



NOAA Special Publication NOS NGS 16

2021 Geospatial Summit Final Report

Silver Spring, MD
May 4–5, 2021

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Introduction

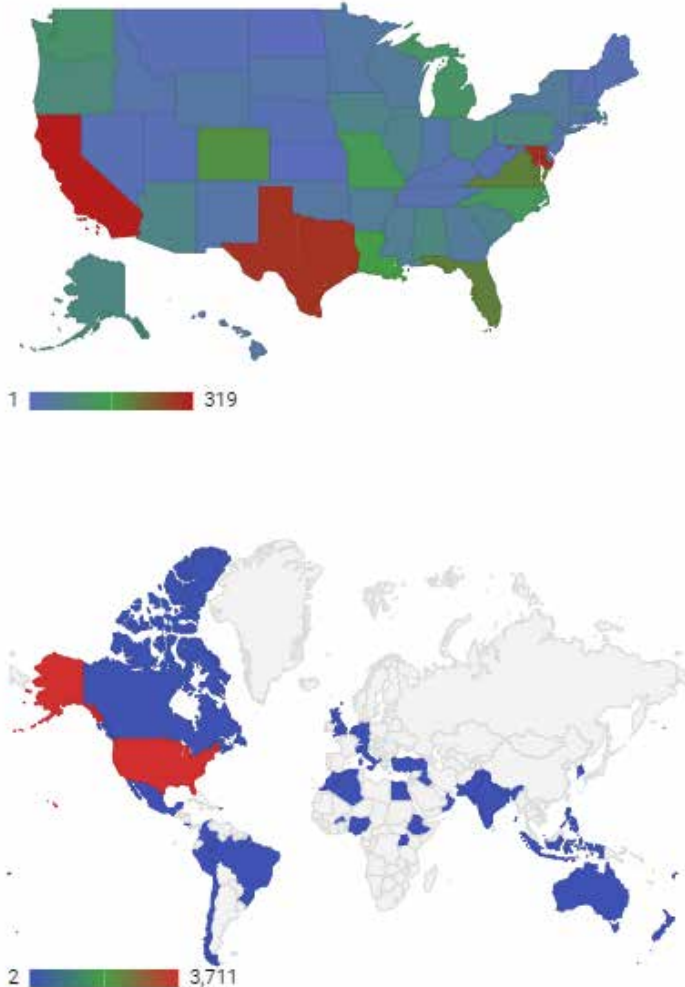
The 2021 Geospatial Summit provided updated information about the planned modernization of the National Spatial Reference System (NSRS). Specifically, NGS plans to replace the North American Datum of 1983 (NAD 83) and the North American Vertical Datum of 1988 (NAVD 88). This major change was originally planned to occur in 2022, but it has been delayed.

The Summit provided an opportunity for NGS to share updates and discuss the progress of projects related to NSRS Modernization. The event was hosted virtually, and more than 1,000 people attended each day. Many attendees were surveyors, but others identified themselves as engineers; GIS or mapping professions; geodesists or other physical scientists; as well as educators and students.

NGS valued hearing feedback from its stakeholders and continued collecting requirements from end users across the federal, public, and private sectors. This event continued discussions from previous Geospatial Summits held in 2010, 2015, 2017, and 2019.

This publication offers a brief summary of the information that was presented at the 2021 Geospatial Summit. More extensive materials from the event including PowerPoint presentation slides and webinar video recordings are available at geodesy.noaa.gov.

Figure 1: Distribution of Summit Registrants across the United States and world.



Day One: May 4, 2021

NSRS Modernization Overview

Dru Smith, Ph.D.

NSRS Modernization Manager, NGS

This presentation provided an overview of the NGS effort to modernize the NSRS, including the status and timelines of ongoing projects. It also reviewed recent updates to “blueprint” publications about defining the new reference frames and geopotential datum and working in the modernized NSRS.

Figure 2: “Blueprint” publications, listed by their numerical and publication title.

Publications can be downloaded from: <https://geodesy.noaa.gov/library/>

Numerical Title	Title (Date)
NOAA Technical Report NOS NGS 62	Blueprint for 2022, Part 1: Geometric Coordinates and Terrestrial Reference Frames (2021)
NOAA Technical Report NOS NGS 64	Blueprint for 2022, Part 2: Geopotential Coordinates and Geopotential Datum (2021)
NOAA Technical Report NOS NGS 67	Blueprint for 2022, Part 3: Working in the Modernized NSRS (2021)

Advancing Geodetic Science and Improving Models and Software

Gravity for the Redefinition of the American Vertical Datum (GRAV-D)

Jeffery Johnson

Supervisor for the Gravity Section, Observations and Analysis Division, NGS

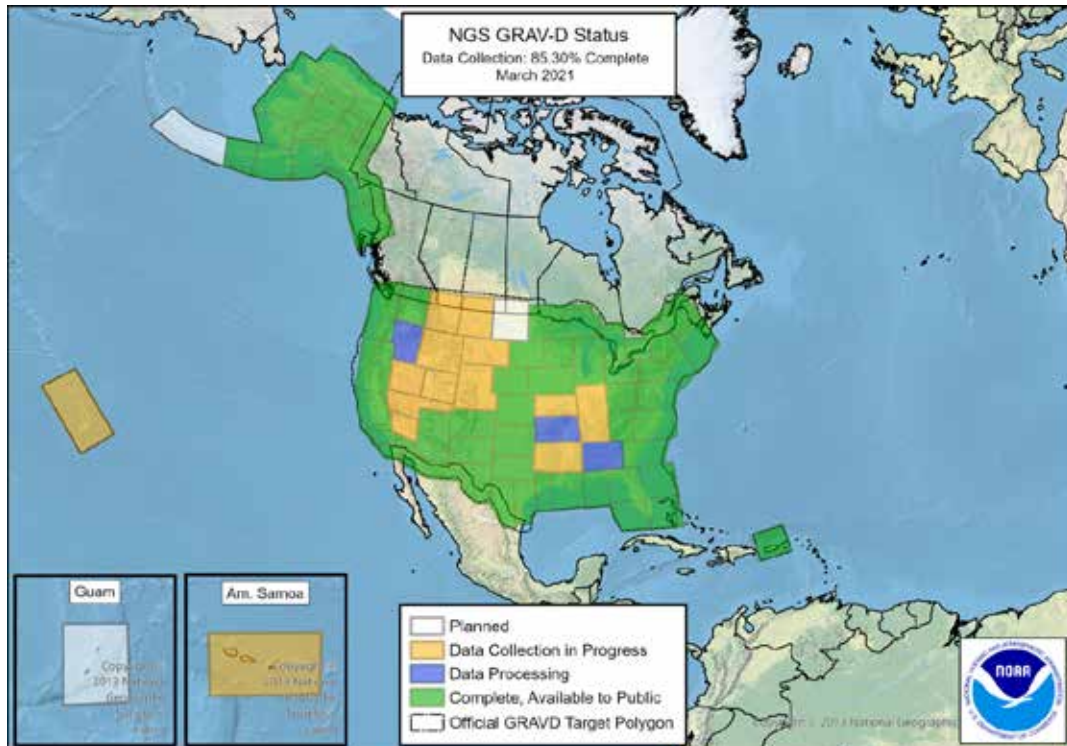
NGS has been collecting airborne gravity data since 2008 for the purpose of modeling a geopotential surface to redefine the way heights (elevations) are determined. The goal of this effort, the GRAV-D project, is to collect airborne gravity data over the entire US and its territories. GRAV-D is just over 85% complete, but much work remains, including some remote regions in the Pacific. We have made major progress in Hawaii and have been able to negotiate some challenging airspace in southwest CONUS. We tentatively have plans to collect data over the Aleutian Islands this spring and summer as well.

The development of NGS airborne gravity processing software has been ongoing and some recent improvements have put us on track to finalize the next iteration of the software, Newton v2.0, this fiscal year. Once the Newton software has been fully vetted,

we will look for an opportunity to marshal NGS’s resources to do a complete reprocessing of existing GRAV-D data sets. These reprocessed data will be provided to the geoid modelers to help them create GEOID22.

Figure 3: The map below shows GRAV-D data collection status, as of March 2021. More information and the latest data collection information can be found online:

<https://geodesy.noaa.gov/GRAV-D/>



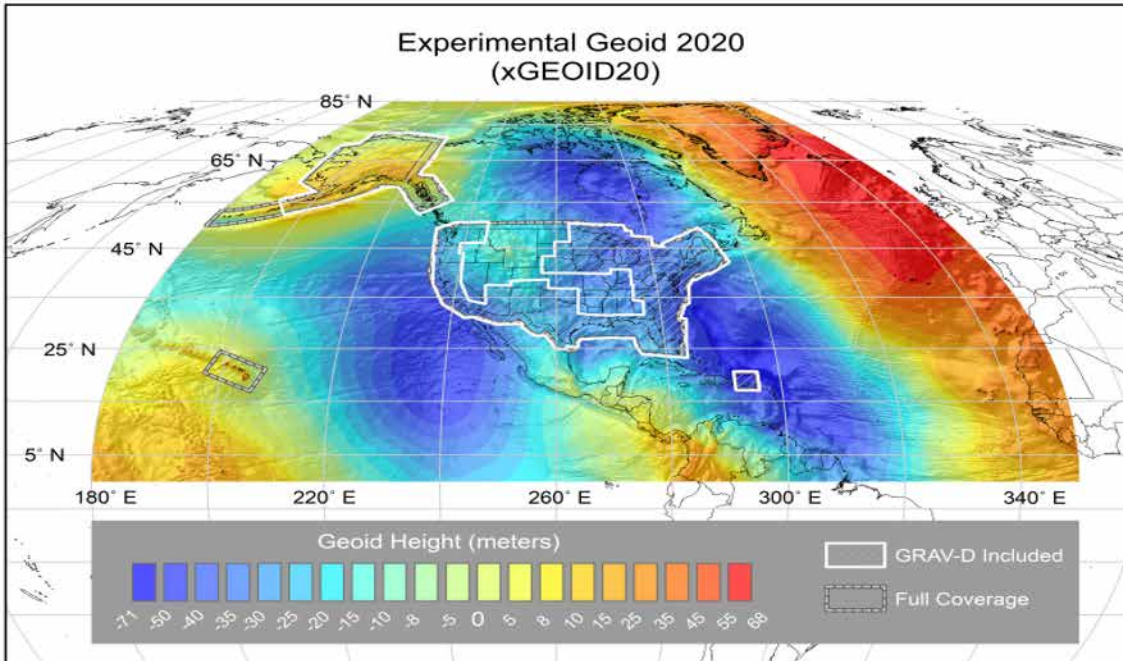
Experimental Geoid Models (xGEOIDs)

Yan Wang, Ph.D.

Geodesist, NGS

From 2014 to 2020, NGS published annual experimental geoid (xGEOID) models. These models contain the gravity data from the latest satellite gravity models, terrestrial gravity, and most importantly, airborne gravity from the Gravity for the Redefinition of the American Vertical Datum (GRAV-D) project. The xGEOIDs provide a preliminary but increasingly accurate view of GEOID2022, the zero-elevation surface in the upcoming North American-Pacific Geopotential Datum of 2022 (NAPGD2022). This talk provided the current status of xGEOID modeling, and a brief introduction to the Colorado geoid experiment, which is an international effort to compare and validate geoid computation methodologies.

Figure 4: The map below shows the experimental geoid model, xGEOID20. It also notes locations that included GRAVD data. More information can be found online: <https://beta.ngs.noaa.gov/GEOID/xGEOID/>



Geoid Slope Validation Surveys — Ground Truth Tests of the Models

Derek van Westrum, Ph.D

Geodesist, NGS

NGS performed three ground truth surveys to test geoid models in various terrains: relatively flat, low elevation (Texas 2011), higher, relatively flat terrain (Iowa 2014), and finally, high, mountainous terrain (Colorado 2017). Results indicate that the slope of the geoid can be determined to 1cm, 2cm, and 4cm, over distances up to 300 km, in these regions, respectively when airborne gravity from GRAV-D is used in the geoid model. This presentation discussed the overall idea, the surveys, the analysis, and the conclusions, and what it all means for determining heights in the new National Spatial Reference System.

Multi-constellation Global Navigation Satellite System (GNSS) software

Andria Bilich, Ph.D.

Geodesist, NGS

NGS is replacing its in-house GPS-only software (PAGES) with an entirely new software suite that uses data from all GNSS constellations, for both positioning and orbit determination. This

new software suite, named M-PAGES (i.e., Multi-GNSS PAGES), will be incorporated into all Modernized NSRS products and services. This talk reviewed M-PAGES progress to date and preliminary results.

Least Squares Adjustment Software

Dru Smith, Ph.D.

NSRS Modernization Manager, NGS

NGS has contracted with Polaris Geospatial Services to write an entirely new, do-it-all Least Squares Adjustment (LSA) software suite. This new LSA suite will replace all existing LSA code in current use around NGS and will be incorporated into all Modernized NSRS products and services. This talk covered the motivation and current status of that project.

Day 2: May 5, 2021

Changes to NGS Products in a Modernized NSRS

State Plane Coordinate System

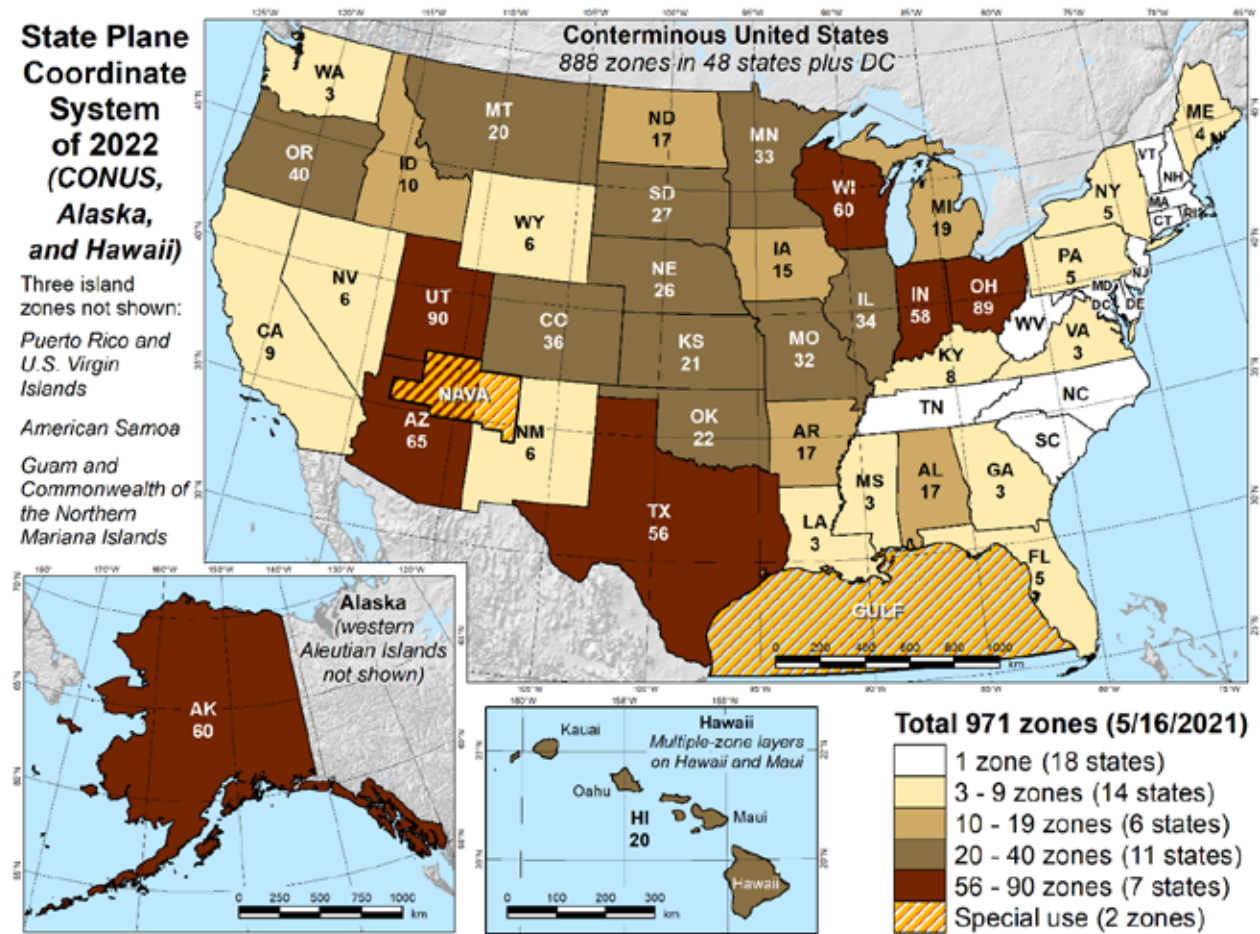
Michael Dennis, Ph.D.

Geodesist, NGS

The State Plane Coordinate System (SPCS) was created by NGS in the 1930s for surveyors and engineers. SPCS has since been adopted by many others in the geospatial community, and their input is contributing to a major update as part of NSRS Modernization. This presentation briefly described how SPCS will change and the role of NGS customers in its evolution.

Figure 5: The map below shows the preliminary proposed State Plane Coordinate System of 2022 (SCPC2022) zones across CONUS, Alaska and Hawaii. More can be found online:

<https://geodesy.noaa.gov/SPCS/index.shtml>.



Retirement of the U.S. Survey Foot

Michael Dennis, Ph.D.

Geodesist, NGS

This presentation covered the recent retirement of the U.S. Survey Foot from all future federal products and services. Since 1959, two nearly identical versions of the foot have been used in the U.S., resulting in costly errors. On December 31, 2022, the U.S. survey foot will be retired and the international foot (hereinafter called just the “foot”) will be the only federally recognized foot, including for the future State Plane Coordinate System. However, for backwards compatibility, NGS will continue to support the U.S. survey foot in tools where it is currently in use, such as for existing State Plane Coordinate System of 1983 (SPCS 83) zones where it is currently used, and for all SPCS 27 zones.

GPS on Bench Marks Campaign

Galen Scott

Constituent Resource Manager, NGS

This talk discussed both the status of the GPSONBM campaign, as well as plans for the data that is collected through this campaign. NGS will automatically reprocess all submitted data and provide 2020.0 reference epoch coordinates (RECs) when the Modernized NSRS is released. NGS will also provide a transformation tool to enable conversions from current datums to new reference frames and geopotential datum. The ongoing GPS on Bench Marks campaign will help improve the future transformation tool and enable local partners to prepare to take full advantage of the benefits of the modernized system.

Two Types of Coordinates

Boris Kanazir

Geodesist, NGS

NSRS Modernization will better account for land motion over time, while also supporting customer needs, which temporarily must assume positions remain "constant." Two types of coordinates will be used to implement this dual-track approach: survey epoch coordinates (SECs) and reference epoch coordinates (RECs). The RECs will be snapshots, every five or ten years, of the entire network of geodetic control points. In contrast, SECs will reflect the actual dates of data collection, providing a time-dependent view of each geodetic control mark.

Designing a Data Delivery System for the Future

Jay Howard.

Geographer, NGS

Information technology improvements, combined with the expansive amount of geodetic and visual information available for geodetic survey marks requires NGS to modernize our data delivery system to best meet the future needs of our customers. This talk focused on replacing traditional “datasheets”, with a data delivery system (DDS). The DDS is the system by which the future NSRS database will be queried. It will yield up information about survey projects, adjustment projects, observations, coordinates, points, stations and sites as well as a number of geospatial relationships not currently available from the existing NGS Integrated Database (IDB).

Working in a Modernized NSRS

Online Positioning User Service (OPUS) Improvements Part 1

Jeff Jalbrzikowski

Regional Geodetic Advisor, NGS

A recent update to OPUS-Projects, known as OPUS-Projects 4.0, allows users to submit their static GPS data for inclusion in the NGS Integrated Database (IDB). NGS will soon add the capability to submit GNSS vectors from RTK, RTN (aka VRS), or post-processed surveys (to be called OPUS-Projects 5.0). These features and the future of OPUS were explained in this talk.

Online Positioning User Service (OPUS) Improvements Part 2

Phillip McFarland

Geodesist, NGS

NGS plans to continue adding functionality to its popular OPUS suite, and we believe it will remain a critical tool used by surveyors to work in the NSRS. Future improvements (to be called “OPUS 6.0”) will include automated recommendations such as what are the best continuously operating reference stations (CORSs) to use as control in a project.

Standard Data File Formats for GNSS, Total Stations, Automatic Levels, and Gravimeters

Dan Gillins, Ph.D.

Geodesist, NGS

Advances in GNSS and the added functionality planned for OPUS will require the introduction and adoption of new formats for data submission. This presentation will discuss common data formats that NGS is pursuing, in coordination with industry and other global standards organizations. Examples of data formats that were discussed included RINEX 3 and GVX.

Figure 6: The table below shows common data formats NGS is pursuing.

Measurement Type	File Format	File Type	Current Status	Use at NGS
Reduced GNSS data (GNSS vector)	GVX	XML	Released final version 1.0 on 2/04/2021	OPUS-Projects v.5, OPUS v.6
Differential leveling (heights differences)	LVX	XML	Under development	OPUS v.6
Classical (angles, distances)	CVX	XML	Under development	OPUS v.6
Relative gravity (gravity differences)	RGX		Planned for 2022	OPUS v.6

Modernized NSRS Use Cases

Nicole Kinsman, Ph.D.

Regional Geodetic Advisor, NGS

NGS has developed four applied use cases to provide users a window into what it will be like to work in the modernized NSRS. These use cases are intended to facilitate stakeholder feedback about necessary products or training, and serve as a starting point for those interested in pursuing detailed data-driven cases studies in the future. The use cases are framed around:

- Flood Mapping,
- Passive Control for a Multi-year Corridor Project,
- Transitioning Data to the Modernized NSRS, and
- Airport and Other Infrastructure Monitoring

Figure 7: Cover page representations of each Modernized NSRS Use Case.



Summary and Next Steps

The 2021 Geospatial Summit was the first major outreach event since the NSRS Modernization delayed schedule was announced. While the transition is a few years away, a lot of progress has been made that NGS shared with its stakeholders. Given the virtual nature of the event, NGS was pleased to see broad attendance from around the country, and even the world. Over the two-day event, Summit attendees came from all 50 states, Washington DC, Puerto Rico, Guam, and six Canadian provinces.

The event was well attended, and the virtual audience was very engaged, asking dozens of questions after presentations, which can be seen in Appendix D. Although the content was very technical and prior knowledge of the material was helpful, the audience satisfaction was very high.

Additionally, many attendees reported that they are somewhat or fully prepared for NSRS Modernization. When asked about other topics of interest, attendees wanted to learn more about vertical datums and heights; coordinate conversions and datum transformations; and practical examples of how changes will be implemented. NGS also will continue to engage with industry and continue inviting external speakers to future Summits based on this feedback.

Appendix A: Attendee Make-up

The professional make-up of the audience was not tracked during registration; rather, attendees had three opportunities to self-identify their profession: through an evaluation survey each day and through a live poll to kick-off day two of the event. The results from each data collection were very similar, although the survey opportunities allowed respondents to select multiple professions — and many did. For simplicity, the poll results from day two are included below in Figure A1, and it shows 60% of attendees were surveyors or engineers; 17% were GIS or mapping users; 14% were Geodesists or other scientists, and 9% were educators, students or “other.” This distribution is similar to NGS website visitors and NGS webinar attendees.

The organizational makeup is summarized in Figure A2 below, and the information shown was based on the attendee’s email address. The table shows 53% of participants were from the public sector (U.S. federal, state or local government); 40% from the private sector; 5% from universities and 2% international. This distribution is similar to previous NGS Geospatial Summits.

Finally, the geographic distribution of cumulative (i.e., across the two days) registrations — versus attendees — is shown in Figure A3 below. The largest registration was from California and Texas, the two most populous states. Canada had the largest international engagement, but there were registrants from around the world.

Figure A1: What is your profession? (n=356)

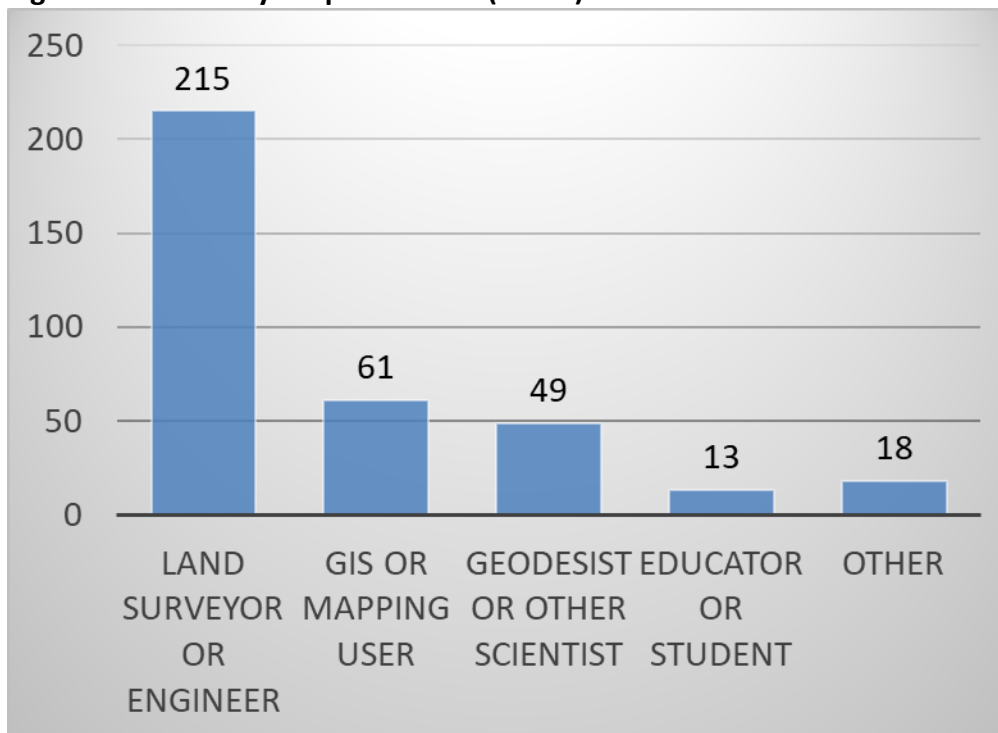
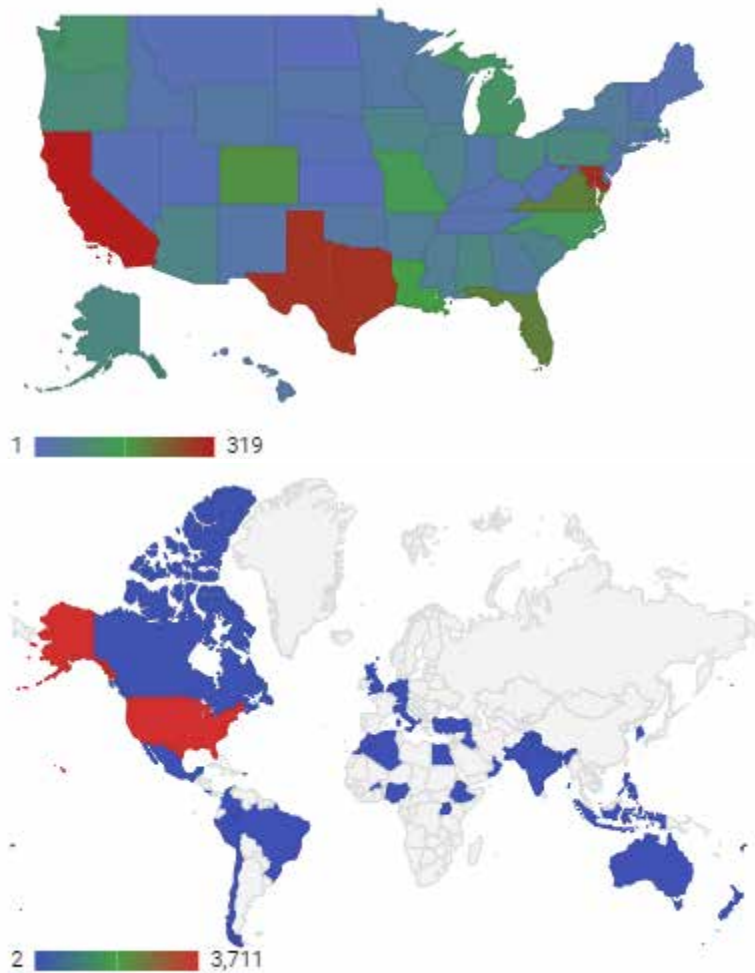


Figure A2: The table below the organization affiliation, by sector, as determined by attendees' email addresses (N=1194)

Organizational category	Email s included	Total Attendees	Largest organization attendance
Public Sector: Federal, State or Local government (US)	.gov, .mil., .us.org	634	123 – NOAA; 39 – USGS; 28 – NGA; 27 – USACE; 20 - NC DOT
Private Sector	.com,net, .biz	481	10 – Fugro; 9 – Quantum Spatial
University	.edu	57	8 – LSU
International	Many	22	7 – Canada

Figure A3: The maps below show the geographic distribution of registrants.



Appendix B: Attendee “Live Polls” Feedback

Live polls were used as a way to engage the virtual audience and also get live feedback to inform NSRS Modernization planning efforts. The same webinar interface was used to share presentation slides and ask poll questions, which allowed for a very high average response rate per poll question of about 45%.

Day 1: May 4, 2021

Figure B1: How prepared are you for the NSRS Modernization? (n=547)

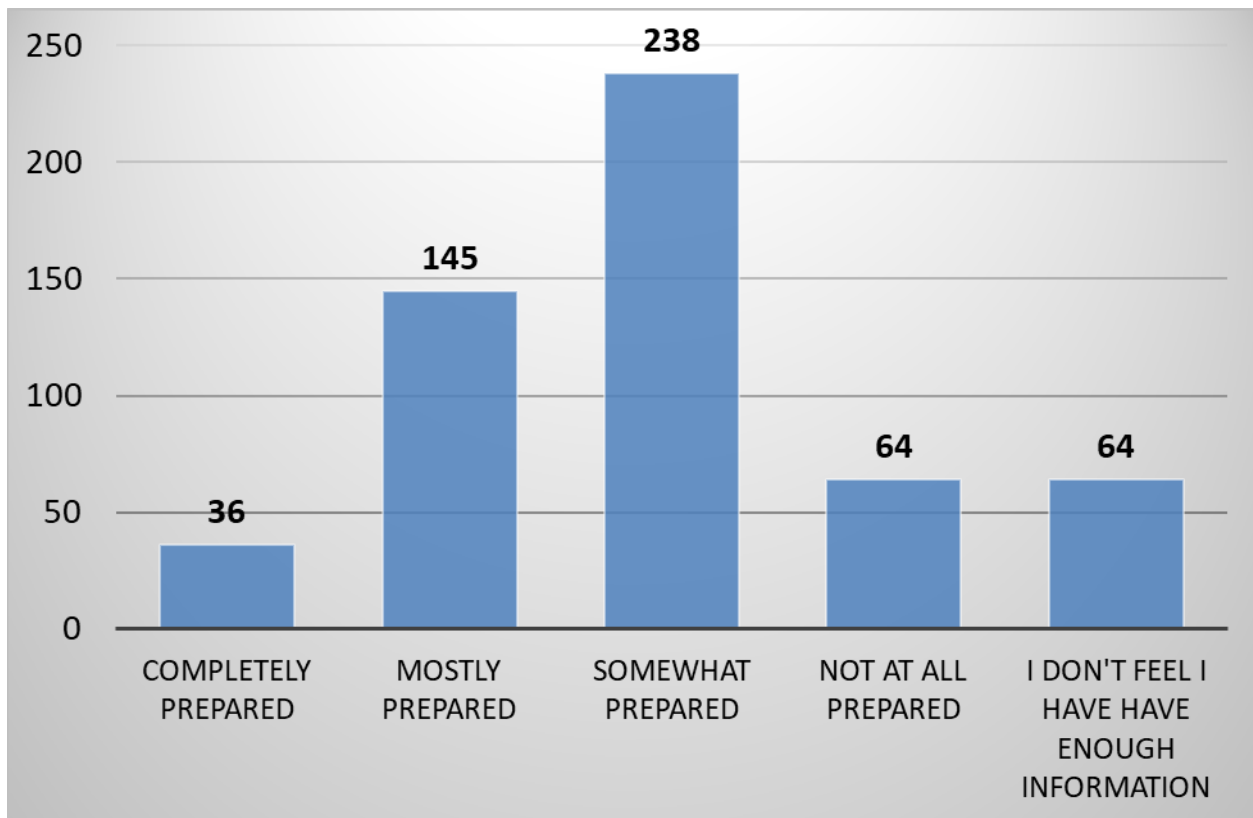


Figure B2: If you don't feel prepared for the NSRS Modernization, is it because? (n=512)

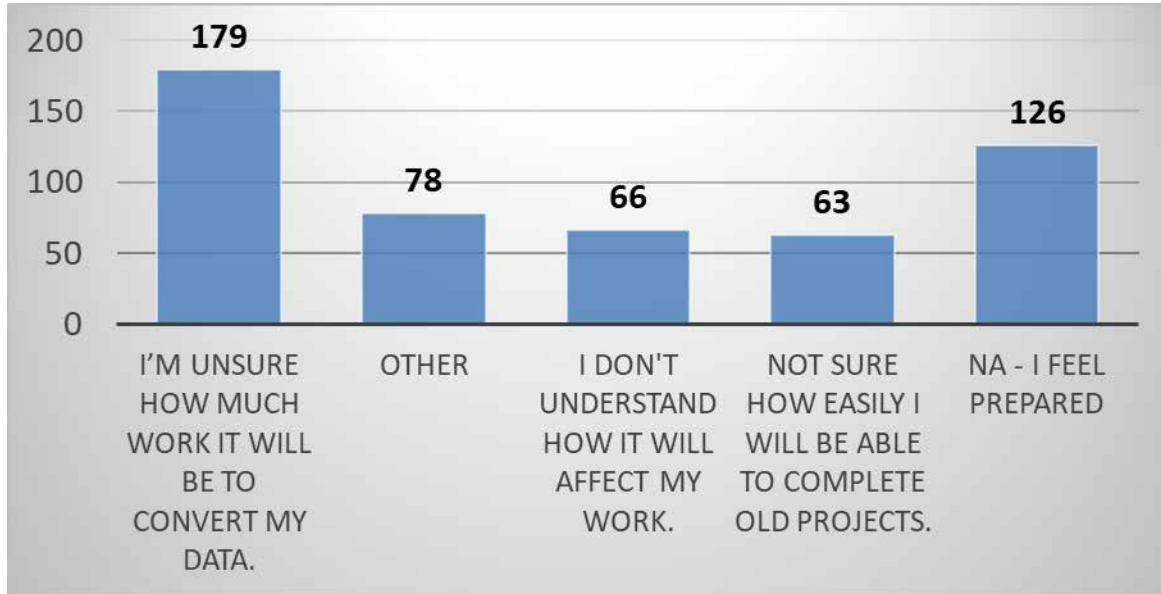
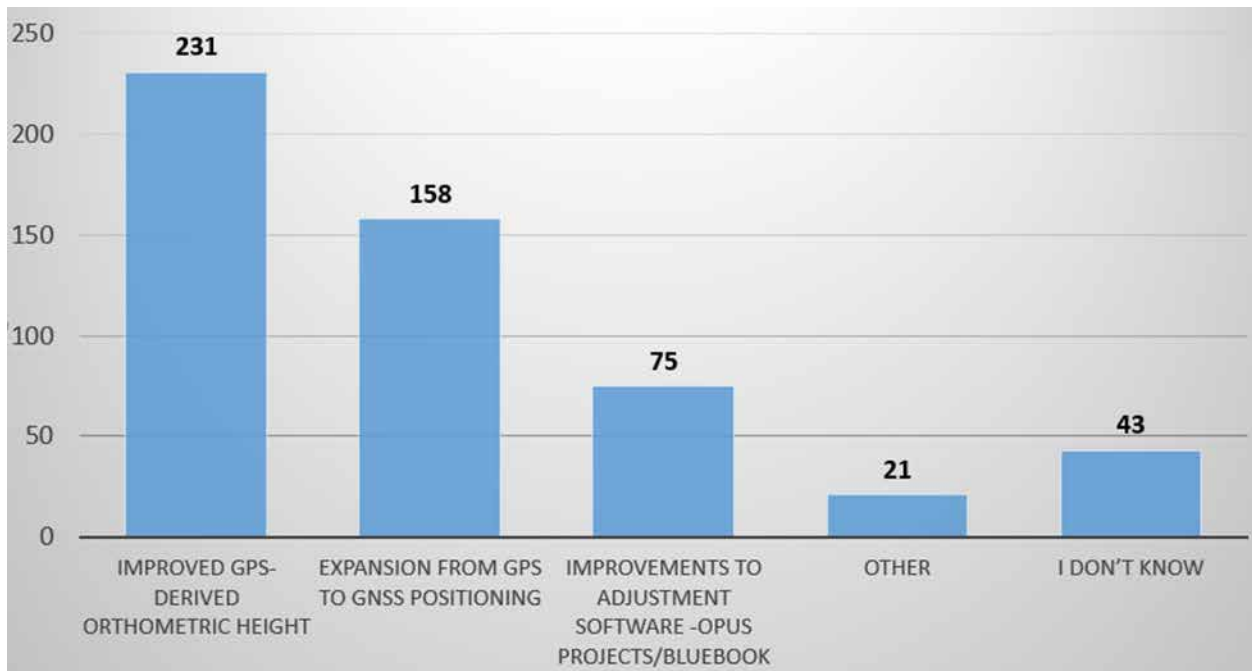


Figure B3: After hearing today's updates, which will most impact your work? (n=528)



Day 2: May 5, 2021

Figure B4: How familiar are you with the GPS on Bench Marks Program? (n=640)

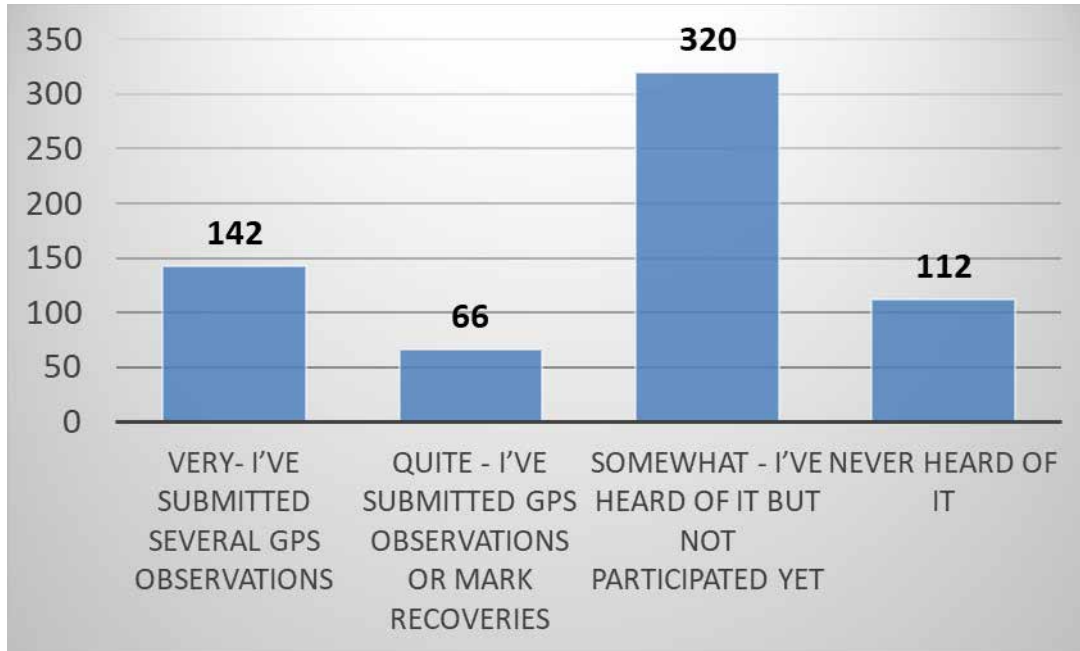


Figure B5: What is your opinion of the look/feel and functionality of the NGS Passive Mark Web Page and Leveling Projects Page? (n=546)

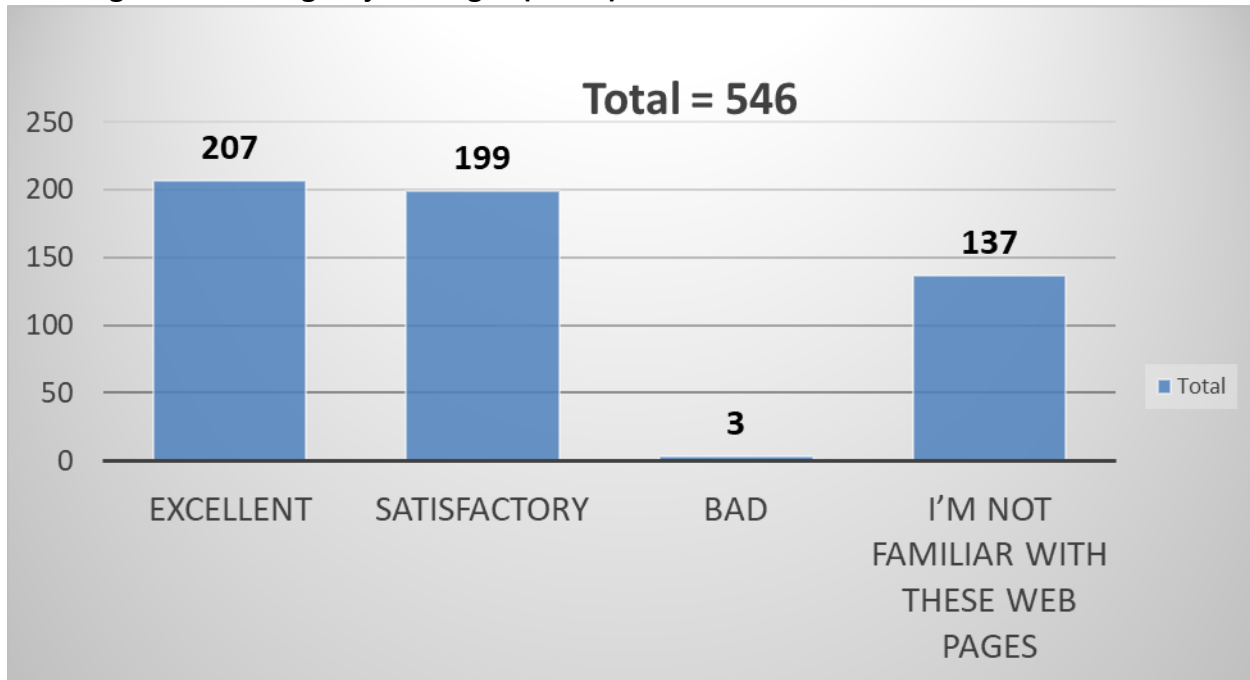
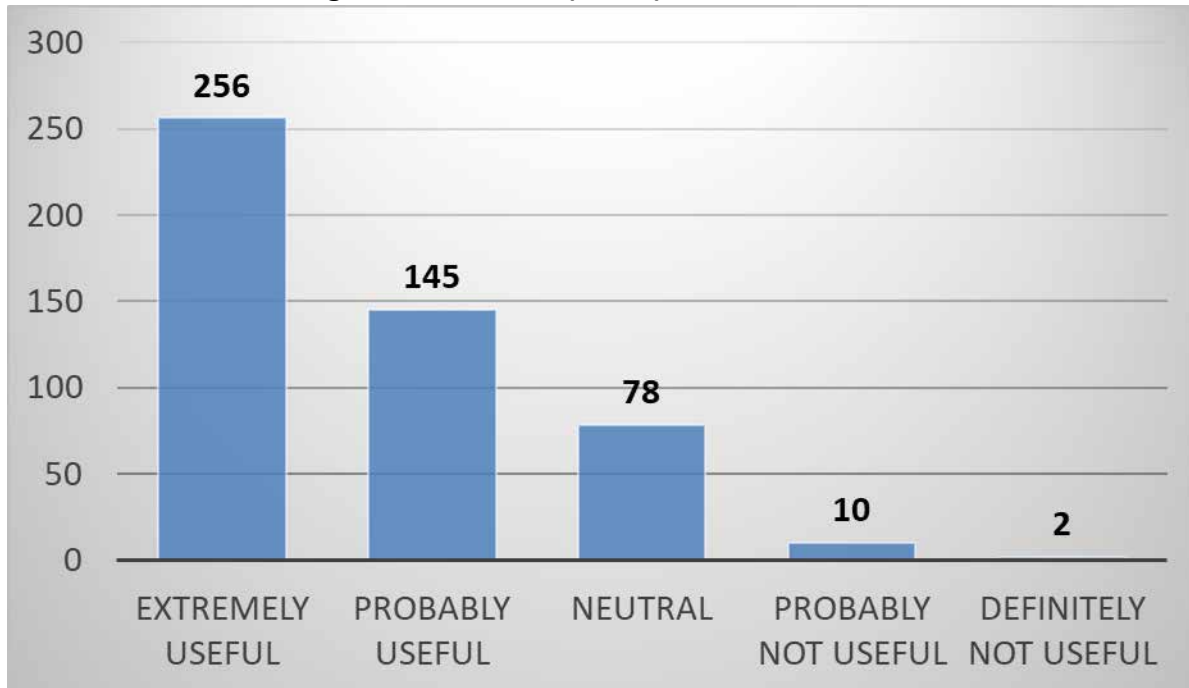
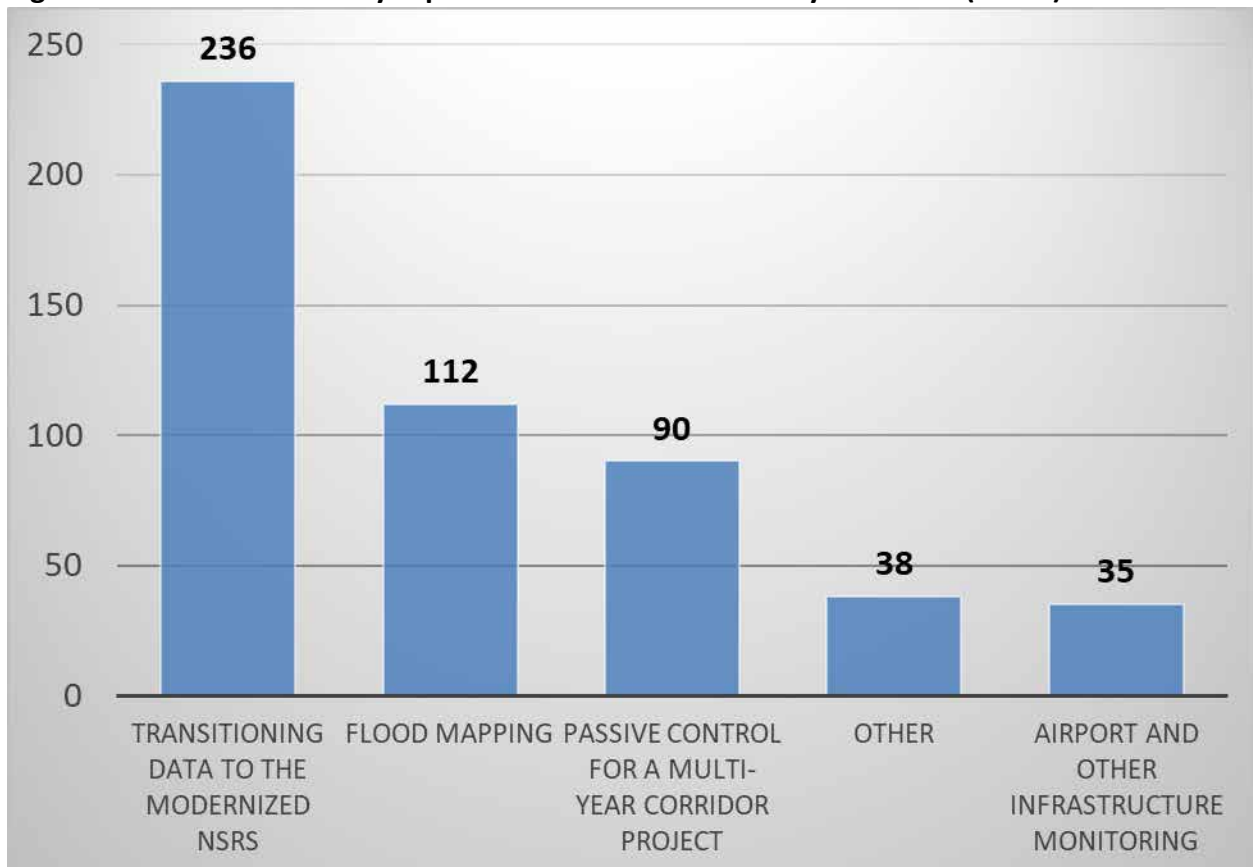


Figure B6: For those familiar with OPUS, how useful would you find a tool that auto selects the best CORS to use as geodetic control? (n=491)



Figures B7: Which case study topics will be most relevant to your work? (n=511)



Appendix C: Attendee Event Evaluation Feedback

Attendees were offered an evaluation survey after each day. The response rate per survey question was about 26% on Day 1 and about 20% on Day 2. The same questions were asked each day, and the responses to the same question are shown together in each of the figures that follow.

Generally, there was “about the right amount” of technical information provided; most attendees were “extremely satisfied” or “satisfied” with the event, and most were “extremely likely” or “likely” to recommend a friend watch the recorded event. Overall, NGS views these evaluations as confirmation it was a successful event from the audience perspective.

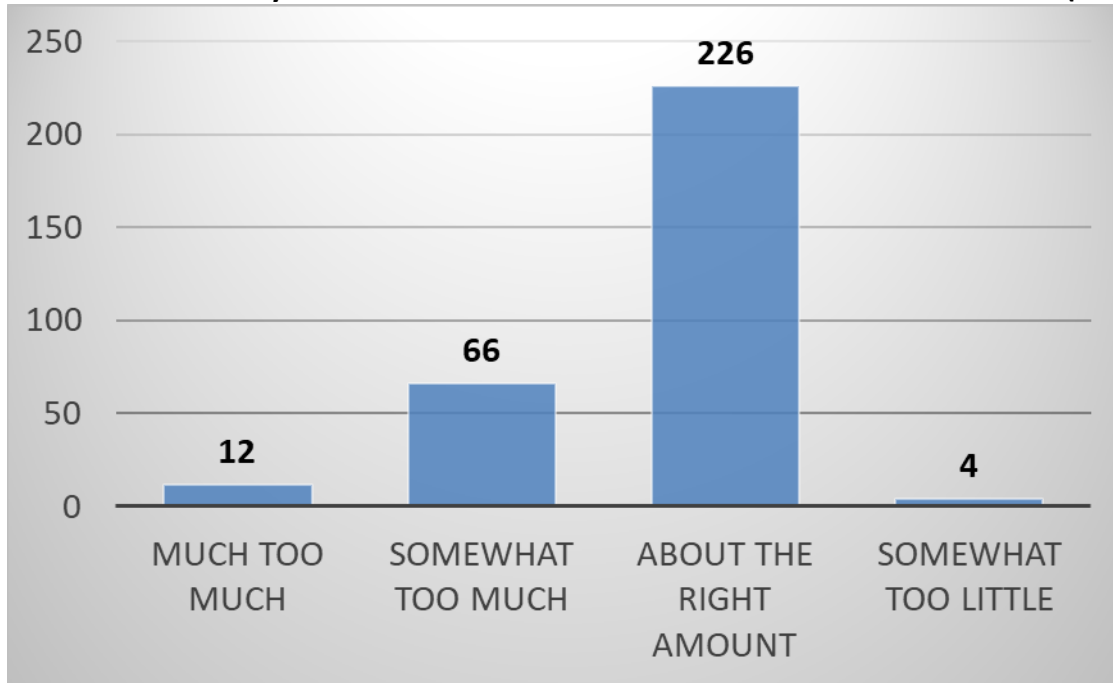
Additionally, while NGS will replace the North American Vertical Datum of 1988 (NAVD88) with the North American-Pacific Geopotential Datum of 2022 (NAPGD2022), there are two other major vertical datum updates coming soon. In the next few years, NGS, NOAA’s Center for Operational Oceanographic Products and Services (CO-OPS), and partner agencies in Canada, are also updating:

- the International Great Lakes Datum (IGLD) used to reference water levels in the Great Lakes and connecting channels; and
- the National Tidal Datum Epoch (NTDE) used to reference water levels along the U.S. Ocean Coastline.

To learn more about who might be interested in these other vertical datum modernization efforts, the final survey question discovered that more than 50% of attendees were “extremely likely” or “likely” to attend an event focused on tidal or Great Lakes datum updates.

Figure C1:

DAY 1 - How would you describe the amount of technical information covered? (n=308)



DAY 2 - How would you describe the amount of technical information covered? (n=241)

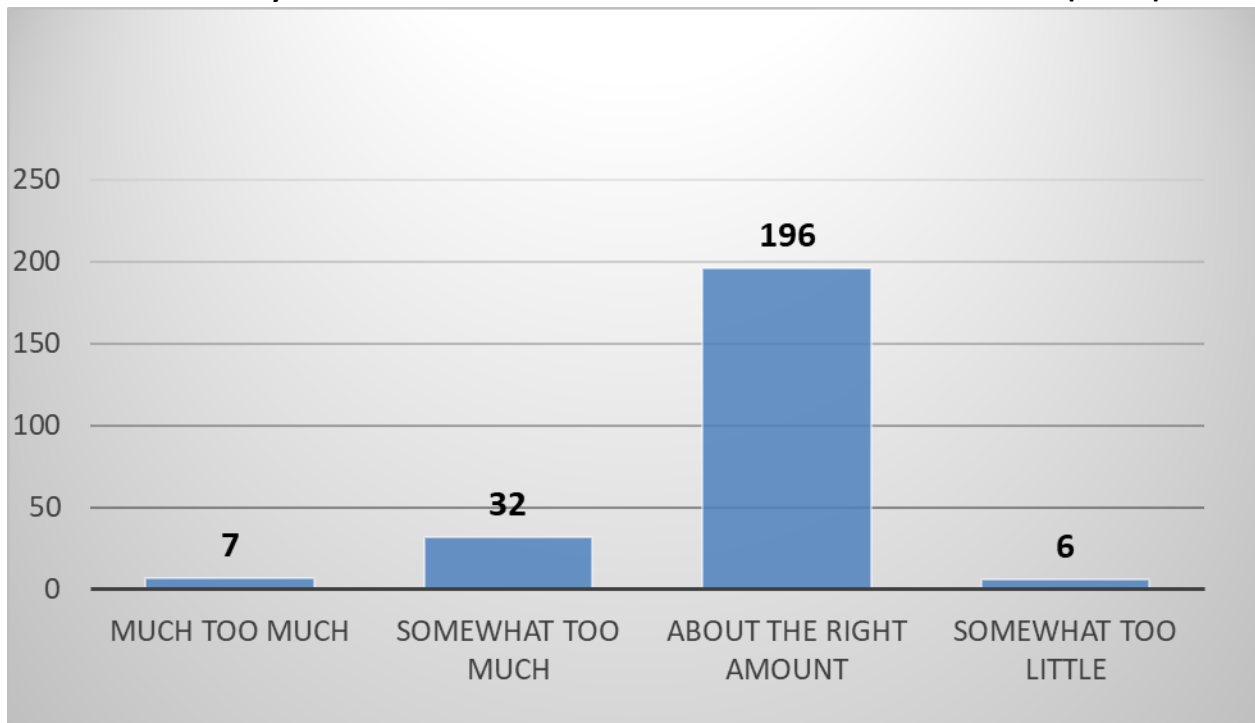
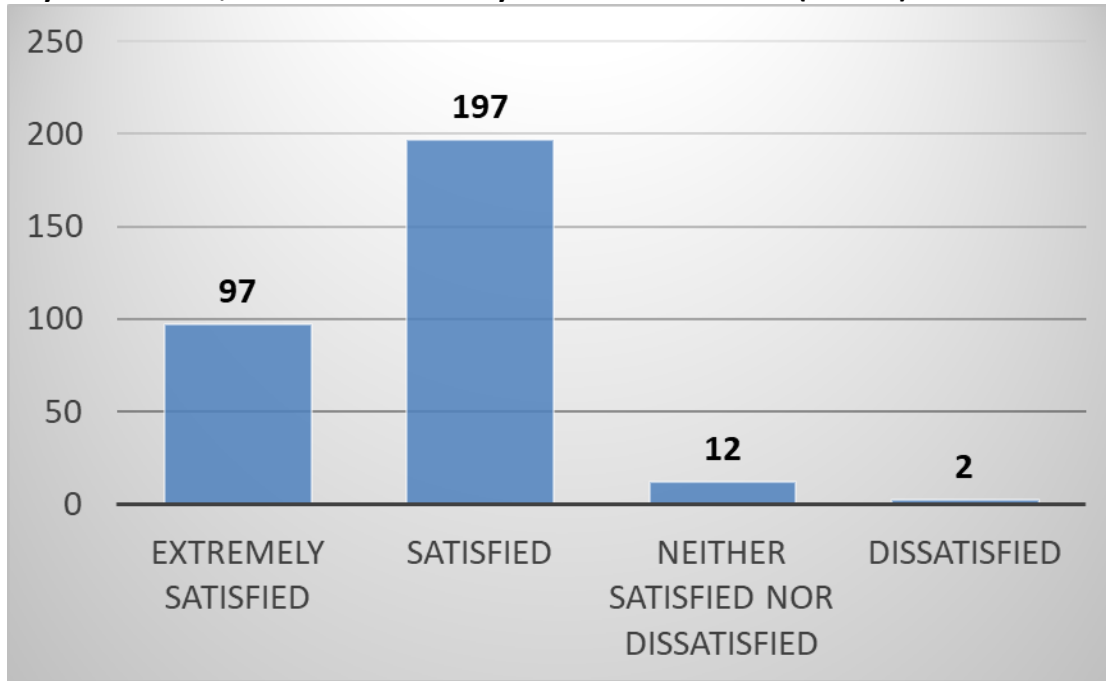


Figure C2:

Day 1 — Overall, how satisfied were you with the Summit? (n = 308)



Day 2 — Overall, how satisfied were you with the Summit? (n = 242)

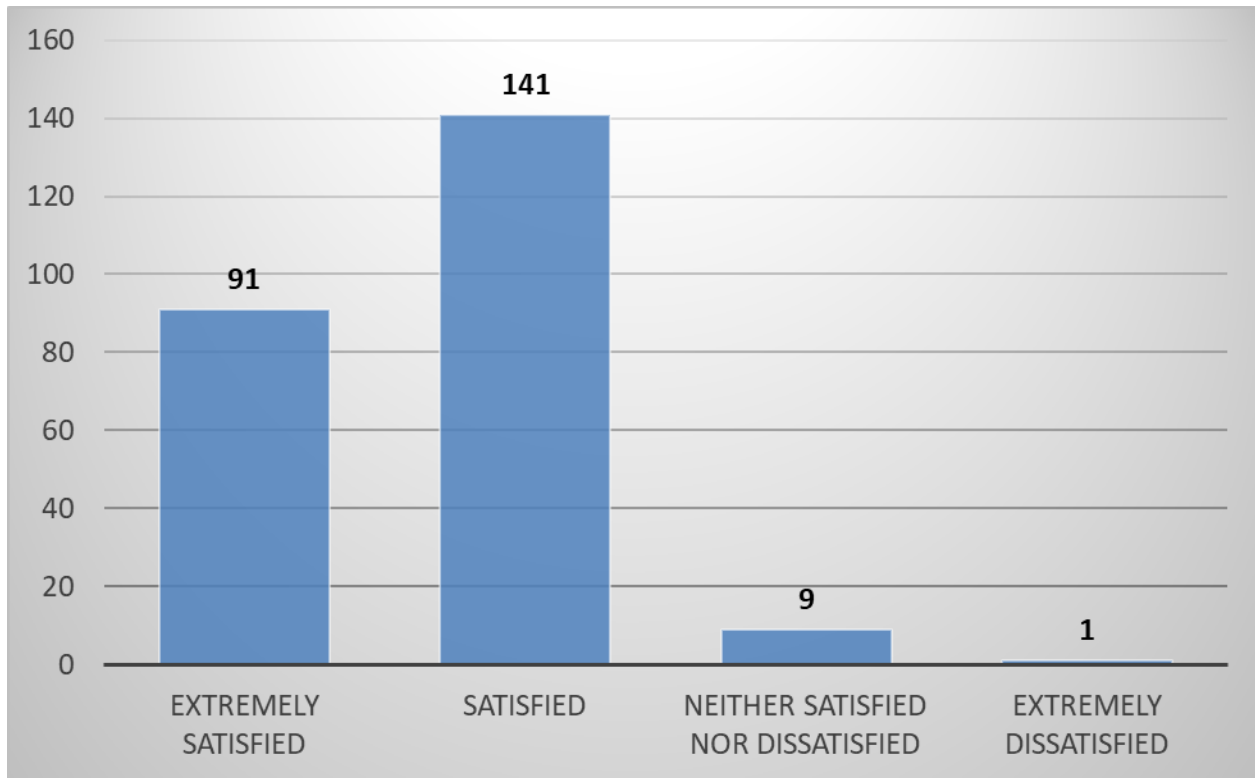
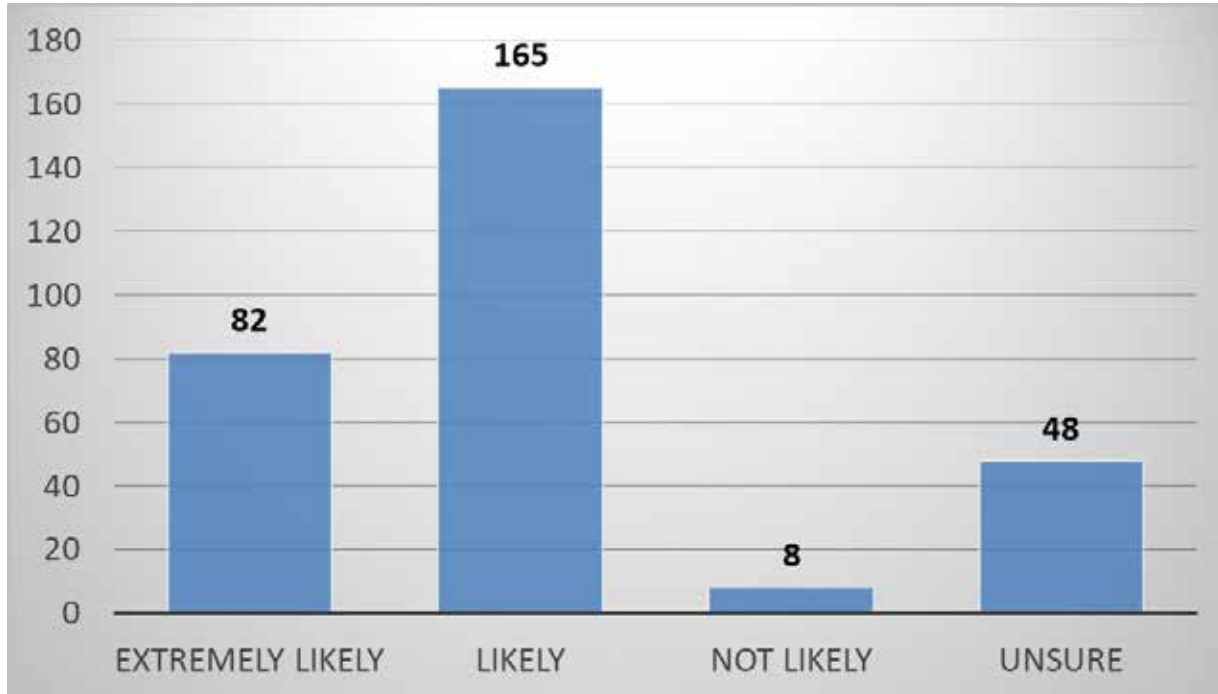


Figure C3:

Day 1 - How likely are you to encourage a friend to watch this event's video recording?
(n=303)



Day 2 - How likely are you to encourage a friend to watch this event's video recording?
(n=239)

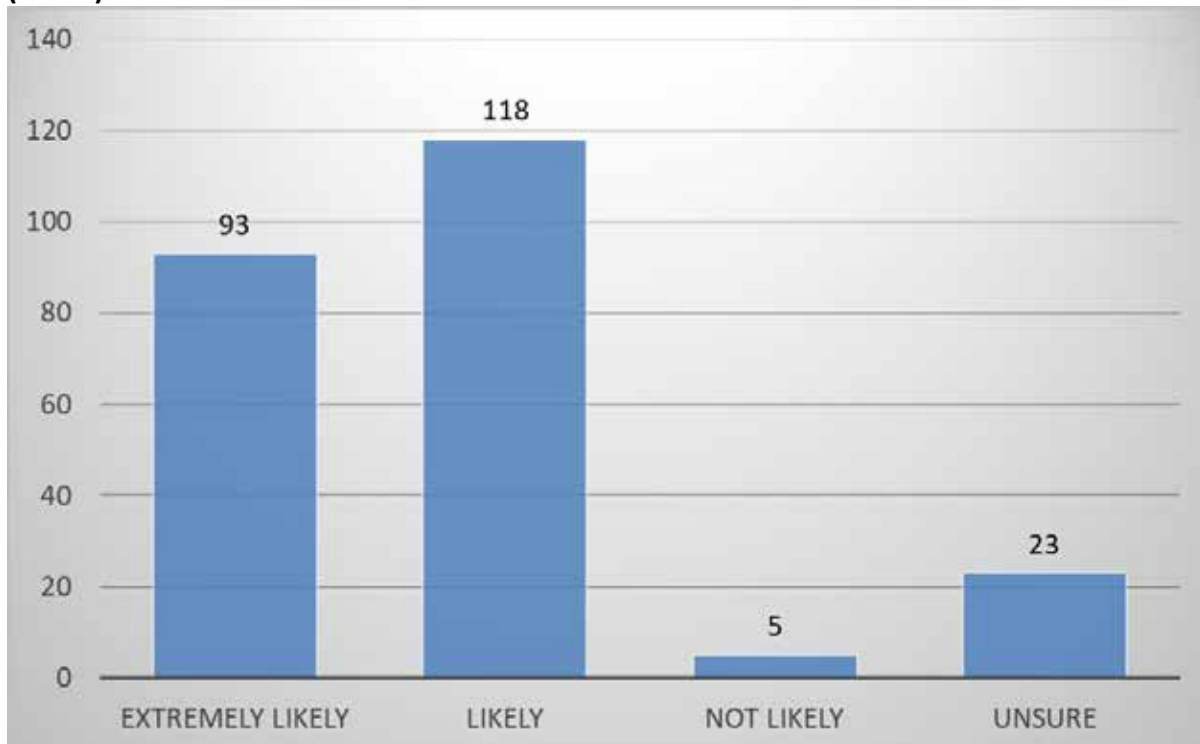
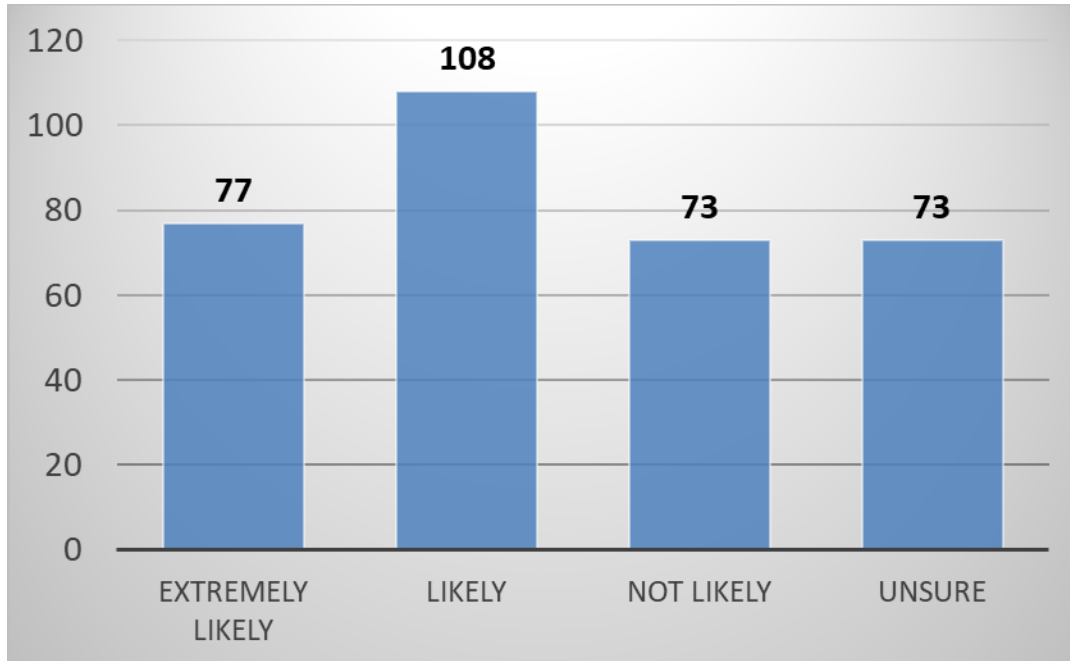
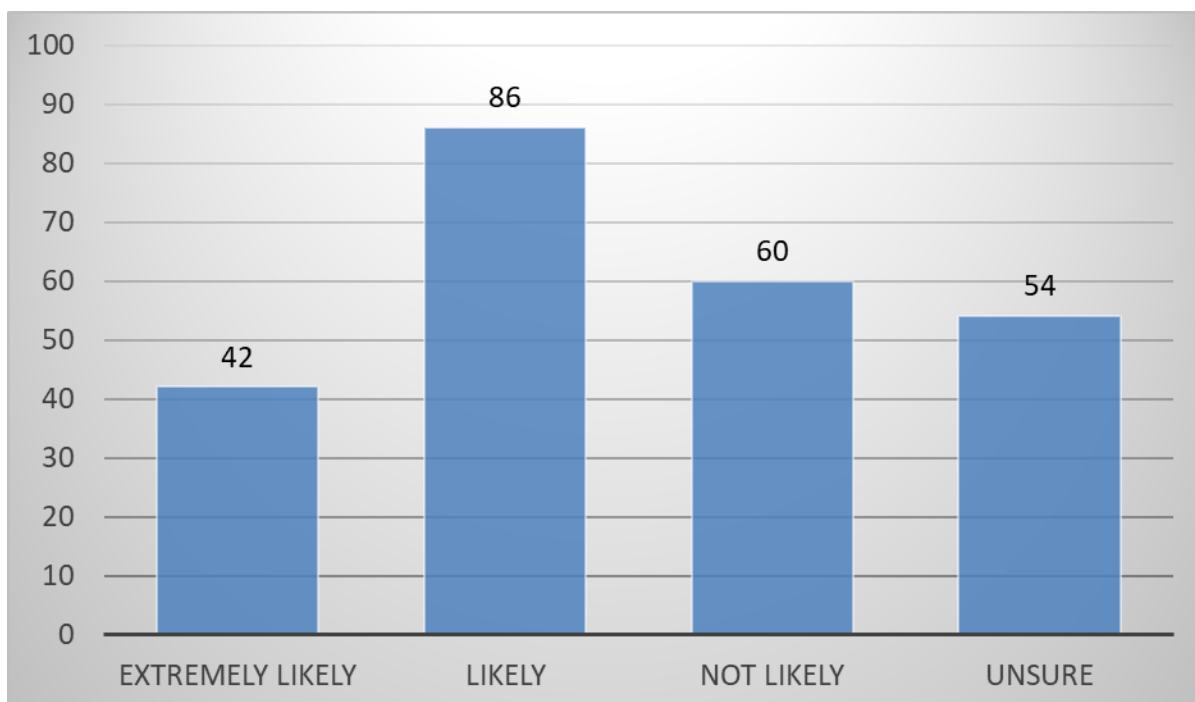


Figure C4:

Day 1 - How likely are you to attend an event focused on tidal or Great Lakes datum, updates? (n=331)



Day 2 - How likely are you to attend an event focused on tidal or Great Lakes datum, updates? (n=242)



Appendix D: 2021 Geospatial Summit Questions and Responses Document

Day 1: May 4, 2021

Topic: National Spatial Reference System (NSRS) Modernization Overview

Dru Smith, Ph.D.

Q: I'm interested in how a NSRS is defined policy-wise; will it be encouraged / required in national data products like charts? Are NAD83 / NADV88 currently required like that?

A: Yes, the Office of Management and Budget (OMB) Circular A-16, does state the requirement for Federal civilian agencies to utilize the NSRS for all geospatial activities. This is true for NAD83/NAVD88, and would include nautical charts by NOAA or USACE. *[Also answered verbally during the webinar]*

Q: Will the new OPUS have a category for PLSS and property control corners?

A: That would be a great category to have in the future NSRS Database (DB) as it exists currently in the IDB (Integrated DataBase) and OPUS Shared database. There is a “Special Application” that can be selected, with options like Tidal BM, etc., and which includes “P - PLSS Corner.” *[Also answered verbally during the webinar]*

Q: Why not choose one terrestrial reference frame with time dependent coordinates?

A: The vast majority of NSRS users prefer to have coordinates that are stable over time versus ITRF-type coordinates. As the major tectonic plates all move quite differently from one another, the different terrestrial frames (NATRF, PATRF, etc) will remove the vast majority of the motion for that corresponding plate. *[Also answered verbally during the webinar]*

Q: Great Webinar, NGS is to be applauded. When will the preliminary EGM be released, not the final? Also systems like IGSN 71 are really non-existent today. Are we moving to a global absolute gravity network anytime soon?

A: We typically update the GGM every year with new GRAV-D data, but don't publically release the coefficients. If you would like them, let us know (ngs.geoid.team@noaa.gov). On the gravity network, it does look like an update will occur. There is an IAG Joint Working Group (JWG 2.1.1 — International Gravity Reference System/Frame) along with a recent publication in Journal of Geodesy (<https://doi.org/10.1007/s00190-020-01438-9>).

Q: I've heard that there will be updates to the International Great Lakes Datum and National Tidal Datum Epoch with a similar timeline. Can you talk about what role — if any — NGS has in these other datum updates?

A: NGS will be partnering with CO-OPS for a webinar in July during which we'll give an overview

of various vertical datums and their planned modernization / updates. Make sure you're signed up for NGS [monthly webinar notices](#).

Q: Is Dru talking about OPUS or "OPUS Projects"?

A: This is a good question, and will be clarified by tomorrow's OPUS Improvements Part 1, at 3pm, but the short and skinny is that OPUS Projects as it expands and integrates with other products like OPUS-S and the Mark reporting and recovery tool will become just "OPUS."

Q: GVX sounds good — will there be an AGX for absolute data?

A: NGS doesn't have a recommendation on this yet. There are some options including adopting the IAG's JWG2.1.2 that is supposed to come up with a format for all gravity meters. We currently rely only on Micro-g's "project.txt" file format (for FG5 and A10) with metadata.

Q: Will OPUS 6 allow the use of and processing of absolute gravity observations and network adjustments?

A: We have not finalized OPUS 6.0 but it is our intent to include some ability to upload/process/adjust only *relative* gravity observations. However, we will allow pre-processed absolute gravity values to be entered as *constraints* on a gravity survey.

Q: What is the projected date this will be ready to use?

A: Please see our Delayed Release of the Modernized NSRS page here and check for updates in the future: <https://geodesy.noaa.gov/datums/newdatums/delayed-release.shtml>

Q: Will VDatum be updated on the same time frame?

A: As we move towards Modernization, NCAT and VDatum will become closer and more aligned. *[Also answered verbally during the webinar]*

Q: So if you make an observation in 2022, correction would be needed to go back to 2020 reference of NSRS 2022?

A: Not necessarily. It depends on what you desire. OPUS will be built so you can adjust your data to any reasonable epoch of your choice. *[Also answered verbally during the webinar]*

Q: Will interframe velocity model be included in the Alpha version? If not, when can a version be expected?

A: NGS will probably have 2 or 3 different "alpha" versions of IFVM2022. Our first is a modified version of HTDP, with the new Ridgecrest earthquake added. We are working on that now. Eventually though, we expect to transition to using TRANS4D, and then, in the next few years, NGS will have re-built the personnel and expertise to create our own models. As each "alpha" version is loaded however, we will be testing it internally first, and then releasing it through the BETA website. This may be another year away still.

Q: Will you be working with the individual RTN operators to improve any issues with stations before issuing grades on the NCN stations?

A: Yes, we intend to stand up an RTN Monitoring Service, based on future versions of OPUS.

Q: So OPUS will no longer accept vendor-specific Static files, and they will need to be converted first to Rinex?

A: The current plan for future versions of OPUS (possibly starting with OPUS 6) would require the user to upload static GPS/GNSS data via a RINEX file. This is due to the deprecation of TEQC within OPUS (TEQC final release was on 02-25-2019 and has met its end-of-life).

Q: Will historic conventional observations be available in the new database for downloading to adjust older existing networks

A: Maybe. Post-1994 classical observations will be used to create the first set of RECs. The data will definitely not “get lost,” but we can’t say for sure right now when that data will be included in the future NSRS DB.

Q: What kind of process would you anticipate would be needed when working with large amounts of data such as LiDAR?

A: For conversion/transformation of large datasets such as lidar, you would probably want to look at downloading NCAT (NGS Coordinate Conversion and Transformation Tool) from our website and integrating it into your workflow. Use the “Download” tab here:

<https://geodesy.noaa.gov/NCAT/> .

Q: What are the transition plans for these new systems? For instance, how long will we be able to use the old OPUS system after the new system comes on line?

A: We haven’t yet decided, but guesses/plans are somewhere around one year or less. *[Also answered verbally during the webinar]*

Q: What factors will be included in the CORS grading criteria?

A: While the Station Selection Criteria are still somewhat To Be Determined, the overall concept is to integrate geographic (e.g. station geometry), quantitative (e.g. temporal stability), and qualitative criteria (e.g. data availability, longevity, etc.) into OPUS.

Q: Regarding geoid models, will Geoid 18 continue to be used for the foreseeable future? Are there plans to implement a new geoid model anytime in the near future?

A: Yes, GEOID18 is the last hybrid geoid model that NGS plans to create. It will remain the official model for getting GPS-derived NAVD88 heights until the Modernized NSRS is released, and NAVD 88 is replaced by NAPGD2022 and the purely gravimetric GEOID2022 model. *[Also answered verbally during the webinar]*

Q: Will we be able to use an NGS application through your website to convert older data without having to buy vendor supplied software?

A: Yes! Our NGS Coordinate Conversion and Transformation Tool (NCAT) is the official source of transformations amongst the different NSRS datums, both horizontal and vertical. *[Also answered verbally during the webinar]*

Q: I am a user in California. Will there be any significant updates to the IFVM in California for

deformation/velocity issues in and around the San Andreas Fault or other faults? Currently HTDP has 4 grids to help with this issue (I believe). Thanks

A: Yes, there will be a significant update to the HTDP velocity grids for the entire NSRS, not just California (and it may include vertical velocities). However, we're not sure when those updates will be implemented and provided in a production version of HTDP, but that likely will occur long before the rollout of the Modernized NSRS (perhaps in 2022).

Q: Was there a mention of the development of a separation model to connect to Hydrographic Chart Datums for marine navigation purposes?

A: We are not sure what the questioner meant by a separation model. If you can please clarify, email ngs.infocenter@noaa.gov.

Q: NAVD88 heights are Helmert Orthometric heights. How compatible will they be with the new height system? Helmert orthometric heights are one of many types of approximation of an orthometric height. NAPGD2022 orthometric heights will be approximated by ellipsoid heights minus geoid undulations. True orthometric heights cannot be measured, so the two approximations are as compatible as their underlying assumptions. [Also answered verbally during the webinar]

Q: This may be too detailed — will isostatic rebound, such as we think we see in the New Madrid Seismic zone — be incorporated into the new models? You mentioned overall plate motion, but there is some interplate motion as well.

A: All 3-D motions (lat, lon, ellipsoid height) will be modeled in the IFVM2022.

Q: Is there any estimate for the amount of lag time from when the NSRS Modernization and associated products will be released and when its use will be required? months? years? Instant?

A: Unless legislation changes this procedure, NGS expects to follow the same procedure as with the release of NAD 83 or NAVD 88 — specifically, the final step is to get the approval of the Federal Geodetic Control Subcommittee (FGCS). When that happens, a Federal Register Notice will be issued stating something similar to the past, such as "...to the extent practicable, legally allowable, and feasible, require that all Federal agencies....undertake an orderly transition to..." the new NSRS. Such a procedure will likely be in the 6–12 month time frame after the release of the modernized NSRS. As for state and local agencies, they are never mandated by the federal government to use the NSRS. [Also answered verbally during the webinar]

Q: With regard to the DEM2022. Is that something that will be available as a seamless nationwide product? Is it the same as other typical elevation DEM datasets?

A: It will not only be a seamless nationwide product — but a seamless product over all of North America (including Canada, Mexico, etc.). The current alpha version is a mixture of a number of different, typical DEM datasets (SRTM, TanDEM-X, etc.). The resolution is 3 arcseconds so it is a very large product to distribute. [Also answered verbally during the webinar]

Q: What about a state that will probably not follow these recommendations for the new

datum? The county I currently live in and work in has 24 different municipalities and there does not seem to be any way they will all commit to using this new datum. For example, the City of Phoenix currently uses NAVD29 for all of their TBMS.

A: Since there is no requirement for states to utilize the NSRS, there isn't really anything NGS can do other than to assist you in explaining to those City personnel the benefits of upgrading to current/modern datums. *[Also answered verbally during the webinar]*

Q: Will OPUS 6 allow the user to disable certain satellites?

A: We currently plan to have the ability for the user to disable/enable different constellations, but decisions on individual satellites have not yet been made.

Q: How will the NSRS Modernization apply to hydrographic surveys per Rear Admiral?

A: All hydrographic surveys performed by Federal agencies, like NOAA or USACE, are required to be tied to the NSRS, so future surveys will need to be tied to ITRF2020 or NATRF, CATRF, PATRF, or MATRF geometrically. We include ITRF2020 explicitly so that federal users with a more global focus (or at least with a focus on more than one tectonic plate) may work in it and still be considered as working in the NSRS.

Q: You indicated that new adjustments would be done every 4 weeks for new geometric and yearly for new orthometric. When you say orthometric, are you referring to leveling projects?

A: Yes, we will stand up three basic types of adjustments: geometric, orthometric, gravimetric. Orthometric adjustments will use differential leveling as their observable. *[Also answered verbally during the webinar]*

Q: I have attended several of your webinars and still trying to wrap my head around time-dependent datums on GIS layers (particularly the vertical). Who is the best person at NGS to talk to about GIS applications?

A: To be cautious with our terminology, the frames themselves are not time-dependent. The frames have a very specific definition and that definition does NOT change with time. The only thing that is time-dependent are the coordinates *within* each frame. Remember that the goal of both the EPP2022 and IFVM2022 is to provide tools that aid the user community in attaining the illusion of stability of coordinates, but yes for GIS users who need to maintain high-accuracy datasets there will be new challenges. Please reach out to us via ngs.infocenter@noaa.gov and our staff will connect you with a good POC.

Q: I understand there is a new space based radar that will help measuring isostatic rebound, will that play into uplift velocities?

A: In developing the IFVM, we have been investigating/researching all possible types of data collection that may be able to contribute to the model.

Q: What specific changes will be incorporated into the datasheets regarding the new vertical component of the NSRS to alert a user about the updates.

A: Our current datasheets will be completely overhauled and replaced by a new concept: the

Data Delivery System (DDS), which will provide users access to far more information than a current datasheet.

Q: What is the resolution of the DEM

A: 3 arc seconds

Q: Where do my 66-ft. Gunter's Chain and my Davis and Co. compass fit in with all of this, lol?

A: They will fit in the storage shed! All jokes aside, with the move more and more towards digital data collection and storage, the days of submitting chain-and-compass data to NGS are long gone, but of course you can still use them for any work that will not be submitted to us! Though watch for developments in OPUS 6 . . . it can process any classical survey, not just those from a total station. If you can get those old chain measurements into CVX format, OPUS 6 just might work!

Q: Will states be able to contribute updates to their portion of the DEM through their own programs?

A: Currently there are no plans to have states contribute data to the DEM. The primary application of DEM2022 is for computing the geoid model, and it is not intended for surveying applications. Adding high resolution and high accuracy data such as lidar is overkill for its intended purpose and will provide little benefit. It should be noted that the DEM will mainly be a satellite-based model, with 3DEP used to fill in voids and other problem areas in the satellite models. Right now the accuracy and resolution of satellite models is good enough, but there is use for lidar and other high accuracy datasets in validating the DEM.

Q: Please remind us how GPS-on-Benchmarks observations contribute to the modernization

A: GPS on Benchmarks will be used as input data in creating an update to VERTCON which will convert NAVD 88 heights to NAPGD2022 heights. Additionally, the data will also be used in the computation of RECs and SECs.

Q: ITRF is not fixed to any plate. Why fix to plates?

A: The majority of the USA (and Territories) user community prefer a system that provides for coordinates that are more stable than ITRF, so the four new NSRS TRFs will be based on the ITRF but will provide that stability by way of the Euler Pole Parameters (EPP) and Intra-Frame Velocity Model (IFVM).

Comment from NGS Chief Geodesist Dr. Dan Roman: NAPGD2022 dynamic heights <=> IGLD2020 dynamic heights - yes, the name stays the same.

Q: Will there be a separation model developed and available to connect water depths from Hydrographic Charts to a Continuous vertical Datum integrating the variety of Chart Datums based of Lowest Astronomical Tides to the new Vertical Datum?

A: This sort of product would be something that would more likely fall under the purview of the NOAA Center for Operational Oceanographic Products and Services (CO-OPS), and possibly provided by way of VDatum.

Q: Regarding the NOAA CORS network, are there any plans to offer a national public RTK or PPP service? Not at this time. Considering the number of private RTNs, a federal system at this point would be seen as competing with private industry, which is not allowed. As for a PPP system, NGS has no current plans to offer such a service, but may do so in the future. [*Also answered verbally during the webinar*]

Q: My earlier question about Helmert heights was an indirect way of asking about how the new height system will account for more rigorous treatment of topographic mass density than Helmert's method. In areas like the Canadian Rockies the differences are ~13cm.

A: In the update to Blueprint Part 2 (https://geodesy.noaa.gov/library/pdfs/NOAA_TR_NOS_NGS_0064.pdf), we have identified the heights to be orthometric heights — where gravity along the plumbline is calculated by a method from Flury and Rummel (2009) — that takes into account the terrain correction (versus a Bouguer slab). This doesn't take into account the density differences but does give differences of ~10 cm in mountainous regions from the Helmert orthometric height.

Q: In areas of high relative subsidence, please describe efforts to capture these changes in the new NSRS Modernization.

A: The IFVM2022 model is a model of mark motion. Its sources will eventually include repeat surveys on passive control (generally rare), CORS velocities (coarse), geodynamic models (coarse) and synthetic aperture radar (fine, but difficult and expensive to work with). Except for the repeat surveys, these data sets will tend to model surface motion, rather than mark motion directly, and so surface motion will have to stand as a proxy for mark motion.

Q: Will you be making any changes or adjustments after a major episodic event such as an earthquake?

A: There are plans to update NCN CORS coordinates for seismic events on a more timely basis than currently, and to better reflect any episodic events (like an antenna change/adjustment) by way of their coordinate functions.

Q: Any chance NGS will move to cloud computing services, like NOAA Big Data, and allow for higher data volume for processing?

A: These types of options are being explored by our experts in working with large datasets.

Q: Previously you talked about working with states to update their legislation to use NSRS without specifics; does this mean that future changes to NSRS might automatically change the "downstream" state planes that have them as a dependency, or would the inheritors need to manually update their products?

A: The overarching idea of updating state legislation is that we recommend using a more simplified language. Specifying "NATRF2022 is the official geometric datum of the State" is not what we would recommend, as then the cycle of needing to change legislation starts again in a few decades when NATRF2022 is phased out. We have been recommending to use language that stating that "the current NSRS published by NGS" (or something of that nature). See the

NSPS (National Society of Professional Surveyors) website for a template legislation language that was drafted by an NSPS-NGS-AAGS working group.

Q: Will we be able to do away with a level and a rod one day. Will elevations be survey grade from CORS in the future?

A: That depends on how much accuracy you need. Leveling continues to be the most accurate method of determining relative heights (mm level at many km). That will not change. However, using a GNSS receiver with an accurate geoid model in the modernized NSRS, one can get very accurate elevation differences, 1–3 cm accuracy at any distance. Over longer distances (50+ km), the GNSS/geoid model method can outperform leveling. The GSVS talk later today will highlight this in great detail.

Q: Status for computing Dynamic Heights in OPUS?

A: OPUS 6 will have a tool for computing dynamic heights from GNSS data, using GEOID2022 and GRAV2022.

Q: How can local surveyors help with updating data (geospatial data or meta data) for NGS monuments?

A: Use our new Survey Mark Recovery tool here: <https://www.ngs.noaa.gov/surveys/mark-recovery/index.shtml>. It's great, you can upload photos, add description information and other condition details straight from your mobile device. The Mark Recovery tool website works on Android, iOS, Windows, so you can use it on your phone, laptop, or even most of your data collectors! (anything with an internet connection)

Q: What is the expected agreement between GEOID2022 model and EGM2008?

A: They are similar at ~10–20 cm. But, they are quite different simply due to the fact that EGM2008 only goes to 5' (~9 km) versus GEOID2022 that goes to 1' (~2 km). This increased resolution is really impactful to users of the NSRS. Additionally, GEOID2022 will include all the new GRAV-D airborne data, new altimetry gravity data over the oceans, new DEM models, and new geoid methodology. All in all, GEOID2022 will be a major upgrade from EGM2008.

Q: The current window for GPS-on-Benchmarks closes this year. Many of the marks are very difficult to observe with GPS-only. Multi-constellation could make a lot of difference, and perhaps enable shorter observation times. Is there any chance that there is some OPUS Beta that could process multi-constellation? It's a very real struggle out there with the current limitation. And/or that when a newer multi-constellation OPUS does become available, the submitted multi-constellation observations could be re-processed?

A: Multi-GNSS processing is currently under development at NGS and will be integrated into appropriate versions of OPUS for later release to the public.

Topic: Gravity for the Redefinition of the American Vertical Datum (GRAV-D)
Jeffery Johnson

Q: How can the gravity coverage be accurate to 2cm while the DEM gridded data available is at ~90 m resolution?

A: These are different things entirely. The geoid accuracy is a vertical accuracy of +/- 2 cm (i.e. how far away vertically is the point of interest from the geoid), while the resolution of the DEM is that it will have values every 3 arcseconds (90 meters).

Q: Should it be American Datum or North American Datum on Slide 1?

A: GRAV-D's acronym has "American VERTICAL Datum", in it, meaning "North American", by default (putting in the "N" in there would have ruined the acronym).

Q: Is the gravity data corrected to the geoid datum and terrain corrected??

A: The current geoid methodology relies on Molodensky's method which does not require the gravity data to be on the geoid. Everything is done on the Earth's surface. This requires the use of a global geopotential model (or reference model) to remove the majority of the signal and then the residual terrain effect is also removed from the gravity data. These components that were removed are then added back as geoid components.

Q: With target of 2 cm accuracy for ortho heights, is there a consistent resolution of the resultant Geoid model grid or is the resolution terrain or gravity anomaly dependent?

A: The geoid resolution at 1 arcminute is adequate for the 2 cm accurate orthometric height. However, errors come into the geoid model due to lack of gravity data coverage (omission) and incorrect gravity data (commission). Additional errors come into the geoid due to DEM errors, incorrect density assumptions, etc. GRAV-D has greatly increased the gravity data coverage previously mentioned, but there are still error sources. Mountainous regions are definitely more difficult for gravity collection and geoid modeling.

Q: South Louisiana...can we expect a Geoid Model soon that will best reflect orthometric heights with minimum errors? FYI...Geoid18 vs Geoid12b in Lafayette/St. Martin/Vermilion Parishes result in differences between 0.35 to 0.50 feet.

A: NGS has no plans to update the hybrid geoid beyond GEOID18. However, you can expect a geoid model that does best reflect orthometric heights when GEOID2022 is released with NAPGD2022. NGS considers GEOID18 to be a significant improvement over GEOID12B for a number of reasons, including the incorporation of GRAV-D data in several parts of the country, including the Gulf Coast.

Q: Will these "new" versions of processing and filtering be applied to the data collected early on?

A: Yes — we plan to go back and perform a consistent reprocessing of ALL GRAV-D blocks prior to the final version.

Q: The gravity data is collecting on ITRF 2014 at epoch 2010?

A: The positioning of the aircraft is in this reference frame. The airborne gravity data is tied to an A10 absolute gravity station at each airport.

Q: So the early data is over 12 years old. By What timeframe will it be outdated? Does gravity change in some locations by amounts that are significant and which would require recollection of gravity data??

A: Gravity definitely changes spatially and temporally (in space-time). At the GRAV-D aircraft altitude(s) and observational precisions, it will be multiple decades before the change in gravity would be detectable even in places in North America where gravity is changing the most (e.g. Alaska). It will be even longer in most of North America. However, if some substantial episodic event (volcanic eruption, certain types of earthquakes) occurs that moves enough mass into or out of a region) occurs, it may be necessary to re-fly that particular region immediately after that event.

Q: How much, if any, will mountains have when this project (GRAV-D) is finished? Do they affect how gravity would be computed?

A: Very much so — for airborne gravity, the aircraft flies over the mountain and the excess mass of the mountain that is closer to the aircraft ‘pulls’ on the sensor, which interprets that as an increase in gravity. This is a bit different than terrestrial gravity surveys which occur on the mountain and see gravity get lower as the elevation increases.

Q: Sorry, this is coming from a novice in regards to gravity...I noticed the GRAV-D measurements include quite a bit of area over the oceans. Are the measurements affected by water or do the measurements go to the sea floor?

A: The gravimeter in the aircraft senses all the mass around and beneath it all the way to the core of the earth, but as the gravimeter gets further away from any specific mass, it has less and less of an impact. So, the gravimeter and the gravity it observes are definitely impacted by the depth of the water, the existence or lack of terrain above the water (like an island), and also the seafloor bathymetry. The gravity is very much correlated with seafloor bathymetry even down to 5000 meters. However, the gravity measurement itself is observed at the aircraft altitude (thousands of meters above the water). Since the water is uniformly dense, its effects can be removed by Bouguer reduction and increase the resolution of the gravity signal from the seafloor bathymetry and the earth’s mass beneath it.

Experimental Geoid Models (xGEOID)

Yan Wang, Ph.D.

Q: I do not understand Lon 170E to Lon 350 E.

A: Longitude can be expressed from 0 degrees (Greenwich) eastward around the globe to 360 degrees. This is the standard in scientific publications. Longitude 170E to 350E means the span of the globe from +170 to -10 (or 170E to 10W).

Q: I've seen papers indicating that Helmert Orthometric values do not match well with true gravity data at locations with denser rock such as mountains. Does the method used with GRAV-D remedy this?

A: NGS continues to assume a constant rock density of 2.67 g/cm^3 in our geoid modeling. We have investigated using a density model but that has been challenging due to a number of factors. You are correct that Helmert heights, which rely on a Bouguer slab ($w/ 2.67$) assumption, are not the most accurate in mountainous regions. In the updated NGS Blueprint Part 2, we have specified a remedy to this by using a different method to compute the gravity along the plumbline (after Flury and Rummel (2009)). This takes into account the residual terrain but is still based on 2.67 g/cm^3 .

Q: The GSVS17 is already published?

A: The GSVS17 study was published in a recent issue of the *Journal of Geodesy*.

Q: Will your article in the Journal of Geodesy be "Open Access" ?

A: We are working on getting this remedied with the publisher or coming up with a suitable option so the public can access the paper.

Q: Dr Yan Wang: I note that in addition to NGS there are other entities providing values for the ellipsoid-geoid separation. All the other tools (NGA, UNAVCO and NRC) refer to their computations being based on versions of the EGM. All differ from one another and from xGeoid from 1 (NRC) to 47 cm (NGA)! Why do these gravimetric geoid values differ? Their site documentation is incomplete.

A: Geoid models are often very different from one another. This is caused by different methods, processing software, interpolation schemes, input datasets (gravity, DEM, etc.), spatial resolution, and fundamental parameters (W0, tidal system, etc.). The large differences are caused by the fundamental parameters. For instance, NGS and NRC use the same fundamental parameters, so the geoid differences are small. NGS and NGA use different fundamental parameters, so the geoid heights differ much more. Using the same fundamental parameters, the international geodetic community can produce geoid models that agree at $\sim 2 \text{ cm}$ RMS even in a mountainous region (max. differences might be 10–20 cm though). If you are interested in understanding why a particular model is different, you will likely need to look at the reference for the model(s).

Topic: Geoid Slope Validation Surveys (GSVS) — Ground Truth Tests of the Models
Derek van Westrum, Ph.D.

Q: Dr van Westrum: Had NGS considered shortening maximum sight lengths during differential leveling as a way to minimize refraction effects?

A: We are currently reviewing both field techniques and processing techniques to minimize refraction errors. Unfortunately, COVID is currently hampering our ability to experiment in the

field, but this is definitely an area of active research.

Q: Isn't 10 W close to Europe? Is this part of the Pacific Plate?

A: Yes, 10W is close to Europe, when at the latitude of Europe or CONUS. It also is a necessary east edge to GEOID2022 to encompass all of Canada and Greenland.

Q: Dr van Westrum: I note that datasheets for points observed in the GSVS17 survey do not include NAVD88 heights nor modeled gravity. Is it due to the "non-standard" treatment of refraction corrections: solving for this effect via adjustment v correcting observations using

A: The relative height uncertainties between marks exceed First order/Class 2 specs, but we were unable to tie into existing marks at this level. So that's why there are no NAVD88 heights listed (remember, for our experiment, we're only interested in the slopes anyway). We did however, use observed (not NAVD88-modeled) gravity to get geopotential values.

Q: Are human-mediated changes in local gravity (say, subsidence under Las Vegas due to ground water pumping, or removal of CU from the Kennecott Copper Mine in UT) significant enough to require accounting?

A: They might be. While monitoring every small gravity change in the US is outside our ability, if the gravity change is large enough over a large enough region — we would like to account for it. Our general rule of thumb is that if the geoid is permanently impacted by 1 cm, then we would like to account for it.

Q: Since MSL is rising at ~ 3 mm/year and the geoid is supposed to be the geopotential surface that best fits MSL, will the geopotential surface chosen for the geoid be updated in time?

A: Great question. There are two schools of thought on this topic, even within NGS. The final answer is found in Blueprint Part 2, but it comes down to defining the geoid as best fit to MSL *for a while* until such time as its rise exceeds a threshold, and then we will define a new geoid. The time dependencies in GEOID2022 are just *shape* changes, not *size* changes (like the difference between squeezing a balloon and inflating a balloon).

Q: Can you explain the difference between a geopotential value and an orthometric elevation that is referenced to an equipotential surface (geoid)?

A: A geopotential value (W) is a measure of the potential of a location that is associated with a particular level surface. Units are in m^2/s^2 . The potential difference (dW) is what is obtained when you level between two locations and take into account the surface gravity. NAVD 88 is based on geopotential value differences. The orthometric elevation (H) as obtained by $(h-N)$ relies on a geoid model (N) that is defined by a particular W_0 , which defines the zero level of the geoid model out of an infinite number of choices.

Q: When you say "put a GNSS antenna out for a couple hours," you do mean a dual-frequency one, right?

A: Right — I'm referring to a geodetic grade antenna with solutions processed through OPUS

(not a cell phone!).

Q: Any idea of a point where we understand that we've reached the limit of definition of geoid potential as compared with subtleties in ongoing and constant geophysical morphology?

A: So we're still pushing toward a model that gets toward 1cm everywhere, but we're not there yet. Perhaps these refinements can be visited in the next 10-year plan? How to most efficiently improve things is an open, internal question at NGS.

Q: Is there a specific location the MSL is determined? Is this referenced to a tide gauge in the US?

A: So, no, unlike NAVD88 where a "golden" bench mark was chosen, the value of geopotential that best "matches" sea level (known as W_{zero}) is determined/chosen by trying to match a regional sea level over all of North America, while taking into account complications like sea-surface topography.

Multi-constellation Global Navigation Satellite System (GNSS) software
Andria Bilich, Ph.D.

Q: What language is M-PAGES being developed in?

A: M-PAGES is being developed primarily in C++ with scripting support in python.

Q: I understand that the original developer of the teqc software no longer works on it. This tool allows observation files from the manufacturer to be translated into RINEX. Is there a

A: That is correct. TEQC is no longer being actively supported and can only translate and perform QC for the RINEX 2 format. Moving forward, NGS is transitioning to RINEX 3 as the standard GNSS format which can often be downloaded directly from modern GNSS receivers. There are several new 3rd party software packages such as GFZRNX and ANUBIS that do support RINEX 3 for things like file splicing and QC (but NOT translation to RINEX). [*Also answered verbally during the webinar*]

Q: Are there actively supported QC tools available to users like teqc is?

A: There are several software packages such as GFZRNX and ANUBIS which can do RINEX operations and RINEX QC similar to teqc, for both RINEX 2 and RINEX 3 formats. Both are actively supported.

Q: Can you provide a link to those TEQC alternative applications?

A:

GFZRNX Link: <https://dataservices.gfz-potsdam.de/panmetaworks/showshort.php?id=escidoc:1577894>

ANUBIS Link: <https://www.pecny.cz/gop/index.php/gnss/sw/anubis> [Also answered verbally during the webinar]

Q: So if M-PAGES will only use single differencing, do you still need NOAA CORS Network to provide baselines?

A: Yes, the NCN will still be needed as M-PAGES will use NCN reference station observations along with user observations to compute single differences to a common satellite. Single- and double-difference processing strategies (as implemented at NGS) are both baseline processing techniques that rely on the NCN.

Q: GAMIT, GLOBK, GIPSY are widely used for global networks. PPP is coming along very quickly. So why did NGS feel it necessary to develop processing software independent of the global processing community?

A: Certain jobs are “inherently governmental.” Writing and operating our own GPS software is one of those. NGS has been in the business of writing GPS software for over thirty years, with PAGES and OMNI before that. Expanding into GNSS was a natural progression, and a necessary one to keep up with modern technology. In addition to needing to do this to fulfill our role as the stewards of the NSRS, we also improve GNSS positioning worldwide by being producing *independent* orbits for contribution to the International GNSS Service (IGS). Without such *independent* orbit software, the IGS could not produce such quality orbits, which end up being used in tools like OPUS.

Q: Decreased occupation time using MPAGES compared to PAGES?

A: We anticipate that multi-GNSS processing will allow shorter occupation times to reach a certain level of accuracy. This is an area of active research and development under the M-PAGES project. [Also answered verbally during the webinar]

Q: Is NGS accepting rinex3? If not, when will you?

A: At present, RINEX3 is accepted for OPUS processing but converted to RINEX2 for processing with the legacy PAGES software with GPS only data. When M-PAGES is integrated into NGS products and services, we will accept and process multi-GNSS data using RINEX3 as the standard GNSS data format.

Q: Is there an anticipated time frame of release for GNSS in OPUS Beta?

A: We anticipate incorporating GNSS capabilities into a beta version of OPUS-S before the end of 2022.

Q: When can we hope to see M-Pages in the Beta site?

A: We anticipate incorporating GNSS capabilities into a beta version of OPUS-S before the end of 2022.

Topic: Least Squares Adjustment (LSA) software
Dru Smith, Ph.D.

Q: Is/was there any consideration of using/integrating NGA's UT:ARL developed surveyor adjustment software SALSA?

A: Yes. NGS is aware of SALSA, and have been given permission by the developers to cannibalize those parts of their code which suit our purposes. However SALSA is more limited than LASER will be, in that it does not allow for leveling and gravity surveys, nor does it provide multiple least squares solutions (such as BLUUE, repro-BIQUUE or partial-MINOLESS), nor is it built to perform adjustments on a national scale with hundreds of thousands of observations, constraints and estimated parameters.

Q: The National Geospatial Intelligence Agency sponsors a least squares adjustment package developed by the University of Texas at Austin. Why would two government agencies create the same type of software? They didn't. SALSA is more limited than LASER will be, in that it does not allow for leveling and gravity surveys, nor does it provide multiple least squares solutions (such as BLUUE, repro-BIQUUE or partial-MINOLESS), nor is it built to perform adjustments on a national scale with hundreds of thousands of observations, constraints and estimated parameters. [Also answered verbally during the webinar]

Q: Is the pre-existing Eigen Library open source and available to the public?

A: It is, here: https://eigen.tuxfamily.org/index.php?title=Main_Page [Also answered verbally during the webinar]

Q: Will this program be accessible to use by other organizations?

A: Yes, it will be publicly available.

Q: What is colored noise?

A: As opposed to white noise, which has equal power at all frequencies, "colored" or "pink" noise has more power at lower frequencies. Often called 1/f noise:

https://en.wikipedia.org/wiki/Pink_noise

Q: Will this program allow for a stochastic model test to make sure the observations are correctly weighted?

A: Hypothesis testing will be built into LASER. In addition, the capability of estimating one or more variances of unit weight, to correct for mis-weighted observations, will be possible.

Q: Will the Least Squares (LASER?) training be available to all users or just NGS staff?

A: At the moment, only to NGS staff. A light version of it may be incorporated into future OPUS 6 training.

Q: As a government entity [county surveyor's office] as we locate section corners in the future after 2022 should we list the location of the mark as of the 2022 date, or should we suggest to our users recalculating to a 'today' location for resetting lost corners?

A: You should recommend to your surveyors to reestablish lost corners according to the BLM manuals. This actually has little to do with NSRS modernization. If the surveyor needs to do some sort of proportioning (i.e., single proportion, double proportion, etc.), then they should first measure the location of adjacent section corners and determine their positions at some common epoch (like 2020.00). Then, do all computations at the same epoch to determine the position of the lost corner. Do not mix epochs or rely on coordinates from older surveys; instead; do a resurvey according to BLM manuals.

Q: This seminar is over my head as a GNSS surveyor and levelling for sub cm accuracy. But I'm getting the gist that the Geoid may be determined so accurately that an autonomous GNSS observation can determine elevation using an ellipsoid + Geoid transformation accurate to 1-2cm for the sat observation + 2-5cm for Geoid errors? If so, that's a fantastic advance.

A: This statement is generally true, but it is not meant for autonomous positioning. If you follow good practices and determine a high-accuracy ellipsoid height, then you can combine it with a geoid height from GEOID2022 to derive an orthometric height to roughly 2 cm accuracy. Thus, the big advance is that orthometric heights can be quickly derived with GNSS and the geoid model.

Q: Accessing the NSRS via GNSS receiver: How does NGS envision the single-frequency GNSS receiver users (eg, GIS, resource-mapping professionals/technicians) accessing the NSRS. The 1-2 cm ellipsoid accuracy (achievement) is dependent on dual-frequency receivers, right? You've talked about using/processing multi-GNSS receivers, but I didn't hear anything today about Single-Frequency RX (with just a GPS signal).

A: NGS is not currently developing any tools for single-frequency receivers.

Q: Are there any papers available for LASER yet? And does it use Block QR factorization or something similar?

A: There are no papers available for LASER as it is still under development. LASER does not compute a QR factorization. Instead it computes a Cholesky factorization of the normal equations with parameter ordering to keep the Cholesky factor relatively sparse. Of course there is a relationship between the Cholesky factor of $A^T A$ and the R factor resulting from a Gram-Schmidt QR factorization of the coefficient matrix $A = QR$. *[Also answered verbally during the webinar]*

**Q: 1) Will LASER work with SINEX files? What import (and export) formats does it use?
2) Will LASER adjust for velocities and/or other time-dependent terms?**

A: LASER is being built as a generic engine and therefore should be thought of as something which manipulates existing vectors and matrices. Getting data into those vectors and matrices will be performed by software outside of LASER.

Q: As the correction for wet troposphere remains uncertain, won't longer observations be needed in order to randomize its effect?

A: Wet troposphere is one of the 'unknowns' in the typical GNSS position solution. Longer observations do help with solving for this slowly-time-varying unknown. The question implies

that shorter observation intervals or sessions may lead to difficulty accounting for wet troposphere. M-PAGES will likely need to independently solve for wet troposphere then use it as an input for short duration sessions. The most effective method will be an area of active research for the M-PAGES and OPUS teams in the months ahead.

Q: What would be the most likely factor for a local surveyor to be three to four meters in error on his GPS measurements? Even if the grid factor, the convergence angle, and difference in U.S. / International Survey Feet is wrong, it would not cause this much

A: If those three elements have been checked and are not suspect, then some likely factors for being this much in error would be: 1) a blunder or some human error, 2) working in the wrong datum, or 3) using an autonomous/un-processed position. We would need more information on this scenario to make an accurate diagnosis of the error described.

Regarding an incorrect grid factor, convergence angle, and foot type, each could actually cause much more than 3–4 m of positional error in the State Plane Coordinate System of 1983 (SPCS 83):

1. An incorrect grid factor can cause tens or even hundreds of meters of error. This can happen when SPCS is “scaled to ground” and is assumed to not be scaled (i.e., “at grid”), or vice versa. The magnitude of the difference depends on the height of topography and distance from the point where scaling is performed (usually the SPCS zone grid origin). For example, the largest SPCS 83 coordinates occur on the northeast corner of Nevada (about N = 8,805,100 m, E = 327,600 m) in the NV East Zone. For an ellipsoid height of topography of 1600 m at that location, the combined factor is 0.99984938. Dividing the SPCS coordinates by the combined factor gives coordinates “at ground” that differ by 1327 m.
2. Convergence angles exceed 1° in many zones. The largest SPCS 83 value is -9°13' at the west end of the Aleutian Islands for Alaska Zone 10, and in CONUS the largest value is -4°47' along the westernmost border of Montana for the MT Zone. Not accounting for a 1° convergence angle will cause more than 3 m of error in a distance of only 200 m.
3. Even though international and U.S. survey feet differ by only 2 parts per million, mixing them up can cause over 3 m of positional error in all or part of more than 30 SPCS 83 zones. Specifically, the error will exceed 3 m if either the northing or easting is greater than 1,500,000 m. For the above example from the NV East Zone, using the wrong type of foot will cause a horizontal error of 17.6 m (which is the largest of all SPCS 83 zones).

Day 2: May 5, 2021

Topic: Day 2 Opening Remarks

Brad Kearsse

Q: What is the implementation plan for Federal users? Is there a mandated requirement to shift over to the 2022 reference frames the way there was for shift to NAD83 from NAD27?

A: Each agency is responsible for their own implementation, although NGS is happy to consult with fellow Federal agencies for advice or assistance. Yes, the Office of Management and Budget (OMB) Circular A-16 and the Geospatial Data Act (GDA), require Federal civilian agencies to utilize the NSRS, and the Federal Register will be used to publicly affirm the new datums as “finalized”, as it was for NAD 83 and NAVD88.

Topic: State Plane Coordinate System

Michael Dennis, Ph.D.

Q: Have there been any issues with FEMA's Risk Map 2.0 September planned implementation because of the delay of the new datums? I am a local government agency trying to migrate with the transition to the new datums when they are implemented.

A: FEMA’s change to Risk Rating 2.0 has few ties to any specific vertical datum, it is more about changing the way properties are evaluated.

Q: How much distortion is actually being solved by having a second layer (multiple zone) Asking from Texas, but what's the smallest state with a multiple zone layer?

A: The smallest state with two multiple-zone layers is Alabama. Having two multiple-zone layers can actually reduce the distortion by a lot. It turns out that Texas is a good example. It will have its same 5 zones, plus 50 zones (based on aggregated counties), which greatly reduces distortion, compared to the 5-zone layer.

Q: Will DC have its own zone?

A: Yes.

Q: Why on earth does Ohio think they need 88 zones when it's relatively flat?

A: The beautiful rolling hills of southeast Ohio can benefit from smaller zones, and NGS has allowed stakeholders (state-based organizations) to make their own decisions and request or propose what they desire for their geographic area. Ohio wanted one zone for each of its 88 counties, which they feel is easier to manage. The minimum zone size is 50 km (for zones that have a height range of less than 250 m). Most (perhaps all) of Ohio’s counties are smaller than this, so an exception from the NGS Director was required to allow Ohio to have such small zones. Two other states also requested and received a minimum size exception, Indiana and Wisconsin. In all three cases, the exceptions were granted mainly because the systems were

already in use and there was very strong state stakeholder support. No other states have requested a minimum size exception.

Q: Why is NGS using the terminology "state plane coordinate system of 2022" to represent multiple systems? I find this to be very confusing, since SPCS has a very different meaning

A: It really depends on what is meant by the word "system." SPCS 83 also includes a wide variety of zones (including one state with two "layers", Kentucky). But it's called the "State Plane Coordinate **System** of 1983." Interestingly, SPCS 27 was called "systems" (plural), but it changed for SPCS 83. We decided to stick with that change.

Q: What is the process for changes to the NSRS to propagate to state planes that use it? Are there version tags, or is it based on the time-dependent coordinates?

A: SPCS coordinates are derivative products from NSRS latitude and longitude, for whatever datum or realization is used for the latitude and longitude. So yes, SPCS2022 coordinates will be implicitly time-dependent, because the geodetic coordinates are time-dependent. However, there will be only one "version" of SPCS2022 itself, based on the GRS 80 ellipsoid, which is exactly what is done for SPCS 83 (i.e., it did change in any way for the multiple NAD83 realizations).

Q: Is NGS submitting all of these zones to the EPSG database?

A: Yes, as well as other standard databases that support projected coordinate systems. The EPSG Geodetic Parameter Dataset is actually part of the International Association of Oil & Gas Producers (IOGP). Other standardized databases include that of the Open Geospatial Consortium (OGC) and the ISO Geodetic Registry (although the latter does not include projected coordinate systems at this time). *[Also answered verbally during the webinar]*

Q: Michael, after the event today, please check the number of zones for Louisiana: La. North, La. South, LA. Offshore, La. statewide skewed. No need to respond today. Thanks.

A: The LA Offshore zone will be classified as a "special use zone", because it covers the entire Gulf of Mexico, which overlaps the offshore boundaries of 5 states (FL, AL, MS, LA, and TX). So it will still exist and be very similar to its SPCS 83 version, but with the name "Gulf of Mexico Zone." However, it can certainly be referenced in LA statute, if the state chooses.

Q: For the new State Plane Coordinates, where the projection surface is minimizing misfit with topography, could result in big changes in scale from neighboring zones. Do you anticipate problems with this?

A: We do not anticipate a problem; this situation already exists in SPCS 83 (e.g., the Montana SPCS 83 zone as compared to any of the zones in its neighboring states). Note that by far the biggest change in scale will occur between layers within states that have more than one layer. In addition, although minimizing distortion at the topographic surface will increase variability in projection axis scale (compared to SPCS 83), it will decrease variability in the combined factor for projected points based on SPCS2022 as compared to SPCS 83.

Q: Have you been approached by USDA regarding implementation yet?

A: No.

Q: As the impetus for the creation of the SPCS was to provide an easier, more accessible, way to compute positions and azimuths, why perpetuate this 2D system in the 21st Century? SPCS are two-dimensional, modern positioning systems are 3D. While mappers and possibly GIS (why aren't they interested in the height component?) are served by this system, why not provide data in XYZ and let them transform them into the form most useful to them.

A: The SPCS is used by so many of our constituents/stakeholders, and since its inception it has become a part of the fabric of positioning in the USA, to the point that abandoning it now would be a detriment to the entire geospatial community of our Nation. The future geopotential datum, NAPGD2022, will serve the needs of users who need or desire heights in the NSRS, and those (and any other) heights can be combined with projected (2D) coordinates (which is how the height component is handled today by most users of SPCS 83). In addition, SPCS is a standardized system, so it facilitates data transferability; "custom" systems may not be readily transferable (few, if any, commercial software packages currently support local geodetic horizon systems). And having NGS create or vet the designs ensures they are rigorously correct. That might not be the case if everyone just made their own local topocentric system. Besides, if someone wants to make their own system, there is nothing to stop them from doing that. They do it now, and some will no doubt also do that in the Modernized NSRS.

Q: Why not simply STOP publishing any NOAA products in ANY foot? Just use meters.

A: We would love that, as NGS stores all our data in SI (metric) units. But that has been attempted more than once here in the States and each time the general populace was not yet "ready." Hopefully soon! *[Also answered verbally during the webinar]*

Q: Alpha-release question: How will NGS support the NSRS Alpha Release and how do you want it to be used? Will GIS vendors be expected to support new GeoTIFF grid format, new SPCS zone definitions, etc. at that time?

A: NGS is actively working with software vendors (and standards organizations) on the new GeoTIFF formats and SPCS zone definitions, as well as other formats/definitions. SPCS2022 definitions will likely be provided in Well-Known Text (WKT) format, and perhaps others (e.g. PROJ). *[Also answered verbally during the webinar]*

Q: For Michael Dennis -- Can the new SPCS definitions be a part of the next xGEOID model so users can better estimate the likely 3-D positional changes from current H&V values for planning purposes?

A: Yes, we plan to provide preliminary ("alpha") SPCS2022 definitions so that people can review and use them for planning purposes. Then, as you suggest, they can be used along with the latest ITRF ellipsoid heights and the latest xGEOID model to get horizontal & vertical positions.

Q: The measurement used in the PLSS is based upon the U.S. Survey Foot. Conversions will still need to be made if retracing PLSS correct?

A: Unit conversions are already very important to any PLSS-related work, as many BLM and GLO

(its predecessor) agency records are stored in chains and links or rods. So yes, if your working units are not international feet then you will need to convert. Note also that there have been nine versions of the Manual of Survey Instructions (beginning in 1855), and that the foot definition changed during its existence (in 1893). So the Manual has accommodated such changes, and it certainly can do so again in the future. How that is specifically handled for the foot is for the BLM to decide.

Q: Who will be responsible for getting EPSG codes, to simplify georeferencing of data, for all the new state plane codes? NGS? States?

A: NGS will submit the parameters of SPCS2022 zones for inclusion in the EPSG registry, and likely to other similar databases, such as that maintained by the Open Geospatial (OGC).

Q: I am SC PLS. Have used GPS- GNSS and SC State Plane for about 30 years. We have adjusted project coordinates though the obvious adjustments that changed coordinates over the years. The NAD 83(2011) obviously most precise. Least error noticed. Question is - since we have gone back to coordinate locations marked by definite points over a number of years with no noticeable movement due to the supposed platonic shifts. Why don't we see these shifts? Just last week we re-located a point from over 30 years ago within 0.05 feet.

A: This is because the NAD83 (2011) functions similarly to the concept of the plate-fixed frame that NATRF2022 will be. You can check the current modeled velocity using HTDP (<https://geodesy.noaa.gov/TOOLS/Htdp/Htdp.shtml>) in NAD 83 and compare it to the ITRF2014 velocity to see the difference. You will see that the NAD 83 velocity is much lower. In addition, everything in the eastern U.S. is essentially moving together, so there is very little relative change between marks. That's probably the biggest contributor to the consistency you're seeing. It also makes me happy, because it means we're doing a good job in maintaining NGS geodetic control!

Q: Will Hawai'i have a sub-zone?

A: Yes, Hawaii has requested that NGS design a multiple-zone layer (with these zones only on the Big Island and Maui), and we will be working on that soon. Those will augment the statewide zone that covers all the Hawai'i counties, and thus all the islands from the Big Island to Ni'ihau. SPCS2022 will not cover any islands west of Ni'ihau (as is the case with SPCS 83).

Q: Will Florida still have 3 zones?

A: Yes, Florida will still have a layer with 3 zones, although the zone extents and names will be slightly different (but still defined by county boundaries). There will also be a Peninsula Zone on its own layer that covers the peninsula, and of course a statewide zone, for a total of 5 zones on 3 layers. Distortion maps of the zones are available at <ftp://www.ngs.noaa.gov/pub/SPCS/DistortionMaps/>. (Note: if your browser does not support FTP, you can simply paste the FTP URL into the Windows File Explorer address bar and it will allow you to access the FTP folders).

Q: Traditional State Plane Coordinate Systems were designed to limit scale errors to 1 in 10,000 and elevation corrections from the ellipsoid being much more important, which meant

engineering projects in State Plane had to include a correction factor on a sheet-by-sheet basis to get from grid to ground. Will the 2022 SPCs, being centered on topography instead of the ellipsoid, make ground to grid scale differences practically nil from a construction standpoint?

A: It depends on the zone being used. That said, if an SPCS2022 zone covers the same area as SPCS 83, the SPCS2022 zone will have less distortion, especially in more populated areas. But there will still be a lot of distortion for zones covering large areas and/or that have a lot of topographic relief. There are 27 states that have submitted zone designs that reduce distortion so much that grid to ground scale differences will be negligible in many locations (i.e., zones that are “low distortion projects”, LDPs). In many of these states (especially in the Midwest), essentially the entire state is covered at such low distortion. In the mountainous states that have LDPs, the zones have usually been designed to give negligible distortion in areas where people live, work, and travel (e.g., in cities, towns, and along highways). In addition to the 27 states with LDPs, many of the eastern states (and DC) will have zones with very low distortion over most or all of their area.

Topic: Retirement of the U.S. Survey Foot

Michael Dennis, Ph.D.

Q: Which foot is used by current NSRS for elevations?

A: See the DSDATA.txt article on our website, which explains most of the Datasheet parameters, including that the units of orthometric heights are published in meters and U.S. survey feet. https://www.ngs.noaa.gov/cgi-bin/ds_lookup.pl?Item=DSDATA.TXT

Q: Please restate the federal register information that was shown on a slide.

A: Please visit this link at the NIST website that contains resources on the U.S. survey foot, including information on those FRNs: <https://www.nist.gov/pml/us-surveyfoot>. Also, these slides will be posted after the Summit concludes. For your convenience, the link to the final determination FRN is <https://www.federalregister.gov/documents/2020/10/05/2020-21902/deprecation-of-the-united-states-us-survey-foot>.

Q: If US Survey Foot will still be supported with the existing NSRS, and the modernized NSRS won't be ready til 2025 — what is the effective consequence of the Dec 31, 2022 date?

A: There is little, if any, effective consequence because NGS tools/products (NCAT, Datasheets, etc.) will continue to support the U.S. survey foot for the datums that do use it. This is true even in the future when our current datums become “legacy” datums: NGS tools/products will support the units that were current for those legacy datums. In addition, NCAT currently gives State Plane coordinates in meters, U.S. survey feet, and international feet for all zones for both

SPCS 83 and 27.

Q: Could you please post the article that Michael suggested the audience to read on the foot?

A: Please visit this link at the NIST website that contains resources on the Survey Foot, including information on those FRNs. <https://www.nist.gov/pml/us-surveyfoot> Also, slides will be posted after the Summit concludes.

Topic: GPS on Bench Marks Campaign

Galen Scott

Q: Are you happy or unhappy with me finding old USC&GS marks that you have 'retired' or given up on?

A: We are thrilled to get information on older marks! These marks have decades of geodetic history and value to other users of the NSRS.

Q: Will NOAA publish a revised vdatum to 2022 and when?

A: As we move towards NSRS Modernization, NCAT and VDatum will become closer and more aligned and will be built using the same base code. VDatum is updated now on a regular basis.

Q: What about SE Texas where there are no valid BMs?

A: There is an ongoing effort led by surveyors in Texas with assistance from NGS to survey marks and then Bluebook the results. If you are interested in assisting with this effort, please reach out to us at ngs.gpsonbm@noaa.gov and we can connect you.

Q: Is this map just for Maryland? It looks like Delaware is pretty thin.

A: The GPSONBM webmap covers the entire United States (including Alaska, Hawaii, Puerto Rico, US Virgin Islands, Guam, American Samoa, etc.) Delaware looks slim because they have submitted data on nearly ALL of the priority bench marks in the state, so NGS currently has the data at the requested 10 km spacing to create the transformation tool.

Q: The striking thing to me when looking at the plots of GPS on BM across CONUS is the wide disparity in participation. Won't this disparity effect modeling? Does NGS ever envision sending observers to fill the voids?

A: For the last 20+ years, NGS has maintained the passive control network primarily through the cooperation of State partners because we do not have the resources to upkeep passive control and GPS is now the primary form of accessing the NSRS. In some states that has meant significant submissions, and in others it has meant little to no submissions. NGS will make the national scale models and tools with the data that we have and by necessity will interpolate over areas without data. The GPSONBM program allows local partners to provide data that will improve the NGS tools in the areas they work. *[Also answered verbally during the webinar]*

Q: I must have missed it: Why use hexagons to represent the GPSONBM regions?

A: Since many regions of the country are sparsely covered by level lines, the hexagon tessellation is better at representing those profiles.

Q: What do we do when there are no marks of NGS that are useable?

A: If there are no marks within a hexagon, that hexagon will disappear. If you are unable to locate a benchmark or you are not able to observe a benchmark (due to vegetation), then please submit a mark recovery to NGS (https://geodesy.noaa.gov/cgi-bin/mark_recovery_form.prl). Once this has been submitted, the mark will be removed from our search list.

Comment: Your Populated Area overlay is great!

A: Thanks! We plan to roll it into the web map in the next few weeks.

Q: What do I do if the priority mark and secondary mark are not there in the 10k hexagon? If I find a leveled mark within the 10 k hexagon does your system pick that up and consider that hexagon completed?

A: If you are unable to locate a benchmark or you are not able to observe a benchmark with GPS (due to vegetation), then please submit a mark recovery to NGS (https://geodesy.noaa.gov/cgi-bin/mark_recovery_form.prl). Once this has been submitted, the mark will be removed from our search list. Yes — you can simply observe another leveled mark with a published NAVD 88 (or similar vertical datum) elevation within that hexagon and it automatically will populate the hexagon.

Q: Do you know if all of the monuments you are requesting to be GPS'd are still there? Are A-1s the priority?

A: We do not know if all those monuments are still recoverable, we use the metadata that we have to prioritize the marks. Please consult the Recovery Notes in the mark's Datasheet for any info submitted to us by other surveyors/users. Priority A is first, B second. The "1" indicates that only 1 additional GPS observation is needed, meaning that someone at some point previously collected and submitted GPS observations on that mark.

Q: Would you share the links for the dashboard and the tracking of populated areas.

A: Here is the link to GPSONBM homepage: <https://geodesy.noaa.gov/GPSONBM/>

Comment: I know you are tired of hearing this, but I'll say it again. If you allowed one turn of a level (double checked by two setups) to a temporary mark with decent sky visibility (not a RESET that takes too much effort), you would gain many additional usable marks to fill gaps. A good fraction of the found disks are vertically mounted or under trees. GPS is lucky to get 1 cm accuracy and anybody can do a level turn to 1 mm.

A: The issue lies with our inability to ingest the data. Unless you are willing to Bluebook your level shot, we have no other way to accept it or store it at this time. In the future, OPUS Projects 6.0 will allow you to submit GPS data along with leveling or total station data and process them together.

Q: A number of surveyors have expressed dismay at their inability to include offset GPS observations to benchmarks set in the sides of buildings, etc. They are willing to run levels to

A: See answer above. There is a solution, but it involves setting a new permanent mark nearby, which is not convenient. Anyone is welcome to follow the Bench Mark Reset Procedures to achieve a GPSONBM for the situation you describe. Here is a link to that Procedures document: https://www.ngs.noaa.gov/PUBS_LIB/Benchmark_4_1_2011.pdf. [Also answered verbally during the webinar]

Comment: The continued reliance on "bluebooking" ignores the standard of practice on how surveying and control is done. This will continue to reduce the amount of data that will be submitted and used.

A: And this is why we have "Re-invented Bluebooking" by making it much easier and more accessible by using OPUS Project 4.0!

Q: What if we have past surveys on some of your targeted BMs, possibly multiple 24-hour surveys repeated over several years, but do not have specific photos?

A: We do request an equipment setup horizon photo and a mark close-up photo for GPSONBM submittals via OPUS Shared. Although we do not encourage any unethical practices, it is up to you how you acquire those photos and we can't do much more than take what you submit for face value.

Q: When will bluebooked monuments be available for those monuments that were redacted by NGS because of subsidence?

A: Until new surveys are completed and the data is submitted to NGS, only the 28 marks listed on the [SE TX Valid Ortho Heights](#) page will be considered to have valid NAVD 88 heights. Once we receive new surveys, and they are bluebooked, NGS will publish new/updated heights on datasheets. [Also answered verbally during the webinar]

Q: Will ngs bring back "find a control" for mobile devices?

A: The "find a control" app was not an NGS product, though we are aware of it. However, we do now have our [Survey Mark Recovery](#) page that includes "Find marks near me." It is mobile compatible for your Android, iOS, or even a data collector with Internet/cell connection! Check it out, here is the link: <https://www.ngs.noaa.gov/surveys/mark-recovery/index.shtml>.

Q: It seems that the GPS over benchmarks will make NAD27 coincident with the latest version of WGS 84. Is this correct?

A: No, NAD 27 and WGS 84 have no role. GPS on Benchmarks relies on NGS's Online Positioning User Service (OPUS), which processes your submitted data against the NOAA CORS Network, providing coordinates with respect to the most recent ITRF and NAD83 (2011, PA11, MA11).

Q: Can you briefly explain how the new GPS on BM submittals will be used for previously established stations with PIDs? Will the new observations be used with the old data to

recompute a 2022 XYZ or will it be primarily used to verify existing data. If it is believed that stations have moved horizontally or vertically, will new observations be given more weight?

A: At this stage, everything is on the table. It is very likely that any new observations will be used in computing the 2020.0 coordinates instead of just verifying the existing data.

Q: Is it possible to gain access to GPS equipment to collect these data?

A: NGS does not typically loan out GPS equipment to users. Any dual-frequency GPS receiver that is in our Antenna Calibration database can be used for OPUS Share, thus GPSONBM. There are some sub-\$3k receivers on the market that fit the bill.

Comment: A mark recovery app (or Collector option) with a high accuracy GPS ability would be great.

A: See our Mark Recovery page here: <https://www.ngs.noaa.gov/surveys/mark-recovery/index.shtml>

Q: You mentioned GNSS observations as part of GPS on BM; Has there been specific guidance put forth on GNSS data collection and scheme standards of GPS/GNSS on BM with NAVD 88 published height?

A: There is an ongoing NGS effort to build a Multi-constellation Global Navigation Satellite System (GNSS) software that will be the new engine of OPUS.

Q: What is the delay between GPS on BM submittal and data acceptance?

A: It typically takes anywhere from 5-10 days from a user submitting their survey to OPUS Share, getting it accepted by OPUS Share, and finally updated into the GPS on Benchmarks web maps.

Q: I located a BM that shows in the Bench Mark app and the App pulls up a data sheet. However, when I search on the NGS Website it does not locate the datasheet? I do not find the data sheet for this mark. BM: L 213 Pid: AV0414

A: Here is a link to a Datasheet for that PID: https://www.ngs.noaa.gov/cgi-bin/ds_mark.prl?PidBox=av0414 Do note that the datasheet shows the Orthometric Height as Not Published, due to being in a subsidence area. This may be why you had trouble finding the mark on the map explorer.

Q: Could the GPS on BM web map be modified so when the recommended site PID is selected the user is able to view its location on Google Earth, Apple Maps, etc?

A: Not really. The web maps are in ESRI's online platform but all of the data is available in multiple formats for download (xls, shapefiles, etc.) that one could include in other software, if desired.

Q: If I have no NGS feedback for GPS on BM submittal after two weeks should I assume an issue?

A: The only interaction you will have with NGS is an email from the OPUS Team asking you to confirm your OPUS Share submission. Once that happens, it will be automatically ingested into

the GPS on Benchmark web maps. If you ever have a specific question about your submission, please reach out to us at: ngs.gpsonbm@noaa.gov

Q: What is the probability that the December 31st deadline for GPS on BM being extended? Would GPS on BM campaign substantively benefit from the upcoming GNSS updates to OPUS?

A: As of now we have no plans to extend the GPSONBM submittal deadline any later than it is. But even after the deadline you can still contribute GPSONBM observations via OPUS Share! *[Also answered verbally during the webinar]*

Q: So as a frequently bored (and under utilized) retiree, if I wanted to help observe some GNSS data on Benchmarks, would the NGS, perhaps through their advisors, have equipment that could be loaned? Kinda like a Get Retirees Into Survey like a Get Kids Into Survey LoL.

A: Sorry, as a federal agency NGS cannot loan equipment. Perhaps you could get in touch with your State Surveying Society and offer your assistance?

Topic: Two Types of Coordinates
Boris Kanazir

Q: Can non-NGS points of stable quality be used to solve a hexagon?

A: Probably not.... The mark needs to have an NAVD 88 (or other similar vertical datum) orthometric height that is stored in the NGS Integrated Database (e.g. it can be found on a Datasheet).

Q: Since vertical movement does not follow anything close to the secular motion of horizontal, is there going to be different terminology and publication intervals for vertical "epoch" dates? Relative vertical movement is perhaps the more defining characteristic. Is there consideration for how to distribute metadata for vertical movement between points or across local regions?

A: In the Modernized NSRS there is no such thing as a "horizontal epoch date" nor a "vertical epoch date." There will be "reference epochs" where attempts to estimate all coordinates (latitude, longitude, ellipsoid height, orthometric height) will be made. There will also be "survey epochs" that represent adjustments of data that surround a survey epoch (right now looking at 4 weeks for geometric adjustments and 1 year for orthometric adjustments).

Q: How will users be able to differentiate between SECs and RECs?

A: By checking the epoch of published coordinates. For the RECs, NGS will estimate coordinates on points at reference epochs, currently scheduled to be five or ten years apart, beginning with 2020.00. For the SECs, coordinates will be estimated at (or very near) the actual date when the surveys took place. *[Also answered verbally during the webinar]*

Topic: Designing a Data Delivery System for the Future

Jay Howard

Q: Does NGS ever plan to replace EPSG codes with a US standard, or is it fine being a de facto standard?

A: There is an international plan to transition to the ISO geodetic registry. NGS is participating in that plan.

Q: Does NGS produce and, if so, can NGS make available a height difference image representing GEOID(N+1) - GEOID(N)?

A: The meaning of “N” is unclear in this question, particularly because “N” is often used to represent a geoid undulation. If the user is asking whether we can create difference maps between one geoid model and another, we do not at the moment, but we certainly can and will pass that suggestion on to the geoid team.

Q: Is it possible to harmonize the global transformation system based on these new methodologies?

A: Unfortunately we could not respond to this question as asked. If you can, send clarifying details to ngs.infocenter@noaa.gov

Q: Could you provide a link to Jay's 'beta' recovery sheets?

<https://beta.ngs.noaa.gov/datasheets/passive-marks/index.html>

Q: So if I can't find NGS marks within a hexagon, for 2022 then the hexagon is empty, but if I share marks in through OPUS then they will show up on the shared marks page but worthless for 2022?

A: These submissions will not be used in the Transformation Tool but you will get new RECs and SECs on these marks with NSRS Modernization.

Q: These new changes in DATUMS will be mandatory to companies to put it in their conversion tools for examples in ArcGIS (ESRI)?

A: The only entities mandated to use the modernized NSRS are federal geospatial agencies. Private companies and state/local governments often adopt them, but there is no mandate.

Q: If SPCS 2022 is based on GRS80 and NATRF2022 is aligned with ITRF2020, does that mean there will be a transformation required from ITRF to GRS80 in order to derive State Plane

A: GRS-80 is not a reference frame. It doesn't fulfill the definition of a “reference system” as we use the term today (such as in ITRS). For all intents and purposes, GRS-80 is just two things: an ellipsoid (expressed with 2 values) and a normal gravity field (also expressed with 2 values). Its geometric use is solely as a convention to take global Cartesian coordinates (XYZ for instance)

and convert them to a more human-understandable latitude, longitude, and ellipsoid height. The GRS-80 ellipsoid is the ellipsoid size and shape used to express geodetic coordinates (LLh) in a specific reference frame such as NATRF2022 or ITRF2020. Both of these reference frames natively use ECEF XYZ coordinates, then the GRS-80 ellipsoid can be used to convert those XYZ coordinates to the LLh coordinates that more users are familiar with. So no, there is no transformation required, rather a conversion (i.e. changing the *units*, not the *frame*).

Q: So the government is relying on private surveyors to provide the data for the benchmark program?

A: In many ways yes, and this has been the case for decades. The last time NGS successfully maintained the field crews to submit anything close to the majority of NSRS data was the FBNs, back in the 1990s.

Q: For Jay's change in the datasheet look and feel, what is the email address we need to use for feedback?

A: Please send any feedback to ngs.feedback@noaa.gov.

Q: I have heard lots of discussion of GNSS observations rather than GPS. Has NGS put forth guidance of GNSS data collections and data schema standards to be included into OPUS?

A: When we use the term GNSS we mean all current and future satellite navigation and timing systems including GPS, GLONASS, Galileo, etc... In the NOAA Technical Report NOS NGS 67 entitled, "[Blueprints for 2022, Part 3: Working in the Modernized NSRS](#)", there is a brief discussion starting in section 2.9 on new surveying specifications. This publication is online and downloadable from the NGS Publications Library.

There are current NGS projects working on enhancing OPUS to allow for the processing of GNSS data, these include MPAGES (currently in development) and the new GVX file format (available with the release of OPUS Projects 5.0 to Beta, additional information available at: <https://www.ngs.noaa.gov/data/formats/GVX/index.shtml>).

Q: Will NGS provide tools to convert RTK vectors from different proprietary formats to new standard format?

A: No. NGS will not be in the business of building and maintaining translators. We expect equipment manufacturers who continue to use their own proprietary formats to provide translators into conventional formats, such as GVX.

Topic: Online Positioning User Service (OPUS) Improvements Part 1
Jeff Jalbrzikowski

Q: Is there a specific Monumentation Section within the Bluebook Guide to direct OPUS Project's users for Control requirements? Addressed inquiry of a Bluebook Network in 2007,

and was advised to follow 1978 NOAA Manual per:

https://www.ngs.noaa.gov/PUBS_LIB/GeodeticBMs/#table2

A: That document on monuments is still current. For more recent guidance on monument design, you could consult the Bench Mark Reset Procedures document from 2011:

https://www.ngs.noaa.gov/PUBS_LIB/Benchmark_4_1_2011.pdf. If your question is more in relation to observation schema, not monument setting, please reach out to one of our Regional Advisors for some assistance.

Q: Will there be an on-line glossary for all the acronyms you have created and "throw around"?

A: Probably the best source for demystifying today's alphabet soup would be the Terminology Guide we have in the Blueprint for the Modernized NSRS, Part 3: Working in the Modernized NSRS. This document and the other two blueprints are available here:

<https://geodesy.noaa.gov/datums/newdatums/policy.shtml>

Q: Will prior Bluebooked projects from before M-Pages be re-processed by NGS to include the other GNSS information when OPUS 6.0 comes out?

A: For the most part, no. Most historic Bluebooked data are stored at NGS as processed GPS vectors. Despite most of those projects also being submitted with supporting raw GPS data (in RINEX or industry-specific formats), that was not required and there were no specific naming or formatting rules associated with those files. NGS performed a formal study in 2018 to determine if the raw GPS data files were correct and could be properly associated with the pre-computed vectors. The study showed significant problems with the metadata of those raw data files, and came up with an estimate of 40 person-years to properly sort out all of the problems with these files. As such, only those few projects that are pre-organized, such as submitted through OPUS-Projects 4.0 or later will be re-processed in the future, and the historic vectors will likely stand as-is forever.

Topic: Online Positioning User Service (OPUS) Improvements Part 2

Phillip McFarland

Q: Kinematic data?

A: OPUS Projects 5.0 (moving soon to Beta) will allow for the processing of GPS/GNSS vectors via the GVX file format. The format is meant for any type of GNSS vector, whether it was derived in a real-time kinematic (RTK) survey or from baseline post-processing. More information at: <https://geodesy.noaa.gov/data/formats/GVX/index.shtml>. If the question is asking about "true" kinematic datasets, then no, NGS has no plans to build a kinematic GNSS processing engine. [*Also answered verbally during the webinar*]

Q: OPUS processing — Will any version of OPUS provide relative network corrections using a local base station for atmospheric corrections, ambiguity resolution, and relative XYZ data?

A: OPUS will be very flexible in how certain things are processed. Users will be allowed to use whatever control they like, though their results may not be “tied to the NSRS” if their choices do not fall within OPUS recommendations. However this flexibility of OPUS will tend toward what control to use and not more esoteric methods of processing as mentioned above. *[Also answered verbally during the webinar]*

Q: In the DDS Level project graphics are great but can you show all the adjacent leveling lines not just one at time?

A: Right now the Beta Leveling Project page only shows the one project at a time, but we will pass this request on to Jay. There is a product in Beta phase, shapefiles of all the leveling projects in each State, which would allow you to do that in your GIS software, reach out if you are interested in more info on that.

Q: For OPUS Recommendations, will we not be able to select from any of the published Epochs and still be tied to a *historic* NSRS?

A: This depends on what the asker means by “historic NSRS.” In the context of there being a “modernized NSRS” then I interpret “historic NSRS” as anything earlier, including all NAD 83 realizations, etc. If that understanding is correct, then yes the user is correct: NGS will not support any historic realizations of the NSRS after the modernized NSRS is rolled-out. Choosing “2010.00” will be allowed, but the only frames you’ll get are ITRF2020, NATRF2022, PATRF2022, CATRF2022 or MATRF2022. NAD 83(2011) will not be available in the OPUS adjustments.

Q: Guess opus is only compatible to GPS and Galileo system. Does NGS has plan to include other GNSS in the future?

A: Yes, the M-PAGES software is being developed to utilize all current and planned GNSS observables for OPUS processing.

Q: What do you mean by OPUS selecting the Best CORS Stations...Quality or geometry?

A: OPUS’ current algorithm for selection of CORSs uses the quality of available stations as well as consideration of resulting geometry.

Q: Historically, OPUS uses only 3 CORS for Static solutions, and 9 CORS for rapid static. Will the number of CORSs used in OPUS solutions change? It seems that maybe additional CORS could give better results.. 

A: NGS does not currently have any plans to increase the number of constrained CORSs in an OPUS-S solution. That said, if you wish more flexibility, then we encourage you to use OPUS-Projects. Within OPUS-Projects, you may select which CORS to constrain, and you may select more than 3 stations. *[Also answered verbally during the webinar]*

Q: For CORS Stations located within subsidence zones (Louisiana Coastal Zone), will the ellipsoid heights be determined from predicted velocities, or can the heights be determined realtime based on actual subsidence?

A: Ellipsoid heights are measured every single day at every CORS. So, we will be able to stack daily solutions at each CORS, then compute the vertical velocities in subsidence zones. Of

course, there is some delay between the time the ellipsoid heights are measured and the time we release the computations of the velocities (we do not support real-time computations of velocities). During that delay or lag, we extrapolate the latest vertical velocities forward. Our last computations of vertical velocities at CORS was done in 2017 and is known as the Multi-Year CORS Solution 2 (MYCS2). The velocities in MYCS2 are based on daily measurements of ellipsoid heights from ~1994-2017. These velocities are extrapolated forward in time until we do another multi-year solution (like maybe in ~2022).

Q: Does NGS capture time series positional plots for all NGS-managed CORS? If so, at what frequency? [*Answered verbally during the webinar*]

Q: Since the earth's surface gravity changes for a given local over time, what is the plan to incorporate this change into the North American-Pacific Geopotential Datum of 2022 (NAPGD2022).

A: This is taken into consideration in the dynamic components of the datum including: DGEOD2022, DGRAV2022, etc. This will be provided in the Modernized NSRS via OPUS.

Q: with respect to the above question how will the NSRS get updated with the new gravity values over time or will these values be based on interpolation

A: It is very unlikely that NGS will be able to monitor every minor change in a very complex gravity field that an absolute gravimeter can measure. We simply are not able to have continuous gravimeters everywhere and will have to rely on a small network of re-observations along with satellite gravity from NASA's GRACE, GRACE-FO, and future satellite gravity missions. The largest impact that NSRS users will see with this is a few mm change (at most) in the geoid over ~yearly time-scales.

Topic: Standard data file formats for GNSS, total stations, automatic levels, and gravimeters

Dan Gillins, Ph.D.

Q: Will OPUS start to use GLONASS data in its solutions?

A: Yes, future integration of the M-PAGES software into OPUS will allow for processing of GLONASS and all other current and planned GNSS.

Q: It looks like NGS is converting raw GNSS data from CORS to RINEX 2.11 data. Is there a plan to change this process to convert to RINEX 3+ soon?

A: Yes, there are efforts underway to begin to ingest and QC CORS data in RINEX 3.

Q: Follow-up to the Monumentation of Bluebook and NSRS inclusion of OPUS Projects data from v5.0+, how is the "Quality of Monumentation" going to be part of the "OPUS Recommendations" beyond the BM Reset guide and original 1978 directive? Standard OPUS

Shared solutions outline monument "Stability". As the move to have OPUS Projects support inclusion into the IDB for future adj.'s, how can users ensure they are meeting Network Monument Quality.... let alone the future use of GVX data on literally a VAST difference in Monuments, and system directives to retain Monument Quality being Set and provided to

A: We recognize that sometimes a survey contains observations to a mix of “high quality geodetic control marks” and “other things” like nails or temporary bench marks. Submissions containing data on things that are non-permanent and/or not points will still be accepted, but only NGS-computed SEC and REC coordinates on high quality geodetic control marks will be made available to the public from the NSRS database.

Q: Will OPUS 5 process Galileo & GLONASS if it comes from RINEX 2?

A: OPUS Projects 5.1 will include processing of GLONASS and Galileo data, however, we plan to require the submission in RINEX 3.xx format for multi-GNSS data submission as information from systems like Galileo and GLONASS can be incorrectly labeled in RINEX 2.xx format. *[Also answered verbally during the webinar]*

Q: Is there a utility available to convert files to Rinex 3 format?

A: One available tool for RINEX 2.xx/3.xx conversion is GFZRNX (<https://dataservices.gfz-potsdam.de/panmetaworks/showshort.php?id=escidoc:1577894>).

Q: Will you continue to process proprietary data in OPUS through the GPS on BMs campaign?

A: The current version of OPUS will continue to process proprietary data by utilizing TEQC. However, the current plan for future versions of OPUS would require the user to upload static GPS/GNSS data via a RINEX file. This is due to the deprecation of TEQC within OPUS (TEQC final release was on 02-25-2019 and has met its end-of-life) and there is no known software that will allow the translation of multiple proprietary data formats to RINEX.

Q: Will it be possible to upload SINEX files to OPUS and OPUS-Projects? Why was it necessary to develop a unique format when an internationally adopted format was available?

A: We are simply unaware of any GNSS receiver that is capable of storing RTK/RTN GNSS vector data in SINEX format. One of the major reasons for developing GVX is so that it is possible to export vector data directly from the receiver. Such data files can then be uploaded to OPUS-Projects. We realize that SINEX exists and is used by some parts of the scientific community, but SINEX has not been widely adopted in industry nor is it a popular format amongst surveyors who are collecting data on bench marks. GVX also has a number of fields and attributes for storing important metadata on RTK/RTN vectors.

Q: How can I download historic CORS Rinex (2005-2006) that has not been decimated or corrupted (timing issues) for South Louisiana? For the last couple of years, it seems that certain CORS are no longer usable for post-processing/adjusting using Trimble Business Center.

A: Here is link to NCEI CORS page, for full logging rate data:
<https://www.avl.class.noaa.gov/saa/products/search?datatype=family=CORS> *[Also answered*

verbally during the webinar]

Q: Can you say which manufacturer has already added GVX support?

A: JAVAD has added GVX support for their Triumph-LS device, but are waiting until OP 5.0 is released so they can test it.

Topic: Modernized NSRS Use Cases

Nicole Kinsman, Ph.D.

Resources:

Blueprint for the Modernized NSRS, Part 3: Working in the Modernized NSRS [Blueprint for the Modernized NSRS, Part 3: Working in the Modernized NSRS](#)

Modernized NSRS Use Cases webinar:

[Modernized NSRS Use Cases | Webinar Series | National Geodetic Survey](#)

Q: When attempting to develop a data collection system for digital leveling to FGCS we were unable to gain manufacturer cooperation. Has NGS considered something similar given the many data elements required for submission shown in the LVX slide? *[Answered verbally during the webinar]*

Q: When will Standard OPUS V5 be released?

A: OPUS Projects 5.0 will be released into Beta in the next month or so and will continue to receive updates until its eventual release to our production environment.

Q: What is the timeline for making NCAT and other source code available via Github?

We should have NCAT and a few other tools on GitHub shortly. There is some code already on GitHub at <https://github.com/noaa-ngs/ncat-lib> *[Also answered verbally during the webinar]*

Session 2 General Questions

Q: What format does cors support and why is the need for it to be converted to observable files. if am not mistaken it is usually converted to rinex 2.11

A: CORS currently supports the ingestion of RINEX 2.11 file formats as well as select proprietary vendor formats. Future plans include the ingestion of RINEX 3.xx format to allow for more appropriate multi-GNSS data availability.

Trivia Question: What outspoken Professor would open his seminars on geodesy with the question "Who needs stink'n benchmarks?"

A: I would guess John Bossler, but only because I hear this question said in his voice.

Q: I have submitted GNSS data to OP a few times. I receive a message that the data limit has been reached. I process 24 hr data on RTN stations at 30 second rates. I usually use vendor software to strip off everything except GPS. What are the file size limits for GNSS RINEX3 data? What is the best way to upload 80 marks for processing in OP? Is there a duration recommendation for data collection other than 24 hrs?

A: Perhaps the data files exceeded the 48 hour UTC crossing requirement Data files cannot not cross UTC midnight more than once. To upload multiple RINEX data to OPUS (presuming the antennas and ARP heights are identical for all files), OPUS will allow users to upload WinZIP compressed file format containing the RINEX data. Within OP there is a maximum number of marks allowed in one project (100 marks). If your project exceeds 100 marks it is advised to divide your project into multiple smaller projects. The default minimum data duration set within OP is two hours.

Q: A follow-up to the subsidence question with an emphasis in Louisiana. the CORS are typically founded with a deep foundation (Pilings) while subsidence is a summation of all downward movement up to the surface. How will this be addressed?

A: IFVM2022 will use multiple sources to model surface motion, though ultimately the goal of IFVM2022 is to model mark motion. The disconnect between motion at a CORS and motion of the surface in which passive control are set is just one of the many problems with using this data, but until NGS has SAR data in IFVM2022, such errors will need to be handled on a case-by-case basis.

Q: Some districts of the U.S Army Corps of Engineers continue to use NAD27/NGVD29. Any way NGS could mandate them to update to current and future datums.

A: Office of Management and Budget (OMB) Circular A-16 does state the requirement for Federal civilian agencies to utilize the NSRS for all geospatial activities so this mandate exists. Federal products that still employ superseded datums are typically employing some type of justified exception language based on lack of access to more recent realizations of the NSRS or to transformation tools. In the modernized NSRS, access will be more consistent nationwide (not heavily reliant on passive control) and transformation tools will lower the barriers that once existed to efficiently transitioning data such that these exceptions will no longer be valid. *[Also answered verbally during the webinar]*

Q: For Dan Gillins, in his presentation did he say all time are "GPS times" or "GNSS times". I may have misheard, I have GPS, Huw

A: All times are in GPS time for the GVX file format.

Q: Daniel Gillins.. How can we QC of GPS data or Calibrate for QA and do we need multiple Bench Marks for quality and reliable vector velocity?

A: It's difficult to answer this question because it depends on the project requirements. I'll just say that it's always a best practice to have more than one control point for any survey project. Ideally, you should tie your GNSS surveys to the CORS, as they are excellent control points. So, I

would recommend trying to at least 3 CORS for every project, and taking a repeat, independent GNSS measurement on every mark in your survey as a means for checking repeatability in the solutions and minimizing mistakes.

Q: Are there any plans to accept PPP solutions into OPUS or OPUS-Projects or otherwise incorporate PPP?

A: All current and planned versions of OPUS are based on differential positioning. No current plans to incorporate PPP as *observations*. However, OPUS 6 will be flexible with what *constraints* a user enters into the adjustment. If a user wishes to use a PPP-based coordinate on a point as a constraint that should be allowed (though it is not likely to be an “OPUS recommendation”, at least until NGS has more PPP experience).

Q: With more frequencies included (aka multi constellation and M-PAGES) how is the new OPUS position algorithm adapted from the historic, double differenced, position estimation solution.

A: M-PAGES will introduce an all-new processing algorithm where a single-difference approach is utilized requiring the estimation of receiver clock biases. Many traditional processing techniques will remain however, including use of the iono-free linear combination. [*Also answered verbally during the webinar*]

Q: In remote areas, far from CORS stations, is OPUS accuracy comparable to accuracy from subscription services like Trimble RTX (RTX claims ~2cm accuracy globally)?

A: NGS has never performed a direct test of this. However distance to a CORS tends to be substantially less important than time on mark.

Q: Could you explain how GVX differs from SINEX?

A: GVX is written in XML and contains numerous modern types of metadata associated with RTK/RTN vectors such as NTRIP settings, IP addresses, IP ports, etc. On the other hand, SINEX is an ASCII file format that has not been adopted widely by industry. I realize that SINEX is often used by the scientific community (and it can carry differential vector components), but I am not aware of any GNSS receiver that can output RTK/RTN vectors and their associated metadata directly in SINEX format.

Q: When you convert data files into rinex 3.02 which 'file' are you supposed to upload of the 3 files that are 'converted'?

A: RINEX3.xx consists of three file types: an observation file, a navigation file, and a meteorological file. For OPUS processing, you should upload the observation file (often ending in .yyo or .yyd where yy is the year the data was collected).