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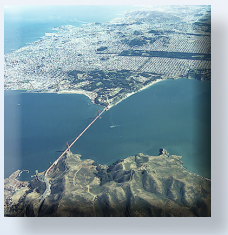
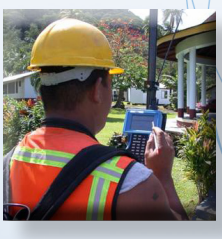
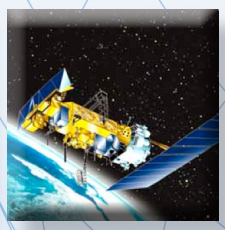
National Geodetic Survey

Ten-Year Strategic Plan

2013–2023

Positioning America for the Future




National Oceanic and Atmospheric Administration • National Geodetic Survey

The National Geodetic Survey Ten-Year Strategic Plan, 2013-2023:

Positioning America for the Future

"I have always found that plans are useless,
but planning is indispensable."

Dwight D. Eisenhower

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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 anytime, anyplace!

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 *operational* products and activities. Where a product is incomplete, is under development, or is otherwise is non-operational, that product is *not* a part of this goal.

Objective 1: "Bluebooking and Datasheets"

Maintain the capability to ingest, analyze, and store internal and external survey data, and return useful information to the public.

NGS intends to maintain its current ability to ingest surveys through "Bluebooking" as it exists in 2012, with improvements being developed for future implementation. Other technical abilities and standards Bluebooking is built upon will continue to be maintained.

Objective 2: "Shoreline"

Maintain annual production of the National Shoreline.

The National Shoreline is that shoreline shown on NOAA nautical charts, and it 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 must continue its current work to define the National Shoreline.

Objective 3: "Airport Surveys"

Maintain airport surveying operational capacity.

The remote sensing and field operations expertise required to fulfill congressional mandates is well illustrated through the Aeronautical Survey Program (ASP). These surveys provide critical information regarding airport features. Internal ability to perform these surveys will be maintained.

Objective 4: "Field Operations"

Maintain geodetic surveying operational capacity.

The way NGS does business has changed in recent decades, with fewer field crews being required to perform surveys; however, it is still critical that the capacity and expertise required to do these types of surveys continues to exist in-house. NGS employees are the resource and authority for many surveying activities, and, therefore, NGS must know and fully understand the associated field-work procedures.

Objective 5: "Online Tools"

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

The most up-to-date information on geodetic coordinates is derived using active control

stations, or Continuously Operating Reference Stations (CORS). Many NGS software tools, such as the Online Positioning User Service (OPUS), make use of data from CORS. As improvements are made to CORS and OPUS, basic functions will be maintained.

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

Goal 2 concerns **projects** as agents of change for the better. Goal 2 focuses on improving what NGS is doing (under three categories: **starting** new work, **improving** existing work, and **retiring** outdated work).

Objective 1: "Replace NAD 83"

By 2022, reduce all definitional and access-related errors in the geometric reference frame to 1 centimeter when using 15 minutes of GNSS data.

The North American Datum of 1983 (NAD 83)—in both its definition and in the services through which NGS provides its access—is in need of improvement. Improvements can be combined into one overarching objective to improve tools over the next ten years, while preparing for the ultimate replacement of NAD 83 with a truly geocentric reference frame.

Objective 2: "Replace NAVD 88"

By 2022, reduce all definitional and access-related errors in orthometric heights in the geopotential reference frame to 2 centimeters when using 15 minutes of GNSS data.

The North American Vertical Datum of 1988 (NAVD 88), in both its definition and in the services through which NGS provides access, is in need of improvement. NGS will continue to collect airborne gravity data through the Gravity for the Redefinition of the American Vertical Datum (GRAV-D) Project, as well as support Height Modernization, and will work across agencies to connect important data.

Objective 3: "Re-invent Bluebooking"

By 2018, increase the efficiency and accuracy of soliciting, accepting, processing, storing, reporting the results of, and reprocessing all survey data, while maintaining the quality standards our external users have come to expect.

The era of expanding the passive control network is coming to an end. 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 point. In the future, tools such as OPUS-Database (OPUS-DB) and OPUS-Projects will be completed to carry the weight and authority maintained by Bluebooking.

Objective 4: "Fix 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 from 2013 to 2016.

NGS' intention is to properly evaluate the tools it provides to the public and to begin a program of creating consistency and modernization, effectively cleaning up the toolkit to make it a more user friendly and scientifically accurate product for the nation. Future NGS products and services should be broadened to include accuracy, velocity, and useful metadata on geodetic control.

Objective 5: "Better Surveying"

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

NGS will engage in a renewed effort of conducting field survey research, updating geodetic survey manuals to the latest technologies, and verifying these manuals with scientific fact. That is, NGS will re-invest in creating surveying standards, not merely guidelines.

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

Goal 3 concerns the **public**; current users of the NSRS and those groups who would greatly benefit by engaging with NGS. Goal 3's focus is on reaching new stakeholders, providing training and education to existing stakeholders, and improving NGS' ability to meet our mission through engagement of outside experts.

Objective 1: "Validate RTNs"

Provide, by 2015, a process for RTN operators to validate that their RTNs are aligned to the NSRS using NGS-acceptable standards.
With RTN use expected to grow, NGS will engage the RTN user community to jointly develop a methodology to give them a complete understanding of how their derived coordinates are consistent with the NSRS.

Objective 2: "Engage New Stakeholders"

Annually increase the number of stakeholder communities directly educated or engaged by NGS.
As the global community becomes more "geospatially enabled," the potential for misuse and misunderstanding of data grows. NGS intends to reach a broader audience, with user-friendly educational material, to increase public understanding of geodesy. The NGS Corbin Training Center (CTC) has provided training to non-traditional customers in the past, but the focus has been on high-accuracy geospatial professionals, not the general public.

Objective 3: "University Engagement"

Annually increase the number of collaborations between NGS and universities for solving research problems over the next three years.
Graduate students can become a significant resource for augmenting the research completed by professionals. NGS will increase university collaborations, whether through grants, the encouragement of NGS employees to achieve advanced degrees, or NGS employees teaching seminars at universities.

Objective 4: "Dynamic Web Presence"

Increase online stakeholder engagement and improve NGS response mechanisms.
NGS intends to consolidate its Web presence, focusing on both outward-looking materials (such as education and outreach), as well as building a tiered response system for inquiries, much like the system of old, where questions are tracked and monitored for message consistency.

Objective 5: "Educational Portfolio"

Achieve, by 2017, the creation of an online educational portfolio, and reduce latency of all components to less than five years.
NGS will continue to organize its overall "educational toolkit," making sure information is easy to find, up to date, easy to use, and regularly monitored. The initial steps must be geared toward improving the actual field manuals NGS uses and provides to the public. Eventually, the portfolio will expand to include all levels, from universities down through the elementary school level.

Objective 6: "IOCM"

Increase the use and users of data obtained through, and provided to, the Integrated Ocean and Coastal Mapping Program (i.e. "Map once use many times").
NOAA implemented the Integrated Ocean and Coastal Mapping (IOCM) program in 2007, recognizing that ocean and coastal geospatial data has multiple uses, including uses for shoreline data. NGS intends to continue to broaden the useable products arising from the Coastal Mapping Program (CMP), as well as leverage IOCM partner data for use in CMP products.

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

Goal 4 is about **employees**, current and future, who enable NGS to fulfill its mission. Goal 4's focus is on ensuring NGS has the most qualified workforce, employs experts in many fields, and that existing employees are trained and compelled to improve, thereby enabling NGS to meet its mission in the long term.

Objective 1: "Educated Workforce"

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

Although there are fewer students graduating with actual "geodetic or remote sensing" science degrees, it is imperative NGS employees have significant knowledge of the finer geospatial details involved in NGS' operations. In order to provide this knowledge, NGS will use a combination of employee-led educational classes, long-term training, and guest lecturers to broaden geodetic knowledge throughout the agency.

Objective 2: "Recruiting"

Align the NGS workforce with the NGS mission over the next three years.

The difficulty NGS has experienced in its ability to systematically hire new staff to fill important gaps in its workforce has led to a situation where over half of the NGS workforce is eligible for retirement. Without a singular effort to recruit and retain new talent, NGS will encounter problems with successfully fulfilling its mission. NGS will, therefore, utilize every tool in the allowable government personnel toolbox to recruit, hire, and retain a broad spectrum of new employees over the next three years.

Objective 3: "Institutional Knowledge"

Achieve succession planning by 2014, and arrange for permanent maintenance of the plan.

NGS will institute a policy of requesting "on the job documentation," whereby NGS staff will document their work procedures and help educate new employees via mentoring, allowing the new employees to learn to do the jobs of retiring staff with continuity. An investigation into the institutional knowledge NGS has lost due to retiring staff, as well as understanding of knowledge that can and should be resurrected, should also be pursued.

Enterprise Goal: Improve Organizational and Administrative Functionality.

All of the above-mentioned goals require NGS' efficient and effective operation, with work performed in a safe workplace and with well-functioning equipment. The Enterprise Goal acknowledges that significant improvements may be made in the day-to-day operations and behind-the-scenes work, resulting in more efficient use of U.S. tax dollars.

Objective 1: "Project Management"

Achieve complete adoption of project management in NGS operations by 2016.

Project management is a tool NGS must adopt in order to properly plan, budget, execute, and evaluate the various projects that have, historically, been performed in an ad hoc fashion.

Objective 2: "Information Technology (I.T.) Support"

Continually maintain I.T. infrastructure.

NGS has experienced varied success with regard to its I.T. infrastructure. NGS will evaluate its I.T. requirements and prepare a budget based on a "must pay" basis prior to undertaking new projects.

Objective 3: "Socio-Economic Awareness"

Update or improve NGS' knowledge base for program evaluation, through analysis of socio-economic benefits of NGS products and services on a 10-year cycle.

Offices are required to perform program evaluation on a recurring basis, however this objective also carries the very real positive benefits of self-reflection, leading to improved services and more efficient use of tax dollars.

Objective 4: "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. Many activities will continue to ensure NGS will be fully organized, efficient, and in compliance with all federal guidance.

Objective 5: "Regional Advisor Program"

Achieve a fully-staffed regional advisor program by 2016.

Recognizing the benefits of NGS' current state advisor program, but also its patchwork nature and the reality of shrinking state budgets, in 2010 NGS decided to transition to a regional advisor program. The regional program will consist of a smaller cadre of advisors, all well-trained and dynamic educators capable of covering multi-state regions. The new advisor program will be at the cost of NGS, alone.

Mission:

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

To understand the mission of the National Geodetic Survey (NGS), it is critical to understand the National Spatial Reference System (NSRS). NGS defines the NSRS as the official reference system of the federal government that allows a user to determine geodetic coordinates (including, but not limited to, latitude, longitude, height, scale, and orientation relative to the International Terrestrial Reference Frame, or ITRF) and which keeps all federal civilian maps in the nation consistent with one another. The NSRS also encompasses the official national shoreline of the United States. NGS' mission is derived from congressional acts, executive orders, National Research Council (NRC) studies, and more than 200 years of history.

The NSRS 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 regarding changing vulnerabilities due to local flooding; to environmental monitoring used in restoration—must be built upon an extremely accurate NSRS.

NGS defines the NSRS and its components through many activities. NGS determines multiple region-specific datums—including NAD 83(2011), NAD 83(PA11), NAD 83(MA11), NAVD 88, PRVD02, ASVD02, NMVD03, GUVD04, and VIVD09. These multi-region datums define latitude, longitude, and height for the entire nation. Additionally, NGS defines the national shoreline used by NOAA and other agencies in their products. NGS also defines a civilian-use geoid, a mathematical approximation of the earth's shape, necessary to connect Global Navigation Satellite Systems (GNSS)-derived ellipsoidal heights to physically-defined ("orthometric," colloquially known as "sea level") heights on the ground. To maintain the NSRS, NGS regularly updates the shoreline, the datums, and the geoid as technology improves, thus enabling accuracy to also be improved. NGS must track all the temporal changes to the defining points of the NSRS in such a way as to maintain the accuracy of the NSRS continually. Without continuous maintenance, the NSRS would soon become obsolete.

NGS provides access to the NSRS in two different ways. Primary access is through precise GNSS orbits and "active control," the Continuously Operating Reference Stations (CORS). Users can access the NSRS through CORS by connecting their own GNSS surveys to CORS, using tools such as NGS' Online Positioning User Service (OPUS). A more historic and increasingly secondary form of access is 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 the online toolkit, provide the tools and knowledge stakeholders need to access and properly utilize the NSRS.

Through its mission, NGS directly supports many activities including geodesy, surveying, remote sensing, mapping, and charting and indirectly supports many more scientific undertakings. In fulfilling the above-stated mission, NGS will provide the latest geospatial foundation to compliment today's technology, enabling world-class positioning services for the United States community.

Vision:

Everyone accurately knows where they are and where other things are anytime, anyplace!

Today, with smart phones, GNSS-enabled cars, and other GNSS-enabled electronics, it may seem as though the above vision of the future is already a reality. But, the accuracy of these devices is the key distinction between what exists today and 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 geospatial 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 average citizen.

When mapping flood plains, monitoring sea-level change, or landing a plane in low visibility, even centimeter differences in accuracy can be crucial. Through diligent work in fulfilling its 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.

Check in on the last Ten-Year Plan…

The last NGS Ten-Year Plan took effect in 2008, and it vigorously advanced the select projects NGS knew it could and would undertake in the upcoming years. Specifically, the 2008 plan encompassed five technical improvewwments NGS intended to undertake to achieve the agency's vision. Following the release of the 2008 Ten-Year Plan, NGS expected to revisit the plan after five years had passed. NGS has now decided to strategically position the entire agency for success by writing a more focused and intrinsic *strategic* plan, encompassing many of the technical advances and new strategic direction identified over the last five years. This new strategic plan will replace the Ten-Year Plan of 2008-2018.

For a more detailed look at what NGS accomplished in the last Ten-Year Plan, please see Appendix A.

Justification of Objectives:

NGS draws its mission and work from numerous orders, laws, and mandates. All the goals and objectives in this plan relate directly to these public requirements or more generally further the science, service, and

stewardship NGS and the National Oceanic and Atmospheric Administration (NOAA) as a whole strive to improve through their strategic plans. NGS' capabilities and the geodetic framework provided through the NSRS play a crucial role in the success of almost all the goals and objectives in the NOAA Strategic Plan. Direct mission-related objectives are drawn from language in Office of Management and Budget (OMB) circular "A-10," 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. While other objectives have a less direct tie to these requirements, they are, nonetheless, critical to the NGS' work for many reasons. As a scientific agency, many scientific requirements and processes must be met before the true mission-related science work can begin; and although this work is not explicitly required, NGS could not meet its mission without completing some of the basic work first. NGS must also internally maintain the personnel and infrastructure to ensure it continually has the necessary tools to meet its mission and further its scientific goals. In all aspects of its work, NGS strives to use tax dollars more efficiently and improve its service to the nation. All objectives in this plan strive for fiscal efficiency, however certain objectives—particularly some discussed in the enterprise goal—focus specifically on improving functionality and organization, enabling taxpayers to receive greater benefits from every dollar spent.

Implementation:

This plan lays out the direction NGS will take in the future, but that is only the initial step. Each *objective* in this plan will have a designated "objective lead" within NGS who will be in charge of writing an objective implementation plan (including the identification of resources and gaps to be addressed for completion of the objective), executing that plan, and measuring progress towards the plan's completion. Many of these objectives will require cross-divisional work, and objective leads will be required to coordinate with numerous subject matter experts. For NGS programs that encompass a variety of objectives, strategic plans will be designed to fit the NGS-wide Ten-Year Plan. The individual strategic plans will clarify how all the pieces will fit together to provide a clear way forward.

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 the agency's *operational* products and activities. Where a product is incomplete, is under development, or is otherwise is non-operational, that product is *not* a part of this goal. Goal 1 is the first goal to be addressed to acknowledge that the majority of NGS resources are currently dedicated to maintaining existing operations, rather than on improving them.

Objective 1-1: Maintain the capability to ingest internal and external survey data, analyze and store the data, and return useful information to the public.

Nickname: Bluebooking and Datasheets

Description: For many years, NGS has used a complex, rigorous process to ensure quality survey data are being used to compute various geodetic quantities on passive control bench marks. Most of this information is reported on one of NGS' primary products, the "datasheet." Specifications describing the format for submitted survey data were originally published by the Federal Geodetic Control Subcommittee (FGCS) of the Federal Geographic Data Committee (FGDC), under the title "Input Formats and Specifications of the National Geodetic Survey Data Base." Because that document was published with a blue cover, the process of submitting survey data came to be called "Bluebooking;" however, a great deal more comprises this objective than merely the actual *blue book*. 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 stations must be monitored, and an up-to-date datasheet creation program must be maintained, just to name a few.

With Objective 1-1, NGS intends to maintain the agency's current ability to ingest GNSS and leveling surveys through "Bluebooking." (This process 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, and after its "re-invention," Bluebooking will be maintained in its new form). This objective addresses the fact that the Bluebooking process as it exists in 2012 will not be interrupted while improvements are being developed.

Examples of strategies supporting this objective:

- Accept all complete GNSS projects from outside users in Bluebook format, evaluate

them, adjust them to the latest realization of NAD 83, and load appropriate projects into the NGS Integrated Database (IDB) within (an annual median timespan of) six weeks of receipt.

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

- Serve as an International GNSS Service (IGS) Analysis Center, and perform GNSS orbit determination 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.

- Select, by the third quarter of Fiscal Year 2013 (FY13), the employees responsible for maintaining and updating Horizontal Time Dependent Positioning (HTDP) and other crustal motion models, such as Vertical Time Dependent Positioning (VTDP), and provide resources so that within one year the employee can update the software.

Examples of evidence of progress:

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

- There are daily orbit computations.

- There is a dedicated employee maintaining HTDP.

Objective 1-2: Maintain annual production of the national shoreline.

Nickname: Shoreline

Description: The National Shoreline is that shoreline depicted on NOAA nautical charts, and it provides critical baseline data for updating nautical charts; defining our nation's territorial limits, including the Exclusive Economic Zone; and managing our coastal resources.

The National Shoreline contributes to our nation's economy by supporting: maritime trade and transportation, coastal and marine planning, coastal engineering and construction, scientific research, and the insurance industry, thereby enhancing our global competitiveness and allowing us to more efficiently manage our resources.

Examples of strategies supporting this objective:

- Conduct shoreline mapping to meet NOAA's annual charting requirements.

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

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

- Conduct Emergency Response missions to meet NOAA requirements, and continue to develop the capability to meet national interests.

- Create a NOAA coastal mapping survey priorities plan, and update the plan annually.

- Maintain operation of VDatum (a datum conversion tool).

Examples of evidence of progress:

- The shoreline is delivered annually, as per NOAA nautical charting requirements.

- The required number of ports with updated shoreline meeting NOAA Nautical Charting requirements is 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 manmade disasters to meet NOAA requirements or when tasked by the appropriate federal partners.
- A coastal mapping survey priority plan is published.

Objective 1-3: Maintain airport surveying operational capacity.

Nickname: Airport Surveys

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

Examples of strategies supporting this objective:

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

Examples of evidence of progress:

- Meet yearly FAA deliverables for the ASP.
- Identify out-year funding and requirements.

Objective 1-4: Maintain geodetic surveying operational capacity.

Nickname: Field Operations

Description: Historically, NGS has maintained field crews to perform critical work, such as leveling, GNSS surveys, gravity surveys, shoreline collection, and more. Although the way NGS does business has changed in recent decades, with less need for field crews, it is critical NGS maintains the capacity and expertise required to do field surveys in-house. NGS employees are the resource and authority for many surveying activities and must know and fully understand the associated field work procedures in order 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 the foundational surveys for which NGS is the authority. NGS employees also provide technical support and training to private surveyors who perform these various types of surveys.

Examples of strategies supporting 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.

- Perform at least three Geoid Slope Validation Surveys (GSVS) prior to 2022.
- Provide annual training for all field personnel and office personnel involved in NGS surveys.
- Maintain the Table Mountain Geophysical Observatory (TMGO) facility and instruments, and train employees in the use of the instruments for continuity in their operations.

Examples of evidence of progress:

- New survey and evaluation methods/ workflows are developed.
- Two NGS-led terrestrial geodetic surveys (leveling, GPS, gravity, etc.) are completed per quarter.
- Current yearly totals for surveys reviewed and added to the NGS database are maintained.

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

Nickname: Online Tools

Description: The most up-to-date information on geodetic coordinates is derived using active control stations, Continuously Operating Reference Stations (CORS). Many NGS software tools make use of GNSS data from CORS and can provide users with timely access to the NSRS. Although CORS have 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. In addition to the well-known GNSS tools in OPUS, NGS has also developed the Leveling Online Computation User Service (LOCUS) as part of the greater set of automated online positioning tools for NSRS users. The improvements for CORS and OPUS are subsequently described in Objectives 2-1, 2-2, and 2-3.

Examples of strategies supporting this objective:

- IGS and North American Datum of 1983 (NAD 83) coordinates are computed for each CORS on a daily basis.
- Within one month of receipt, single and multi-frequency geodetic-quality GNSS antennas are calibrated, and calibration data is 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% of all submissions.

Examples of evidence of progress:

- NGS receives positive status reports and Web transaction logs of CORS and OPUS.
- Coordinate time series plots for all CORS are available to the public online.
- There is no decline in the monthly counts of OPUS solutions.
- New antennas are calibrated at the NGS Facility at Corbin, Virginia, within one month of production.

Goal 2: Modernize and Improve the National Spatial Reference System

Goal 2 concerns **projects** as agents of change for the better. The focus of Goal 2 is to improve what NGS is doing under the three categories of **starting** new work, **improving** existing work, and **retiring** outdated work. Each of the objectives under this goal is effectively a project (or a program consisting of multiple projects), a temporary venture with a specific product or output, which if adopted, will change operations.

Objective 2-1: By 2022, reduce all definitional and access-related errors in the geometric reference frame to 1 centimeter when using 15 minutes of GNSS data.

Nickname: Replace NAD 83.

Description: The North American Datum of 1983 (NAD 83)—in both its definition, as well as the services NGS provides for its access—is in need of improvement. From the standpoint of its definition, NAD 83 is non-geocentric by over two meters and has non-zero, residual plate velocities. Both of these exist, despite NGS' best attempt in the 1980s to originally define NAD 83 as "geocentric" and "plate fixed." Since the mid-1990s, NAD 83 has been defined through its relationship to the International Terrestrial Reference Frame (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). Because of this reliance on the ITRF, it is NGS' duty to contribute to the upkeep of ITRF. However, the running of VLBI and SLR sites by the U.S. Government is currently a National Aeronautics and Space Administration (NASA) function. NGS has contributed to the ITRF by restarting the International Earth Rotation Service (IERS) Site Survey program (ISS) and by acting as both an analysis center and analysis center coordinator of the International GNSS Service (IGS), which represents the GNSS arm of the ITRF. However, in the future, NGS can and will do much more. Because of poor geographic coverage of the IGS-tracking network in the United States, NGS has proposed the installation of new GNSS sites as suitable IGS fiducial sites. These new installations will be called "Foundation CORS," and NGS is scheduled to begin their installation in 2013, with a total of approximately 20 when the set is complete.

As a separate issue beyond datum definition, users often must take hours of GNSS data and post-process the data to achieve one centimeter of positional accuracy within the datum itself.

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

Examples of strategies supporting this objective:

- Start establishing and continue to establish at least one Foundation CORS each year until 2023.
- Conduct one International Earth Rotation and Reference Systems Service (IERS) local terrestrial site survey each year until 2023.
- Continue to improve access to the NSRS, i.e. Precise Point Positioning (PPP) and RTNs, by 2017.
- By 2015, define the term "plate fixed," so it may be implemented and will truly provide the least change to the most coordinates over time on the various plates.
- By 2023, research alternative methods of using GNSS to access the NSRS (rather than maintaining a GNSS differentially-processed network with thousands of stations).
- A working and updated version of HTDP exists.

Examples of evidence of progress:

- The number of Foundation CORS increases.
- An NAD 83 stakeholder transition plan exists.
- The number of IERS site surveys increases.
- Research papers are published comparing PPP to Differential GNSS.

Objective 2-2: By 2022, reduce all definitional and access-related errors in orthometric heights in the geopotential reference frame to 2 centimeters when using 15 minutes of GNSS data.

Nickname: Replace NAVD 88.

Description: The North American Vertical Datum of 1988 (NAVD 88) is in need of improvement, in both its definition and in the services NGS provides to access it. From the standpoint of definition, NAVD 88 has a bias of half a meter and a one-meter tilt, relative to the best-known geoid model. For access, users must often collect hours of GNSS data or rely on passive control with heights that may be decades old. Vertical motion is not tracked in a systematic way, although the existence of vertical motion has been known for decades.

The NGS National Height Modernization Program ("Height Mod") will play a significant role in meeting this objective. Improvements in all these areas can be combined into one overarching objective, improving tools over the next ten years, while preparing for the ultimate replacement of NAVD 88 with a true four-dimensional geopotential field capable of describing heights, deflections, and other aspects of the gravity field at any location on or near the Earth's surface. Of specific interest to NGS stakeholders, the vertical datum will be accessed through GNSS and an accurate geoid model, rather than through publication of heights on passive geodetic bench marks. Furthermore, NGS must develop a comprehensive strategy for incorporating past and future leveling data into a GNSS/geoid-based vertical datum and include a connection between the new geoid-based vertical datum and the update to the International Great Lakes Datum (IGLD) in 2015. This guidance must be provided to NGS stakeholders.

The early years of Height Mod focused on improving access to NAVD 88 (and other official vertical datums) by using GNSS to establish orthometric heights. The Height Mod program's effectiveness at densifying the passive control network has greatly improved the hybrid geoid model, and the program continues to work with partners in this effort. The Height Mod program has expanded and grown to additionally support the GRAV-D Project and improvements to geoid modeling; improvements that will be instrumental to the replacement of NAVD 88.

Related to all the above work, NGS must ensure an actual connection to the NSRS and charting data. The National Tidal Reference Service (NTRS), used for oceanographic charts created by the Office of the Coast Survey (OCS), is maintained through the National Water Level Observation Network (NWLON) of the Center for Operational Oceanographic Products and Services (CO-OPS). NGS 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 NSRS and charts.

Examples of strategies supporting this objective:

- Annually compute and publish a gravimetric geoid model for all U.S. territories using all available gravity sources, until 2021.
- By June 2013, develop and acquire approval for a plan to improve and execute a long-term NGS terrestrial gravity program. Have all elements of the plan successfully executed by January 2018.
- Ensure a rigorous vertical deflections database is in use by 2023.
- Achieve a ground-based network for monitoring temporal geoid changes within five years.
- Investigate how and whether existing leveling can be used to improve the definition of the new geopotential framework, as well as how, once established, it would be incorporated into the geopotential reference surface.
- Use Interferometric Synthetic Aperture Radar (InSAR) and other remote-sensing technologies to monitor vertical motion in the United States.

Examples of evidence of progress:

- An NAVD 88 stakeholder transition plan has been formulated.
- A vertical crustal monitoring expert is hired or identified.
- The GRAV-D percentage of flights flown meets the Government Performance and Results Act (GPRA) standard.
- A gravity and deflection database manager has been identified and/or hired.
- The number of successful research grants (academic or private industry) supported by Height Mod, and/or supporting Height Mod, has increased.

Objective 2-3: By 2018, increase the efficiency and accuracy of soliciting, accepting, processing, storing, reporting the results of, and re-processing all survey data 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 rise of easy-to-use GPS equipment providing geodetic quality

surveys to a broader population, NGS began accepting external survey data. The acceptance of external survey data also served the purpose of expanding or updating the static definitive coordinates on the NSRS' passive control network. As of 2012, over 90 percent of all survey data processed by NGS came from external parties via Federal Geodetic Control Subcommittee (FGCS) specifications.

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, including monitoring vertical motion of critical infrastructure, such as levees; providing a local network in order to recreate active stations, such as tide gauges and CORS in the event of their failure; and providing an updated starting point coordinate so a non-GNSS survey (such as leveling or transits) may begin.

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 NGS 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 its secular motion into the 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."

For the NSRS of the future, tools such as OPUS-DB and OPUS-Projects, currently in various stages of development, will have been completed and will carry the weight and authority of Bluebooking while supporting the new business model of using survey data.

Examples of strategies supporting this objective:

- By January 2014, produce a software design document for current GNSS project processing, as well as a design for an improved and more efficient process.

- By January 2016, NGS will have rebuilt the entire GNSS holdings of the IDB through the re-processing of hundreds of thousands of original receiver files.

- Assess the long-term viability of the NGS Electronic Distance Measurement Instruments (EDMI) Calibration Base Lines (CBL) program by Sept 2013; operate the CBL service on an as-scheduled basis until an assessment is made.

- By January 2014, develop and implement a new, efficient method of soliciting, accepting, processing, storing, reporting the results of, and re-processing **GNSS** projects from external users, while maintaining the standards of quality expected by external users.

- If it is determined that leveling will continue to be used and ingested by NGS, then by January 2018, develop and implement a new, efficient method of soliciting, accepting, processing, storing, reporting the results of, and re-processing **leveling** projects from external users, while maintaining the standards of quality expected by external users.

- By January 2016, develop and implement a new, efficient method of soliciting, accepting, processing, storing, reporting the results of, and re-processing **terrestrial gravity** projects from external users, while maintaining the standards of quality expected by external users.

Examples of evidence of progress:

- There will exist a project plan for re-inventing Bluebooking.

- The entire GNSS archive at NGS is categorized, stored, and readily accessible in a geodatabase.
- A modern format (e.g., XML) of the NGS datasheet replaces the current datasheet.
- OPUS-Projects (i.e., PAGES/GPSCOM) has proven to be as good as or better than PAGES/ADJUST.
- There will be written documentation on the processing steps required for NGS' acceptance of leveling, GNSS, and gravity field projects.

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 from 2013 to 2016.

Nickname: Repair the Toolkit.

Description: NGS has more than 800 computer programs in its geodetic "toolkit" (with many being obsolete), and only a small number are publicly available. Most of these programs were written decades ago in response to a particular need without much consideration of overlap with other programs, creating a situation that has led to two basic difficulties. The first difficulty is that NGS employees as a whole do much of their work in command-line mode, rather than with commercially available geospatial software, such as those used in Geographic Information Systems (GIS). This failure to adopt commercial software means many tools written by NGS are not specifically geared for the large growing field of GIS-literate geospatial professionals.

The second problem is that there is no consistency between related programs. As an example, VDatum, NADCON, VERTCON, and INTG—all official NGS products—interpolate data from a grid using different interpolation methods. This inconsistency creates systematic errors when comparing data from various products.

It is NGS' intention to properly evaluate the tools it provides to the public, establish a program to create consistency and modernization, 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 dissemination of coordinates to include accuracy, velocity, and useful geodetic control metadata.

Examples of strategies supporting this objective:

- By January 2015, 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 by January 2018.
- By June 2014, offer at least one NGS product or service for the Web that can be integrated with GIS and surveying tools.
- Consolidate multiple versions of interpolation modules into a standard toolkit by 2014.
- By 2018, ensure transformations between datums are freely available, transparent, and consistent with the most recent global standards.
- By 2016, achieve the public availability of single datum/plate motion software, incorporating all aspects of VDatum, NADCON, VERTCON, and HTDP.
- Develop an online feedback tool for every tool in the toolkit.

Examples of evidence of progress:

- A well-defined list of applications tied directly to quality control activities exists.

- 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.

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 NGS' 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 expertise dwindled as our stakeholders relied more and more on CORS and networks provided by the GNSS receiver manufacturers.

The above situation is viewed as untenable, as "access to the NSRS" (an integral part of the 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 merely guidelines. Active research of new technologies or existing technologies for new purposes will also be an important key to improved surveying in NGS.

Examples of strategies supporting this objective:

By January 2014, replace NGS 58 and NGS 59 with new best practices guidance for using GNSS to obtain ellipsoid heights, orthometric heights, and dynamic heights, also addressing how the replacements for NAD 83 and NAVD 88 will impact work.

- Write new standard field procedures for NGS-conducted GNSS, leveling, gravity, and transit surveys (including airports) by June 2014.

- 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, and 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:

- NGS 58 and 59 are 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.

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 groups who would benefit greatly from beginning to engage with NGS. The focus of Goal 3 is reaching new stakeholders, providing training and education to existing stakeholders, and improving NGS' ability to meet its mission through the participation of outside experts. Objectives under this goal demonstrate how NGS plans to engage with the public and how the agency responds to and meets 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, to ensure continued involvement with a growing number of users and improved interactions with existing stakeholders.

Objective 3-1: By 2015, provide a process for RTN operators to validate their RTNs are aligned to the NSRS and meet NGS' acceptable standards.

Nickname: Validate 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 people in the positioning community rely on RTNs. Most RTNs are capable of expressing NSRS coordinates, yet NGS has no formal guidance or mechanism for validating whether such coordinates are consistent with the NSRS, nor to what accuracy. NGS' responsibility includes providing "access to the NSRS" and therefore views the situation as one requiring clarification and validity to the end user.

With RTN use expected to grow, it would be wise to engage the RTN user community in the development of a methodology for understanding how their derived coordinates are consistent with the NSRS.

Examples of strategies supporting this objective:

- By January 2015, define and make operational a process for RTN operators to validate their RTNs are aligned to the NSRS and meet NGS' acceptability standards.
- By January 2014, hold an RTN symposium.
- A new NSRS compliant RTN validation manual is written.

- A new NSRS compliant RTN user manual is written.
- NGS enters into a public-private partnership with an RTN operator for the purpose of directly validating the procedures outlined above.
- A list of "valid" RTNs is posted on the NGS website.

Examples of evidence of progress:

- RTN operators routinely meet with NGS to discuss validation.
- Feedback from a symposium will be used to update NGS RTN Guidelines.
- Manuals are completed.

Objective 3-2: Annually increase the number of stakeholder communities directly educated or engaged by NGS.

Nickname: Engage new stakeholders.

Description: As the global community becomes more "geospatially enabled" (consider the number of electronic gadgets we carry that utilize some form of GNSS-enabled technology), the potential for misunderstanding and misuse of that data grows. For example, street maps in smartphones contain no metadata on the geometric reference frame underlying that data. This is not yet a problem, with GNSS being inaccurate to a few meters at ground level. But as GPS gives way to multi-constellation GNSS and further technological improvements arrive, the two- meter horizontal offset between NAD 83 and the World Geodetic System 1984 (WGS 84, an international geodetic reference frame) will become apparent and will affect "lane information" navigation. Where GNSS will provide information on where a car is located in WGS 84, the roads may be expressed in NAD 83, and failure to account for the different frames may make a serious difference to lane identification.

Another example of the need to educate stakeholders is evident when environmental scientists have a newfound ability to geo-reference data sets very precisely, without fully understanding the advantages of connecting those measurements to the NSRS.

NGS has a long history of engagement with other related agencies, such as 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), and state geodetic agencies. Considering the vast number of changes proposed in this plan, NGS will increase partnerships and engagements with these and other agencies to ensure their successful adoption of an improved NSRS.

To address issues such as those described above, NGS intends to reach a broader audience with user-friendly educational material. If NGS can reach a broader community of users with the same tax dollars used to support its mission, the efficiency of those dollars spent grows. While in the past, the NGS Corbin Training Center (CTC) has provided training to non-traditional customers, such as environmental scientists, the primary focus has been on geospatial professionals interested in high accuracy. The CTC should reach out to a broader spectrum of the geospatially-enabled public (such as by offering a fundamental course on geodesy to GIS professionals).

Examples of strategies supporting this objective:

- Host national partner and stakeholder meetings or 'town halls' to brief stakeholders on changes to NGS products and services and to receive feedback from users.
- Participate in regional conferences held by our partners.

- Solicit feedback on NGS' operational activities.

- Engage local users by utilizing NGS regional advisors, spatial reference centers, universities, or other partners in areas where NGS field activities are being conducted. · NGS will develop a plan to engage with academia, the private sector, and other government agencies (federal, municipal, state, and tribal).

- Convert the Geodetic Glossary to the first draft of an NGS wiki by June 2013.

- Complete a formal user-community needs assessment (paying particular attention to non-surveyors) regarding NGS products and services by September 2016.

- By 2015, implement a partnership program to establish strategically located, OPUS-DB-derived passive "commemorative" monuments in high-visibility locations such as national park visitor centers with the function of "calibrating" GNSS hand-held devices and educating the public on NGS.

- Build capacity within the user community to inform users about NGS activities, products, and services through training classes and workshop efforts.

Examples of evidence of progress:

- The number of attendees at Corbin Training Center classes and NGS webinars increases.

- A needs assessment of the user community has been completed.

- Satisfaction of website visitors is high, as measured via a customer satisfaction review service (e.g. Foresee).

- An on-line suggestion box is active, suggestions are being considered, and suggestions are being acted upon.

Objective 3-3: Annually increase the number of collaborations between NGS and universities for solving research problems over the next three years.

Nickname: University engagement

Description: Graduate students, mentored by professors, can become a significant resource to augment research completed by paid professionals. Every interaction or collaboration with a university also has the potential of leading to new hires for the agency.

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

Examples of strategies supporting this objective:

- By January 2014, a one-hour college-level seminar on NGS is developed, and the seminar is delivered to at least four American universities per year, every year.

- By 2015, to develop and maintain NGS core capability, NGS will provide direct and indirect support to academic institutions with geodetic, surveying, and remote sensing programs.

- By 2015, NGS will build and leverage interagency and academic partnerships (the Joint Airborne LiDAR Bathymetry Technical Center of Expertise and the University of New Hampshire/Joint Hydrographic Center, etc.).

- Collaborative research with universities has increased by 2014.

- By September 2014, NGS will prepare technical specifications and a geographically prioritized plan for potential partners (mostly universities) to participate in the GRAV-D program with the collection of ground-based

gravity data. NGS will also provide a webinar to potential partners to introduce the criteria for the GRAV-D program.

Examples of evidence of progress:

- Graduate students are working on NGS research problems.
- NGS employees are sent on long-term training.
- NGS materials are routinely used in an increasing number of academic courses and the continuing education programs of professional organizations.

Objective 3-4: Increase online stakeholder engagement and improve NGS response mechanisms.

Nickname: Dynamic Web presence

Description: In the pre-email era, questions for NGS came in the form of written letters, which were then filtered through the NGS Information Center for reply by appropriate individuals. Today, 200 NGS employees, each with their own email address, provide 200 entry points through which people may send inquiries, resulting in less consistent answers to stakeholder questions and a serious drain on NGS employees who feel obligated to respond to constituents directly.

NGS will consolidate its Web presence, focusing it both on outward-looking materials (such as education and outreach), as well as building a tiered response system for inquiries, much like the system of old, where questions are tracked and monitored for message consistency. One such example is a "speaker request queue," initiated in 2012 as the one and only method by which external users may request an NGS employee to travel to a user-requested speaking engagement or educational function.

Examples of strategies supporting this objective:

- NGS will have developed and implemented a tiered "request" queue for all public queries by June 2014.
- By July 2013, NGS will have developed a "speaker request" policy to ensure the agency is effective and efficient with its resources, matching appropriate speakers to requests from current and potential NSRS users.
- NGS Information Center services will be expanded by 2016.
- NGS will improve consistency in receiving, tracking, and addressing comments from users of NGS products and services by Sept 2016.

Examples of evidence of progress:

- An NGS Facebook page is running and is regularly updated.
- The FGCS website is continually updated and maintained.
- An NGS Twitter account is running, with tweets sent out on a regular basis to update stakeholders on major events and new items of interest.

Objective 3-5: Achieve creation of an online educational portfolio, and reduce latency of all components to at or below five years by 2017.

Nickname: Educational portfolio

Description: Through creation of the Corbin Training Center, NGS dedicated itself to providing training and education outreach to NSRS users. NGS then took a further step of organizing all outreach presentation materials into a single, easy to-use-website. With these first steps in mind, NGS will continue to organize its overall "educational toolkit," making sure information is easy to find, up to date, easy to use, and regularly monitored.

Initial steps must be geared toward improving the field manuals NGS uses and provides to the public, as these are truly "learn by doing" manuals that teach people how to access the NSRS accurately. Furthermore, NGS should engage universities to ensure textbooks are being written with updated NGS material. Eventually, all materials, including those for the elementary school level, will be available on the NGS website for teachers and professors to use in the classroom.

In addition, NGS should engage professional surveying organizations to help design and vet the content of NGS field manuals to ensure their value to geospatial professionals.

Examples of strategies supporting this objective:

- Inventory the entire suite of NGS operational products and services, and develop some form of training, manual, or tutorial (online, or not) for each by January 2014.
- Develop three new outreach/education learning modules by 2016.
- Develop curriculum and training materials for core geodetic topics by July 2016.
- Support current and potential users of the NSRS through Web-based and classroom training opportunities. By 2018, at least one training option each year will highlight the new datums, and at least two will be centered on OPUS Projects (once it is an official NGS tool).
- Review and revise specifications and guidelines for acquiring heights using leveling and GNSS by September 2015 (first draft), with the final draft by September 2016.
- Educate state lawmakers and professional societies regarding the planned replacement of NAD 83 and the need to address NAD 83-specific laws.

Examples of evidence of progress:

- Seminars or webinars on new datums are created and regularly delivered.
- A "new datum informational packet" is prepared for state lawmakers to assist in changing NAD 83-specific laws.
- Web-based training modules on core geodetic topics are completed and available by July 2016.
- Manuals or tutorials exist for each NGS operational product or service.

Objective 3-6: Increase the use and users of data obtained through and provided to the Integrated Ocean and Coastal Mapping Program (i.e. "Map once use many times.").

Nickname: IOCM

Description: Recognizing the availability and multiple uses of ocean and coastal geospatial data, including uses for shoreline data as well as other applications, in 2007 NOAA implemented the Integrated Ocean and Coastal Mapping (IOCM) program. The mission of IOCM is to plan, acquire, integrate, and disseminate ocean and coastal geospatial data and derivative products in a manner that permits easy access and use by the greatest range of users: "Map once, use many times." NGS has embraced the IOCM program, as the Coastal Mapping Program (CMP) data has many uses and stakeholders beyond nautical chart applications, including other government agencies, as well as state, local, and public entities along the coast. NGS 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, representing a more efficient use of tax dollars.

Examples of strategies supporting this objective:

- By June 2015, in conjunction with NOAA's Center for Operational Oceanographic Products and Services (CO-OPS) and Office of Coast Survey, NGS has identified applicable IOCM requirements for topographic-bathymetric Light Detection and Ranging (LiDAR) and has incorporated those requirements into LiDAR-based coastal mapping program data collections.

- A methodology is researched and developed to extract bathymetry from commercial satellite imagery to meet NOAA nautical charting requirements, including reconnaissance of uncharted regions and remote areas.

- NGS continues to be a leader in IOCM, leveraging this leadership role to align data providers and stakeholders.

- The Continually Updated Shoreline Product (CUSP) is developed as a new, separate product from the National Shoreline currently mapped by NGS.

Examples of evidence of progress:

- Topographic/bathymetric ("topo-bathy") elevation data that can be reliably used for shoreline extractions and shallow water depths is developed to NOAA standards.

- Reconnaissance bathymetry for Alaska and the Pacific Trust Territories is delivered.

- CUSP is operationally available the second quarter of fiscal year 2013.

- IOCM partner data is incorporated into CUSP and shoreline products, and vice versa.

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

Goal 4 is about **employees**, current and future, who enable NGS to fulfill its mission. This goal focuses on ensuring NGS has the most qualified workforce and employs experts in many fields, and that existing employees are trained and compelled to be better, so that NGS can meet its mission in the long term. Each of the objectives under this goal aims to develop employees and the workforce as a whole to best meet the needs of NOAA and the nation. Goal 4 also attempts to instill best practices in the workforce, so that projects, like those undertaken to fulfill the preceding goals, can always be performed consistently.

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

Nickname: Educated Workforce

Description: Compared to many other disciplines, the fields of geodesy and remote sensing are small, and the number of institutions generating degrees in these fields is shrinking. Consequently, the number of individuals NGS has hired with actual "geodetic or remote sensing science" degrees has been reduced over the last 10 years. Working at NGS requires attention to geodesy; for the employees to more effectively perform their jobs within the agency, it is imperative they have significant knowledge of the finer geospatial details of NGS' work.

To broaden geodetic knowledge throughout the agency, NGS will use a combination of employee-led educational classes, long-term training, and guest lecturers.

Examples of strategies supporting this objective:

- Develop four in-house classroom training courses (for NGS employees and contractors) on basic geodesy, remote sensing, surveying, least squares adjustments, and NGS operations by June 2013, and offer these courses on a bi-annual basis through the Corbin Training Center. (For example, compare CATREF, NETSTAT, GPSCOM, and ADJUST.)
- Increase the number of NGS employees actively involved in professional organizations.
- By June 2014, provide at least one day of GIS training each year to each NGS employee.
- Provide and encourage rotational assignments within and outside the organization to share and gain knowledge of core function areas.

- Increase the use of GIS; provide a way for NGS to perform core data processing, analysis, and display in a GIS environment to increase productivity and geographical analysis by September 2015.

- By 2018, 80 percent of NGS geodesists, technicians, and program analysts will utilize NGS products and tools written in computer languages and platforms developed in the last decade.

- Develop a training plan for educating the NGS workforce on java, C++, Oracle, Microsoft Office, GIS, and other modern software tools.

- Develop an NGS orientation class for new employees.

Examples of evidence of progress:

- An NGS-wide employee education plan exists.

- An increased number of rotational assignments are offered.

- There is an increase in the number of GIS software licenses on NGS computers.

- The number of free industry-provided software licenses on NGS computers increases.

Objective 4-2: Align the NGS workforce with the NGS mission over the next three years.

Nickname: Recruiting

Description: In the last 20 years, despite consistent efforts to recruit new employees, NGS has not been able to systematically hire and fill important gaps. Most new hires are done one at a time, often on an ad hoc basis, leading to a situation where over half the NGS workforce is eligible for retirement. Without a singular effort to recruit and retain new talent, NGS will encounter problems in successfully fulfilling its mission. NGS will therefore use every tool in the allowable government personnel toolbox to recruit, hire, and retain a broad spectrum of new employees over the next three years.

Examples of strategies supporting this objective:

- Employ (short or long term: contracts, internships, or otherwise) at least ten new field employees before the end of 2015.

- Employ (short or long term: contracts, internships, or otherwise) at least ten new office employees before the end of 2015.

- Create a standing vacancy for anyone to apply to, any time.

- Advertise frequently and broadly to universities offering bachelor degree programs in a field related to NGS' work (e.g. Surveying, Civil Engineering, Aerospace Engineering, Mathematics, Physics, Electrical Engineering, etc.).

- Create educational orientation materials outlining the work NGS is involved in, as well as orientation information on the work each NGS division performs and how the divisions help NGS accomplish its goals.

- Develop a training plan for educating the work force in the use of GIS.

Examples of evidence of progress:

- There is an increased number of short- and long-term NGS employees—after accounting for retirees—over the next three years.

- A standing opening for NGS employment exists.

- Quarterly flyers about NGS are posted at universities.

Objective 4-3: Achieve succession planning by 2014, and maintain it perpetually.

Nickname: Institutional knowledge

Description: Much of NGS' workforce has highly specialized knowledge gained by decades of expertise and experience. Although external education and employee training can improve general knowledge about NGS-specific methodologies, for the larger field of geodesy and other specific interest areas, there is a large resource of knowledge solely held by NGS subject-matter experts. Knowledge of past surveying techniques and specific anecdotes from past adjustments are examples of the many types of experiences retiring or retired employees alone hold. There is a critical need to immediately inventory and maintain institutional knowledge before it is lost forever.

NGS should immediately institute a policy of requesting "on the job documentation," including dissemination of such information through mentoring from those employees who are preparing to retire. In this way, new employees will be able to perform the jobs of retiring employees with continuity. Furthermore, an investigation into institutional knowledge that has disappeared due to staff retirement, etc., and which can and should be resurrected, should be pursued. Soon-to-be retired employees with such knowledge should be sought out, and that knowledge should be regained and distributed to existing employees.

Examples of strategies supporting this objective:

- Core capabilities are defined by June 2013.
- Critical field experience and technical knowledge is maintained within NGS by offering at least one internal training/field experience per year open to all employees.
- A geographically specific "succession" plan for each region in the advisor program is prepared by 2016.
- A core set of experts on various projects, programs, and key points of contact is developed. Additional people as needed are sought out to begin shadowing those experts and assisting with writing documents on the work they do.

Examples of evidence of progress:

- The number of mentored employees increases.
- A document of core capabilities exists and is developed into office and project manuals.
- An archive of core work exists for each employee who retires or otherwise leaves NGS in 2013 or later.

Goal 5: Improve Organizational and Administrative Functionality (Enterprise Goal)

All of the above-mentioned goals require that NGS operates efficiently, effectively, in a safe workplace, and with functioning equipment. Goal 5 acknowledges that some significant improvements, and therefore taxpayer savings, may be gleaned by improving day-to-day operations and behind-the-scenes work. An effectively managed office is instrumental for NGS to meet its mission. The objectives under Goal 5 assist management and personnel in support roles to maintain office operations, respond to needs within NOAA, and comply with guidelines and partnerships across the government.

Objective 5-1: Achieve complete adoption of project management in NGS operations by 2016.

Nickname: Project management

Description: NGS has historically been staffed with employees skilled in the sciences. This has led to a wealth of useful service to the nation, but a somewhat unfocused and individualized approach to managing tasks, despite an ever-shrinking resource pool. Project management is a tool NGS must adopt to properly plan, budget, execute, and evaluate the various projects that have historically been performed in an ad hoc fashion.

NGS must arrive at a point where its business logic consists of "no resources are put toward unauthorized projects." This strategy will include an accounting system to prevent the under-assigning of tasks to certain employees and the over-assigning of tasks to others. Only when this is implemented, can NGS efficiently spend resources on priority items.

Examples of strategies supporting this objective:

- A project management method will be designed and approved as part of the NGS decision-making process by June 2013.
- By 2017, NGS will not approve any major resource allocation without approving a project plan first.

Examples of evidence of progress:

- All supervisors and managers have received project management training.
- An easy project management process is developed for new and long-term projects.
- Software and templates exist for creating, approving, and tracking projects.

Objective 5-2: Continually maintain I.T. infrastructure.

Nickname: I.T. Support

Description: NGS has experienced varied success with I.T. infrastructure. On the one hand, PCs are replaced on a regular cycle, but very little attention is paid to a long-term view of I.T. requirements. Budgeting for such needs has always been ad hoc, and this must change immediately.

NGS will evaluate the actual state of its I.T. requirements and prepare a budget on a "must pay" basis, prior to other projects.

Examples of strategies supporting this objective:

- All NGS computer systems are maintained in an operational capacity, resolving 90 percent of all issues within 24 hours and 100 percent of all issues within 2 weeks.
- By September 2014, the existing and predicted future data-processing load on NGS computers is evaluated, and the number of servers is modified as necessary to achieve this load.
- A transition from Sybase to Oracle occurs by September 2014.
- A budget is created to address and meet NGS' I.T. operational requirements.
- NGS' Continuity of Operations Plan (COOP) site in Boulder, Colorado, and existing cloud computing technology are used to enable our I.T. architecture to be more robust and fault tolerant by 2014.

Examples of evidence of progress:

- Sybase is completely retired.
- The annual budget for I.T. is an integral part of the NGS planning cycle.
- Users no longer ask for specific computer equipment, nor are they given a budget for computer equipment, but rather they request resource needs in a general sense.
- Project plans provide clearly identified computing and data storage needs, along with long-term operational documentation.

Objective 5-3: Update or improve the knowledge base for program evaluation through analysis of socio-economic benefits of NGS products and services on a 10-year cycle.

Nickname: Socio-Economic Awareness

Description: As part of Office of Management and Budget and Department of Commerce mandates (as illustrated in the FY 2012 Budget: Analytical Perspectives), offices are required to perform program evaluation on a recurring basis. Part of this program evaluation is to analyze the socio-economic benefits of services offered to the nation. However, even without a mandate, this objective carries the very real positive benefits of self-reflection, leading to improved services and more efficient use of tax dollars.

NGS has performed socio-economic studies on Height Modernization (1998); CORS and GRAVD (in 2009); and the Coastal Mapping Program (2012). NGS has 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, the Aeronautical Survey Program, has never been performed. NGS should periodically review and evaluate the socio-economic and cost benefits of NGS' signature products and services, including proposals for new initiatives such as Foundation CORS. NGS will share its findings with the National

Coordination Office, which is also performing GNSS socio-economic studies.

Examples of strategies supporting 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 publicized via the NGS website.
- Socio-economic information and data is incorporated into NGS communications, press releases, budget formulation, and outreach activities.
- NGS works with the NOAA Chief Economist and other staff on social science needs assessments and any other activities that advance and promote the development of benefit analyses of NGS products and services.

Examples of evidence of progress:

- One new socio-economic benefits study (for example, on the NGS/FAA Aeronautical Survey Program) has 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.

Objective 5-4: Improve the management of NGS records.

Nickname: Records Management

Description:
In 2011, NGS began a process of coming into compliance with federal and NOAA-specific records retention guidelines. File rooms and cabinets were purged of trash, extra copies of publications, and all records that had been kept beyond approved retention periods. Many tasks remain to be done:

- Keep NGS's records retention schedules up-to-date as NGS activities and record keeping needs evolve.
- Manage records in accordance with the retention guidance found at: **http://www.archives.gov/records-mgmt/grs/** and at: **http://www.corporateservices.noaa.gov/audit/records_management/.**
- Consolidate records kept in file rooms, and reallocate empty space to others in NOAA so NGS can realize cost savings on rent.
- Create a digital online library of all official papers ever written by NGS employees, including an offsite backup library. The digital library will replace the fragile and deteriorating paper copies, which are (in many cases) the only copies of official papers still available.
- Create a single system for receiving and archiving digital survey files. This system will replace the aging and haphazard "Sybase"-based Integrated Database, whose haphazard nature was the result of years of force-fitting new data into old definitions.

Examples of strategies supporting this objective:

- One records clean-out day is conducted per year.
- One paper-shredding event is conducted per year.
- All (appropriate) digital copies of documents are available on-line.
- Document sharing relationships are established with related and similar organizations.

Examples of evidence of progress:

- NGS has a digital library of every official paper ever written by its employees.

- An archivist is hired.
- All GNSS data is stored in Oracle.

Objective 5-5: Achieve a fully staffed regional advisor program by 2016.

Nickname: Regional Advisor Program

Description: The NGS "State Geodetic Advisor" program has engaged a long-standing cost-sharing partnership between NGS and various states. On many levels it is a success, especially in those states with very active geodetic communities and advisors whose personalities are well suited to dynamically engage with the state's citizens. However, the program has been a patchwork success and does not serve the nation equitably. Recognizing this imbalance, as well as the reality of shrinking state budgets, in 2010 NGS determined to transition to a regional advisor program. The regional program will consist of a smaller cadre of advisors, all well-trained and dynamic educators capable of serving multi-state regions, and the new program will be run all at the cost to NGS alone.

Examples of strategies supporting this objective:

- Regional advisors provide train-the-trainer opportunities in NGS-related core topics, such as new datums, Ten-Year Plan objectives, and OPUS.
- Achieve, by 2015, continuity of leadership, skills, and knowledge by developing people with the potential and desire for succession.
- NGS transitions from a state advisor program to a regional advisor program by October 2016.

Examples of evidence of progress:

- Regions are identified by the states contained within them.
- The geodetic advisor website is updated.
- A regional advisor on-going education plan is in place by 2016.

Appendix A: Comparison with the Previous NGS Ten-Year Plan (2008–2018)

At its core, the new Ten-Year Strategic Plan represents a different approach to planning, but many of the projects and principles found in the last Ten-Year Plan carry through to the updated version. NGS continues to advance many of the same projects and continues to fulfill its mission and mandates, but with some important improvements. Below is an explanation of some of the changes that can be found when comparing the two plans.

Mission

NGS maintains the same core mission across both Ten-Year Plans, however the secondary mission from the 2008-2018 Ten-Year Plan is no longer articulated. Global leadership is seen as something that comes with good work, not as a goal to be explicitly achieved, in and of itself.

Vision

The vision in the previous Ten-Year Plan did not describe how the world would look if NGS fulfilled its mission, but rather it was a statement of what NGS was doing. The new vision truly encompasses what it is NGS is aiming to achieve.

Goals, Objectives, and Strategies

The terminology "Goals, Objectives, and Strategies" was used inconsistently throughout the previous Ten-Year Plan. The five "technical improvements" in the plan were a hybrid of what are now called "Goals" or "Objectives." But, regardless of their categorization or terminology, below is a limited snapshot of NGS' progress at the halfway point.t

Complete Success:

1. NGS began an absolute antenna calibration program.

2. There are new CORS positions and velocities (NAD 83[2011] from the MYCORS effort).

3. The Table Mountain Geophysical Observatory has been revitalized.

4. A new absolute gravimeter (A-10) was purchased.

5. Digital cameras are used for shoreline mapping.

6. A critical analysis has been made of the geodetic advisor program.

7. FGCS membership has been reestablished, and the FGCS is being kept active.

8. NGS continues to provide airport surveys to the FAA, as requested, through a mix of core capabilities and outside contracting (overseen by NGS).

Moderate Success:

1. We have proof that one-centimeter geoid accuracy is achievable (GSVS11: in one area, and only with new airborne gravity).

2. Functionality of VDatum in all areas of the United States.

3. The NGS website is updated.

4. Efficiency of shoreline mapping is improved to a 15-year cycle.

Measurable, but Minor Success:

1. CORS are located on tide gauges.

2. Field personnel are trained in use of relative gravimeters.

3. There is a plan for a new vertical datum.

4. There is a joint USA/Canada North American Geoid.

5. DOS-based programs are being phased out.

6. Field manuals and technical documents are available digitally.

7. An annual budget is set aside for visiting scientists.

8. There is a vertical crustal velocity model.

Still Awaiting Initialization:

1. Foundation CORS.

2. OPUS use of the following data: Galileo, GLONASS, single-frequency, triple-frequency, code-only, kinematic, L5, or L1C.

3. GLONASS orbits.

4. Hiring a gravity database manager.

5. New gravity interpolation tool.

6. Formally adopt a geospatial graphic and analysis tool for use by all of NGS.

7. Identify critical institutional knowledge, and develop a plan to retain it.

8. Develop requirements for researchers to publish regularly.

9. Develop a college level course on geodesy.

10. Develop K-12 educational material.

Some of the items included under "measurable, but minor, success" and "still awaiting initialization" are included in the new strategic plan. However, after five years, NGS has determined that some of these items are no longer realistic or necessary to call out in and of themselves; for example, NGS leadership does not believe there should be a *requirement* for researchers to publish regularly (yet, it is a likely outcome of determining better survey methods). Likewise, just because complete success was reached in only five years does not mean that all work on that topic has been left out of the new plan. For example, NGS has re-established membership of the FGCS, but work to maintain the group must continue as well as expand. The old plan and the new plan have both called out projects on very different levels, but while this plan is an improved, more complete document capable of moving NGS forward, it recognizes the importance of the majority of the original projects.

Appendix B: List of Acronyms

ASVD02	American Samoa Vertical Datum of 2002
CONUS	Conterminous United States
CO-OPS	Center for Operational Oceanographic Products and Services
CORS	Continuously Operating Reference Station(s)
DOC	Department of Commerce
FGCS	Federal Geodetic Control Subcommittee
FGDC	Federal Geographic Data Committee
GNSS	Global Navigation Satellite Systems
GPRA	Government Performance and Results Act
GPS	Global Positioning System
GRAV-D	Gravity for the Redefinition of the American Vertical Datum
GUVD04	Guam Vertical Datum of 2004
IDB	Integrated Database (as in "NGS IDB")
IERS	International Earth Rotation and Reference System Service
IGS	International GNSS Service
INTG	Interpolation from Geoid Grids Utility
IOCM	Integrated Ocean and Coastal Mapping
ITRF	International Terrestrial Reference Frame

LiDAR	Light Detection and Ranging
MYCORS	Multi-Year CORS Reprocessing Project
NADCON	North American Datum Conversion Utility
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(PA11)	A 2011 updated realization of NAD 83 for the Pacific tectonic plate
NAD 83(MA11)	A 2011 updated realization of NAD 83 for the Mariana tectonic plate
NAVD 88	North American Vertical Datum of 1988
NGS	National Geodetic Survey
NMVD03	Northern Marianas Vertical Datum of 2003
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NSRS	National Spatial Reference System
NWLON	National Water Level Observation Network
OMB	Office of Management and Budget
OPUS	Online Positioning User Service
PRVD02	Puerto Rico Vertical Datum of 2002
RTK	Real-Time Kinematic
SRC	Spatial Reference Center
VDatum	Vertical, Horizontal, and Tidal Datum conversion utility
VERTCON	Vertical Datum Conversion Utility
VIVD09	Virgin Islands Vertical Datum of 2009