup><https://geodesy.noaa.gov/GPSonBM/>

<sup>8</sup><https://geodesy.noaa.gov/OPUS/about.jsp#sharing>

(Continued from Page 14)

edit RINEX to strip out whole constellations or individual satellites.

Q: Is there a link to information to explain the difference between RINEX, RINEX2, and RINEX3 formats? I found this: <https://www.gisresources.com/rinex-receiver-independent-exchange-format/>

A: RINEX formats are now specified by the International GNSS Service. You may enjoy the visualizations at [gage.upc.edu/Rinex v2.11](http://gage.upc.edu/Rinex_v2.11) and [Rinex v3.01](http://gage.upc.edu/Rinex_v3.01) and the GUI for manipulating RINEX at <http://teqc.silkwerks.com/> Note, these are NOT NGS products.

Q: Will OPUS upload Trimble native .T02 files?

A: No, they will have to be converted to .DAT or RINEX before submitting to OPUS. Support for vendor-specific formats is waning, as the enabling 3rd party translator TEQC is past end-of-life. The future is RINEX!

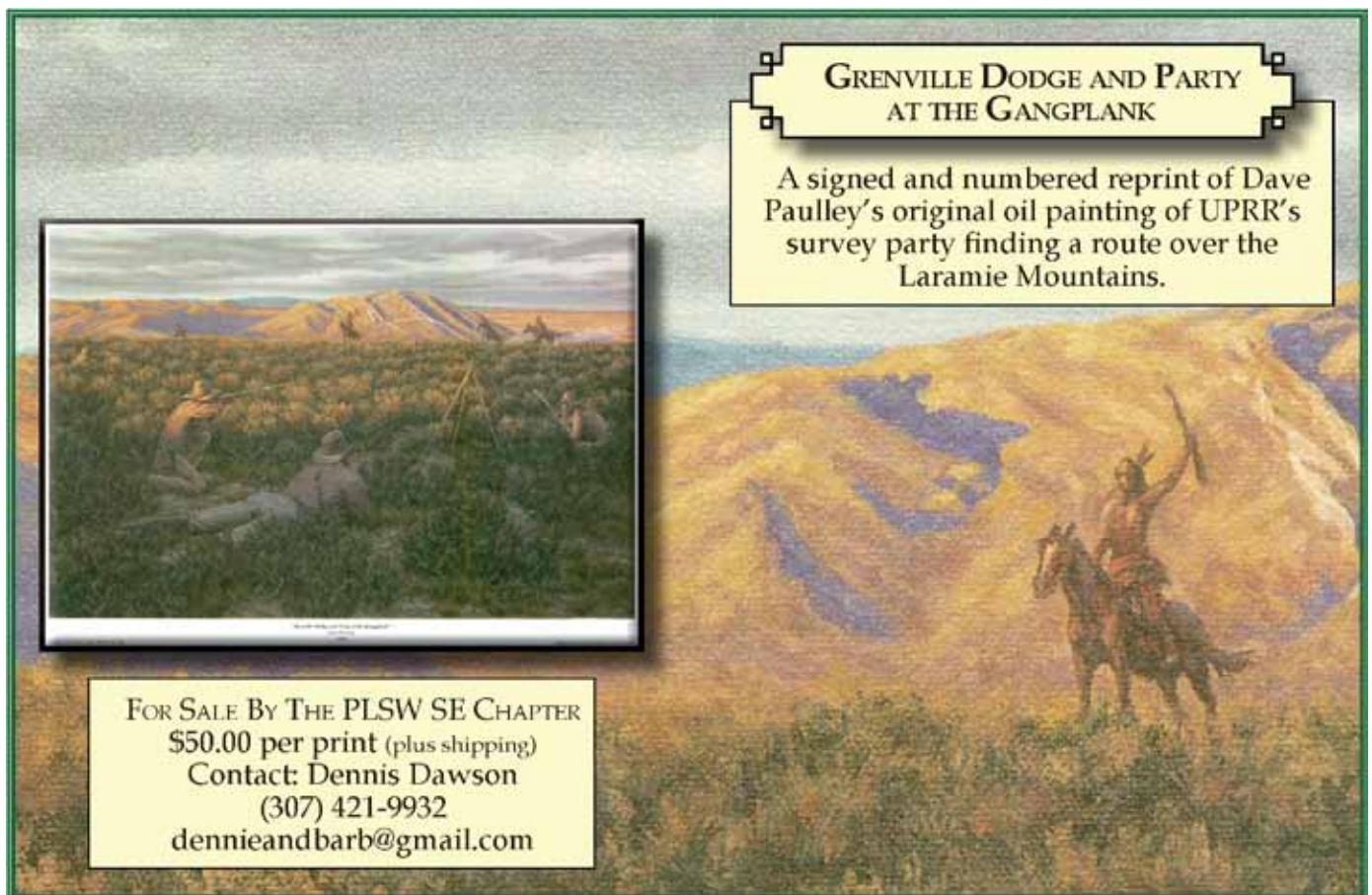
Q: Can OPUS remove satellites that have too many slips?

A: Yes, OPUS attempts to detect and remove cycle slips. You may also choose 3rd party

software to remove satellites from the data file before uploading it to OPUS.

Q: Is the vertical peak-to-peak an appropriate indicator of orthometric height uncertainty, or is there a piece of info in the OPUS report that would be better to use?

A: Hard to say; as compared with traditional geodetic control, a single OPUS solution lacks the observation redundancy necessary to determine the accuracy of the computed height. None of the possible metrics correlate strongly with accuracy. As seen in the answer and graph above (not published in this response), the orthometric height 'peak-to-peak' value reported on the OPUS solution is often VERY conservative, though not always for about 14% of GPSBM solutions. NGS will need to tackle this when redesigning both the NGS datasheet and next version OPUS solution reports; fortunately the mathematical relationship to the next vertical datum will be simpler. For accurate results, use good field technique in ideal (good sky visibility) conditions, and conduct multiple observations, at different times of day.



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**Q: To convert our local NAVD88 BMs to the new 2022 Datum in a couple of years, will it be as simple as uploading RINEX files to OPUS in 2022?**

A: Simpler! While OPUS can serve for this purpose, if you already have an ellipsoid height for the mark, NGS will provide conversions to translate that into new orthometric heights, as well as a lower-accuracy transformation tool to convert leveled NAVD88 orthometric heights directly. So, you will have the choice to reprocess (OPUS) to convert (NCAT).

**Q: I would like to know the difference in VRS and OPUS and when it is best to use one over the other when setting temporary benchmarks on a job site.**

A: VRS is a type of network corrector method that a local or regional Real-Time Network (RTN) can provide. VRS can provide wonderfully accurate and productive surveying, where they exist, and when they are set up correctly. NOAA's OPUS works worldwide, and is maintained to stay aligned to modern international reference frames, as well as the official US datums, through

the use of more time-intensive static- and rapid static survey techniques. You'll have to make a professional choice, depending on your project goals and accuracy requirements. Based on some research conducted at NGS, we have found that a 5-minute VRS solution (in an RTN with an interstation spacing less than 70 km that is aligned with the NSRS) will have a horizontal accuracy less than 2.5 cm and a vertical (ellipsoid height) accuracy less than 5 cm at 95% confidence. The accuracies rival what can be achieved with a 2-h occupation post-processed in OPUS-S. Any observations that is longer than 2 hours in duration and post-processed in OPUS-S will be more accurate than a VRS solution.

**Q: Will the Vnetworks (in this case from DOT) eventually takeover from the RTK opus conversion surveys?**

A: See answer above; and yes, if the RTN base station coordinates are correctly aligned with the National Spatial Reference System, then they will provide results to the stated accuracies above. Depending on your project needs and goals, you can choose which works best for

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you. However, if you wish to send your RTN data to NGS for publication, then you should upload your data to OPUS-Projects, run its adjustments, and submit your results. OPUS-Projects is currently the gate for sending RTN survey data to NGS.

**Q: Should we wait until the Ephemeris is listed as "Precise" before we share data? This sometimes takes 2 - 3 weeks.**

A: Don't wait for three reasons. One, the impact of precise orbits is minimal for most US solutions. Two, shared solutions are eventually reprocessed after tool or frame upgrades, and so will then use the precise orbits. Three, your memory of fieldwork only fades with time, so it is best to upload while your memory is fresh! That being said, our CORS team does wait for the precise orbits before running most network monitoring activities, as it provides the best results.

**Q: When I share solutions and am submitting two separate 4 hr. plus observations, should I submit my photos with both submittals? I only took photos with one of the observations.**

A: Yes, for now, each solution is treated as

independent and each form requires two photos. It doesn't check that your photos are unique, so if conditions are identical for the observations, yes you can re-use the photos. Note, we recommend taking lots of photos, and this provides you the opportunity to upload different views (e.g. north vs. south) if you have spares.

**Q: For OPUS-Share, we have a 17 hour observation, but we can split into two 4 plus hour observations. Is there actually any benefit in submitting as two shorter observations vs 1 longer one?**

A: No and yes. All things considered, it is better to leave an observation intact. However, you may wish to split an observation for our GPSBM project, to get double credit, thereby counting the bench mark as "DONE".

**Q: Are old USC&GS monuments that are no longer in your "Benchmark Locator" still better than a new made monument?**

A: Yes, from a geodetic network perspective, we prefer observations focused on existing monuments, but you should use those monuments that are convenient and appropriate for you.



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