2019
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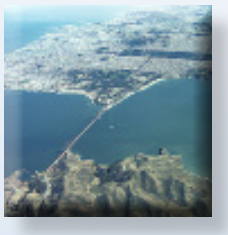
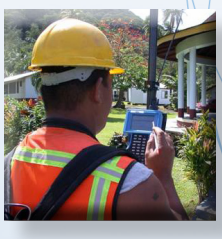
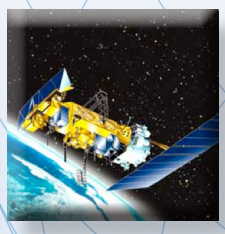
National Geodetic Survey

Strategic Plan

2019–2023

Positioning America for the Future




National Oceanic and Atmospheric Administration • National Geodetic Survey

The National Geodetic Survey

Strategic Plan 2019–2023

Positioning America for the Future

"However beautiful the strategy, you should occasionally look at the results."

~Sir Winston Churchill

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Executive Summary

Mission

To define, maintain, and provide access to the National Spatial Reference System (NSRS) to meet our nation's economic, social, and environmental needs.

Vision

Everyone accurately knows where they are and where other things are at all times and in all places!

Goal 1: Support the Users of the National Spatial Reference System.

Goal 1 is an **operational** goal focused on the good work the National Geodetic Survey (NGS) currently performs through our organization's *operational* products and activities. Should a product be incomplete, under development, or otherwise be non-operational, that product is *not* a part of Goal 1.

Objective 1: "Bluebooking and Datasheets"

Maintain our capability of ingesting internal and external survey data, analyzing and storing those data, and returning useful information to the public.

NGS intends to maintain our current capability of ingesting Global Navigation Satellite Systems (GNSS) and leveling surveys through "Bluebooking" in the same manner we have employed since 2012. Improvements are being developed for future implementation; however, the Bluebooking process as it exists in 2019 will not be interrupted while improvements are being developed. After its "re-invention," Bluebooking will be maintained in its new form.

Objective 2: "Coastal Mapping"

Maintain annual production of the Coastal Mapping Program.

NGS' Coastal Mapping Program (CMP) is responsible for defining the official National Shoreline and providing the nearshore bathymetry depicted on National Oceanic and Atmospheric Administration (NOAA) nautical charts. This bathymetric data provides critical baseline data for updating nautical charts; defining our nation's territorial limits, including the Exclusive Economic Zone; and managing our coastal resources.

NGS' CMP also supports NOAA's homeland security and emergency response requirements by both acquiring and rapidly disseminating a variety of spatially- referenced datasets to federal, state, and local government agencies, as well as the general public.

Objective 3: "Airport Surveys"

Maintain the operational capacity of airport surveying to support airport infrastructure.

The remote sensing and field operations expertise required to fulfill congressional mandates is well illustrated in NGS' Aeronautical Survey Program (ASP). Aeronautical surveys provide critical information regarding airport features, obstructions, and aids to navigation. We will continue to maintain our internal ability to perform these surveys.

Objective 4: "Field Operations"

Maintain our capacity and capability to perform geodetic surveying operations.

Historically, NGS has maintained field crews to perform critical survey work, such as leveling, GNSS surveys, gravity surveys, coastal mapping, and more. Today, however, fewer field crews are required to perform surveys. Nevertheless—and as measurement technologies continue to evolve—it remains critical for us to retain the capacity and expertise to perform these surveys in-house. NGS employees are the resource and authority for many surveying activities, and, therefore, we must fully understand the associated fieldwork procedures.

Objective 5: "Online Tools"

Maintain the online tools to allow users to access the NSRS.

The most up-to-date information on geodetic coordinates is derived using active control stations, otherwise known as 'Continuously Operating Reference Stations' (CORS). Many NGS software tools, such as the Online Positioning User Service (OPUS), make use of GNSS data derived from the CORS Network and can provide users with timely access to the NSRS. While improvements are made to the CORS Network and OPUS, all basic functions will continue to be maintained.

Goal 2: Modernize and Improve the National Spatial Reference System.

Goal 2 addresses our **projects** as agents of change for the better. The focus of Goal 2 is to improve our activities under the three categories of **starting** new work, **improving** existing work, and **retiring** outdated work. Each of the objectives under this goal will result in changes to existing NGS operations.

Objective 1: "Replace NAD 83"

Define and provide access to four geocentric, time-dependent, terrestrial reference frames (TRFs) by year 2022.

The North American Datum of 1983 (NAD 83) —in both its definition, as well as in the services we provide so users may access it—will be improved. Improvements can be combined into one overarching objective to upgrade products and tools over the next 10 years, while preparing for the ultimate replacement of NAD 83 with true geocentric reference frames.

Objective 2: "Replace NAVD 88"

Define and provide access to a geocentric, time-dependent, geopotential datum by year 2022.

The North American Vertical Datum of 1988 (NAVD 88) is also in need of updating In this regard, we will continue to collect airborne gravity data through our Gravity for the Redefinition of the American Vertical Datum (GRAV-D) Project, support Height Modernization, and work across agencies to connect important data.

Objective 3: "Re-invent Bluebooking"

Increase our ability to efficiently and accurately solicit, accept, process, store, report, and reprocess all survey data. Accomplish this while maintaining the standards of quality expected by external users.

The era of expanding the passive control network has come to an end. Passive control stations are expensive to maintain, and surveys merely provide a static snapshot in time. NGS will build models and tools for the future that allow users to easily see and understand all existing information—both historic and current—for a given survey mark. In the future, the OPUS suite of tools will be completed and expanded to carry the weight and authority previously maintained by Bluebooking.

Objective 4: "Repair the Toolkit"

Continually increase the use of commercially available software, the usefulness of all NGS products and services, and the interoperability of NGS software with commercial software.

We intend to properly evaluate the tools we provide to the public. In particular, we will establish a method for simplifying and modernizing the NGS toolkit and thus revitalize it into a more effective, user-friendly,

and scientifically accurate product for the nation. Future NGS products and services will be broadened beyond the dissemination of coordinates to include accuracy, velocity, and other useful geodetic control metadata. Similar functions will be packaged together as single easy-to use tools, such as by combining all coordinate conversions and transformations in the NGS Coordinate Conversion and Transformation Tool (NCAT).

Objective 5: "Better Surveying"

Continually improve the efficiency and accuracy of geospatial data-collection methodologies.

NGS will engage in a renewed effort to perform field-surveying research, to update geodetic surveying manuals to the latest technologies, and to verify the manuals with scientific fact. We will re-invest in creating surveying standards that better integrate with the new models and tools we will be developing, and this effort will result in more accurate positioning and measurement procedures.

Goal 3: Expand the National Spatial Reference System Stakeholder Base through Partnerships, Education, and Outreach.

Goal 3 addresses outreach to the **public**: both current NSRS users and others who would greatly benefit by engaging with NGS. The focus of Goal 3 is to reach new stakeholders, provide training and education to existing stakeholders, and improve our ability to meet our mission through the participation of outside experts.

Objective 1: "Align RTNs"

Provide Real-time Network (RTN) operators with a process they can use to check whether their RTNs are aligned to the NSRS. This alignment process should be accomplished by 2022 and should be performed using NGS-approved standards.

NGS' responsibility includes providing "access to the NSRS," and with the expected growth of RTN use, we will engage the RTN user community in the development of a methodology for understanding how their derived coordinates are consistent with the NSRS. Note, however, that to derive coordinates in the NSRS, these coordinates will necessarily need to be processed using our OPUS suite of tools (Objective 2-3).

Objective 2: "Stakeholder Engagement and Dynamic Web Presence"

Improve stakeholder engagement, improve NGS response mechanisms, and increase the number of stakeholder communities we directly educate or with whom we engage.

NGS has a long history of engagement with other related federal and state agencies. We will increase our partnerships and engagements with many of these organizations to ensure their adoption of an improved NSRS is successful. We also intend to reach an even broader audience via a more user-friendly web presence, and we will engage in improved communications and outreach to increase the public's understanding of geodesy. Our NGS Testing and Training Center (TTC) has provided training to non-traditional customers in the past, but our primary concern has been on geospatial professionals focused on high accuracy, rather than the general public. By reaching a wider community of users while utilizing the same tax dollars as those used to support our basic mission, we will greatly increase the efficiency of dollars spent.

Objective 3: "University Engagement"

Annually increase the number of collaborations between NGS and universities as a means of solving research problems and addressing other NGS mission needs over the next three years.

Graduate students, when mentored by professors, can be a significant resource in aiding and augmenting the research completed by established professionals. Additionally, every interaction and collaboration we have with a

university has the potential of bringing new hires to our agency. Regardless of the type of collaboration—whether it be by providing grants, engaging students as collaborators on NGS research activities, encouraging our employees to pursue advanced degrees, or by our employees teaching seminars at universities—we should increase such collaborations over the next few years and then focus on maintaining them indefinitely.

Objective 4: "Regional Outreach"

Annually increase stakeholder engagement through the Regional Advisor Program, with a combination of advice, outreach, education, and training.

Our NGS "Regional Geodetic Advisor Program" provides expert guidance and assistance to constituents who manage the geodetic component of geospatial activities tied to the NSRS. Our geodetic advisors are subject matter experts in geodesy and regional geodetic issues, and they collaborate internally across NGS and the NOAA to further the missions of their constituents' organizations. This program consists of a cadre of 14 advisors, all well-trained and dynamic educators, and each advisor is capable of serving multi-state regions.

Objective 5: "Educational Portfolio"

Maintain and continue to develop the online educational portfolio, and ensure the existing material is updated at least every five years.

NGS will continue to organize our overall "educational toolkit" to ensure information is easy to find, up to date, easy to use, and is regularly monitored. Initial steps must be geared towards improving the field manuals we use and provide to the public. Eventually, all materials will be available on the NGS website for teachers and professors to use in the classroom.

Objective 6: "IOCM"

Increase the use of data obtained through, and provided to, the Integrated Ocean and Coastal Mapping Program (i.e., "Map once, use many times"). Also, increase the number of users of these data.

Recognizing the availability and multiple uses of ocean and coastal geospatial data, in 2007 NOAA implemented the Integrated Ocean and Coastal Mapping (IOCM) program. The IOCM program's mission is to plan, acquire, integrate, and disseminate ocean and coastal geospatial data and derivative products in a manner permitting easy access and use by the greatest range of users, thus, "Map once, use many times." Indeed these data have many uses and stakeholders beyond nautical chart applications, and NGS has embraced the IOCM program. We will continue to broaden the useable products derived from the CMP, as well as leverage IOCM partner data for use in CMP products, without expending significant additional resources.

Goal 4: Develop and Enable a Workforce with a Supportive Environment.

Goal 4 is centered around our **employees**, current and future, who enable us to fulfill our mission. This goal is focused on ensuring we have the most qualified workforce available and that we employ experts across many fields. Additionally, this goal aims to see our existing employees are well-trained and are inspired to perform better so as to allow us to meet our mission over the long term.

Objective 1: "Educated Workforce"

Annually increase the scientific and technical knowledge, as well as the capabilities, of NGS' workforce.

Whereas it is true fewer students today are graduating with science degrees in geodesy or remote sensing, it is imperative NGS employees have knowledge of the finer geospatial details involved in our daily operations. To provide this background, we will use a combination of employee-led educational classes, lunchtime "Lunch and Learn" webinars, long-term training opportunities, guest lecturers invited to provide

talks to broaden the agency's geodetic knowledge, as well as other helpful programs. Such activities will not only make certain our employees' educational necessities are being met, but they will also better allow our entire workforce to become engaged in planning for NGS' future and in ensuring a non-hostile work environment exists for our employees.

Objective 2: "Recruitment and Retention"

Make it a priority over the next three years to align our workforce with our mission.

NGS has experienced significant difficulty in systematically hiring new staff to fill important gaps in our workforce. Without a singular effort to recruit and retain new talent, we will inevitably encounter problems in successfully fulfilling our mission. Since 2010, we have been focusing on reshaping our workforce to address critical skill gaps. Our hiring decisions required us to study our current roster of allocated job series and then strategically reshape the roster to select job series that will better move us into the future. Roughly half of our NGS workforce is now eligible for retirement. As we continue to focus on recruiting and retaining new talent, we will reduce this demographic to ensure we have a workforce to match our future needs and fulfill our mission requirements. NGS plans to use every tool in the allowable government personnel toolbox to recruit, hire, and retain a broad spectrum of new employees.

Objective 3: "Institutional Knowledge"

Achieve succession planning.

NGS will institute a policy of documenting our operating procedures to capture institutional knowledge and store vital information. This knowledge will be made accessible and shared via mentoring opportunities and on-the-job training by employees prior to their retirement. This process will allow new employees to be prepared to perform our critical positions with continuity. Retiring employees with critical institutional knowledge shall be interviewed and shadowed, and their skills and expertise will be captured and distributed to those employees positioned to take their place. An investigation into the institutional knowledge NGS has lost due to retiring staff, and recognition of such knowledge that can and should be resurrected, should also be pursued.

Goal 5: Enterprise Goal: Improve Organizational and Administrative Functionality.

All the above-mentioned goals require that our organization operates efficiently and effectively, in a safe workplace environment, and with well-functioning equipment. Goal 5 acknowledges that some significant improvements, and therefore taxpayer savings, may be gained by improving day-to-day operations and behind-the-scenes work. Goal 5 is focused on assisting those in management and personnel support roles, so they may conduct office operations, respond to needs within NOAA, and comply with guidelines and partnerships across the government effectively and efficiently.

Objective 1: "Information Technology Support"

Continually improve Information Technology (IT) infrastructure.

NGS has experienced varied success with regard to our IT infrastructure. Whereas personal computers are replaced on a regular cycle, too little attention is paid to a long-term view of our IT requirements. We will evaluate the existing state of our IT requirements and explore alternative approaches such as cloud computing. From these evaluations, we will prepare a budget on a "must-pay" basis.

Objective 2: "Socio-Economic Awareness"

Engage in an analysis of the socio-economic benefits of our products and services on a 10-year cycle as a means of updating and improving our knowledge base and evaluating the benefits of our programs.

Offices are required to perform program evaluations on a recurring basis. Such evaluation carries the very real benefits of self-reflection, which leads to improved services and more efficient use of tax dollars.

Objective 3: "Records Management"

Improve the management of NGS records.
In 2011, NGS began a process of ensuring stricter compliance with federal and NOAA-specific records-retention guidelines. We thoughtfully and purposely evaluated our records and publications and deleted duplications and those documents that had been kept in excess of their approved retention periods. This process shall be ongoing to ensure NGS will be fully organized, efficient, and in compliance with all federal guidance.

Objective 4: "Facilities"

Improve the functionality of NGS-owned facilities through facility condition assessments and by committing resources to the findings.
NGS will assess changes in staffing levels, priorities, and space needs/functionality, and we will marry such changes with the results of a Facility Condition Assessment (FCA), in order to make informed decisions regarding where to commit appropriate resources. Our first priority will always be the safety of our employees. Our second priority will be to ensure our employees are working in properly functioning facilities designed to meet our mission requirements.

Mission

To define, maintain, and provide access to the National Spatial Reference System to meet our nation's economic, social, and environmental needs.

As recognized by the Office of Management and Budget's (OMB) Circular A-16 and the Geospatial Data Act, the National Spatial Reference System (NSRS) underpins all data and metadata associated with the National Spatial Data Infrastructure (NSDI). To understand the mission of the National Geodetic Survey (NGS), it is critical to understand the historical context and existing National Spatial Reference System. Also key to our mission are the forthcoming international agreements that will necessitate changes to both the definition of the NSRS and how it is accessed by users.

Through a heritage tracing back more than 200 years, NGS' mission and that of our predecessor organizations has revolved around the establishment of geospatial control, access to that control, and the standards required to achieve the greatest certainty of accuracy from the measurements utilizing that geospatial control. Our mission is variously derived from congressional acts, executive orders, and National Research Council (NRC) studies and now has a clearer mandate from an international perspective through the United Nations.

NGS defines the NSRS as the official federal government reference system that allows a user to determine geodetic coordinates (for, but not limited to, latitude, longitude, height, scale, gravity, and orientation) and know with certainty that consistency is being maintained among all federal civilian maps in the nation. The NSRS also encompasses the official National Shoreline of the United States, and it is the foundation for all surveying, mapping, charting, and positioning activities in the United States and its territories. All activities—from hydrographic mapping, which allows commerce to flow through U.S. ports; to subsidence monitoring, which informs communities of changing vulnerabilities due to local flooding; to environmental monitoring used in restoration—must be built upon an extremely accurate NSRS.

NGS defines the current realization of the NSRS and its various components through many activities. We determine region-specific datums, or reference frames, for North America and the Pacific and Mariana Islands. These datums define latitude, longitude, and height for the entire nation in both a simplified geometric reference frame and a more complicated physical height datum.

The geometric reference frame is a mathematical representation of Earth as an ellipsoid. This ellipsoidal reference system can easily be accessed using Global Navigation Satellite System (GNSS) technology. However, physical or "orthometric" heights are more desirable, because they are directly related to Earth's gravity field and are more closely tied to mean sea level.

The determination of mean sea level is critical for programs including coastal floodplain management, emergency response activities, and evacuation route planning, just to name a few. NGS also defines geoid height models, which connect GNSS-derived ellipsoidal heights to physically-defined orthometric heights on the ground. Additionally, we define the National Shoreline used by the National Oceanic and Atmospheric Administration (NOAA) and other agencies in their products.

To maintain the NSRS, we regularly update all these elements: the ellipsoidal reference frame (geometric coordinates), the orthometric datum (physical heights), geoid height models, and the National Shoreline. We do this as technology improves, thus enabling improvements in the accuracy of our products and services. Earth is dynamic, and NGS must track temporal changes to the defining points of the NSRS to continually maintain the accuracy of the NSRS. Without continuous maintenance, the NSRS would soon become obsolete.

NGS currently provides access to the NSRS through more than one million passive geodetic control marks with published (but generally unmonitored) coordinates. We provide guidelines and specifications via an online toolkit to enable stakeholders to properly access and utilize the NSRS.

Whereas previous NSRS updates were primarily focused on realizing a slightly improved version of the same datums, the future NSRS will rely more on GNSS observations processed via online tools. By achieving the greatest accuracy and precision possible, the future NSRS will meet the needs of those users requiring the very highest level of accuracy. To achieve this goal, the GNSS-derived components will be aligned to an International Terrestrial Reference Frame (ITRF), as defined by the International Association of Geodesy (IAG). The IAG, a scientific non-governmental organization dedicated to developing the most rigorous scientific models, has developed many such models over the years and has well-demonstrated their utility, accuracy, and precision.

The United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) mandated the adoption of a Global Geodetic Reference Frame (GGRF). The UN-GGIM has clarified this to mean the adoption of the IAG's ITRF models, as well as a forthcoming International Height Reference Frame (IHRF). (Please refer to the section on Justification for further details.) The United States was a leading proponent of, and signatory to, this mandate, which justifies the evolution of NGS' mission to adopt both the ITRF and IHRF. The ITRF is well defined, however the IHRF has been broadly interpreted to mean a physical datum aligned with global satellite gravity field models.

"Goal 2: Modernize and Improve the NSRS" in this document addresses the adoption of the ITRF- and IHRF-based systems. Primary access will be through precise GNSS orbits and "active control," the Continuously Operating Reference Station (CORS) Network. Users will access the NSRS through the CORS Network by connecting their own GNSS surveys to the CORS Network using tools such as NGS' Online Positioning User Service (OPUS). These tools will provide an improved and simplified interface for processing positional data for multiple applications. Coordination with private enterprise geodetic vendors will facilitate a seamless transition between government and commercial sectors. The more historical and increasingly secondary form of access will be via the more than 1,000,000 passive geodetic control marks with published (but generally unmonitored) coordinates. Regardless of the method of access, NGS has written and continues to write guidelines and specifications that, along with our online toolkit, provide the tools and knowledge stakeholders need to access and properly utilize the NSRS.

Through our mission, NGS directly supports many activities, including geodesy, surveying, remote sensing, mapping, and charting. We also indirectly support many other scientific undertakings. In fulfilling our above-stated mission, NGS will provide the latest geospatial foundation to compliment today's technology, thus enabling world-class positioning services for the U.S. community.

Vision

Everyone accurately knows where they are and where other things are at all times and in all places!

Today, with smartphones, GNSS-enabled cars, and other GNSS-enabled electronics, it may seem as though the above vision of the future is already a reality. However, the accuracy of these devices, as well as their interoperability—or how well the myriad types of data involved align with one another—are what distinguish today's devices from the world NGS envisions for tomorrow. The function of the NSRS is to provide a consistent coordinate system, the foundation of all current and emerging geosptial technologies in the United States and its territories. Providing positions and elevations of the highest accuracies meets the full-spectrum of positioning needs for any user within the country, from the scientist requiring critical positioning data to the everyday citizen.

When mapping floodplains, monitoring sea-level change, or landing a plane in low visibility, even centimeter differences in accuracy can be crucial. Through diligent work in fulfilling our mission, NGS strives to support a world where everyone knows their own position, as well as the position of other things and their relationship to each other, not merely "generally," but accurately.

Strategic Plan Versus Ten-Year Plan

This document updates the 2013-2023 NGS Ten-Year Strategic Plan, and it also supersedes previous NGS strategic plans.

Many of the objectives and tasks identified in our previous strategic plan have been updated. We are also identifying tasks in each goal for follow-on analysis and implementation.

In this Strategic Plan, the concern of Goal 1 is to maintain the **existing NSRS**. Goal 2 in this plan will continue to develop the **new** NSRS that will be put in place in year 2022. Subsequently, Goals 3, 4, and 5 will provide operational support to Goals 1 and 2 of this Strategic Plan.

***After* year 2022,** we will be developing a **new** Strategic Plan. In that plan, again, the maintenance of the completed Terrestrial Reference Frames and the North American Geopotential Datum will be handled by Goal 1. Goal 1 tasks will also be used to access superseded datums for purposes of continuity (backward compatibility). The new NSRS will be refined and updated with Goal 2, and Goal 2 will also be used to conduct research to meet emerging customer needs. Goals 3, 4, and 5 will continue to provide operational support to Goals 1 and 2.

Our first NGS Ten-Year Plan was penned in 2008, and it vigorously advanced the select projects we knew it could, and would, undertake in upcoming years. Specifically, the 2008 plan encompassed five technical improvements NGS intended to focus on to achieve our agency's vision, and we expected to revisit the 2008 Ten-Year Plan five years after its release. Indeed, we did revisit the plan, and we provided

an update in the form of the Ten-Year Plan 2013-2023. The 2013-2023 plan clarified some of the work from the earlier document and provided a mid-course correction to the goal of implementing the new NSRS in 2022. The updated plan was a more intrinsic strategic plan; a strategic plan designed to encompass both technological advances and a new strategic direction for our organization. This new 2019 Strategic Plan is replacing the Ten-Year Plan of 2013-2023, and in it we are focusing on the tasks necessary to implement the NSRS over the upcoming five years. Elements that had been in previous Ten-Year Plans, but are not required to achieve the goals laid out for 2022, will be retained as aspirational goals to potentially be achieved by, or after, 2022.

For a more detailed look at what NGS accomplished in the previous Strategic (e.g., Ten-Year Plans), please see Appendix A.

Justification of Objectives

NGS draws its mission and work from numerous executive orders, laws, and mandates, and the goals and objectives in this plan directly relate to these public requirements. NGS' goals also serve to further the science, service, and stewardship of NOAA as a whole. Indeed, the capabilities and the geodetic framework NGS provides through the NSRS play a crucial role in the success of almost all the goals and objectives held within NOAA's Strategic Plan. Direct mission-related objectives are drawn from language in Office of Management and Budget (OMB) circular "A-16," as well as from Executive Order 12906, or from the original legislation used to create NGS' predecessor agencies, the U.S. Coast and Geodetic Survey Act. NGS complies with additional OMB, Department of Commerce (DOC), and Congressional mandates, including the Air Commerce Act of 1926.

OMB A-16 mandated the formation of the Federal Geographic Data Committee (FGDC) as a means to coordinate all U.S. governmental activities related to geospatial information. Numerous subcommittees exist within the FGDC, and NGS leads the Federal Geodetic Control Subcommittee (FGCS). Geodetic Control is fundamental to all of NGS' work, and it also underpins all geospatial activities of the organizations comprising the FGDC.

The United States is a leading member of the UN-GGIM. The UN-GGIM has stipulated that all countries adopt a Global Geodetic Reference Frame (GGRF) to ensure standardized positioning of geospatial information. The effort to implement the GGRF is led by the United Nations SubCommittee on Geodesy (UN-GGIM SCoG).

The UN-GGIM functions internationally in much the same way the FGDC functions within the United States, in that the UN-GGIM provides a forum for defining a common geospatial format and its various applications. The FGCS, as a component of the FGDC, provides the control to underpin and coordinate all geospatial activities for the United States government. The FGCS performs many of the same activities as the UN GGIM SCoG.

The GGRF is planned for both three-dimensional coordinates realized through GNSS and physical heights defined above a nominal sea level. The GGRF will be realized by adoption of the International Association of Geodesy's (IAG) International Terrestrial Reference System (ITRS). Various realizations of the ITRS are generated periodically, with the most recent being the International Terrestrial Reference Frame of 2014 (ITRF14). Additionally, an International Height Reference Frame (IHRF) is being developed to provide a similar standard for orthometric heights.

Updates envisioned in this document will deliver an NSRS explicitly tied to the ITRF and IHRF, with improved user access for high-precision surveying and engineering work. Through collaboration with the UN-GGIM, common regional models will be available to better serve the interests and needs of the United States. NOAA forecasting will be improved through the use of a common reference framework for weather and ocean observations delivered from a broader source of inputs. Control of waterways by various international control boards along the U.S and Canadian borders will improve water management and safety-of-life applications.

As a scientific agency, many scientific requirements and processes must be met before the true mission-related work can begin. For example, in processing GNSS orbit data we determine the location of the satellites in the geometric frame, and this likewise enables us to derive positions on the ground in the same geometric frame. Positions on the ground are determined from the positions of the GNSS satellites, so clearly, accurate satellite orbits are necessary if accurate positions on the ground are to be obtained. This is an example of the background scientific process we must accomplish before our customers can access the NSRS to perform their work, and this is what we mean in our mission statement when we say we 'provide access.' Another example is evidenced in our monitoring the position and character of the National Shoreline to capture an accurate 'before' image for comparison with Emergency Response Imagery.

NGS must also internally maintain the personnel and infrastructure to ensure we continually have the necessary tools to meet our mission and further our scientific goals. Maintenance of infrastructure includes our collaboration with other federal and international entities, such as the National Aeronautics and Space Administration (NASA) and Natural Resources Canada (NRCan). In all aspects of our work, we strive to utilize tax dollars more efficiently and improve our service to the nation, and by leveraging common networks through collaborative involvement with other partners we are able to successfully move towards accomplishing this goal. All objectives in this plan strive for fiscal efficiency, however certain objectives—particularly several discussed in the enterprise goal—focus specifically on improving functionality and organization, enabling taxpayers to receive greater benefits from every dollar spent.

Implementation

Each of the five goals in this document supports the evolving requirements necessary to implement an updated NSRS. Each goal is then broken down into objectives., with each objective being assigned a designated "objective lead," an individual within NGS charged with the task of writing an objective implementation plan. The objective implementation plans will identify the resources needed, and the gaps that must be addressed, in order to accomplish the particular objective. The implementation plans shall also discuss specifics on how each plan will be executed and the steps for measuring the degree of progress made towards the plan's completion. Many of these objectives will require cross-divisional work, and the objective leads will be required to coordinate with numerous subject matter experts. For NGS programs encompassing a variety of objectives, implementation and project plans have been designed to fit the NGS-wide Strategic Plan.

Goal 1 represents the maintenance of ongoing operational support while new work to update and replace the NSRS is completed. **Goal 2** focuses on the research necessary to develop the new NSRS. Ultimately, our work from Goal 2 is designed to roll into Goal 1 and become the new and ongoing NSRS via a paradigm shift. **Goals 3, 4,** and **5** directly support and enable the efforts of Goals 1 and 2. Ultimately, Goal 1 will evolve, and Goals 3, 4, and 5 will continue; however, much of the work in developing the new NSRS will require further refinement and improvements. Hence, the goals envisioned here will continue beyond the 2022 implementation and will evolve to meet the new work that will be necessary to maintain the NSRS as specified in our NGS mission.

Goal 1
Support the Users of the National Spatial Reference System

Goal 1 is an **operational** goal focused on maintaining the good work NGS currently performs through our agency's *operational* products and activities. Should a product be incomplete, under development, or otherwise be non-operational, that product is *not* a part of Goal 1. By definition, Goal 1 acknowledges that the majority of NGS resources are dedicated to maintaining, rather than improving, existing operations.

Objective 1-1: Maintain our capability of ingesting internal and external survey data, analyzing and storing the data, and returning useful information to the public.

Nickname: Bluebooking and Datasheets

Description: For many years, NGS has employed a complex and rigorous process to ensure quality survey data are being used to compute various geodetic quantities on passive control survey marks. Most of this geodetic control information is reported on one of NGS' primary products, the "datasheet." Specifications describing the format for submitted survey data were originally published by the FGCS of the FGDC, under the title "Input Formats and Specifications of the National Geodetic Survey Data Base." That particular document was historically published with a blue cover, hence the process of submitting survey data came to be referred to as "Bluebooking." A great deal more than the mere *bluebook* comprises this objective, however. To properly ingest data, accurate orbits must exist, GNSS antennas and level rods must be calibrated, least squares adjustment software must exist, a network of CORS must be monitored, and an up-to-date datasheet creation program must be maintained, just to name a few of the procedures that must be followed. NGS is exploring a new data delivery system that will eventually be programmed into OPUS to enable users to customize their data output.

With Objective 1-1, NGS intends to maintain our current ability to ingest GNSS and leveling surveys through "Bluebooking" in the same manner we have employed since the 1980s. This process, however, is in need of an update, and those updates are covered in Objective 2-3. Once the improvements have been made, this objective will continue to be met. After its "re-invention," Bluebooking will be maintained in its new form. Objective 1-1 addresses the fact that the Bluebooking process as it exists in 2019 will not be interrupted while improvements are being developed.

Activities to advance this objective:

- Accept from our users all complete GNSS Bluebook-formatted projects, evaluate those projects, adjust them to the latest realization of NAD 83, and then load appropriate projects into

the NGS Integrated Database (IDB) within (an annual median timespan of) six weeks from the time of receipt.

- Accept from our users all complete Bluebook-formatted geodetic leveling projects, evaluate those projects and adjust them to the latest realization of NAVD 88 (or comparable official vertical datums, e.g., PRVD02), and load appropriate projects into the IDB within (an annual median timespan of) six weeks from the time of receipt.

- Serve as an International GNSS Service (IGS) Analysis Center, and perform orbit determination for at least one GNSS on a continuing basis.

- Contribute to the global tracking network used by the IGS Analysis Centers.

- Continually maintain the operational delivery of datasheets and other currently available NGS geospatial products.

Examples of evidence of progress:

- The annual median delay in loading GNSS projects is never greater than six weeks.

- There are daily orbit computations.

- Time-dependent functionality is maintained, such as the Horizontal Time-Dependent Positioning (HTDP) program (or its successor).

- Online Bluebooking capability has been created through OPUS.

Objective 1-2: Maintain annual production of the Coastal Mapping Program.

Nickname: Coastal Mapping

Description: The National Geodetic Survey's Coastal Mapping Program (CMP) is responsible for defining the official National Shoreline of the United States and providing the nearshore bathymetry depicted on NOAA nautical charts. This bathymetric data provides critical baseline data for updating nautical charts; defining our nation's territorial limits, including the Exclusive Economic Zone; and managing our coastal resources.

NGS' CMP also supports NOAA's homeland security and emergency response requirements by both acquiring and rapidly disseminating a variety of spatially-referenced datasets to federal, state, and local government agencies, as well as to the general public. We provide the tools, technology, and expertise in a timely and efficient manner during an emergency response effort, and data are promptly disseminated to aid emergency managers in developing recovery strategies and providing damage assessment through comparison of before-and-after imagery. Imagery collected to support emergency response also allows evacuees see images of their homes and neighborhoods, often before being allowed back to their communities.

The Coastal Mapping Program contributes to our nation's economy by supporting scores of industries and services, including maritime trade and transportation, coastal and marine planning, coastal engineering and construction, scientific research, and the insurance industry. Our CMP is key in enhancing our global competitiveness and allowing the United States to more efficiently manage our resources.

Activities to advance this objective:

- Conduct coastal mapping to meet NOAA's annual charting requirements for shoreline and nearshore bathymetry.

- Update the shoreline and nearshore bathymetry in ports to meet NOAA's annual charting requirements.

- Maintain the Coast and Shoreline Change Analysis Program (CSCAP).

- Conduct Emergency Response Imagery (ERI) missions to meet NOAA requirements, and continue to develop our emergency response capabilities to meet national interests.

- Create a NOAA CMP survey priorities plan, and update the plan annually to maintain its alignment with NOAA's Office of Coast Survey and other interests, as appropriate.
- Maintain VDatum (datum conversion tool).

Examples of evidence of progress:

- Shoreline and nearshore bathymetry is delivered annually, as per NOAA nautical charting requirements.
- The required number of ports with updated shoreline and nearshore bathymetry meets NOAA nautical charting requirements and has been delivered.
- Annual evaluations of priority ports for coast and shoreline change are used to update NOAA nautical charts.
- Timely, near real-time geo-referenced imagery is provided in the wake of natural or human-induced disasters to meet NOAA requirements or when tasked by the appropriate federal partners.

Objective 1-3: Maintain the operational capacity of airport surveying to support airport infrastructure.

Nickname: Airport Surveys

Description: The remote sensing and field operations expertise required to fulfill congressional mandates is well illustrated in NGS' Aeronautical Survey Program (ASP). Our ASP provides the position, height, and orientation information necessary to ensure safe navigation, and also provides the quality assurance if these data are collected by private surveyors. Aeronautical surveys provide critical information regarding airport features, obstructions, and aids to navigation. The Federal Aviation Administration (FAA) uses our ASP information to establish instrument approach and departure procedures, determine takeoff weights, and update aeronautical publications. This information is also used for airport planning and construction studies. NGS' ASP also supports the FAA by developing standards and guidance documents for conducting aeronautical surveys.

Activities to advance this objective:

- Provide quality assurance for commercially conducted surveys.
- Provide routine support, training, and outreach to ASP partners and commercial surveyors.
- Annually conduct remote sensing studies to verify obstacles in the FAA Obstacle Repository System, and provide improved accuracies for obstacles.
- Complete aeronautical surveys to maintain NGS' core capability and expertise.

Examples of evidence of progress:

- Our ASP yearly deliverables for the FAA have been met.
- Out-year funding and requirements have been identified.

Objective 1-4: Maintain our capacity and capability to perform geodetic surveying operations.

Nickname: Field Operations

Description: Historically, NGS has maintained field crews to perform critical survey work, including leveling, GNSS, and gravity surveys; coastal mapping; and more. Whereas it is true fewer field crews are required to perform such surveys today, it nonetheless remains critical that we continue to maintain the capacity and expertise to perform these surveys in-house. This is a particularly necessary requirement as measurement technologies continue to evolve. NGS employees are the resource and authority for many surveying activities, and therefore we must fully understand the associated fieldwork

procedures to properly quality-check data, assess the work of partners, write field standards and guidelines, integrate new technologies into current survey practices and procedures, and undertake foundational surveys. Our employees also provide technical support and training to private surveyors who perform these various types of surveys.

Activities to advance this objective:

- Perform routine geodetic surveys and training in coastal and wetland environments, thereby providing scientific research and monitoring programs with sufficient access to the NSRS.
- Plan and implement geodetic surveys requiring highly accurate data and field logistics.
- Provide annual training for all personnel involved in surveys.
- Maintain expertise in gravity measurement and processing methods.
- Maintain the Table Mountain Geophysical Observatory (TMGO) site and the instruments housed there, and train employees in the use of those instruments for continuity of operations.
- Maintain the capabilities at NGS' Woodford, Virginia, Testing and Training Center (TTC) to calibrate GNSS antennas, as well as the cooperative Electronic Distance Measuring Instrument (EDMI) Calibration Base Lines.

Examples of evidence of progress:

- New survey, evaluation methods, and workflows are developed.
- The number of surveys reviewed and added to the NGS database are being tracked

Objective 1-5: Maintain the online tools to allow users to access the NSRS.

Nickname: Online Tools

Description: The most up-to-date information on geodetic coordinates is derived using active control stations, or CORS. Many NGS software tools, such as OPUS, make use of GNSS data derived from the CORS Network and can provide users with timely access to the NSRS. Although the CORS Network has many uses, including control for Bluebooking (see Objective 1-1), their maintenance and monitoring, as well as the use of the OPUS software suite, are included in this objective. The Leveling Online Computation User Service (LOCUS) will be replaced by OPUS for Leveling, a tool planned for development prior to year 2022 as part of our 'OPUS for Everything' suite. The improvements for the CORS Network and OPUS are subsequently described in Objectives 2-1, 2-2, and 2-3.

Activities to advance this objective:

- ITRF and NAD 83 coordinates are computed for each CORS on a daily basis.
- Within two months of receipt, multi-frequency geodetic-quality GPS antennas are calibrated, and calibration data are published in accordance with IGS standards.
- Dual-frequency GNSS submissions to OPUS are accepted from outside users, and results are processed and returned within 15 minutes of receipt for 95 percent of all submissions.

Examples of evidence of progress:

- NGS receives positive status reports and web transaction logs of the CORS Network and OPUS.
- Coordinate time series plots for all stations in the CORS Network are available to the public online.

- There is no decline in the monthly counts of OPUS solutions.
- NGS is rewriting the current GPS-only processing engine to utilize all GNSS in view and allow it to be more easily maintained in the future.
- The NGS antenna calibration database and website are kept up to date with the most recent calibrations provided by NGS and IGS.
- Multiple methods for accessing and displaying geodetic control information (e.g., Datasheets, Datasheet shapefiles, Data Explorer, CORS data, Datasheet and shapefile archives) are maintained.

Goal 2
Modernize and Improve the National Spatial Reference System

Goal 2 concerns our **projects** as agents of change for the better. The focus of Goal 2 is to improve our activities under the three categories of **starting** new work, **improving** existing work, and **retiring** outdated work. Each of the objectives under this goal will result in changes to existing NGS operations.

Objective 2-1: Define and provide access to four geocentric, time-dependent, terrestrial reference frames (TRFs) by year 2022.

Nickname: Replace NAD 83.

Description: NAD 83—both its definition and the services we provide to access it—needs to be improved. By definition, NAD 83 is non-geocentric by over two meters, and has non-zero, residual plate velocities, despite NGS' best attempt in the 1980s to originally define it as "geocentric" and "plate fixed." Since the mid-1990s, NAD 83 has been defined through our relationship to the ITRF of the International Earth Rotation and Reference System Service (IERS). The ITRF itself is realized through the analysis of data from four primary space-geodesy observation networks: Very Long Baseline Interferometry (VLBI), Satellite Laser Ranging (SLR), GNSS, and Doppler Orbitography and Radio Positioning Integrated by Satellite (DORIS). Our reliance on the ITRF makes it our duty as an agency to contribute to its upkeep, as well. However, the running of VLBI and SLR stations by the U.S. Government is currently a National Aeronautics and Space Administration (NASA) function. NGS' contribution to the ITRF has been to restart the IERS Site Survey program (ISS) and to act as both an orbit analysis center and an antenna calibration center for the International GNSS Service (IGS)—the GNSS arm of the ITRF. NGS can and will do much more in the future, however. Poor geographic coverage of the U.S. IGS-tracking network has caused us to propose the establishment of new GNSS stations as suitable IGS fiducial stations. Together, these new stations will form the Foundation CORS Network (a subset of the CORS Network), with a total of approximately 36 stations making up the Foundation CORS Network when the set is complete. Additionally, the remainder of the CORS Network will be addressed with an eye to ensuring those sites integrally align to the ITRF and provide access for users.

Improvements in all these areas can be combined into this one overarching objective to improve tools over the next 10 years, while preparing for the ultimate replacement of NAD 83 with a true geocentric reference frame.

Activities to advance this objective:

- Define the requirements of the Foundation CORS Network, and establish Memoranda of Understanding (MOUs) to transfer existing stations to NGS.
- Conduct one IERS local terrestrial site survey each year in perpetuity.
- Define the relationship between the four new TRFs and the IGS frame.
- Provide a deformational Intra-Frame Velocity Model (IFVM) for each of the four new TRFs.
- Develop a modernized version of the State Plane Coordinate System (SPCS) compatible with the new TRFs.

Examples of evidence of progress:

- The number of stations in the Foundation CORS Network increases.
- Documents exist that define the relationship between the IGS frames, the four Terrestrial Reference Frames (TRFs), and the IFVM.
- The broader CORS Network is integrated into the NSRS.

Accomplishments between 2013 and 2018:

- NGS and Canada agree on the name and general structure of NATRF2022.
- Blueprint for 2022, Part 1—
Geometric coordinates are written, outlining the following decisions:

  There will be four (global) National TRFs, each named for one tectonic plate.
  NATRF: North American Terrestrial Reference Frame
  CATRF: Caribbean Terrestrial Reference Frame
  PATRF: Pacific Terrestrial Reference Frame
  MATRF: Mariana Terrestrial Reference Frame

  Each frame will be tied to the ITRF using one set of Euler Pole Parameters (EPP), and an Intra-Frame Velocity Model will capture all non-EPP motion in three dimensions.

- **NGS adopts the following decisions:**
A densified ITRF2014 frame will be the underlying frame for the four TRFs.

  The primary epoch of the four TRFs will be 2020.00, and subsidiary epochs will be defined every five years.

- **In preparation for the State Plane Coordinate System of 2022 (SPCS2022):**
The report "The State Plane Coordinate System: History, Policy, and Future Directions," *NOAA Special Publication NOS NGS 13,* is published, and draft SPCS2022 Policy and Procedures documents are released for public comment (with comments received as of August 2018).
- **The initial Foundation CORS plan is established:**

  Prospective sites, partnerships, and costs to implement Foundation CORS have been identified, and

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  Discussions with IAG are complete regarding ties between FCRS and ITRF models.

Objective 2-2: Define and provide access to a geocentric, time-dependent, geopotential datum by year 2022.

Nickname: Replace NAVD 88.

Description: Improvement of NAVD 88 is also due. By definition, NAVD 88 has a bias of half a meter with a one-meter tilt, relative to the best-known geoid model. For access, users must often rely on passive control with heights that may be decades old. Vertical motion is not tracked in a systematic fashion, although the existence of vertical motion has been known for decades.

To improve these issues, NGS will continue our efforts to collect airborne gravity data through our Gravity for the Redefinition of the American Vertical Datum (GRAV-D) Project.

We will also support Height Modernization and work across agencies to connect important data. We will define a geocentric time-dependent geopotential datum capable of describing orthometric heights, dynamic heights, geoid undulations, deflections of the vertical, and other aspects of the gravity field at any location on or near Earth's surface. Of specific interest to our stakeholders, the vertical datum will be primarily accessed through GNSS and an accurate geoid model, rather than through the publication of heights on passive geodetic bench marks, although a database of time-dependent heights on such marks will be available for public access. Furthermore, NGS will develop a comprehensive strategy for incorporating past and future leveling data into a GNSS/geoid-based vertical datum, including a connection between the new geoid-based vertical datum and the update to the International Great Lakes Datum (IGLD) in 2025. This guidance will be provided to our stakeholders.

Related to all the above work, we must ensure an actual connection to the NSRS and charting data. The National Tidal Reference Service (NTRS), used for oceanographic charts created by NOAA's Office of the Coast Survey (OCS), is maintained through the National Water Level Observation Network (NWLON) of NOAA's Center for Operational Oceanographic Products and Services (CO-OPS). We will work with these agencies to use GNSS technology to track vertical motion of tide gauges and water level gauges on the Great Lakes to maintain the accurate connection between the NSRS and charts.

Activities to advance this objective:

- Annually compute and publish a gravimetric geoid model for U.S. territories using all available gravity sources, until 2021.
- Develop and implement a process for monitoring temporal geoid changes.
- Write new leveling procedures for working in a geoid/GNSS based geopotential datum.

Examples of evidence of progress:

- The GRAV-D percentage of flights flown meets the Government Performance and Results Act (GPRA) standard.
- Documents exist (e.g., Blueprint Part 2) that define the geopotential datum.
- A new leveling manual exists that outlines the role of leveling in a geoid/GNSS-based geopotential datum.

Accomplishments between 2013 and 2018:

- We are in agreement with Canada and Mexico on the name and general structure of the North American-Pacific Geopotential Datum of 2022 (NAPGD2022).
- Geopotential coordinates are written for our Blueprint for 2022, Part 2, outlining the following decisions:

  Build the entire datum upon a global spherical harmonic model of Earth's external gravity potential.

  Define three areas—the North American-Pacific, Guam and the Commonwealth of the Northern Mariana Islands (CNMI), and American Samoa—covering the derived products of the geoid, Deflection of Vertical (DoV), Digital Elevation Model (DEM), and surface gravity.

  All elements will have time-dependency.
- NGS adopts decisions:
  The primary epoch of NAPGD2022 will be 2020.00.

  Subsidiary epochs will be defined every five years.

Objective 2-3: Increase our ability to efficiently and accurately solicit, accept, process, store, report, and reprocess all survey data. Accomplish this while maintaining the standards of quality expected by external users.

Nickname: Re-invent Bluebooking.

Description: Prior to the 1980s and the rise of GPS to define, maintain, and provide access to the NSRS, NGS field parties generally received and stored data to provide static, definitive coordinates on passive control. With the completion of the original NAD 83 and NAVD 88 projects and the increase of easy-to-use GPS equipment to provide geodetic quality surveys to a broader population, we began accepting external survey data. The acceptance of external survey data also served to expand or update the static definitive coordinates on the NSRS' passive control network.

As first mentioned in the 2008-2018 NGS Ten-Year Plan, the era of expanding the passive control network to provide a static coordinate on a point is coming to an end. Yet, there are other (real, critical, and possibly legal) reasons for surveying passive control bench marks. Some of these reasons include monitoring vertical motion of critical infrastructure, such as levees; providing a local network to recreate active stations, such as tide stations and stations within the CORS Network in the event of their failure; and providing an updated starting point coordinate to allow the start of a non-GNSS survey (such as in leveling or classical surveying).

In 2012, NGS debated, and as a matter of policy decided, to continue receiving survey data from outside parties. This decision came with the understanding that the purpose of such surveys is not to expand the passive control of the NSRS using the same "most-recent-coordinate-wins" business model. Rather, the tools we will build for the future will allow users to easily see and understand all existing information on a point, both historical and recent, including the estimation of a point's motion into the past or future. If, under the current business model, "Bluebooking" refers to the way survey data is entered into the NGS IDB, then "Bluebooking" must be "reinvented."

There are reasons for surveying passive control marks, but the tools NGS will build for the future will allow users to easily see and understand all existing information—both historical and current—for a given survey point. In the future, tools such as OPUS-Database (OPUS-DB) and OPUS Projects will be completed to carry the weight and authority previously maintained by Bluebooking.

For the NSRS of the future, NGS will have a single portal for all survey data submissions, no matter how small, large, or of what methodology. To accomplish this, OPUS Projects will be significantly expanded and improved upon to work with all possible GNSS surveys—of any duration, any number of marks, and using any GNSS-based technology—as well as leveling, gravity (relative and absolute) and classical surveys (e.g., the OPUS suite of tools).

Activities to advance this objective:

- A new NSRS Database (DB) is built, and it is capable of storing all data relevant to NGS' mission.
- NGS will have organized all GNSS holdings of the IDB. Additionally, we will have re-processed at least the Federal Base Networks (FBNs) into IGS 14, and we will have stored them in the NSRS DB.

Examples of evidence of progress:

- The entire GNSS archive at NGS is categorized, stored, and readily accessible in a geodatabase.
- A modern format (e.g., XML or JSON) of the NGS datasheet replaces the current datasheet.

- OPUS-Projects is expanded to include vector data from RTN observations.

Accomplishments between 2013 and 2018:

- A prototype NSRS DB exists, and progress has been made on loading, storing, and viewing:
  - Data from the CORS Network,
  - Airborne gravity, and
  - Historic GPS surveys archived in the existing NGS DB.
- OPUS Projects was expanded to make it a viable portal for traditional Bluebooking.
- OPUS Projects for Real-time Networks (RTN) has a build team and progress is underway.
- *NOAA Technical Manual (TM) NOS NGS 74,* released May 2018, outlines the adjustment protocol for adjusting leveling data to GNSS/geoid-based orthometric heights.
- Historic GPS data is actively being investigated. Estimates are gathered on the time required to organize all 50- to 100- thousand occupations in our holdings. Organizing is in preparation for re-processing and storage of these occupations in the NSRS DB.

Objective 2-4: Continually increase the use of commercially available software, the usefulness of all NGS products and services, and the interoperability of NGS software with commercial software.

Nickname: Repair the Toolkit.

Description: In 2012, NGS had more than 800 computer programs in our toolkit. Many of those 800 programs were obsolete, and only a small number of them were publicly available. Most of the programs had been written decades earlier in response to a particular need, without special consideration of overlap with other programs. This lack of concern for overlap created a situation that led to two basic difficulties.

The first difficulty is that our employees do much of their work in command-line mode, rather than with the aid of commercially available geospatial software, such as is used in Geographic Information Systems (GIS). The failure to adopt commercial software means many tools our agency has written are not specifically geared for the large, ever-growing field of GIS-literate geospatial professionals.

The second difficulty is that there has been little to no consistency between related programs. For example, VDatum, NADCON, VERTCON, and INTG—all official NGS products—interpolate data from a grid using different interpolation methods from one-another. This inconsistency creates systematic errors when comparing data from the various products.

NGS intends to properly evaluate the tools we provide to the public. We will establish a program to create consistency, and we will modernize and effectively clean up the toolkit, making it a more user-friendly and scientifically accurate product for the nation. Future NGS products and services should be broadened beyond the dissemination of coordinates to include accuracy, velocity, and other useful geodetic control metadata.

Activities to advance this objective:

- Evaluate NGS' entire online suite of programs, and develop a prioritized plan for continuing, repairing, or retiring each program in the suite.
- Provide complete coverage of VDatum for the entire United States.
- Ensure transformations between datums are freely available, as well as transparent and consistent with the most recent global standards.

■ Update NADCON and VERTCON software so they may be quickly executed with the release of the four TRFs and the geopotential datum.

Examples of evidence of progress:

■ VDatum, GEOCON, NADCON, VERTCON, and HTDP are rolled into a single comprehensive transformation tool.

■ The use of GIS-licensed software increases, and there are more GIS-trained employees.

Accomplishments between 2013 and 2018:

■ NADCON software was completely rebuilt from scratch, tested against existing NADCON grids, and used to create NADCON 5. NADCON 5 now replaces all older versions of NADCON and GEOCON.

■ VERTCON software is three-quarters built, also completely from scratch.

■ NCAT was built, incorporating six different pieces of NGS software, including NADCON 5.

■ In deference to established user groups with specific needs, a decision was made to keep VDatum and NCAT as unique applications with different audience-targeted interfaces, yet with identical:

Code for overlapping functions (as with NADCON), and

Support for data transfer (I/O), including data formats, web services, ability to be downloaded, and language.

■ A prioritized list was created for all major toolkit functions requiring attention. This effort will lead to a comprehensive overhaul and improvement of the toolkit.

Objective 2-5: Continually improve the efficiency and accuracy of geospatial data-collection methodologies.

Nickname: Better Surveying

Description: Originally, the only surveyors providing NGS with data to create the NSRS were our own surveyors; NGS employed the nation's geodetic surveying experts. Over time, and particularly as local users densified the passive control network using leveling or GNSS, the field of geodetic surveying grew. NGS' role as the nation's sole source of geodetic control diminished as our stakeholders increasingly relied on the CORS Network and other privately- and publicly-owned GNSS networks.

The above situation is viewed as untenable, as "access to the NSRS" (an integral part of our NGS mission) includes providing instructions to users on the best field procedures. For this reason, NGS will engage in a renewed effort to perform field-surveying research, to update geodetic surveying manuals to the latest technologies, and to verify the manuals with scientific fact. That is, NGS will re-invest in creating surveying *standards,* not mere guidelines. Active research into cutting-edge or existing technologies for new purposes will also be an important key to improved surveying in NGS.

Activities to advance this objective:

■ Replace *Guidelines for Establishing GPS-Derived Ellipsoid Heights (Standards: 2 Centimeter and 5 Centimeter) Version 4.3 (NOS NGS 58)* with new best practices guidance for using GNSS to obtain ellipsoid heights.

■ Write new standard field procedures for NGS-conducted GNSS, leveling, gravity, and transit surveys (including airports).

■ Through implementation of the NGS IERS Site Survey (ISS) program, contribute to future realizations of the IGS frame and ITRF by conducting an annual local IERS site survey.

Actively participate in the IERS site survey and co-location working group

- Research new surveying technologies and techniques with the potential of improving the production cycle without increasing costs.

Examples of evidence of progress:

- *NOS NGS 58* is replaced with new manuals based on scientific studies.
- A prioritized field surveying research plan exists.
- A new leveling manual is written.
- A new gravity survey manual is written.

Accomplishments between 2013 and 2018:

- An update was released in November 2015 to our document, *Geodetic Leveling (NOS NGS 3)* Chapter Four for "River or Valley Crossing Procedures for Theodolite Instruments."
- Field research was conducted at our NGS Testing and Training Center to support the use of leveling in a GNSS/geoid-based vertical datum.
- An update to *NOS NGS 58* is underway.

Goal 3

Expand the National Spatial Reference System Stakeholder Base through Partnerships, Education, and Outreach

Goal 3 concerns the **public**—current NSRS users and those who would greatly benefit by engaging with NGS. The focus of Goal 3 is for us to reach new stakeholders, provide training and education to existing stakeholders, and improve our ability to meet our mission by participating with outside experts. Objectives under this goal demonstrate how we plan to engage with the public and how we respond to and meet existing stakeholder needs. In many cases, the objectives and activities pursued under this goal will be performed on a continual basis, rather than on a set timeline. Continued and regular involvement will help ensure our ability to meet with an ever-growing number of users, as well as improve our relationship with our existing stakeholders.

Objective 3-1: Provide RTN operators with a process they can use to check whether their RTNs are aligned to the NSRS. This process should be performed using NGS-approved standards.

Nickname: Align RTNs

Description: Real-Time Reference Networks (RTNs) are providing a fast and efficient method for users, particularly the surveying community, to utilize GNSS to obtain nearly instantaneous centimeter positioning, thus eliminating the need for additional equipment and post-processing of their data. NGS recognizes that a large and growing number of users in the positioning community rely on RTNs. Most RTNs are capable of expressing NSRS coordinates, however RTN operators have no mechanism for checking whether such coordinates are consistent with the NSRS, nor to what degree of accuracy. Additionally, it is important that data from *different* RTNs can be compared with one another through the NSRS. The NSRS provides the **common reference frame** for comparing all RTNs, and it provides a means to check the level of confidence on how well systems on one RTN might work with a different RTN (interoperability).

It is our responsibility at NGS to provide "access to the NSRS." With the expected growth of RTN use, we will engage the RTN user community in the development of a methodology for understanding how their derived coordinates are consistent with the NSRS.

Activities to advance this objective:

- By March 2019, define and make operational a first-generation tool for RTN operators. The tool will allow operators to check whether their RTNs are aligned to the NSRS and are within an acceptable tolerance. This tool will likewise enable users of an RTN to understand how well their coordinates also align. However, these

coordinates are not considered a part of the NSRS unless the Rover vectors are processed through the OPUS suite of tools being developed in Objective 2-3.

- Host an RTN symposium.
- Host at least one webinar regarding the RTN alignment service.
- Revise and release a new version of NGS' *Guidelines for Real-Time GNSS Network Operators.*
- A new *Accessing the NSRS Through RTNs* user manual is written.
- RTN alignment accuracies are posted on our website.
- Coordinate train-the-trainer sessions, particularly involving our regional advisers, as a means of disseminating information, conducting training, and developing standards for tools and models being developed in Goal 2. This is to be done pursuant to developing a new NSRS in 2022.

Examples of evidence of progress:

- RTN operators routinely meet with NGS.
- Feedback from RTN operators and users will be used to update NGS' *Guidelines for Real-Time GNSS Network Operators.*
- Manuals are completed.
- A tool is available on the NGS website for RTN operators.
- An NGS web page is available for RTN users to check RTN alignment accuracies.

Accomplishments between 2013 and 2018:

- We have completed both an inventory of available nationwide RTNs and a draft website.
- NGS attends regular meetings with RTN operators from state departments of transportation, and we have frequent interaction with other RTN operators.
- A process for checking RTN alignment with the NSRS has been defined.

Objective 3-2: Improve stakeholder engagement, improve NGS response mechanisms, and increase the number of stakeholder communities we directly educate or with whom we engage.

Nickname: Stakeholder Engagement and Dynamic Web Presence

Description: As the global community becomes more "geospatially enabled"—consider the number of electronic gadgets we carry, each utilizing some form of GNSS-enabled technology—the potential stakeholder base for our products and services increases rapidly. Unfortunately, the potential for misunderstanding and misuse of such geospatial data grows with increased use.

Over the years, NGS has engaged with many other agencies, including the U.S. Army Corps of Engineers (USACE), the National Geospatial-Intelligence Agency (NGA), the U.S. Geological Survey (USGS), the Federal Emergency Management Agency (FEMA), as well as Bureaus of Land Management and state agencies that utilize geodetic information. Considering the vast number of changes proposed in this plan, NGS will increase partnerships and engagements with these and other agencies to ensure they meet with success in their adoption of an improved NSRS.

To address issues such as those described above, we intend to reach a broader audience via a more user-friendly web presence, as well as improved communications and outreach to increase the public's understanding of geodesy. Our NGS TTC has provided training to non-traditional customers in the past, with a focus on high-accuracy geospatial professionals,

rather than the general public. By reaching an even broader community of users with the same tax dollars used to support our mission, we will increase the efficiency of dollars spent.

Activities to advance this objective:

- Host stakeholder meetings or 'summits' to brief stakeholders on changes to NGS products and services and to receive feedback from users.
- Engage with key stakeholder associations, such as the Management Association for Private Photogrammetric Surveyors (MAPPS), the National Association of Counties (NACo), the National States Geographic Information Council (NSGIC), the National Society of Professional Surveyors (NSPS), and the American Association for Geodetic Surveying (AAGS). Continued engagement with these organizations through meetings and other interactions will help us build long-term relationships with their constituents.
- Participate in conferences held by our partners.
- Solicit feedback on NGS' products, policies, and procedures.
- Develop a plan to engage with academia, the private sector, and other government agencies (federal, municipal, state, and tribal).
- Develop a formal plan to leverage NGS' "commemorative mark" program for outreach and education by promoting commemorative monuments in high-visibility locations. Locations such as national park visitor centers will serve to educate the public on our products and services.
- Build capacity within the user community to inform users of NGS activities, products, and services through training classes and workshop efforts.
- Implement a "Web Content Management" system for the NGS website.
- Investigate social media options (such as Facebook, Instagram, or Reddit), and leverage corporate NOAA social media accounts. By utilizing social media portals, we can broaden awareness of our NSRS modernization efforts to surveyors, engineers, and other audiences.
- Provide regular updates regarding new or changing NGS products, services, and publications (e.g., via the use of Granicus or other news release mechanism).
- Engage with media during annual nationwide events, such as National Surveyors Week and GIS/Geography Day events.

Examples of evidence of progress:

- Satisfaction of website visitors is high, as measured via a customer satisfaction review service (e.g. Foresee Results).
- NGS has converted our high-traffic static web pages to the "Word Press" Web Content Management System.
- We have created a photo library of NGS activities and events to aid and improve the development of our presentations and outreach materials.
- NGS has a library of 100 Frequently Asked Questions (FAQs) from the public.
- NGS continues to increase the number of subscription email lists year after year.
- To reach the widest possible audience, our most popular static-content pages are in plain language and are directed to a grade level nine or lower.

Accomplishments between 2013 and 2018:

- NGS developed and implemented a tiered "request" queue for all public queries titled "One Voice." One Voice allowed us to track and respond to stakeholder inquiries with input from NGS subject matter experts.

- NGS held Geospatial Summits in 2010, 2015, and 2017. The summits prepared the user community for the replacement of NAVD 88 and NAD 83 datums and the introduction of a new gravity-based vertical reference system.

- NGS held an Industry Workshop and webinar in 2018. Commercial equipment and software representatives participated to discuss their needs and concerns regarding the NSRS modernization.

- As measured through our Foresee Website Customer Satisfaction Survey, the NGS website annual satisfaction score was consistently above the mean satisfaction score for participating government websites. Our website also exceeded a score of "80" in 2013, 2014, 2015, and 2017. Foresee considers this score to be the threshold of excellence in customer satisfaction.

- We updated and maintained "News" subscription email lists, with more than 1,500 subscribers, and we emailed news to constituents via this mechanism approximately one to two times per month.

- We developed new web content focused on new or infrequent web visitors.

- We created new "pop-up" banners, posters, and "rack cards" to provide updated outreach materials consistent with both our current NGS brand and our organizational priorities.

- We used Federal Register Notices to acquire feedback on draft policies and procedures for the Calibration Baseline Program and State Plane Coordinate System.

- Established quarterly meetings were held with the NSPS and AAGS.

- The NGS GPS on Bench Marks program was successfully created to build customer engagement and awareness.

- Absolute gravimeter comparisons were conducted at TMGO in 2014, 2016, and 2018 with various federal and foreign agencies and one private company.

Objective 3-3: Annually increase the number of collaborations between NGS and universities as a means of solving research problems and addressing other NGS mission needs over the next three years.

Nickname: University Engagement

Description: University research groups can become a significant resource to augment research completed by paid professionals, and every interaction or collaboration we have with a university has the potential of bringing new hires to our agency.

Regardless of the type of collaboration—whether by providing grants, encouraging our employees to pursue advanced degrees, or by our employees teaching seminars at universities—these collaborations should increase over the next few years and subsequently be maintained indefinitely.

Activities to advance this objective:

- NGS office personnel and geodetic advisors will work with at least four American universities each year to present a one-hour college-level seminar. The seminar shall discuss a topic such as: the upcoming new datums, NGS research, cooperative NGS field projects, or an overview of NGS activities.

- To develop and maintain NGS core capability, we will provide direct and indirect support to academic institutions with geodetic, surveying, and remote sensing programs.

- We will build and leverage interagency and academic partnerships (such as with the Joint Airborne Light Detection and Ranging Bathymetry Technical Center of Expertise and the University of New Hampshire/Joint Hydrographic Center, etc.).

- We will increase collaborative research with universities.

Examples of evidence of progress:

- Graduate students are working on NGS research problems.
- NGS employees are engaged in long-term training opportunities.
- NGS materials are routinely used in an ever-growing number of academic courses and in the continuing education programs of professional organizations.
- NGS has ongoing research grants with multiple universities.
- Our NGS regional geodetic advisors regularly work with universities in their areas to provide seminars on topics such as: the upcoming new geometric and geopotential datums, GPS theory, processing data with OPUS-Projects, participating in the national GPS-on-Bench Marks Campaign, Digital Leveling, etc.

Accomplishments between 2013 and 2018:

- An FY17 research grant titled "Towards Optimizing the Determination of Accurate Heights using GNSS" analyzed 24 GNSS test projects in OPUS Projects and assisted in the development of new guidelines similar to those in *NGS-58*.
- An FY18 grant titled "New generation, multi-GNSS Processing Capability for NGS" researched multi-GNSS algorithms and created preprocessing and point positioning software in C++.
- Airborne Topobathymetric Lidar (TBL) returns must be integrated into NOAA's hydrographic surveying and charting workflows, and Total Propagated Uncertainty (TPU) models are needed to generate uncertainties in accordance with international standards. In FY18, NGS worked with partners to research these models.
- NGS Regional Geodetic Advisors visited more than 20 universities in FY17 and FY18 to provide seminars on a wide variety of geodetic topics.
- NGS hosted Hollings Scholars in both FY17 and FY18, thus enhancing our future hiring prospects by influencing undergraduate students to consider NGS as a career opportunity.
- NGS offices in Silver Spring hosted research presentations, such as the use of GPS for water levels.
- NGS personnel in Boulder, Colorado, are working with partners to perform leveling and gravity surveys at two atomic clock laboratories.
- NGS has collaborated with more than 14 international universities regarding the Geoid Slope Validation Survey of 2017 (GSVS17), GRAV-D, and the 1-centimeter Geoid Comparison (IAG WG 2.2.2).
- Oregon State University performed research and submitted four reports on GNSS-derived heights (one each in 2015 and 2017 and two in 2018).
- Ohio State University performed data analysis and submitted a report on GNSS-derived heights (2015).
- NGS participated in a surveying and geomatics conference held at California State Polytechnic University, Pomona, (2018) in collaboration with the Utility Engineering and Surveying Institute (UESI) of the American Society of Civil Engineers (ASCE).

Objective 3-4: Annually increase stakeholder engagement through the Regional Advisor Program, with a combination of advice, outreach, education, and training.

Nickname: Regional Outreach

Description: The NGS regional geodetic advisors provide expert guidance and assistance to

constituents who manage the geodetic component of geospatial activities tied to the NSRS. Our geodetic advisors are subject matter experts in geodesy and regional geodetic issues, and they collaborate internally across NGS and NOAA to further the missions of their constituents' organizations. The program consists of a cadre of 14 advisors, all well-trained and dynamic educators, each capable of serving multi-state regions.

Activities to advance this objective:

- Regional advisors provide train-the-trainer opportunities in NGS-related core topics, such as new datums, NGS Strategic Plan objectives, and OPUS.
- Advisors establish and maintain contact with new and existing constituents through participation in regional and state conferences, committee/work group meetings, constituent training on geodetic topics, and personal interaction.
- Advisors assist NGS' Information Center by responding to constituent queries. Additionally, they review and provide feedback for beta product versions, as well as initial releases and updates of NGS products.
- Advisors participate in research and analysis of geodetic activities in their respective regions, and they support priority requirements and deliverables of NGS activities and projects.

Examples of evidence of progress:

- Yearly, regional advisors provide training in all states. For the purpose of this milestone, both webinar and "in person" attendees are included.
- Advisors broadly participate in NGS field campaigns and support other activities to advance NGS strategic objectives.
- The Regional Geodetic Advisor Program has a consistent and current web presence, with contact information readily available.
- Our NGS regional geodetic advisors regularly work with universities in their areas to provide seminars on topics such as: the upcoming new geometric and geopotential datums, GPS theory, processing data with OPUS-Projects, participating in the national GPS-on-Bench Marks Campaign, Digital Leveling, etc.

Accomplishments between 2013 and 2018:

- In 2016, NGS completed the transition from a primarily state geodetic advisor program, covering only 24 participating states, to a new regional advisor program comprised of 14 regions covering all the United States, the territories, and Washington, D.C.
- NGS has encouraged the states to participate in the State Geodetic Coordinator Program, with the result being a substantial growth in the number of states and territories that now have state coordinators.
- In 2018, NGS commissioned an independent socio-economic scoping study on the benefits of our regional advisor program. The study, conducted by ARCBridge Consulting of Herndon, Virginia, estimates the 2018 annual total benefits of our program to be between $18.6 and $38.7 million.

Objective 3-5: Maintain and continue to develop the online educational portfolio, and ensure the existing material is updated at least every five years.

Nickname: Educational Portfolio

Description: We have dedicated ourselves to providing training and educational outreach to NSRS users through the creation of our NGS Testing and Training Center. We have taken the further step of organizing our outreach presentation materials into an easy-to-use

website. With these formative steps in mind, we will continue to organize our overall "educational toolkit" to ensure information is easy to find, up to date, easy to use, and is regularly monitored.

Initial steps must be geared towards improving the field manuals we use and provide to the public. These "learn-by-doing" manuals are excellent tools for teaching users how to accurately access the NSRS. Eventually all materials, including those geared from the elementary school level onward, will be available on the NGS website for teachers and professors to use in the classroom.

NGS should also engage professional surveying organizations to help us design and assess the content of our field manuals to ensure their value meets the expectations of geospatial professionals.

The NGS TTC has provided training to non-traditional customers such as environmental scientists in the past; however, our primary focus has been on geospatial professionals interested in high accuracy. We should reach out to a broader spectrum of the geospatially-enabled public, by offering a fundamental course on geodesy to GIS professionals, for example.

Activities to advance this objective:

- Design a form of training—a manual or tutorial (online or otherwise)—for each of NGS' core operational products and services.
- Develop new educational learning modules.
- Develop curriculum and training materials on geodetic topics.
- Support current and potential users of the NSRS through both web-based and classroom training opportunities.
- Host a regular webinar series to educate users on NGS products and services.

Examples of evidence of progress:

- Seminars or webinars on new datums are created and regularly delivered.
- Web-based training modules on core geodetic topics have been created and are available.
- Manuals or tutorials exist for core NGS operational products and/or services.
- The number of attendees at TTC classes and NGS webinars has increased.

Accomplishments between 2013 and 2018:

- NGS has developed 12 educational videos on basic geodetic topics since 2014.
- NGS has developed four comprehensive online lessons, including quizzes and course completion certificates.
- In collaboration with NSPS, we have developed a legislative template for states to use when replacing NAD 83-specific laws.
- Since 2014, NGS has provided OPUS Projects training to 3,041 stakeholders through 176 in-person or virtual events.
- Since June 2015, we have held 368 NGS Webinar series programs, hosting over 6,650 attendees.
- We have updated and maintained "training" and "webinar" subscription email lists, with more than 1,500 subscribers. We regularly email these constituents once or twice a month.

Objective 3-6: Increase the use of data obtained through, and provided to, IOCM (i.e. "Map once, use many times."). Also, increase the number of users of these data.

Nickname: IOCM

Description: Recognizing the availability and multiple uses of ocean and coastal geospatial data, including uses for shoreline data and

other applications, in 2007, NOAA implemented the IOCM program. The mission of IOCM is to plan, acquire, integrate, and disseminate ocean and coastal geospatial data and derivative products in a manner permitting easy access and use by the greatest range of users, thus, "Map once, use many times." NGS has embraced the IOCM program; indeed our CMP data have many uses and stakeholders beyond nautical chart applications. Users including other government agencies, as well as state, local, and public entities all along the nation's coastline take advantage of our CMP data. We will continue to broaden the useable products derived from the CMP, as well as leverage IOCM partner data for use in CMP products, without expending significant additional resources. This effort will represent a more efficient use of tax dollars in the spirit and methodology of "Map once, use many times."

Activities to advance this objective:

- Embrace the National Coastal Mapping Strategy as the interagency approach to the collection, processing, sharing, and dissemination of coastal geospatial data. This strategy will ensure continued coordination and standardization of operations, data collection, delivery standards, and stakeholder engagement.
- Continue IOCM requirements for the collection and delivery of topographic-bathymetric Lidar (Light Detection and Radar) used in updating NOAA Nautical Charts and for numerous environmental, modeling, and decision support needs in the coastal zone.
- Continue to develop the methodology and research to extract bathymetry from commercial satellite imagery to meet NOAA nautical charting requirements, including reconnaissance of uncharted regions and remote areas.
- Continue to promote the Continually Updated Shoreline Product (CUSP) as a new and separate product from the National Shoreline currently mapped by NGS.
- Continue to develop the methodology and application of small Unmanned Aerial Systems (sUAS) and small satellites for NGS and IOCM coastal mapping applications.
- As we continue to be a leader in IOCM, leverage this leadership role to align data providers with stakeholders.

Examples of evidence of progress:

- Topographic/bathymetric ("topo-bathy") elevation data continues to be reliably used for shoreline extraction and nearshore bathymetry as per NOAA and National Coastal Mapping Strategy standards.
- Small satellite coastal mapping data and sUAS are used for updating NOAA Nautical Charts. They are shared with the larger IOCM community through Digital Coast.
- National Shoreline and CUSP users and the numbers of our stakeholders continue to grow.

Accomplishments between 2013 and 2018:

- In 2017, NGS updated 287 Nautical Charts and 33 Electronic Navigation Charts with new shoreline and nearshore bathymetry.
- In 2017, 53 datasets of orthoimagery and 6 topobathy Lidar datasets for IOCM applications and the general public were available in Digital Coast (DC).
- NGS provided 6,677 of the 13,551 imagery requests to DC between Jan 2013 and March 2018.
- In 2017, NGS provided four datasets derived from satellite derived bathymetry to support NOAA Nautical Charting requests.

Goal 4
Develop and Enable a Workforce with a Supportive Environment

Goal 4 is about our **employees**, current and future, who enable NGS to fulfill our mission. This goal focuses on ensuring we have the most qualified workforce possible and that we employ experts in many fields. Additionally, this goal looks to see our existing employees are well trained and inspired to perform better so as to allow us to meet our mission over the long term. Each of the objectives under this goal aims to develop employees and the workforce at large to best meet the needs of NOAA and the nation. Goal 4 also attempts to instill best practices in the workforce so that projects, such as those undertaken to fulfill the preceding goals, can always be performed consistently.

Objective 4-1: Annually increase the scientific and technical knowledge, as well as the capabilities, of NGS' workforce.

Nickname: Educated Workforce

Description: It is true there are fewer students graduating with science degrees in geodesy or remote sensing today; however, it is imperative NGS employees have significant knowledge of the finer geospatial details involved in our daily operations. To provide this knowledge, we will use a combination of employee-led educational classes, lunchtime "Lunch and Learn" webinars, long-term training opportunities, and guest lecturers to broaden geodetic knowledge throughout our agency. As much as possible, given travel and training funding availability, NGS will support the professional development of our employees as a means of advancing our agency's mission.

Activities to advance this objective:

- Organize internal classroom training courses for NGS employees on both scientific, administrative, and management topics. Offer these courses in Silver Spring or through NGS' TTC. Increase the number of NGS employees actively involved in professional organizations.
- Develop a training plan and offer regular GIS training to NGS employees, and promote the increased use of GIS analysis and mapping tools within our organization.
- Provide rotational assignment opportunities both within and outside of NGS, and encourage employee participation in them as a means of enabling employees to share and gain knowledge of core function areas.
- Develop NGS orientation procedures for new employees.
- Have a clear policy for long-term training opportunities, and support those opportunities through an open and equitable process.

- As feasible, involve employees in 'tiger teams,' working groups, and committees, so they may contribute their viewpoints in the development of tools, guidelines, and policies.

- Ensure all employees are engaged in ongoing professional education. A well-educated workforce helps establish a more valuable, non-hostile work environment—an environment that maintains an open forum for discussion.

Examples of evidence of progress:

- An NGS-wide employee internal training plan exists.

- An increased number of rotational assignments are offered and filled.

- More NGS employees are using GIS software.

Accomplishments between 2013 and 2018:

- NGS has developed 12 educational videos on basic geodetic topic since 2014.

- NGS has developed four comprehensive online lessons, including quizzes and course completion certificates.

- In 2017, NGS surveyed employees and we developed a 2018 NGS Internal Training Plan. The plan provided six internal group training courses on a variety of topics, including Project Management and Managing Workforce Diversity.

- New SF-182 Request for Training Policy and Procedures documents were approved by the NGS Executive Steering Committee. The new documents provide a clearer understanding of the training request and approval process.

- Since January 2016, NGS has held over 50 lunchtime "Lunch and Learn" webinars for employees on a wide variety of administrative and technical topics.

- A series of 12 tutorial videos on OPUS Projects were recorded and posted to the NGS website, all easily accessible to NGS employees.

Objective 4-2: Make it a priority over the next three years to align our workforce with our mission.

Nickname: Recruitment and Retention

Description: NGS has experienced great difficulty in systematically hiring new staff to fill important gaps in our workforce. Without a singular effort to recruit and retain new talent, we will encounter problems in successfully fulfilling our mission.

Since 2010, we have been focusing on reshaping our workforce to address critical skill gaps. New hires have included recent graduates of geodesy programs to fill career ladder positions; professional administrative hires to ease the pressure of those in a scientific series from being required to perform administrative duties; and geodesy specialists, such as gravity and geoid scientists, specifically with an eye towards our future needs. These hiring decisions required us to study our current roster of allocated job series and then strategically reshape and design them to move us into the future.

Roughly half of our NGS workforce is eligible for retirement, and our workforce is currently maintaining this retirement-eligible demographic. As we continue to focus on recruiting and retaining new talent, we will alter and refine this demographic to ensure we have a workforce to match our future needs and fulfill our mission requirements. NGS plans to use every tool in the allowable government personnel toolbox to recruit, hire, and retain a broad spectrum of new employees.

Activities to advance this objective:

- Develop a hiring plan to include the positions we anticipate needing in the upcoming several years. Communicate our plans for anticipated hiring to NOAA leadership.

- Annually review and adjust our tactical hiring plan to anticipate and meet future critical skill requirements. Create an open

announcement for scientific series. Continue to share all open vacancy announcements with partner, stakeholder, college, and university contact lists.

- Target the Pathways Program as an ideal opportunity for entry level hiring (Band I and II) in critical positions.
- Continue our practice of following NOS diversity guidance for hiring panels, thus ensuring fair consideration of all candidates.
- Continue to encourage direct hire authority for geodetic positions.
- Engage in job fairs and other outreach opportunities. Create NGS orientation materials that outline the nature of our work.

Examples of evidence of progress:

- There is a reduction in the demographic ratio of retirement-eligible employees.
- Critical skills gaps are lessened, and critical vacancies are filled.
- Our position inventory matches the job series necessary to move NGS into the future.
- NGS divisions are engaged in strategically aligning our workforce to our agency's needs.
- An open announcement for NGS geodetic positions exists.
- Women and minorities are represented in the same demographic composition as the surrounding geographic area.
- Critical field positions have been filled.
- University students are applying for NGS position vacancies.

Accomplishments between 2013 and 2018:

- Four recent graduates came on board within the last year.
- A Pathways student came on board as a geographer.
- A geoid modeler came on board, and a second geoid modeler position is is expected to be forthcoming.
- An airborne scientist is now on board.
- Six new professional administrative positions are on board.
- A few GNSS researchers are now on board.
- Two CORS analysts are to be selected from the current certificate.
- The CORS Program Manager job series has been redefined, enabling us to now hire an eligible candidate under the proper series.
- A critical supervisory position was filled for the chief of the Spatial Reference System Division.

Objective 4-3: Achieve succession planning.

Nickname: Institutional Knowledge

Description: Many in our workforce have highly specialized knowledge derived from decades of expertise and experience across a variety of job series, both administrative and scientific. For many years, our subject matter experts have followed often-undocumented, NGS-specific methodologies that have made their knowledge difficult to share with new employees. Knowledge of past surveying techniques and specific relevant anecdotes from past adjustments are examples of experiences retiring or retired employees alone hold that will be lost if NGS does not act to create a knowledge repository. There is a critical need to immediately inventory and maintain the vast reservoir of institutional knowledge before it is lost forever.

In the finance, procurement, and human resources areas there are processes, procedures,

and systems that also remain undocumented. It is critical for this knowledge to be documented for future professional administrative employees.

We will institute a policy of documenting our operating procedures to make certain we capture institutional knowledge and store vital information. This knowledge will be made accessible and shared via mentoring opportunities and on-the-job training by employees prior to their retirement. In this way, new employees will be better prepared to perform our essential positions with continuity. Retiring employees with critical institutional knowledge shall be interviewed and shadowed, and their skills and expertise will be captured and distributed to those employees positioned to take their place. An investigation into the institutional knowledge NGS has lost due to retiring staff, and recognition of such knowledge that can and should be resurrected, should also be pursued.

Activities to advance this objective:

- Core capabilities are defined and targeted to allow thoughtful consideration of new hiring requirements.
- Critical field experience and technical knowledge is maintained within the organization by offering at a minimum one internal training/field experience per year, open to all employees.
- Succession planning is included in our tactical and strategic workforce planning.
- A core set of experts on various projects and programs is developed, including key points of contact.
- Career Development Plans are created.
- Formal exit interviews are established.
- Employees outside of the retirement-eligible demographic are assigned to shadow identified experts and assist with documenting critical institutional knowledge.

Examples of evidence of progress:

- A repository exists for reference.
- Employees are using the critical institutional knowledge captured in daily work and project assignments.
- Documented core capabilities exist and are accessible in the repository.

Goal 5
Enterprise Goal: Improve Organizational and Administrative Functionality.

All the above-mentioned goals require that we operate efficiently and effectively, in a safe workplace environment, and with well-functioning equipment. **Goal 5** acknowledges that some significant improvements, and therefore taxpayer savings, may be gained by improving our day-to-day operations and behind-the-scenes work. An effectively managed office is necessary for NGS to meet our mission. The objectives under Goal 5 are focused on assisting those in management and personnel support roles so they may conduct office operations, respond to needs within NOAA, and comply with guidelines and partnerships across the government effectively and efficiently.

Objective 5-1: Continually improve IT infrastructure.

Nickname: IT Support

Description: Information Technology advancement has occurred at a fast pace over the past few years and is expected to continue into the future. The cost of hardware, software, and professional services continues to increase year after year, and this puts a significant strain on budgets. Keeping up with the pace of new technology is vital, as existing infrastructure will soon be rendered obsolete. Through increased automation, productivity improvements, and consolidation efforts across NOS and NOAA, we will find ways to have our IT costs consume a manageable proportion of our overall budget.

Activities to advance this objective:

- All NGS computer systems are maintained in an operational capacity, resolving 90 percent of all problem issues within 24 hours, and 100 percent of all problem issues within 2 weeks.
- NGS' IT funding needs will be given important consideration in budget formulation.
- We will support data center consolidation efforts across NOS and NOAA to reduce redundant systems, processes, and labor.
- We will enable Continuity of Operations (COOP) for popular NGS products and services, such as OPUS and OPUS Projects.
- With the goal of reducing overall IT costs, we will transition certain processes, such as development, testing, on-demand processing, and COOP to the Cloud.
- We will invest in staff training to update the skills needed to implement and support newer technologies.

Examples of evidence of progress:

- Our annual IT budget is an integral part of the NGS planning cycle and is given a high priority.

- IT infrastructure architecture allows advancement of our mission at the lowest possible cost.
- Legacy systems are updated or replaced by newer, more modern systems.
- Project plans provide clearly identified computing and data storage needs, as well as long-term operational documentation.
- Hybrid cloud computing models combining on-premise and public cloud infrastructure are made available.
- Our field sites in Norfolk and Woodford, Virginia, are connected to corporate systems over a high-bandwidth, wide-area network.
- Wireless access at field sites is made available where applicable.

Objective 5-2: Engage in an analysis of the socio-economic benefits of our products and services on a 10-year cycle as a means of updating and improving our knowledge base and evaluating the benefits of our programs.

Nickname: Socio-Economic Awareness

Description: As part of the OMB and DOC mandates (as illustrated in the FY 2012 Budget: Analytical Perspectives), offices are required to perform program evaluations on a recurring basis. Part of this program evaluation is to analyze the socio-economic benefits of services offered to the nation. However, even if we were not mandated to do so, this objective carries the very real benefits of self-reflection, which leads to improved services and more efficient use of tax dollars.

At NGS, we have performed socio-economic studies on Height Modernization (1998), the CORS Network and GRAV-D (2009), the Coastal Mapping Program (2012), and the Regional Geodetic Advisor Program (2018). We have also participated in several other studies and evaluations, including the 2010 National Research Council study "Precise Geodetic Infrastructure: National Requirements for a Shared Resource." However, a comprehensive analysis of many other NGS products and services, including, for example, our Aeronautical Survey Program, has to date not been performed. We should periodically review and evaluate the socio-economic and cost benefits of our signature products and services, including proposals for new initiatives, such as the Foundation CORS Network. We will share our findings with the National Coordination Office, as they are also performing socio-economic research studies on GNSS.

Activities to advance this objective:

- A priority list of NGS products and services that could benefit from socio-economic analysis is developed.
- Socio-economic information relating to NGS products and services is gathered and made available to the public via our website.
- Socio-economic information and data is incorporated into NGS communications, press releases, budget formulation, and outreach activities.
- We work in conjunction with the NOAA Social Science Committee on social science needs assessments, as well as other activities that may promote the development of benefit analyses for NGS products and services.

Examples of evidence of progress:

- New socio-economic benefits studies (for example, on the NGS/FAA Aeronautical Survey Program) have been conducted and published.
- NGS has participated in at least one interagency study through the National Academies of Science or similar entity to investigate the socio-economic benefits of NGS products and services.

Accomplishments between 2013 and 2018:

- In 2018, we established a five-year Blanket Purchase Agreement (BPA) contract earmarked for NGS socioeconomic studies.
- In 2018, NGS commissioned an independent socio-economic scoping study on the benefits of our Regional Advisor Program. The study estimated 2018 annual total benefits of the program to be between $18.6 and $38.7 million.

Objective 5-3: Improve the management of NGS records.

Nickname: Records Management

Description: In 2011, NGS began a process of ensuring stricter compliance with federal and NOAA-specific records-retention guidelines. We did this by thoughtfully and purposely evaluating our records and publications, and removing duplications and those documents that had been kept in excess of their approved retention periods. Such work shall remain an ongoing process to ensure NGS will be fully organized, efficient, and in compliance with all federal records guidance. Towards this end, we will develop an official Records Management System (RMS) to include any necessary NGS-specific policies and procedures.

Activities to advance this objective:

- Ensure employees become familiar with NOAA records management guidance.
- Coordinate with the NOAA Records Officer to ensure compliance with federal mandates and NOAA policy.
- Leverage other program offices to take maximum advantage of their established record-management programs.
- Keep NGS's records schedules up-to-date as NGS activities and record keeping needs evolve.
- Frequently communicate with NGS employees regarding the Records Management System to ensure they have the necessary information to comply with requirements.
- Regularly schedule routine filing and clean-out days throughout the year.
- Ensure NGS data management plans are kept up to date.
- Develop an NGS internal records audit system to ensure compliance.

Examples of evidence of progress:

- Divisional file inventories are complete.
- Records schedules are complete.
- Points of contact have been established for those individuals who will receive additional records training, and they will provide RMS guidance to their respective divisions.
- An up-to-date record file plan is developed that follows NOAA guidance.
- Records Management' and 'Data Management' are terms we have defined for our organization. We have documented where these two concepts overlap and where they are distinct.
- Data management plans are up to date.
- NGS has a list of reference documents that dictate or substantially influence how we address records management and data management. Reference documents may include DOC/NOAA/National Ocean Service (NOS) guidance, as well as guidance from the National Archives.
- We have approved NGS Records Management System policies and procedures.

Objective 5-4: Improve the functionality of NGS-owned facilities through facility condition assessments and by committing resources to the findings.

Nickname: Facilities

Description: NGS owns three facilities and their associated properties outside of the Silver Spring area. Our Observation and Analysis Division (OAD) Field Operations Branch is housed in Norfolk, Virginia; our OAD Field Operations Branch/Survey Section B is housed in the "Table Mountain Field Site" in Longmont, Colorado; and our Geodetic Services Division (GSD) Instrumentation and Methodologies Branch is housed in the NGS TTC in Woodford, Virginia.

Facility condition assessments can address:

- Life safety deficiencies—improvements characterized as a life safety concern requiring immediate action;
- Deferred maintenance—items requiring correction within a one- to two-year timeframe, identified as Priority One, Priority Two, and local work items;
- Long-term capital expenditures; and
- Replacement values of real property.

NGS will assess changes in staffing levels, priorities, and space needs/functionality, and marry these with the results of the Facility Condition Assessment (FCA), so as to make informed decisions regarding committing the appropriate resources where needed. The first priority will always be the safety of our employees. The second priority will be to ensure our employees work in properly functioning facilities that meet our NGS mission.

Activities to advance this objective:

- We coordinated with NOS in 2017 to have a Facility Condition Assessment conducted for the NGS Testing and Training Center in Woodford, Virginia.
- Coordinate with NOS to have a facility condition assessment conducted for the Field Operations Branch facility in Norfolk, Virginia.
- Coordinate with NOS to have a facility condition assessment conducted for the Field Operations Branch/Survey Section B located at the "Table Mountain Field Site" in Longmont, Colorado.

Examples of evidence of progress:

- Final report findings and recommendations are made for the NGS TTC in Woodford, Virginia. A draft final report dated March 2017 with NGS' comments were submitted to the contractor working for NOS. We need to re-engage NOS to obtain the final report and discuss the findings at the NGS Executive Steering Committee.
- Final report findings and recommendations are made for the Field Operations Branch facility in Norfolk, Virginia. NGS asked NOS for a facility condition assessment in May 2017, but NOS declined, stating "the FCA would probably not be conducted until FY 2018." NGS needs to re-engage for FY19, however, this may depend on the decisions of NOAA leadership to relocate OMAO and OCS facilities which are adjacent to NGS in Norfolk, Virginia.

Appendix A
Comparison with the Previous NGS Ten-Year Plan (2013–2023)

This new Strategic Plan refines the elements presented in our last plan, with a focus on definition and delivery of the new NSRS by year 2022. Some of the less essential activities stated in the objectives and goals from our previous plan are being deferred until the roll-out of the new NSRS, and these issues will be addressed in a post-2022 strategic plan.

Mission

Whereas our basic NGS mission remains unchanged, several aspects surrounding and reinforcing our mission have changed. First and foremost of these changes was the Geospatial Data Act of 2018. This act formalized many of the structural aspects and mission requirements the FGDC laid out in OMB Circular A-16. Additionally, the UN-GGIM as a body (including U.S. leadership) stipulated that all countries adopt a common GGRF. The condition that all countries adopt a common GGRF ensures the new U.S. NSRS is aligned with the ITRF, much as was designed and expressed in this and our previous NGS Ten-Year and Strategic Plans. So, whereas our mission did not change, the significance and relevance of our mission did. In fact, this is no longer an NGS mission, but a U.S. mission that we, at NGS are poised to implement.

Vision

The vision laid out here is consistent with our previous NGS Strategic Plan. We continue to envision an accessible and accurate NSRS available to all. However, the weight and significance of the Geospatial Data Act and the GGRF add clarity to that vision.

Goals, Objectives, and Strategies

Some of the previously stated objectives were completed or moved from one goal to another in this new Strategic Plan. Additionally, some new objectives have been added. However, the main structure of our previous Strategic Plan has been maintained. As with the objectives, certain activities have been completed, and other new activities have been added, as required. Below is a limited snapshot of NGS' progress at this final check point prior to publication of this, our latest Strategic Plan.

Complete Success:

1. We are in agreement with Canada on the name and general structure of NATRF2022.

2. Blueprint for 2022, Part 1: Geometric coordinates are written, outlining these decisions:

- There will be four (global) national TRFs, each named for one tectonic plate:

NATRF: North American Terrestrial Reference Frame
CATRF: Caribbean Terrestrial Reference Frame
PATRF: Pacific Terrestrial Reference Frame
MATRF: Mariana Terrestrial Reference Frame

- Each frame will be tied to the ITRF using one set of Euler Pole Parameters (EPP).
- An Intra-Frame Velocity Model will capture all non-EPP motion in three dimensions.

3. NGS adopts the following decisions:

- A densified ITRF2014 frame will be the underlying frame for the four TRFs.
- The primary epoch of the four TRFs will be 2020.00.
- Subsidiary epochs will be defined every five years.

4. In preparation for the State Plane Coordinate System of 2022 (SPCS2022):

- Publish the report "The State Plane Coordinate System: History, Policy, and Future Directions," *NOAA Special Publication NOS NGS 13,* and
- Release the draft SPCS2022 Policy and Procedures documents for public comment (with comments received as of August 2018).

5. There is an agreement with Canada and Mexico on the name and general structure of the North American-Pacific Geopotential Datum of 2022 (NAPGD2022).

6. Geopotential coordinates are written for our Blueprint for 2022, Part 2, outlining the following decisions:

- Build the entire datum upon a global spherical harmonic model of Earth's external gravity potential.
- Define three areas—the North American-Pacific, Guam and the Commonwealth of the Northern Mariana Islands (CNMI), and American Samoa—covering the derived products of the geoid, Deflection of Vertical (DoV), Digital Elevation Model (DEM), and surface gravity.
- All elements will have time-dependency.

7. NGS adopts decisions:

- The primary epoch of NAPGD2022 will be 2020.00.
- Subsidiary epochs will be defined every five years.

8. NADCON software was completely rebuilt and tested against existing NADCON grids, and it was used to create NADCON 5. NADCON 5 replaces all previous versions of NADCON and GEOCON.

9. NCAT was built, incorporating six different pieces of NGS software, including NADCON 5.

10. An update was released in November 2015 to *Geodetic Leveling (NOS NGS 3)* Chapter 4 for "River or Valley Crossing Procedures for Theodolite Instruments."

11. Field research was conducted at our NGS TTC to support the use of leveling in a GNSS/geoid-based vertical datum.

12. We successfully created the GPS on Bench Marks program to build customer engagement and awareness.

13. Absolute gravimeter comparisons were conducted at TMGO in 2014, 2016, and 2018, with various federal and foreign agencies, as well as one private company.

Moderate Success:

1. An initial Foundation CORS plan was established:

- Prospective sites were identified, as well as possible partnerships with whom we may engage, and the costs to implement were estimated.
- We have finalized discussions with the IAG regarding ties between Foundation CORS (FCORS) and ITRF models.
- We are in the process of developing MOA's with NASA, NSF, NGA, and Canada.

2. A prototype NSRS DB exists, and progress has been made regarding the loading, storing, and viewing of:

- Data from the CORS Network,
- Airborne gravity, and
- Historic GPS surveys archived in the existing NGS DB.

3. OPUS Projects was expanded to ensure it is a viable portal for traditional Bluebooking.

4. *NOAA Technical Manual (TM) NOS NGS 74* was released in May 2018 outlining the adjustment protocol for adjusting leveling data to GNSS/geoid-based orthometric heights.

5. NGS held Geospatial Summits in 2010, 2015, and 2017. The summits prepared the user community for the replacement of the NAVD 88 and NAD 83 datums and the introduction of a new gravity-based vertical reference system.

6. NGS held an Industry Workshop and webinar in 2018. Commercial equipment and software representatives participated and discussed their needs and concerns regarding the NSRS modernization.

Measurable, but Minor Success:

1. OPUS Projects for Real-Time Networks (RTN) has a build-team and is making progress. This effort will allow uploading and processing of RTK/RTN vectors.

2. Historic GPS data is actively being investigated. Estimates are being gathered on the time required to organize all 50- to 100-thousand occupations in our NGS holdings. We are in the preparation stages of organizing these occupations for re-processing and storage in the NSRS DB.

3. VERTCON software is three-quarters built, entirely from the ground-up.

4. An update to *NOS NGS 58* is underway.

Still Awaiting Initialization:

1. A prioritized list was created for all major NGS toolkit functions requiring attention. The effort will lead to a comprehensive overhaul and improvement of the toolkit.

2. The broader CORS Network will be integrated into the NSRS using FCORS as control.

Many action items now moving through the process may soon be labeled as either moderate or complete successes. This is not surprising, given the degree of effort exerted over the past decade.

Whereas integration of the broader CORS Network is described above as "Still Awaiting Initialization," the development of the plan is well underway. Progress, however, depends on developing an equitable way forward for the existing CORS Network, while ensuring the integrity, accuracy, and precision of coordinates determined in the future NSRS.

Additionally, our efforts must be synergized with those of other U.S. government entities, as well as neighboring countries. This synergistic

and more broadly global vantage point must be taken into consideration to ensure the NSRS in 2022 is compatible regionally, as well as nationally, for the broad scope of activities requiring positioning and measurement with centimeter-level accuracy and precision.

Appendix B
Acronym List

AAGS	American Association for Geodetic Surveying
ASCE	American Society of Civil Engineers
ASP	Aeronautical Survey Program
BPA	Blanket Purchase Agreement
CATRF	Caribbean Terrestrial Reference Frame
CMP	Coastal Mapping Program
CNMI	Commonwealth of the Northern Mariana Islands
COOP	Continuity of Operations
CO-OPS	Center for Operational Oceanographic Products and Services
CORS	Continuously Operating Reference Station
CSCAP	Coast and Shoreline Change Analysis Program
CUSP	Continually Updated Shoreline Product
DB	Database
DC	Digital Coast
DEM	Digital Elevation Model
DOC	Department of Commerce
DORIS	Doppler Orbitography and Radio Positioning Integrated by Satellite
DoV	Deflection of Vertical
EDMI	Electronic Distances Measuring Instruments
EPP	Euler Pole Parameters
ERI	Emergency Response Imagery
FAA	Federal Aviation Administration
FBNs	Federal Base Networks
FCA	Facility Condition Assessment
FCORS	Foundation CORS
FEMA	Federal Emergency Management Agency
FGCS	Federal Geodetic Control Subcommittee
FGDC	Federal Geographic Data Committee
FY	Fiscal Year
GEOCON	Set of NGS software tools for performing three-dimensional coordinate transformations

GGRF	Global Geodetic Reference Frame
GIS	Geographic Information Systems
GNSS	Global Navigation Satellite Systems
GPRA	Government Performance and Results Act
GPS	Global Positioning System
GPS-on-BMs	GPS on Bench Marks
GRAV-D	Gravity for the Redefinition of the American Vertical Datum
GSD	Geodetic Services Division
GSVS17	Geoid Slope Validation Survey of 2017
HTDP	Horizontal Time-Dependent Positioning
IAG	International Association of Geodesy
IDB	Integrated Database (as in "NGS IDB")
IERS	International Earth Rotation and Reference System Service
IFVM	Intra-Frame Velocity Mmodel
IGLD	International Great Lakes Datum
IGS	International GNSS Service
IHRF	International Height Reference Frame
INTG	Interpolation from Geoid Grids Utility
IOCM	Integrated Ocean and Coastal Mapping
IT	Information Technology
ITRF	International Terrestrial Reference Frame
ITRF14	International Terrestrial Reference Frame of 2014
ITRS	International Terrestrial Reference System
JSON	JavaScript Object Notation
Lidar	Light Detection and Ranging
LOCUS	Leveling Online Computation User Service
MAPPS	Management Association for Private Photogrammetric Surveyors
MATRF	Mariana Terrestrial Reference Frame
MOA	Memoranda of Agreement
MOU	Memoranda of Understanding
NACo	National Association of Counties
NAD 83	North American Datum of 1983
NAD 83(2011)	A 2011-updated realization of NAD 83 for the North American tectonic plate
NAD 83(MA11)	A 2011-updated realization of NAD 83 for the Mariana tectonic plate
NAD 83(PA11)	A 2011-updated realization of NAD 83 for the Pacific tectonic plate
NADCON	North American Datum Conversion Utility

NAPGD2022	North American-Pacific Geopotential Datum of 2022
NASA	National Aeronautics and Space Administration
NATRF	North American Terrestrial Reference Frame
NATRF22	North American Terrestrial Reference Frame of 2022
NAVD 88	North American Vertical Datum of 1988
NCAT	NGS Coordinate Conversion and Transformation Tool
NGA	National Geospatial-Intelligence Agency
NGS	National Geodetic Survey
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NRC	National Research Council
NRCan	Natural Resources Canada
NSDI	National Spatial Data Infrastructure
NSF	National Science Foundation
NSGIC	National States Geographic Information Council
NSPS	National Society of Professional Surveyors
NSRS	National Spatial Reference System
NTRS	National Tidal Reference Service
NWLON	National Water Level Observation Network
OAD	Observation and Analysis Division
OCS	Office of Coast Survey
OMB	Office of Management and Budget
OPUS	Online Positioning User Service
OPUS-DB	OPUS Database
PATRF	Pacific Terrestrial Reference Frame
PRVD02	Puerto Rico Vertical Datum of 2002
RTK	Real-Time Kinematic
RTN	Real-time Network
SCoG	United Nations SubCommittee on Geodesy
SLR	Satellite Laser Ranging
SPCS	State Plane Coordinate System
SPCS2022	State Plane Coordinate System of 2022
sUAS	small Unmanned Aerial Systems
TBL	Topobathymetric Lidar
TM	Technical Manual
TMGO	Table Mountain Geophysical Observatory
TPU	Total Propagated Uncertainty
TRF	Terrestrial Reference Frame
TTC	Testing and Training Center
UESI	Utility Engineering and Surveying Institute

UN-GGIM	United Nations Committee of Experts on Global Geospatial Information Management
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
VDatum	Vertical, Horizontal, and Tidal Datum Conversion Utility
VERTCON	Vertical Datum Conversion Utility
VIVD09	Virgin Islands Vertical Datum of 2009
VLBI	Very Long Baseline Interferometry
XML	Extensible Markup Language