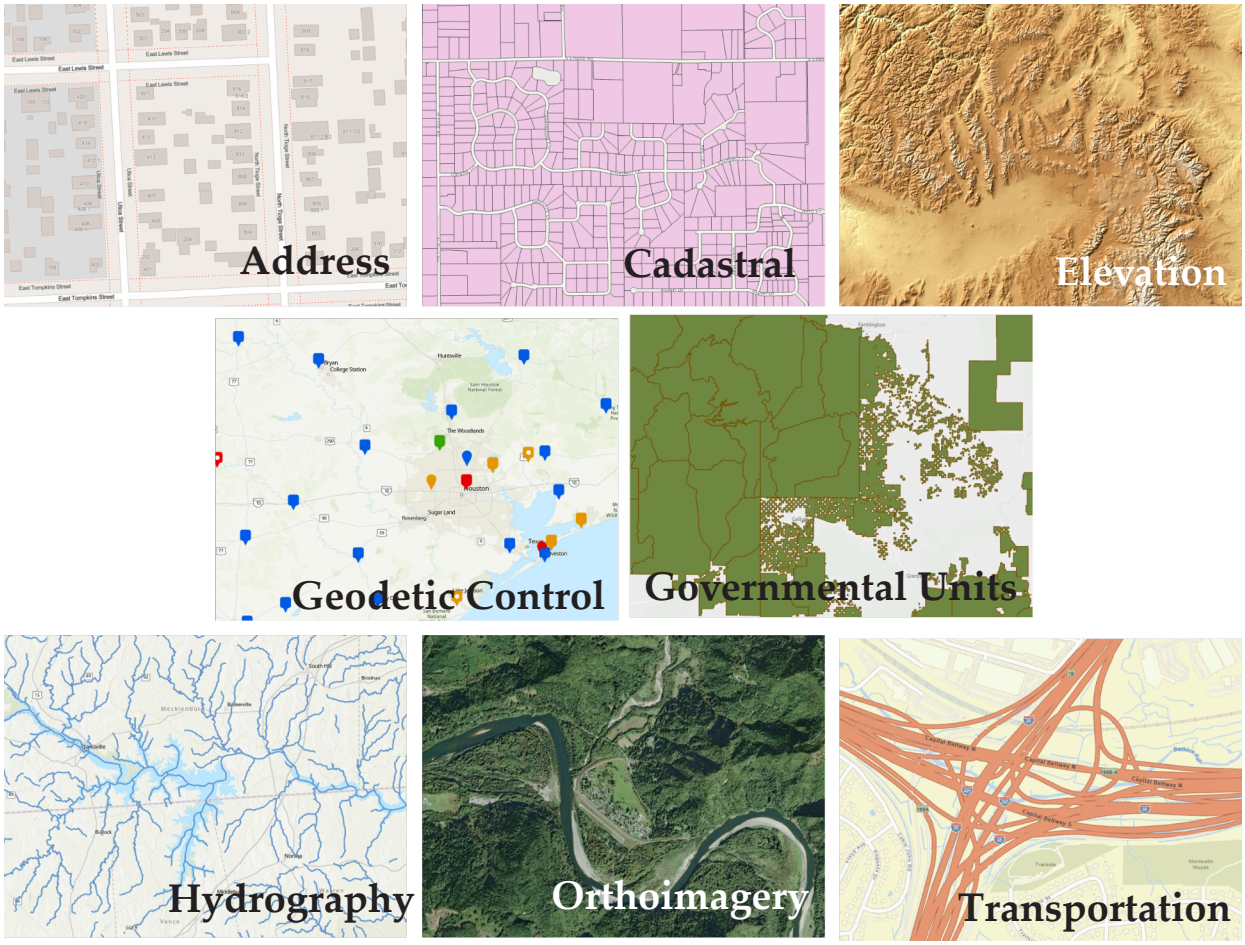
The 2024 U.S. National Spatial Data Infrastructure Assessment



COALITION OF GEOSPATIAL ORGANIZATIONS

American Association for Geodetic Surveying (AAGS)
American Association of Geographers (AAG)
American Society of Civil Engineers (ASCE)
American Society for Photogrammetry and Remote Sensing (ASPRS)
Cartography and Geographic Information Society (CaGIS)
Geographic Information Systems Certification Institute (GISCI)
International Association of Assessing Officers (IAAO)
Management Association for Private Photogrammetric Surveyors (MAPPS)
National Society of Professional Surveyors (NSPS)
National States Geographic Information Council (NSGIC)
United States Geospatial Intelligence Foundation (USGIF)
University Consortium for Geographic Information Science (UCGIS)
Urban and Regional Information Systems Association (URISA)

Foreword

The Coalition of Geospatial Organizations (COGO) recognizes the individual contributions of all Federal, state, regional, tribal, and local government agencies that have worked in concert with the private and academic sectors to develop the National Spatial Data Infrastructure (NSDI) as it exists today. This work has spanned entire careers, and COGO applauds the sincerity of their efforts and the value of their contributions.

However, without the proper governance, authority, or resources to do this important work, the NSDI concepts, first laid out in 1994 via Executive Order 12906, have not been fully realized. Federal, state, regional, tribal and local government agencies cannot together build the NSDI as it was originally envisioned without a strong national collaborative geospatial governance structure.

To develop this third assessment of the NSDI, COGO commissioned eight expert theme-focused work groups. These work groups, drawn from the thirteen member organizations of COGO (Appendix A), focused on the NSDI Framework to grade National efforts, and candidly point to some of the shortcomings of those efforts. COGO offers its profound appreciation for the volunteer work completed by the Assessment work groups.

Collectively, the thirteen COGO Member Organizations represent approximately 170,000 geospatial practitioners. Together, they are delivering this assessment to help Congress, the Administration, Federal agency executives, and others understand the status and shortcomings of the NSDI. The Member Organizations want to continue to engage Congress, Federal agencies, and the Federal Geographic Data Committee (FGDC) to discuss and identify common sense improvements that will lead to a more robust National Spatial Data Infrastructure.

COGO Member Organizations

American Association for Geodetic Surveying (AAGS)

American Association of Geographers (AAG)

American Society of Civil Engineers (ASCE)

American Society for Photogrammetry and Remote Sensing (ASPRS)

Cartography and Geographic Information Society (CaGIS)

GIS Certification Institute (GISCI)

International Association of Assessing Officers (IAAO)

Management Association for Private Photogrammetric Surveyors (MAPPS)

National Society for Professional Surveyors (NSPS)

National States Geographic Information Council (NSGIC)

University Consortium for Geographic Information Science (UCGIS)

United States Geospatial Intelligence Foundation (USGIF)

Urban and Regional Information Systems Association (URISA)

For more information on COGO, please see https://www.COGO.pro/

NSDI Assessment Steering Committee

Chair
Cy Smith

Members
Karen Rogers
Carl Zimmerman
Will Craig
Christine Stinchcomb

Managing Editor
Diana Sinton

Content Area Leads

Address Data Theme
Kathrine Cargo, Theme Lead

Cadastral Data Theme
Christine Stinchcomb, Theme Lead

Elevation Data Theme
John Copple, Theme Lead

Geodetic Control Data Theme
John Doody, Theme Lead

Government Units Data Theme
Matt Rice, Theme Lead

Hydrography Data Theme
Jenna Leveille, Theme Lead

Orthoimagery Data Theme
Tonda Shelton, Theme Lead

Transportation Data Theme
Dan Ross, Theme Lead

Please use the following citation for this report:
Smith, C., Rogers, K., Zimmerman, C., Craig, W., Stinchcomb, C., and Sinton, D. (Eds.). (2024). Third Assessment of the U.S. National Spatial Data Infrastructure. Compiled by the Coalition of Geospatial Organizations. September.

Table of Contents

Abbreviations

3DEP	3D Elevation Program
3DHP	3D Hydrography Program
3DNTM	3D National Topography Model
AAG	American Association of Geographers
AAGS	American Association for Geodetic Surveying
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
ASPRS	American Society for Photogrammetry and Remote Sensing
AWS	Amazon Web Services
BAS	Boundary Annexation Survey
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BOEM	Bureau of Ocean Energy Management
CAGIS	Cartography and Geographic Information Society
CLDXFv1	Civic Location Data Exchange Format, version 1
COGO	Coalition of Geospatial Organizations
CORS	Continuously Operating Reference Stations
CSV	Comma-Separated Value (data exchange format)
DCA	Data Collaboration Announcement
DEM	Digital Elevation Model
DoV	Deflection of Vertical
EDH	Elevation-Derived Hydrography
EEZ	Exclusive Economic Zone
EO	Executive Order
EPSG	European Petroleum Survey Group
ETL	Extract - Transform - Load
FEMA	Federal Emergency Management Association
FGCS	Federal Geodetic Control Subcommittee
FGDC	Federal Geospatial Data Committee
FTP	File Transfer Protocol
FY	Fiscal Year
GBAS	Ground Based Augmentation Systems
GDA	Geospatial Data Act of 2018 (H.R. 302, P.L. 115-254)
GIO	Geospatial (or Geographic) Information Officer
GIS	Geographic Information Systems
GISCI	Geographic Information Systems Certification Institute
GISP	GIS Professional (credential administered by GISCI)
GMS	Geoid Monitoring Service
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
GRAV-D	Gravity for the Redefinition of the American Vertical Datum
GRP	Geometric Reference Point
GSA	General Services Administration
HLM	Horizontal Land Motion

Abbreviations

IAAO	International Association of Assessing Officers
IAG	International Association of Geodesy
IFDM	Intra-Frame Deformation Model
IfSAR	Interferometric Synthetic Aperature Radar
IHRF	International Height Reference Frame
INCITS	International Committee for Information Technology Standards
ISO	International Standards Organization
LCA	Lead Covering Agency
LiDAR	Light Detection and Ranging
LMA	Lifecycle Maturity Assessment
MAPPS	Management Association for Private Photogrammetric Surveyors
NAD	National Address Database (in context of Addresses)
NAD	North American Datum (in context of Geodetic Control)
NAVD	North American Vertical Datum
NAPGD	North American - Pacific Geopotential Datum
NBG	National Boundary Group
NBS	National Bathymetric Source
NCEI	National Centers for Environmental Information
NCN	NOAA Continuously Operating Reference Stations (CORS) Network
NDOP	National Digital Orthoimagery Program
NENA	National Emergency Number Association
NGAC	National Geospatial Advisory Council
NGDA	National Geospatial Data Asset
NGS	National Geodetic Survey
NOAA	National Oceanic and Atmospheric Administration
NOMEC	Natoinal Ocean Mapping, Exploration, and Characterization
NSDI	National Spatial Data Infrastructure
NSGIC	National States Geographic Information Council
NSPS	National Society of Professional Surveyors
NSRS	National Spatial Reference System
NSTC	National Science and Technology Council
OCMIA	Ocean and Coastal Mapping Integration Act of 2009
OGC	Open Geospatial Consortium
OMB	Office of Management and Budget
OPC	Ocean Policy Committee
OST	Ocean Science and Technology
PLEO	Proliferated Low Earth Orbit
PLSS	Public Land Survey System
PPP	Precise Point Positioning
QA/QC	Quality Assurance / Quality Control
RTN	Real Time Kinematic Network

Abbreviations

SOST	Subcommittee on Ocean Science and Technology
SPCS	State Plane Coordinate System
UCGIS	University Consortium for Geographic Information Science
UN-IGIF	United Nations Integrated Geospatial Information Framework
UN-GGIM	United Nations Global Geospatial Information Management
URISA	Urban and Regional Information Systems Association
USACE	United States Army Corps of Engineers
USGIF	United States Geospatial Intelligence Foundation
USGS	United States Geological Survey
USPS	United States Postal Service
VIIRS	Visible Infrared Imaging Radiometer Suite
VLM	Vertical Land Motion

List of Figures

List of Figures

List of Tables

Executive Summary

The National Spatial Data Infrastructure (NSDI) is designed for accurate, consistent, and current geospatial data to be available to users at all levels. To promote the NSDI and increase the likelihood of its successful development, the Coalition of Geospatial Organizations (COGO) has coordinated the production of a regular series of evaluative reports that serve as an overall assessment of the NSDI's ability to meet current and future national geospatial data needs. Each NSDI Assessment, now being produced on a four-year cycle, documents achievements and accomplishments, identifies shortcomings and persistent challenges, and provides recommendations for continuing essential and necessary progress on the NSDI.

COGO recognizes its unique perspective on and connection to national-level geospatial matters. Since its founding in 2008, the COGO Member Organizations, now numbering thirteen, include the largest and most active geospatial entities in the United States and directly represent approximately 170,000 geospatial practitioners and professionals. In taking on the responsibility of systematically and regularly evaluating the NSDI, COGO demonstrates its commitment to supporting and advancing the NSDI by assessing and publicizing how well the NSDI is currently meeting its goals. The assessment process itself involves coordinating a volunteer and collaborative effort to gather, consolidate, and interpret stakeholder input.

The NSDI consists of multiple connected components, including the technology, policies, standards, and human resources necessary to acquire, process, store, distribute, and improve the utilization of geospatial data. Having a complete and robust NSDI will be a positive benefit to the United States and its residents. A well-functioning NSDI is both desirable and legally mandated. The Geospatial Data Act of 2018 (GDA) (H.R. 302, P.L. 115-254) formalized and established multiple geospatial entities and policies, including the NSDI, in order to ensure access to and sharing of geospatial data.

Assessing the status of every component of the entire NSDI, however, would require significant funding and cooperation from all Federal agencies and many other organizations, and is beyond the scope of the COGO initiative.

Instead, every four years this Assessment first considers eight NSDI Framework data themes, listed below, as these are recognized as the backbone of the NSDI.

NSDI Framework Data Themes

1. Addresses
2. Cadastre
3. Elevation
4. Geodetic Control
5. Governmental Units
6. Hydrography
7. Orthoimagery
8. Transportation

To evaluate these eight Data Themes, a COGO-based Steering Committee oversaw eight work groups with over 40 geospatial experts representing COGO organizations, state and federal agencies, and the Federal Geographic Data Committee (FGDC). Additional data were acquired via a 2023 national survey distributed via COGO members, and meetings with additional NSDI and data theme experts.

Each of the eight Data Theme work groups:

- researched and documented theme-specific collaborations and partnerships
- highlighted progress in data standards,
- provided an estimate of the theme's completeness,
- gauged the accessibility of its theme's data, and
- described how well the theme is being governed and managed.

In addition to assigning a letter grade to their Data Theme, several of the work groups drafted theme-specific recommendations. All additional details on the assessment criteria, composition of the work groups, and evaluative processes followed are summarized in the full report.

NSDI Assessment: Data Themes			
	Report Year		
Data Theme	**2015**	**2018**	**2024**
Addresses	N/A	B+	B
Cadastral	D+	C-	C-
Elevation	C+	B-	A-
Geodetic Control	B+	A-	A-
Governmental Units	C	A-	A-
Hydrography	C	B-	B-
Orthoimagery	C+	B-	B
Transportation	D	C	C
Average Data Grade	**C**	**B-**	**B**

In the 2024 NSDI Assessment, an average grade of B was calculated for the eight Framework Data Themes.

Two of the data themes, Elevation and Geodetic Control, have undergone substantial improvements since COGO's first evaluation in 2015. Critical investments in resources, support, and significant cross-agency activities are contributing factors. In fact, important progress in collaborations and partnerships was a common positive characteristic across the eight work groups, while lack of standards and funding uncertainty were two of the most significant shortcomings. Extensive explanations for these grade assignments can be found in the remainder of this report.

As a second and related activity, COGO also compiles input from multiple stakeholder groups and summarily asseses the NSDI as a whole. This collective effort assigns grades to each of seven criteria.

Evaluation Criteria for the NSDI as a Whole

1. Capacity
2. Condition
3. Funding
4. Future Need
5. Operation and Maintenance
6. Public Use
7. Resilience

Input about the NSDI with regards to these criteria was drawn from expert opinion from multiple sources, including COGO's 2023 national survey, the Data Theme work groups, other NSDI experts, the Steering Committee, and

representatives from COGO member organizations. Narrative summaries about each criterion are provided in the report.

In the 2024 NSDI Assessment, an overall grade of C- has been assigned to the NSDI as a whole.

NSDI Assessment: NSDI Overall		
	Report Year	
Criteria	**2015**	**2024**
Capacity	C	C
Condition	D	D
Funding	D	D
Future Need	D	D
Operation & Maintenance	C	C
Public Use	C	C
Resilience	C	C-
Overall NSDI Grade	**C-**	**C-**

Overall, some progress has been made toward a more integrated and accessible NSDI since the 2015 and 2018 evaluations, but no positive significant changes have happened. In terms of its resilience, the NSDI has experienced setbacks since it was first evaluated by COGO almost a decade ago. The original vision and the greatest potential value of the NSDI Framework have not yet been fulfilled. The governmental organizations charged with the stewardship of the NSDI, including its Framework data and other elements, face obstacles in terms of both authority and, more importantly, funding. Three areas of particular concern for advancing the NSDI overall include 1) national governance, 2) the number of National Geospatial Data Assets, and 3) an absence of Framework data standards.

We cannot emphasize enough the importance of coordinating with authoritative sources for an accurate and equitable aggregation of nationwide data for the public good. Definitive sets of nationally consistent, fully integrated, and reliable data do not exist for the entire nation, even while multiple versions of datasets for each of the themes can be accessed through the National Geospatial Platform. As an example of an underlying factor, often the most accurate and current geospatial data are routinely collected by local government organizations. Therefore, a successful NSDI demands that these high-resolution data become part of the NSDI Framework. Yet the most consistent, nationwide information about roads and land records exist in proprietary databases that Federal agencies lease from commercial firms. These commercial data cannot become part of the NSDI due to licensing restrictions. Bridging these discrepancies is an ongoing challenge for the NSDI stewards.

Having over 170 National Geospatial Data Assets produces unintended consequences. While the reporting mandated by the GDA has been somewhat useful to understand the status of the NSDI data themes, the level of effort required to conduct that reporting is overwhelming and needs to be re-evaluated. At a minimum, this NSDI Assessment suggests a compelling need for a thorough assessment of user needs and requirements for a modern data system.

Lastly, there has been a lack of standards development and update in the six years since the last NSDI Assessment. FGDC has recently indicated that their data standards work will be re-initiated with an effort to identify and update, then endorse, existing standards. This process would then be followed by an effort to identify, develop, and endorse necessary new standards. Such a process could take many years. The vital importance of standards for the NSDI demands that this work be pursued with alacrity.

The organizational goals of this 2024 COGO NSDI Assessment have been to (1) highlight the persistent and critical need for increased investment in accurate, consistent, and current geospatial data for the United States and (2) pursue and model a more robust and collaborative evaluative process that includes expanded input from a broader range of stakeholders and authoritative sources, including domain practitioners, non-Federal agencies, and the FGDC. With these organizational goals accomplished, COGO respectfully submits this 2024 NSDI Assessment. It is our hope that it serves as a valuable resource for the FGDC to direct its time and resources wisely to make requisite advances to the NSDI.

2024 NSDI Assessment

COGO's SUMMARY RECOMMENDATIONS

For a more fully integrative and robust National Spatial Data Infrastructure

1. Identify sufficient funding to meet future needs of the NSDI for all Framework Data Themes.

2. Develop Strategic and Implementation Plans for each Framework Data Theme.

3. Develop partnership agreements with States, Tribal governments, and local governments to facilitate continuous exchange of data.

4. Work with the geospatial community to develop and implement a national collaborative NSDI governance structure.

5. Evaluate the number of National Geospatial Data Assets (NGDA) to decrease the number of such data sets and thereby lessen the reporting burden.

6. Facilitate assessment of all stakeholder needs for Framework Data.

7. Develop processes and procedures for integrating Framework Data across all governmental levels.

8. Quickly evaluate existing Framework data standards, undertake any necessary updates right away, and endorse those standards in as short a time frame as possible.

Introduction

The Coalition of Geospatial Organizations (COGO) serves as a forum for thirteen non- profit member organizations and seven advisory organizations concerned with national geospatial issues (see Appendix A). Collectively, COGO represents approximately 170,000 individual geospatial practitioners in the United States. The mission of COGO is to provide a forum for organizations concerned with national geospatial issues that improves communications among the member organizations, that provides educational information on relevant issues for their respective memberships, that aligns and strengthens COGO Members' respective policy agendas, and that facilitates development of strategies to address national issues.

In support of its mission, COGO is committed to advancing the development of the National Spatial Data Infrastructure (NSDI). Having a complete and authoritative NSDI will be a positive benefit to the United States and to every COGO member organization, as well as the nation's residents.

To focus attention on the NSDI and its data themes, COGO commissioned its first NSDI Report Card in 2013. A similar type of Report Card assessment is conducted every four years by the American Society of Civil Engineers (ASCE) and is highly regarded as an effective way to monitor infrastructure improvements and deficiencies. COGO's first NSDI Report Card, produced by an appointed panel of seven experts led by former Wyoming Governor Jim Geringer, was published in February 2015. Its conclusions highlighted both valuable strengths and considerable shortcomings within the NSDI and its data themes. Overall, the Report Card served its purpose to raise awareness of NSDI inadequacies and to foster discussions between COGO and federal agencies whose lead roles in NSDI development and curation had been part of the evaluation. While an important and worthwhile first effort, both the Federal Geographic Data Committee (FGDC) and COGO member organizations anticipated improving the process of the assessment going forward.

Production of the second Report Card, published in 2018, shifted research and writing responsibilities to small groups of experts focused on the Data Themes. Addresses was added as a Framework Data Theme only in 2016, hence its absence in the first 2015 Report Card. A small COGO Steering Committee coordinated the efforts of the expert groups to assess the data but no final comprehensive grade was generated for the NSDI Framework as a whole.

This third assessment differs from the prior iterations in two important ways: 1) the extent of the research input and 2) the enhanced coordination with FGDC and other federal entities. To begin, the base of stakeholders involved in data theme assessment was expanded to a group of 40 content experts, recruited from among the thirteen COGO member organizations and grouped into eight data-theme specific teams. In addition, the Steering Committee developed a survey that the COGO organizations widely distributed to their members. Thus the survey gathered information about the NSDI and the status of its various Framework data sets directly from data users and providers across the country. Approximately 450 responses were

received from local and state government staff, as well as users in non-profit organizations, higher education, and businesses across the nation. Survey results relevant for specific data themes were distributed to their respective workgroup leaders to inform their research efforts.

Secondly, the important and valid criticism that emerged from the earlier Report Card processes, that the FGDC had not been sufficiently involved in the assessment workflows, was thoughtfully and intentionally addressed for this 2024 Assessment. Members from COGO began discussions with members of the FGDC in 2022 and regular exchanges ensued throughout the research and writing process. In addition to this, the FGDC provided data theme leads to serve as Points of Contact (POCs) for each of the eight assessment teams (see Appendix A). Each assessment team interfaced with their respective POCs to ask questions, and to share preliminary assessments and receive feedback. This allowed the FGDC to share key information with the content experts about FGDC coordination processes related to Framework data sets.

The constructive criticism provided to COGO following the first two Report Cards was carefully and thoughtfully considered to ensure this third iteration of the assessment would be as robust, valid, and current as possible. As a member organization of COGO, the leadership of ASCE worked with COGO leadership to better align COGO's NSDI Assessment with ASCE's *Report Card for America's Infrastructure*. This alignment included changing the name of the COGO report to the NSDI Assessment, as well as staggering the publication of the two respective reports so that each is produced every four years going forward.

The primary goal of this third evaluation continues to be raising attention about the need for increased investment in current and accurate geospatial data for the United States. As was the case for the first two assessments, no cost estimates for completing the NSDI or for bringing the Framework to a specified level have been estimated or included. A secondary goal in this third round has been to enhance engagement with the FGDC in an even more collaborative assessment process.

COGO is committed to having the NSDI Assessment be as helpful a product as it can be, and its development workflow be fair and transparent, while not overly taxing any of the individual volunteers who dedicate themselves to its research and production. It is our hope that it serves as a valuable resource for the FGDC to direct its time and resources wisely to make requisite advances to the NSDI.

NSDI Background

Calls for coordinated approaches to manage the survey and mapping data of the United States have long been part of the nation's history. In 1906, President Roosevelt signed an Executive Order (EO) establishing the U.S. Geographic Board that was to advise on projects, take measures to avoid duplication, and improve the standardization of maps. Over the next 84 years, numerous other Orders and Circulars were issued with related intentions. In 1990, the 1953 OMB Circular A-16 was revised to create the FGDC to "coordinate surveying, mapping and related spatial data activities and to promote the coordinated development, use, sharing and dissemination of surveying, mapping and related data

across the Federal Government." A major objective of the revised Circular was the eventual "development of a national digital spatial information resource with the involvement of Federal, state, and local governments and the private sector." A secondary objective identified the key need for criteria and standards that would enable the sharing and efficient transfer of spatial data between producers and users.

The 1990s was a time of significant forward movement in the development of the United States as an information society, and a linked recognition that an information society depended on spatial data and information. The National Research Council's Mapping Science Committee issued reports in 1993, 1994, and 1995 that addressed the concepts, needs, and potential contents of an NSDI, stating in one of its reports that "The NSDI should be the means to assemble geographic information that describes the arrangement and attributes of features and phenomena of the Earth." The 1993 NRC Report, *Toward a Coordinated Spatial Data Infrastructure for the Nation* (NRC 1993) suggested that an *ad hoc* NSDI already existed but was in need of substantial formalization. Two specific goals and related actions were recommended: "first, to make the existing NSDI more coherent and coordinated; and second, to position the U.S. more competitively in the growing and increasingly international geospatial data and technology arena."

Apart from helping to define the NSDI, the NRC Mapping Science Committee Reports also specified four principles to guide its development:

1. Data should be widely available.
2. Accessing spatial data should be easy.
3. The NSDI should be flexible and not dependent on current technology, data, or organizational structures.
4. The NSDI should be a foundation to foster new applications, services, and industries.

The NRC Reports laid important groundwork for further federal action. On April 11, 1994, President Clinton issued Executive Order 12906 that charged the FGDC to lead and coordinate the development of the NSDI. The EO broadly defined the NSDI as "the technology, policies, standards, and human resources necessary to acquire, process, store, distribute and improve utilization of geospatial data," language that came directly from the 1993 NRC Report. FGDC was given nine months to consult with state, local, and tribal governments to prepare a plan for the initial implementation of a national digital geospatial data framework, which itself was to be completed by January 2000.

The most important federal legislation to date for the NSDI has been the Geospatial Data Act of 2018 (GDA). It was enacted on October 5, 2018 and as a component of the FAA Reauthorization Act (H.R. 302, P.L. 115-254). As part of the U.S. Code, specifically Title 43 Public Lands, Chapter 46, several key provisions and entities were formally and officially codified, including:

1. Federal Geographic Data Committee: Coordinates geospatial data activities across federal agencies.
2. National Geospatial Advisory Committee (NGAC): Provides guidance on geospatial matters.
3. National Spatial Data Infrastructure: Ensures access to and sharing of

geospatial data.

4. Geospatial Data Standards: Promotes consistency and interoperability.
5. GeoPlatform: Supports geospatial data sharing and collaboration.
6. Covered Agency Responsibilities: Identifies which agencies are required to comply with geospatial data standards.
7. Limitation on Use of Federal Funds: Ensures proper utilization of funds for geospatial data activities.
8. Lead Covered Agency Reporting: Lead agencies for each National Geospatial Data Assets (NGDA) data theme to report on theme status annually.

The GDA was enacted to provide statutory direction for the continued development and formalization of the NSDI. The Act declares "the NSDI shall ensure that geospatial data from multiple sources (including the covered agencies, State, local, and tribal governments, the private sector, and institutions of higher education) is available and easily integrated to enhance the understanding of the physical and cultural world."

The GDA provides statutory authorization and structure for the FGDC as the lead entity in the Executive Branch for development and implementation of geospatial data, as well as the NSDI strategic plan. It directs federal agencies to report to Congress on progress and status of the NGDA data sets, as noted, and provides direction for all federal agencies on efficient development and sharing of geospatial data. It further directs the federal government to partner with state, local and tribal governments, the private sector, higher education and non-profit organizations to develop the NSDI.

The Current NSDI

The concept of the NSDI has evolved since the 1990s but much of the original vision of the NRC Reports and EO 12906 remains. Central is the understanding that geographic information promotes economic development, improves stewardship of natural resources, and protects the environment. Coordination is another key tenet, with President Clinton's EO stating that the FGDC "shall develop, to the extent permitted by law, strategies for maximizing cooperative participatory efforts with State, local, and tribal governments, the private sector, and other non-federal organizations to share costs and improve efficiencies of acquiring geospatial data consistent with this order." The 2018 GDA further codified that principle.

In the FGDC's 2021-2024 NSDI Strategic Plan document, the NSDI was promoted as:

- A geographic resource for both the present and the future.
- A foundation for helping the public and private sectors use geospatial data for better decision making.
- A resource for many people and organizations working together towards common goals.
- A collection of current and accurate geospatial data available for local, state, national, and global use.
- An infrastructure for geospatial applications and services.
- A flexible resource that changes as technology, business requirements,

and user needs change.

Infrastructures can be physical or virtual systems with sets of interconnected elements needed to carry out the operations of society, a single enterprise, or a group of enterprises. Like our transportation, banking, and financial infrastructures, a spatial data infrastructure such as the NSDI is an interconnected system designed to facilitate a state of cooperation and connectivity. This enables government, businesses, private institutions, and residents to share and use spatial information and services to meet their basic operational needs.

Thus, the core values of the NSDI, as written in the FGDC's 2025-2035 NSDI Strategic Plan, are:

- Findability, Accessibility, Interoperability, and Reusability principles are applied to geospatial data and related information;
- Dependability of geospatial services to build trust and expand use;
- Quality to ensure data is fit for purpose;
- Collaboration to leverage resources, share expertise, and avoid duplication of efforts; ,
- Innovation to address emerging challenges and opportunities;
- Transparency to build trust among stakeholders and foster accountability; and
- Sustainability to ensure long-term resilience, stability, and reliability.

The NSDI has long been understood to include the technologies, policies, organizations and people necessary to promote cost-effective production, ready availability, and greater utilization of high-quality geospatial data among a variety of sectors, disciplines, and communities. It should provide a common structure of practices and relationships among data producers and users to facilitate data sharing and use, as well as new ways to access, share, and use geographic data. The NSDI is necessarily comprised of multiple and connected elements including:

- Clearinghouses, catalogs, and portals for discovery and access;
- Metadata or information that captures the characteristics of data or information technology resources;
- Framework data (a reliable and standardized source of commonly used and shared data that can form the foundation for connecting all other geospatial data);
- Thematic data developed and used for particular business requirements;
- Standards for geospatial data and technology developed through voluntary, consensus-based processes to promote interoperability, effective sharing, and use;
- Collaborative partnerships between the private sector, academia, non-profits, and state, local, and tribal governments to efficiently and cost-effectively collect, integrate, maintain, disseminate, and preserve spatial data, building on local data wherever possible;
- Public policies that promote greater public access to government data, data sharing, privacy protection, simplified and unified business processes, and reduced duplication of data collection

and government services.

Standards

Standards are a core element of the NSDI as a key to interoperability and effective sharing and use of geospatial data and technology. This Assessment will reference a variety of existing standards that have been endorsed by different standards development organizations, but each is important in providing a level of conformity and consistency. For example:

- The GDA requires FGDC-endorsed standards for use by Federal agencies;
- American National Standards Institute (ANSI) standards are required for use in the U.S. marketplace; and
- The International Organization for Standardization (ISO) develops international standards for products, services, and systems to ensure quality, safety, and efficiency, and to facilitate international trade.

Standards from any of these organizations - as well as technology standards and specifications from organizations such as the Open Geospatial Consortium (OGC) - may be appropriate for use by an organization. Standards may also move from national or governmental approval to international approval. A key part of the standards development and maintenance process of these recognized organizations is the periodic review of adopted standards. Reviews are conducted to determine if standards meet current user needs and are up to date with accepted practices and technology. Good management practices call for standards to be checked to ensure they are current prior to being promoted for use in major new NSDI initiatives.

Due mainly to funding constraints, there has been no development or maintenance activity of standards by FGDC in the last six years. The GDA explicitly states that federal agencies will not be allowed to expend funds on geospatial data that does not meet FGDC-endorsed standards starting five years after such a standard has been endorsed for a particular data set. Based on a recent legal opinion, FGDC has decided to deprecate all existing FGDC-endorsed standards and initiate a new process to evaluate and endorse standards. This new process is absolutely essential to further development of the NSDI.

Evolving FGDC Management of the NSDI

To manage the NSDI and other federal geospatial resources with all of their complexity requires a tremendous amount of coordination and structure. In the mid-1990s, the FGDC adopted a Framework Approach that placed emphasis on 1) the most commonly used themes of geospatial data; 2) procedures, technology, and guidelines that provide for integration, sharing, and use of these data; and 3) institutional relationships and business practices that encourage the acquisition, maintenance and use of data.

In this way, the Framework incorporated all elements of the NSDI and progress on the Framework was illustrative of overall NSDI coordination and advancement. The NSDI Framework remains important to the continued development of the interconnected system that enables government at all levels, businesses, private institutions, and the public to share and use spatial information and

services to meet their basic operational needs.

In 2014, the FGDC began using a Portfolio Management approach for its geospatial data, in accordance with the OMB Circular A-16 Supplemental Guidance. Portfolio Management is a business approach that identifies assets, and in this case our Federal datasets are considered National Geospatial Data Assets (NGDA). Assets of this type support mission goals of multiple federal agencies, are statutorily mandated, or support national or Presidential priorities as expressed by Executive Order or by the OMB. Framework data are not specifically identified as such in the Portfolio but are part of the construct of 16 Themes identified in the NGDA Portfolio.

The NSDI Strategic Plan, now mandated by the GDA to be prepared and regularly maintained by the FGDC, describes the expectations and needs for updates and modernization of Federal geospatial programs. The Strategic Plan sets priorities and describes the actions that the FGDC community will take, in collaboration with partners, to develop and maintain the NSDI.

The three goals of the forthcoming NSDI Strategic Plan, aimed to span the years 2025 - 2035, are to:

1. Implement National Governance
2. Modernize the Infrastructure and Leverage Advanced Technology
3. Build a Skilled and Inclusive Geospatial Workforce for a Sustainable Future

Each of these goals is highly relevant to the successful development of NSDI data themes as a resource for the entire geospatial community.

Notably, a national collaborative governance structure for the NSDI, in which all public and private sectors participate, has always been absent in the past despite its recognition in strategic plans starting in 1994. This critical element is expected to become even more essential going forward.

Assessing the NSDI Framework Data Themes

Assessing the status of every component of the entire NSDI would require significant funding and cooperation from all Federal agencies and is beyond the scope of a COGO initiative. However, focusing on eight framework data themes that are recognized as the backbone of the NSDI is appropriate and feasible. The importance of these data themes as fundamental building blocks of the NSDI has been recognized since the issuance of EO 12906. The Strategic Plans have focused upon data as one component within the goals of the 2004 NSDI Future Directions Initiative. Seven of the Themes are ones that COGO had included in its 2015 Report Card, and they are assessed again for this report. The Address Data Theme is an additional eighth theme that was officially added as a Framework theme in 2016 and subsequently added to COGO's NSDI Report Card in 2018.

This COGO Assessment is intended to help address the need for accessible, accurate spatial data. Such data could be provided efficiently from reliable and standardized sources for the eight most commonly needed and used spatial data themes. The NSDI Framework has the following eight designated themes of data. The Elevation and Cadastral themes each contain two sub-parts.

Table Introduction-1. Eight NSDI Framework Data Sets Assessed by COGO. Table is continued on the next page.

Data Theme	Federal Custodians	Description
Addresses	Dept of Commerce - Census Bureau & Dept of Transportation	The Address Theme consists of the data elements, attributes, and metadata that specify a fixed geographic location by reference to a thoroughfare or landmark, or specify a point of postal delivery, or both.
Cadastral	Dept of Interior - Bureau of Land Management (BLM) (land) and Dept of Interior - Bureau of Ocean Energy Management (BOEM) - off-shore	Cadastral information refers to property interests. Cadastral data represent the geographic extent of the past, current, and future rights and interests in real property. It is the spatial information necessary to describe the geographic extent, and the rights and interests in property includes surveys, legal description reference systems, and parcel-by-parcel surveys and descriptions. The offshore cadastre is the land management system used on the Outer Continental Shelf. It extends from the baseline to the extent of United States jurisdiction. Existing coverage is currently limited to the conterminous United States and portions of Alaska.
Elevation	Dept of Interior, USGS (terrestrial) and Dept of Commerce, NOAA (water)	Elevation data provide information about terrain. Elevation refers to a spatially referenced vertical position above or below a datum surface. The Framework includes the elevations of land surfaces as well as the depths below water surfaces (bathymetry).
Geodetic Control	Dept of Commerce - NOAA	Geodetic control provides a common reference system for establishing the coordinate positions of all geographic data. It also provides the means for tying all geographic features to common, nationally-used horizontal and vertical coordinate systems.

Table Introduction-1, *continued*. Eight NSDI Framework Data Sets Assessed by COGO.

Data Theme	Federal Custodians	Description
Governmental Units	Dept of Commerce - Census Bureau	Governmental Units include boundary data of the nation, states and statistically equivalent areas, counties and statistically equivalent areas, incorporated places and consolidated cities, functioning and legal minor civil divisions, Federal and state recognized American Indian reservations and trust lands, and Alaska Native regional corporations.
Hydrography	Dept of Interior - USGS and US Fish and Wildlife Service	Hydrography data include surface water features such as lakes and ponds, streams and rivers, and canals. Each of these features has the attributes of a name and a feature identification code.
Orthoimagery	Dept of Agriculture - Farm Service Agency (FSA) (leaf-on) and Dept of Interior - USGS (leaf-off)	Orthoimages are positionally correct images of the Earth. An orthoimage is a georeferenced image prepared from an aerial photograph or other remotely sensed data from which displacements of images caused by sensor orientation and terrain relief have been removed.
Transportation	Dept of Transportation - Bureau of Transportation Statistics	Transportation data include the following major common features of transportation networks and facilities: roads, trails, railroads, waterways, airports, ports, bridges, and tunnels.

Assessment Methodologies

Evaluation Processes

This 2024 Assessment, first launched in 2021, has been led by a COGO-based Steering Committee. This group coordinated the extensive and collaborative effort by volunteers to gather and consolidate stakeholder input. Eight work groups were formed with over 40 geospatial experts representing COGO organizations, state and federal agencies, and the FGDC (see Appendix B). The Steering Committee also designed and distributed a large survey via COGO members. Meetings were held with outside experts for several of the data themes, and with various COGO members for insights into the NSDI as a whole. Lessons learned from production of the earlier assessments, previously referred to as Report Cards and published in 2015 and 2018, were incorporated.

Leaders of each workgroup were provided with instructions on the scope and extent of their tasks, the criteria to consider, and their group membership, including their FGDC Points of Contact. They were also provided with results from the national survey results that were relevant or specific to their respective data theme. Group leaders were given discretion in design and composition of their report, including whether to reference survey results, include graphics or tables, or use supplemental research materials. Groups were responsible for self-organization and task completion prior to the overall timelines established.

Draft versions of the full report were compiled prior to a final review and approval by current COGO leadership.

Evaluation Criteria

For each of their respective data themes, the eight work groups researched and documented 1) collaborations and partnerships that have been undertaken, 2) progress in data standards, 3) estimates of the theme's completeness, 4) accessibility of its data, and 5) how well the theme is being governed and managed. Each was provided with the results from the 2023 national survey conducted by COGO to gather user feedback on the data themes. The survey had received about 450 responses, so this also served as an important stakeholder input into the assessment processes. Some of the theme assessments have additional objective metrics, particular to that assessment, that were considered in the evaluation.

For consideration of the NSDI overall, seven general criteria are used, modeled on the assessment criteria used by the ASCE *Report Card for America's Infrastructure* (https://infrastructurereportcard.org/). Several work groups also considered these explicitly within their data theme evaluation.

Evaluation of the NSDI based on these criteria was drawn from expert opinion from multiple sources, including a national survey, the Data Theme work groups, other NSDI experts, the Steering Committee, and representatives from COGO member organizations. Narrative summaries for each criterion are provided in the report.

1. **CAPACITY:** The NSDI's ability to meet current and future demands.
2. **CONDITION**: The existing or near-term condition of the Framework themes as an integrated whole.
3. **FUNDING**: The funding capability of the NSDI.
4. **FUTURE NEED**: Whether future-funding prospects will be able to meet the need.
5. **OPERATION AND MAINTENANCE**: The ability of key lead organizations to develop and maintain the Framework and to adopt new technology, procedures, and standards.
6. **PUBLIC USE**: The NSDI's ability to provide data resources that meet the everyday needs of organizations.
7. **RESILIENCE**: The ability of the geospatial community to participate in development of the NSDI and to contribute to its sustainability as a long-term asset of value for the nation.

Grading System

The following explains the grading system that was used in this 2024 assessment, as well as the previous two assessments. While the explanation for each grade refers to the Framework data themes, the same grading system was used to assess the overall NSDI.

A = FIT FOR THE FUTURE

The data theme is generally in excellent condition and meets the needs for the present and the future. Few geographic areas of the nation require attention. Standards for data and assured public access are met. Specific data are identified as Framework and are integrated for use consistently across the United States. Data identified as Framework are also in a standards-based form that can be readily incorporated into an integrated Framework data network across the United States. Users are able to easily identify, integrate, and use data from this theme in a wide variety of applications.

B = ADEQUATE FOR NOW

The data theme is in good to excellent condition, but some geographic areas of the nation require attention for significant deficiencies. A substantial majority of the theme data that have been designated as Framework follow appropriate standards and are available. Data identified as Framework are integrated for use consistently across the United States and can be incorporated into an integrated Framework data network with minimal work by users. Users are able to find, integrate, and use data for a majority of U.S. locations.

C = REQUIRES ATTENTION

The data theme is in fair to good condition, but it requires attention for many geographic areas of the nation. Standards for this data theme exist and are used for most of the data that are designated as Framework. Users have some difficulty finding, integrating, and using data, and a consistent integrated network for this theme is not in place across the United States. Significant effort will be required to incorporate data identified as Framework into an integrated Framework data network. Some locations in the U.S. are missing Framework data for this theme.

D = AT RISK

The data theme is in poor to fair condition and mostly below the goals envisioned for the NSDI. A large portion of the data for this theme have not been developed sufficiently to make them accessible or are unable to be integrated with other data from this theme. Standards exist for data designated as Framework for this theme, but the standards are not being consistently used among data providers and developers. For many locations, data are not useful without significant work by the user and cannot be integrated into a network for consistent use across the United States.

F = UNFIT FOR PURPOSE

The data for this theme is in an unacceptable condition and provides little to no value to users. Standards for the data theme do not exist or are not being used by most of the users, providers, or data developers. Most of the data cannot be found or used in applications at national or local levels and cannot be integrated into either a network for the theme or an integrated Framework data network for use across the United States.

Overall NSDI Assessment Results

Overall Grade for the NSDI: C-
Requires Attention

Discussion:

In 2015, the expert panel that COGO invited to objectively grade the NSDI provided a perspective that, to a great extent, remains valid today, despite areas of progress. Indeed, after almost a decade of activity, we find that the C- grade the panel gave to the NSDI in 2015 continues to accurately reflect the overall status of the NSDI today.

The NSDI Framework was envisioned to be an integrated data resource "from which other data sets may be derived or to which other data sets can be referenced." It was to be a collaborative effort to create a widely available source of basic geographic data. Its purpose was to provide the most common geographic data that users will need, and to serve as a building block for the NSDI. The Framework was intended to provide data that are trusted, standardized, described according to common principles, and publicly available at minimal or no cost to the user.

The vision of the NSDI, however, has not yet been fulfilled. The NSDI exists and provides substantial value to users through the large amounts of publicly available thematic data, but while there are many versions of datasets for the Framework themes, definitive sets of reliable, authoritative Framework data are not as consistently available as they need to be. The Framework is not an integrated whole, but still remains mostly as eight separate themes.

There have been many positive actions in the implementation of the NSDI. For example, a number of individual thematic datasets have been developed. This Assessment report highlights individual Framework data themes whose development merits the higher marks they have earned. Metadata and some data standards have been adopted and are used by data collectors. Government agencies generally make their data assets publicly available through data portals and spatial data clearinghouses.

The grade of C- indicates that the entire NSDI is in fair condition but requires attention for many components, including a number of individual Framework data sets. Users generally have some difficulty finding, integrating, and using data, and many locations in the U.S. are missing data for one or more individual themes. There has been no progress or work on data standards in the past six or more years. The number of NGDA data sets, which all require detailed reporting, has increased to unsustainable levels from a reporting standpoint. In addition, there is no collaborative NSDI governance structure whereby partners from all sectors can make decisions together to create a shared infrastructure, even though the need for such a governance structure has been called out since the NSDI was first initiated in 1994. For those reasons, even though some progress has been made since the first NSDI assessment by COGO in 2015, when the grade for the overall NSDI was C-, the grade has not improved. Therefore, the condition, state of development, and use is:

REQUIRES ATTENTION

Impacts:

The availability of large amounts of reliable geospatial data in the eight thematic Framework categories represents a great benefit to the nation. However, it is difficult for users to know which data sets are the authoritative Framework data. While there are still many concerns about Federal agencies focusing almost exclusively on Federal needs and programs, many datasets that could be part of the NSDI Framework are being developed at state and local levels. Although this local data is sufficient for issues and problems that are specific to a particular jurisdiction, local data that has not been standardized and aggregated as part of the NSDI is woefully inadequate for any issue or problem that affects more than a single jurisdiction.

Many users in government, business, academic, and NGO sectors are able to use this local data to do their jobs within a single jurisdiction. But they must expend considerable effort to aggregate local data for multiple jurisdictions when needed. Most of these users, including general public users, do not associate the data they use with the NSDI or with the Framework. This signifies that the NSDI is not readily identifiable (branded), and that it does not exist as an integrated entity. Additionally, the lack of a national collaborative governance structure means that non-federal stakeholders do not have a say in how their potential NSDI contributions are governed. That lessens confidence and trust in the NSDI.

NSDI Assessment: NSDI Overall		
	Report Year	
Criteria	**2015**	**2024**
Capacity	C	C
Condition	D	D
Funding	D	D
Future Need	D	D
Operation & Maintenance	C	C
Public Use	C	C
Resilience	C	C-
Comprehensive NSDI Grade	**C-**	**C-**

Individual Criteria: Discussion & Grades

1. CAPACITY

NSDI's ability to meet current and future demands.

GRADE = C

Requires Attention

The NSDI's capacity to meet demands is quite strong from the perspective of individual themes of data. Many of the themes are robust with extensive collections of data covering much of the United States. Data collection will continue to expand as technologies develop and grow, and as events such as natural disasters and climate change continue to affect the nation.

However, the ability to effectively use this current and increasing amount of data is not certain. The Framework data resources are currently difficult to identify and integrate. As new or updated

data are added across the nation, the ability of users to determine what data are authoritative Framework data will likely be even more difficult than at present.

As mentioned earlier, the GDA directs federal agencies to report to Congress on progress and status of the data considered to be National Geospatial Data Assets (NGDA). FGDC began using a Portfolio Management approach some time ago for its geospatial data, in accordance with the OMB Circular A-16 Supplemental Guidance. This business approach identifies Federal datasets that could be considered NGDA.

Assets of this type support mission goals of multiple federal agencies, are statutorily mandated, or support national or Presidential priorities as expressed by Executive Order or by the OMB. Framework data are not specifically identified as such in the Portfolio but are part of the construct of 16 Themes identified in the NGDA Portfolio. To date, approximately 170 data sets have been identified as NGDA. The sheer number of NGDA data sets and the reporting requirements for those data has created a very great burden for FGDC and the agencies covered by the Geospatial Data Act. The number of NGDA data sets should be evaluated with an objective to decrease the number of such data sets classified as NGDA. The intent is not to reduce the importance of particular data sets, but to lessen the reporting burden and enable limited funding to be expended instead on development and use of the data.

2. CONDITION

The existing or near-term condition of the Framework themes as an integrated whole.

GRADE = D
At Risk

Ongoing data collection activities are updating and adding to many of the datasets in the individual Framework themes. Data holdings are extensive and generally accessible through government data portals and clearinghouses at Federal, state, and local levels. Most of these data have standards-compliant metadata that helps users understand the lineage and use characteristics of the data.

However, the Framework has significant shortcomings as an integrated whole. It is very difficult to identify which of the potentially numerous datasets are actually Framework data for a specific theme, or for a given geographic area. In addition, the NSDI has not developed an integrated set of all Framework data themes. Because of these shortcomings, a user must find individual theme data and also tie all of the themes together before they can form a comprehensive view of their area of interest.

There are benefits to having extensive amounts of data available for a particular area to address the many different needs of users. However, the vision of an integrated Framework that is a data backbone and building block for the NSDI is not yet fulfilled.

3. FUNDING

The funding capability of the NSDI.

GRADE = D
At Risk

Geospatial data are collected and used in a number of different ways. Across government, specific programs are funded for the collection and provision of

some themes of data. Orthoimagery and geodetic control are two examples. Other programs are authorized and funded to achieve certain government missions, such as maintaining the Public Land Survey System or understanding and managing the water resources of the nation. These mission programs require and produce geospatial data as a direct outcome. Federal cadastral data and hydrography data of the 3D National Topography Model hydrography and elevation data are examples of these types of programs.

A third government source of Framework theme data are those programs and projects that exist to provide government services such as public safety, flood hazard protection, navigation safety, and public transportation construction. Geospatial data are collected as part of these programs and projects. Many times, these data are related to a Framework theme and can become part of the NSDI if they are collected and managed to meet established standards and specifications.

The current funding for these various data collection and management activities would be difficult if not impossible to identify. Lack of funding has often been identified as a barrier to the development and implementation of the NSDI. A tremendous amount of geospatial data has been collected and disseminated over the more than 30 years since the NSDI was established. This growth in geospatial data resources is largely because most government organizations and private companies understand how important these resources are in meeting their missions and addressing their business needs. These goals are not necessarily the same for the Federal Government.

Many of the Framework themes have national coverages that are accessible to users from government and private sector data portals and clearinghouses. Efforts at education and outreach have helped to enhance the management and use of geospatial data. However, continued outreach to determine best practices for collecting and maintaining Framework data should be maintained and enhanced.

The development of an integrated NSDI Framework is a collaborative effort that requires participation from the entire geospatial community. Funds for this type of collaboration and for better management of Framework theme data - including activities around standardization, documentation, dissemination, and integration - are lacking. In addition, an effectively integrated system for the NSDI Framework to enable the full exploitation of data, including location and delivery of the data that are most suitable for individual purposes, has not been architected.

4. FUTURE NEED

Whether funding prospects will be able to meet the need.

GRADE = D

At Risk

The NSDI Framework was envisioned to be an integrated resource of eight common data themes most often needed by users. Funding initiatives for a number of efforts related to Framework data have been proposed and are identified in theme chapters later in this report. These initiatives are specific to individual Framework themes and will be greatly beneficial for those themes if implemented.

In addition to funding Framework data projects, there is a critical need to fund the infrastructure that supports data coordination, management, maintenance, and distribution functions.

These are typically not "sunk costs" that have already built adequate infrastructure. They are ongoing costs that are essential for maintaining data accuracy and currency, as well as changing technologies. While budgets are always tight, there have been a number of opportunities recently that have provided some funding for specific Framework themes.

In addition, large investments have been made recently in physical infrastructure nationwide. Some of that funding has been made available for geospatial infrastructure, including Framework data, but much more should be done to target those funds and make them available at every level for NSDI development and update. Geospatial data and infrastructure are essential to the construction and maintenance of the nation's physical infrastructure.

5. OPERATION & MAINTENANCE:

The ability of key lead organizations to develop and maintain the Framework and to adopt new technology, procedures, and standards.

GRADE = C
Requires Attention

The FGDC and lead agencies for Framework themes generally have the capability to maintain the current condition of the Framework and to operate it in much the same way as in the past several years. State governments continue to develop state-level spatial data infrastructures and portions of the Framework based on their respective priorities. New technologies, processes, and standards will undoubtedly be adopted or acquired as part of normal agency operations, resulting in incremental steps forward. While these efforts should keep a status quo, it does not promise significant steps forward for the NSDI.

Because the FGDC has been significantly underfunded for the past two decades, the important operational work to coordinate federal and national geospatial activities related to the NSDI and Framework data have not happened effectively. This has been particularly noticeable with regard to the lack of standards development and update in the last six years since the last COGO Assessment was conducted.

FGDC has recently indicated that their data standards work will be re-initiated with an effort to identify and update, then endorse, existing standards. This process would then be followed by an effort to identify, develop, and endorse necessary new standards. The Geospatial Data Act (GDA) indicates that federal funds are not to be spent on non-standardized data five years after the adoption of a standard. Because there were a number of endorsed Framework data standards in place in 2018 when the GDA was enacted, it is recommended that those standards be evaluated quickly, any necessary updates be undertaken right away and those standards be endorsed in as short a time frame as possible.

Furthermore, a laddered approach should be used to develop and endorse standards as quickly as possible, rather than evaluating or developing and endorsing standards in a sequential manner. The

extensive nationwide geospatial community should be mobilized to participate in this vital process.

6. PUBLIC USE

The NSDI's ability to provide data resources that meet the everyday needs of organizations.

GRADE = C
Requires Attention

Framework theme data resources are readily available to the public through a variety of data portals and clearinghouses that are part of the NSDI. The datasets provide a wealth of data for a wide variety of needs. The vast majority of this data is documented according to standards and available for public access and use at no charge. In addition, improvements have been made over the last couple of years to the GeoPlatform that have made it easier to use. FAIR principles (Findable, Accessible, Interoperable, and Reusable) have been fairly widely adopted at the federal level for Framework data and some progress has been made toward implementing those principles.

However, there is no definitive designation that identifies specific data as the Framework data that are "authoritative." This problem has been difficult to address and often makes users unsure if a specific dataset is fit for use. One possible solution to this problem is to use block chain technology to tag Framework features produced at any level with a unique hash that indicates those features are authoritative.

Users must currently determine which data should be considered Framework, and this can lead to significant inconsistency among users, governments, and companies. While these individual theme datasets are often easy to find and access, they are not well integrated, nor are they available as a comprehensive NSDI Framework.

7. RESILIENCE

The ability of the geospatial community to participate in development of the NSDI and to contribute to its sustainability as a long-term asset of value for the nation.

GRADE = C-
Requires Attention

The NSDI was envisioned as a national effort with leadership by the Federal government and with active partnerships, participation, and contributions from other levels of government and non-government sectors. State, local, and tribal governments, professional associations, and companies have all played important roles in the development and implementation of the NSDI and the Framework.

Individual Framework data themes have had major contributions by non-federal participants. Cadastral and address data are collected primarily at the local level in the United States. Orthoimagery and elevation data are collected in a strong partnership with many states and a number of local governments, which collaboratively fund private sector contractor collection. This coordination and collaboration has served to broaden the number of organizations with a stake in the success of the NSDI. This should serve to provide a measure of resilience and sustainability.

The basic leadership, responsibility, and

authority for the NSDI is with the Federal government. Neither the other levels of government, nor the private sector, are positioned to provide national leadership. All levels of government and the private sector are willing to develop new working relationships and new ways of sharing responsibility.

As noted earlier, the first goal in the forthcoming 2025-2035 NSDI Strategic Plan is to implement national collaborative governance for the NSDI. The next steps in the draft strategy involve development of NSDI implementation plans by each of the sectors (Federal, state, local and tribal governments, higher education, non-profits, and private sector). Those implementation plans are an essential element for the development and maintenance of the NSDI. However, the development of those plans will not come to fruition without a functional collaborative governance structure. Furthermore, a much greater prioritization and focused investment must be made in the NSDI at the national, state and local levels, as well as in the private sector through public/private partnerships, if the NSDI is to be completed and then maintained over time as a critical national asset.

Framework Data Themes Assessment Results

Average Grade for the Framework Data Themes: B

Adequate for Now

Each theme has achieved some level of success and development since last reviewed in 2018. Two of the data themes, Elevation and Geodetic Control, have in particular undergone substantial improvements since COGO's first evaluation in 2015. Critical investments in resources, support, and significant cross-agency activities are contributing factors. In fact, important progress in collaborations and partnerships was a common positive characteristic across the eight work groups. However, all of these Framework Data Themes need additional work. A current lack of standards and funding uncertainty were two of the most significant shortcomings. Extensive explanations for these grade assignments can be found in the remainder of this report.

NSDI Assessment: Data Themes

	Report Year		
Data Theme	**2015**	**2018**	**2024**
Addresses	NA	B+	B
Cadastral	D+	C-	C-
Elevation	C+	B-	A-
Geodetic Control	B+	A-	A-
Governmental Units	C	A-	A-
Hydrography	C	B-	B-
Orthoimagery	C+	B-	B
Transportation	D	C	C
Average Data Theme Grade	**C**	**B-**	**B**

I. Address Data Theme

Executive Summary

The Address Theme is the newest NSDI theme in the NGDA portfolio, and it is still under construction. At the beginning of this assessment period (2018 through 2023), barely a year had passed since the theme was created and defined. Much progress has been made since. The National Address Database (NAD) has expanded to 76.8M records, roughly half the nation's addresses, with records from all or parts of 42 states, territories, and DC, updated every year or two.

The lead agencies, theme leads, and the stakeholders who form the Address Subcommittee have established a solid foundation of governance policy and data management procedures. Together with the state and local partners who supply the data, they have demonstrated the administrative and technical practicality of the local-state-federal aggregation approach to creating a NAD.

Much work remains to build the NAD into a complete, current, valued, nationwide database. NAD operations will have to scale up to process twice the number of records, with much more frequent updates. NAD stakeholders will have to define and provide NAD-based products and services that are useful to both federal and non-federal stakeholders.

These demands will likely require a more complex system architecture, or increased staff, or both. As of the end or 2023, there is no discussion within the theme Subcommittee about undertaking any planning studies to ascertain the level of support required for a complete, current, nationwide address data set, and no commitment from the lead agencies to provide additional funding if it is needed.

Address Theme Grade: B

Adequate for Now, Needs Attention for the Future

I. Introduction

Description of the Framework

Note: This assessment covers the calendar years 2018 through 2023. (The prior COGO assessment covered the years 2015-2017). Prior history is included for background.

I.A. The Theme Definition

"*The Address Theme consists of the data elements, attributes, and metadata that specify a fixed geographic location by reference to a thoroughfare or landmark, or specify a point of postal delivery, or both. The Address Theme does not include information about occupants or addresses, nor does it include the attribute information about any features that may be specified by an address point. The Address Theme may include linkages to these feature attributes and other location reference methods.*" (OMB 2017).

I.B. Background on the Development of the Address Theme

In the United States, local governments originate almost all address data. Addressing has evolved over many decades, under the control of thousands of local jurisdictions, in many different record and database formats, and to serve many purposes. As a result, address data pose complex modeling and geoprocessing challenges. The FGDC Address Data Standard was not completed until 2011, five years after the other NGDA theme standards. The NENA Civic Location Data Exchange Format (CLDXFv1) standard was completed in 2014. The NENA GIS Data Model (v1) was completed in 2018, and v2 was released in 2022.

In 2015, USDOT funded a pilot project to create a minimum content data schema and test workflows for aggregating state and local data into a national address database. At its conclusion, in 2016, the database included 16.8M records from all or parts of AR, AZ, DC, MO, NJ, OH, UT, and VA. This became the nucleus of the National Address Database (NAD).

In 2016 the FGDC Steering Committee added addresses as a new NGDA data theme and created the Address Subcommittee, with Census and USDOT as the theme lead covered agencies. In 2017, the Address Theme definition and Subcommittee charter were approved. The Subcommittee charter was superseded in part by the Geospatial Data Act of 2018, which codified into law many FGDC theme governance requirements.

The Address Subcommittee is formally a committee of federal agency representatives, co-chaired by Census and USDOT, which encourages the participation of interested individuals from all stakeholder sectors (federal, tribal, state, local, private, academia and non-profit). The Subcommittee advises the theme leads in setting the policies that govern the development of the NAD.

This assessment covers the years 2018 through 2023. During this time the Address Subcommittee held scheduled meetings 10-11 times annually, with representation from the federal, state, local, private, and professional association sectors. Key milestones occurring during those years included:

- 2018 – NADv1 released to the public (44M records from all or parts of 20 states DC).
- 2019 – First Address Theme Strategic Plan approved, covering 2019-2021.
- 2019 – State-level workflow adopted and augmented in 2020 by addition of the workflow validations matrix.
- 2022 – NAD adopted as an official National Geospatial Data Asset (NGDA) Dataset in September 2022, by the Federal Geographic Data Committee (FGDC) Steering Committee. NAD had been a proposed NGDA Dataset prior to that time.
- 2022 – NAD data content requirements adopted in August 2022, including both minimum and supported content requirements.
- 2023 -- Developed a file geodatabase template based on the NAD Content Requirements, published in April 2023, for NAD partner use.
- 2023 – As of the end of 2023, the NAD had grown to include 76.8M records from 42

state-level data partners.

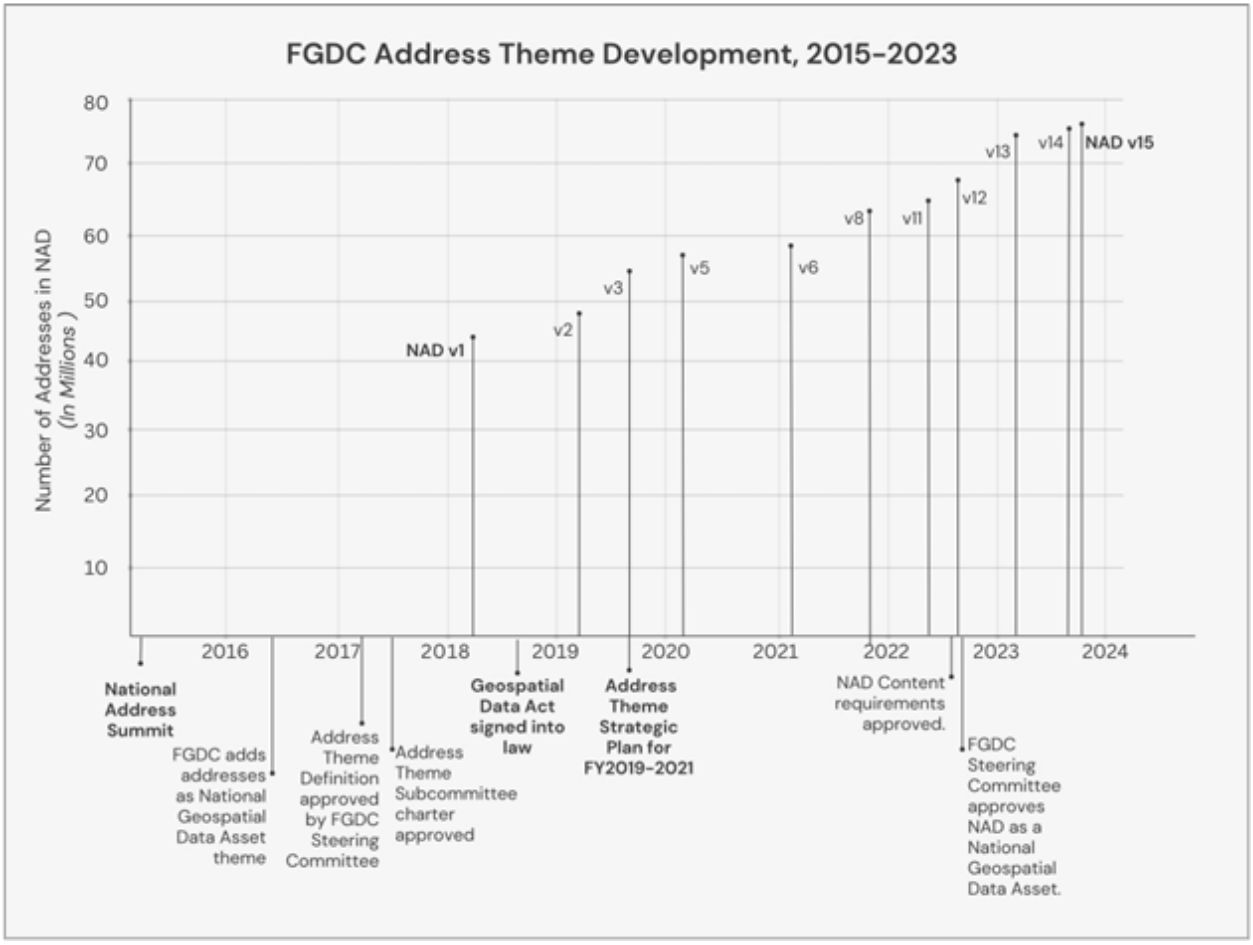


Figure Address-1. FGDC Address Theme Development, 2015 - 2023.

I.C. Address Theme Evaluation and Assessment

The COGO Address Theme assessment is organized into six sections, including this Introduction. Sections II, III, and IV provide background, status, and assessment of the Address Theme from three perspectives:

- Section II: Address Theme Governance and Management
- Section III: NAD Development
- Section IV: Address Theme Resources

Subsections within each section present the following:

1. A statement of scope
2. Relevant GDA and Subcommittee Charter requirements
3. Status and background

4. Assessment and recommendations

Section V synthesizes the preceding sections into an assessment of the theme as a whole, in terms of the NAD assessment criteria. Section VI summarizes the assessment into an overall assessment and grade.

II. Address Theme Governance and Management

Scope: Address theme governance includes the NAD governance structure and processes, and stakeholder relations, organizational assessments, requirements analyses, public access policies, standards and metadata, strategic and implementation plans, and performance reports that underpin Address Theme planning and implementation.

Introduction. The Address Subcommittee advises the Co-Chairs/theme leads on governance policies. The terms of governance are set most directly by the Address Theme definition and Subcommittee charter, which the FGDC approved in 2017. The charter was superseded in part by the Geospatial Data Act of 2018 (GDA). The Subcommittee charter, where it does not conflict with the GDA, remains in full force and effect.

II.A. Strategy, Planning, and Theme Administration

Scope: Strategy and planning for Address Theme management and NAD implementation; and the timely submission of strategic plans, implementation plans, and performance reports, as required by the Geospatial Data Act and FGDC guidance pursuant thereto.

GDA Requirements

1. "The Committee shall prepare and maintain a strategic plan for the development and implementation of the National Spatial Data Infrastructure in a manner consistent with national security, national defense, and emergency preparedness program policies regarding data accessibility." (GDA 2804(c)

2. "[The lead covered agencies shall] establish goals that support the strategic plan for the National Spatial Data Infrastructure prepared under section 2804(c) of this title;" (GDA 2805(b)(3)(C)

3. "[The lead covered agencies shall] provide leadership and facilitate the development and implementation of a plan for nationwide population of the National Geospatial Data Asset data theme, which shall … (v) expedite the development of necessary National Geospatial Data Asset data themes;" GDA 2805(b)(3)(B)(v)

4. "[The lead covered agencies shall] as part of administering the National Geospatial Data Asset data theme—

(i) designate a point of contact within the lead covered agency who shall be responsible for developing, maintaining, coordination relating to, and disseminating data using the GeoPlatform;

(ii) submit to the Committee:

(I) a performance report, at least annually, that documents the activities relating to and implementation of the National Geospatial Data Asset data theme, including progress in achieving the requirements under subparagraphs (A), (B), (C), and (D); and

(II) comments, as appropriate, regarding the summary and assessment of the performance report provided by the Committee under section 2802(c)(12) of this title;" (GDA 2805(b)(3)(E)(i and ii)

Subcommittee Charter

"The Address Subcommittee shall develop an annual goals and objectives plan and provide it to the FGDC Coordination Group and FGDC Secretariat. The Address Subcommittee will also develop an annual summary of accomplishments. All progress documented as a result of Subcommittee activities shall be submitted to the FGDC Coordination Group and the FGDC Secretariat and posted on the committee's FGDC web page (https://www.fgdc.gov)."

Status and Background

Strategic Principles and Priorities. During the assessment period (2018-2023), the Address Theme leads have set and executed a clear and consistent set of strategic principles and priorities. Review of Subcommittee meeting notes and documents shows substantial effort directed to the following top priorities, with significant results:

1. **Address Subcommittee.** Provide, via Address Subcommittee, a forum where interested persons from all sectors can discuss and agree on Address Theme policies and priorities.
   Results: During 2018-2023, the Subcommittee met 10-11 times annually, with typical attendance of 30 persons, including federal employees, state GIOs, and persons from professional associations, local government, and the private sector. Discussion topics covered all significant theme policies and priorities. See Section II.B for further discussion.
2. **NAD Development**. Develop and maintain the NAD as an authoritative address data set, by aggregating from local to state to federal (national) spatial databases.
   Results. During 2018-2023, the NAD has expanded from 24.6M records to 75M records. (By comparison, USPS has about 148M delivery addresses nationwide, excluding PO Boxes). See Section III.B. for further discussion.
3. **Wider Data Partner Network**. Expand the reach of the NAD by seeking out voluntary partnerships with state GIOs, or, if that is not possible, with local address authorities or aggregators within the state.
   Results. During 2018-2023, state-level partnerships increased from 25 to 42 states plus territories and DC). Local partnerships increased to 47, including counties, municipalities, tribal areas, and a military base. See Section II.D for further discussion.
4. **NAD Data Content**. Define the content required and permitted within the NAD.
   Results. In 2022, the Subcommittee adopted detailed content requirements and implemented them as a template for NAD operations. See Section III.B. for further discussion.
5. **NAD Workflow**. Define the workflow for aggregating data from partners.

Results. The state-level workflow description was approved by the Subcommittee in 2019. Since then, technical improvements have been made as problems have been encountered. See Section III.C for further discussion.

6. **NAD Publication**. Provide free and open access to NAD data and metadata.
Results: The NAD has been available for public download since April 2018. The NAD web feature service has been in service since October 2021. See Section II.E for further discussion.

For various reasons, less priority was given to the following:

1. **Business use case analysis**. Work on the functional user needs (i.e. data requirements to keep the NAD functional by defining the data schema, data quality tests for submitting data to the NAD, data submittal process, etc) continued during the assessment period. However, during this time there was no review of the existing business use cases, nor identification of new business use cases (i.e. how the NAD data could be valuable to end users) that justify creating the NAD in the first place. Work on NAD data partnerships, content, and workflows took precedence - without a functional NAD, there would be nothing for users to use. See Section II.C for further discussion.
2. **Standards Review**. The Address Standard Maintenance Subgroup has reviewed several proposed revisions to the FGDC address standard. As of the end of 2023, work was suspended pending FGDC issuance of the procedure and timeline for FGDC review and re-endorsement of all its geospatial standards. See Section II.F for further discussion.
3. **Publication of Address Data and Metadata via the GeoPlatform**. Address Theme data and metadata have not been published to the GeoPlatform due to technical issues with the GeoPlatform.

Strategic Plans. The GDA requires NGDA theme leads to submit a theme strategic plan every three years. The Address Subcommittee submitted the first strategic plan, for FY 2019-2021, in September 2019. The plan was a brief (7pp) list of three goals, eight objectives and their anticipated outcomes, and 26 actions. It was not a key reference document in the Subcommittee discussions of FY2020 and FY2021.

Per FGDC direction, no strategic plan was submitted for FY2021-FY2024, because the FGDC had not completed a Strategic Plan template that was compliant with the GDA and consistent with the NSDI Strategic Plan FY2021-FY2024 goals/objectives.

Performance Reports and Covered Agency Reports. In addition to strategic plans, theme leads must submit annual performance reports for their theme. The Address Theme co-chairs have delivered their performance reports on time each year.

The GDA requires sixteen federal agencies ("covered agencies") to submit two reports annually: 1. The covered agency geospatial strategies report, and 2. The covered agency annual report. All agencies have submitted their reports in a timely manner each year. The covered agency reports (as opposed to the lead covered agency reports)

communicate geospatial data activities generally within each of the federal agencies, so none of them focus on the Address Theme specifically.

Point of Contact: The GDA requires theme lead covered agencies to designate a point of contact responsible for theme administration. Census and USDOT have named points of contact as required.

Assessment:

A. **Leadership and facilitation of the development and implementation of a plan for the nationwide population of the Address Theme.** During the assessment period, the theme leads set strategic priorities and executed significant accomplishments in theme governance, extension of the partnership network, development and implementation of the NAD, defining NAD data requirements and workflows, and publishing NAD data. For various strategic reasons, less priority was given to user needs analysis, maintenance of the FGDC address standard, and publication to the GeoPlatform.

B. **Strategic Planning and Strategic Plans**. The NAD is a large-scale, multi-agency geospatial database program. Such programs typically take many years to mature from initial concept to full operational status—much longer than the three-year planning period set by the GDA. Neither the brevity of the 2019-21 strategic plan, nor the lack of any strategic plan document for FY 2022-24, prevented the Address Theme leads from actually setting and executing strategic priorities.

C. **Required Plans, Reports and Points of Contact.** The theme leads have submitted all required plans and reports in a timely manner and named points of contact as required.

Recommendation:
The FGDC currently requires theme strategic plans every three years. The NAD will take longer than three years to reach operational maturity. Consider creating, outside the scope of the GDA requirements, a longer-term strategic outlook for the Address Theme.

II.B. Governance

Scope: "Governance Process" in this assessment is defined as the organizational structure, stakeholder roles and relations, and procedures and priorities by which Address Theme policies are decided, and by which supporting activities are defined and accomplished. These activities and definitions include organizational assessments, user requirements analyses, data aggregation and feedback partnerships, public access, standards, strategic and implementation plans, and performance reports that underpin NAD planning and implementation.

Subcommittee Charter Scope and Objectives

A. *"Establish a governance process for the Address Theme." (Scope #2)*

B. *"Advise the Address theme leads on the creation, management, and maintenance of the Address Theme and associated National Geospatial Data Assets (NGDAs)." (Scope #1)*

Status and Background
The FGDC created the Address Subcommittee to advise the Address Theme leads on the creation, management, and maintenance of the Address Theme and associated National Geospatial Data Assets (NGDAs). The Subcommittee is constituted as an FGDC theme subcommittee, co-chaired by Census and USDOT. The Subcommittee's purpose and scope were set forth in the Address Theme definition and the subcommittee charter, and approved by the FGDC in the first half of 2017. The charter was superseded in part by the Geospatial Data Act of 2018 (GDA), but the charter remains in effect where it does not conflict with the GDA.

The Subcommittee welcomes any interested participants from all stakeholder sectors in the meeting discussions. Decisions are typically made by consensus. If a formal vote is taken, only designated Federal Agency representatives may vote.

The Address Subcommittee meets 10-11 times annually with approximately 30 attendees per meeting. Typical attendance is 60% federal staff, 20% State GIS representatives, and 20% from professional associations, private sector, or local government. Regular participants in CY2023 included:

- Federal agencies: Census, USDOT, USPS, Federal Emergency Management Agency (FEMA), General Services Administration (GSA), Veterans Administration, Oak Ridge National Laboratory
- States: IN, MN, MT, NY, OR, PR, VI, VT, AR
- Associations: URISA, NSGIC
- Local Govt: Pima County, AZ
- Private sector: Participation from different firms

For matters requiring in-depth review and discussion, the Subcommittee forms a subgroup of interested volunteers, which reports recommendations to the Subcommittee for review and revision/approval. Current subgroups include NAD Data Content, NAD Workflow, NAD Strategic Planning, and Address Standards Maintenance.

Assessment:
Since its inception in 2016, the Subcommittee has established and proven a collaborative governance model for the Address Theme. The Subcommittee meets consistently, and it has brought together an interested and active group of federal, state, local, and private address data users to define the Address Theme.

The Subcommittee has devised, and proven in practice, an entirely voluntary local-state-federal address aggregation process for the NAD that has, as of the end of 2023, handled tens of millions of records, from over 40 states and territories, and the District of Columbia, through fifteen data releases.

II.C. User Requirements to Assure Use of the Data

Scope: User requirements analyses are needed to ensure that Address Theme data products and services will be useful to federal and non-federal stakeholders.

GDA Requirements

- *"[The lead covered agencies shall] as necessary, collect and analyze information from users of geospatial data within the National Geospatial Data Asset data theme regarding the needs of the users for geospatial data and incorporate the needs of users in strategies relating to the National Geospatial Data Asset data theme;" (GDA 2805(b)(3)(D)*
- *"[The lead covered agencies shall] provide leadership and facilitate the development and implementation of a plan for nationwide population of the National Geospatial Data Asset data theme, which shall …(ii) meet the needs of users of geospatial data; …." (GDA 2805(b)(3)(B)*

Subcommittee Charter Scope and Objectives

"*Collect user requirements from tribal, federal, state, county, and local governments along with non-profit organizations and commercial vendor requirements for data processing and distribution capabilities to assure and facilitate the use of address data." (Objective #2)*

Status and Background

The GDA requires the lead covered agencies to collect and analyze information on the requirements of GIS data users, and to include those requirements into NGDA theme strategies. For the Address Theme, user requirements analyses will focus on the NAD, the sole NGDA in the Address Theme.

User requirements analysis involves four types of analysis:

1. Business use cases – Who will use the NAD? How will they use it within their organization? What NAD products and services are needed to make it useful in the organization's everyday operations?
2. Data requirements – What information do these products and services require, in terms of data content, metadata, completeness, currency, and quality?
3. Process requirements – What organizational tasks or workflows must the NAD support? What operations must it automate?
4. Functional requirements – What NAD system capabilities are needed to provide the outputs and execute the processes?

System design begins with the business use cases. Questions about data, process, and functional requirements cannot be framed until key use cases are known.

Over the years, several reports have considered how the NAD might be used:

- Prior to the pilot project, reports by the NGAC and the General Accountability Office (GAO) in 2012 and 2014 discussed possible use cases to show the business purposes that would justify undertaking the NAD pilot project. The reports were important inputs to the 2015 Address Summit meeting, where the decision was made to undertake the pilot project.
- In February 2017, Census and USDOT convened a NAD Federal User

Requirements Workshop, with representatives of 15 federal departments and agencies, along with persons from tribal, state, and local governments and private industry. The workshop focused on the federal agency content, metadata, and functional requirements for the NAD. In that context, some specific uses were mentioned, and additional information was obtained from the federal agency representatives via a pre-workshop questionnaire.

- The story map on the USDOT NAD web page illustrates three state-government use cases and two federal-government use cases. In addition, NSGIC has published white papers as part of its Addresses & Transportation initiative, which may contain some information on potential state-government use cases.

The use case studies have provided some guidance over the years, especially in 2015, prior to the NAD pilot project. However, during the assessment period there has been no review of the existing business use cases, nor identification of new business use cases.

The Subcommittee has focused on expanding the partnership network, expanding the data holdings, and defining NAD data content and workflows.

As of the end of 2023, known Federal users include Federal Emergency Management Agency, the U S Army Corps of Engineers, and the General Services Administration. Known private sector users include Google, Esri, Here, TomTom, and FedEx. The Subcommittee has not contacted the current users to inquire how they use the NAD.

Assessment:
The Subcommittee has not evaluated the use cases compiled in 2012 -2017, nor conferred with current NAD users, to target a priority list of use cases that can orient NAD development planning. As a result, the business case for future NAD investment is vague.

Recommendations:
1. Review the past descriptions of NAD business use cases and assess them for current relevance.
2. Confer with current NAD users to determine how they are using NAD data, and what enhancements might make the NAD more valuable to them. Assess their suggestions for feasibility.
3. In assessing relevance and feasibility, consider the following questions: Are the organizations interested in implementing the use case now? Do they require data not currently in the NAD? Can their uses be accommodated within current or reasonably foreseeable NAD system and staff resources? Which organizations are willing to commit some of their own staff time and resources to changing their business process as needed to incorporate NAD data and assigning staff to perform the revised process?
4. Provide the results to the Subcommittee for use in selecting priority use cases that can orient NAD development planning and strengthen the business case for future NAD development.

5. Collaborate with interested professional associations (such as NSGIC, URISA, and NENA) to publicize the NAD via conference presentations, webinars, and other informational events, with the goal of finding interested state and local government officials with practical ideas for how they could use the NAD in their operations.

II.D. Partnerships for Data Creation and Consolidation

Scope: Create and manage the partnerships for address data aggregation and feedback between local, state/tribal, and federal stakeholders that are necessary to develop and maintain the NAD.

GDA Requirement

"[The lead covered agencies shall] provide leadership and facilitate the development and implementation of a plan for nationwide population of the National Geospatial Data Asset data theme, which shall (i) include developing partnership programs with States, Indian tribes, institutions of higher education, private sector entities, other Federal agencies, and local governments; … and (v) expedite the development of necessary National Geospatial Data Asset data themes;" (GDA 2805(b)(3)(B)

Subcommittee Charter Scope and Objectives

1. *"The primary objective of the Address Subcommittee is to develop and document a sustainable process and necessary content to gather, maintain, and make publicly available address related national geospatial data assets." (Objective #1)*
2. *"Identify and promote partnerships with tribal, federal, state, county, and local government addressing authorities as well as private and non-profit organizations to promote the creation and consolidation of accessible, accurate, and spatially referenced national address data." (Scope #3)*

Status and Background

NAD development is based on the principle that local authorities are the authoritative source for address assignment and are data set originators, and that state authorities should be statewide aggregators of county and local data sets. The theme co-chairs partner with state GIOs (or equivalent) where possible. If no state partner can be found, then the theme co-chairs will partner with local or regional address authorities or aggregators. All partnerships are voluntary.

NAD development began with a pilot project in 2015. Version 1 was made available for public download in 2018. Version 15, the most recent, was published in October 2023. It includes approximately 76 million records covering all or parts of 41 states and the District of Columbia. (No data has been received from any of the five territories.) By comparison, the USPS delivers mail to approximately 148 million addresses (excluding PO Boxes). By that measure, the NAD includes roughly half the addresses in the United States. As of 2023, data submittals are typically 1-2 years old.

The records have been aggregated from 42 state-level data partners and 47 non-state partners. As of the end of 2023, of the remaining states and territories:

- 7 states, if they have address data, do not share it with the public (HI, MI, MN, NH, OR, SC, SD).
- At least sixteen states and territories have no address data aggregation program.
- Non-state partners include counties (or county equivalents), cities, two Native American tribes and one military base.

Figures 2-4 show the extent of state participation, data coverage, and data currentness of the National Address Database (NAD) as of October 2023.

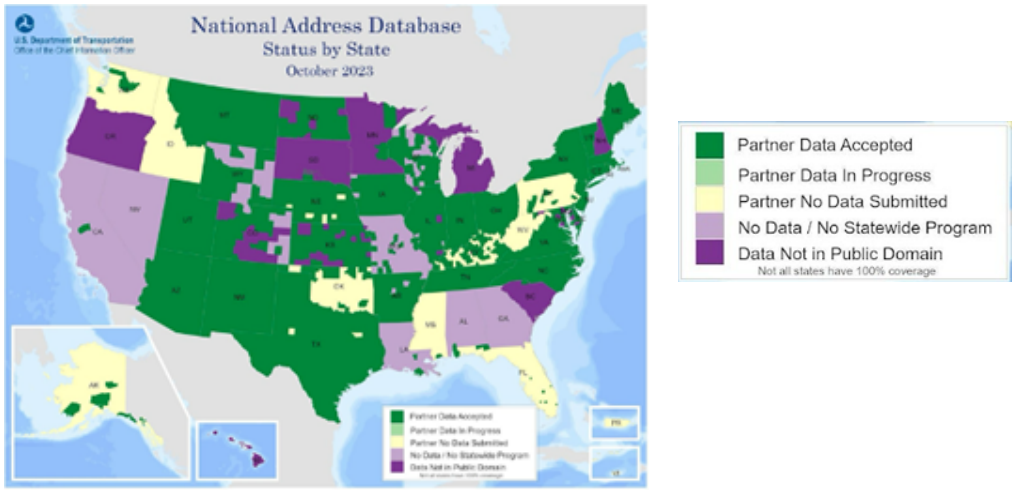


Figure Address-2. NAD Status by State, as of October 2023.

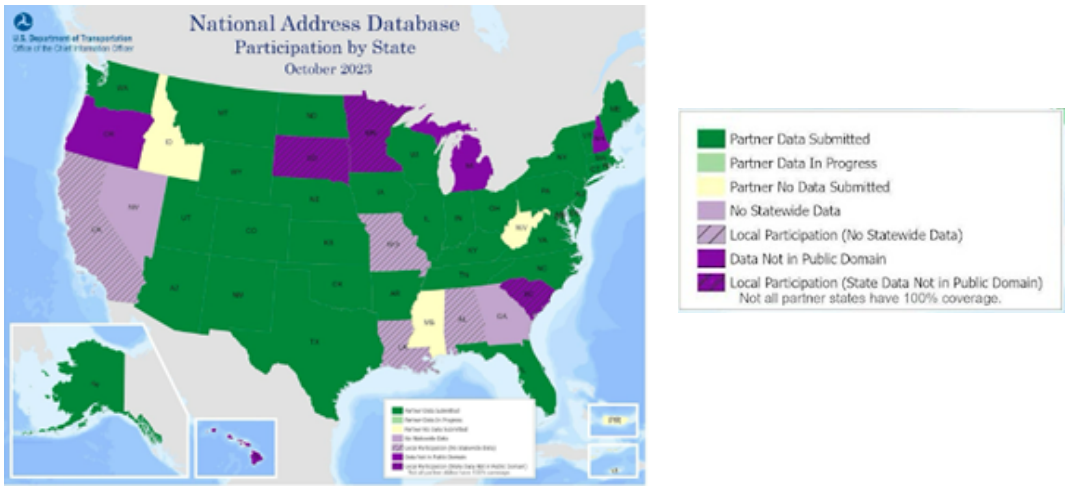


Figure Address-3. NAD Participation by State, as of October 2023.

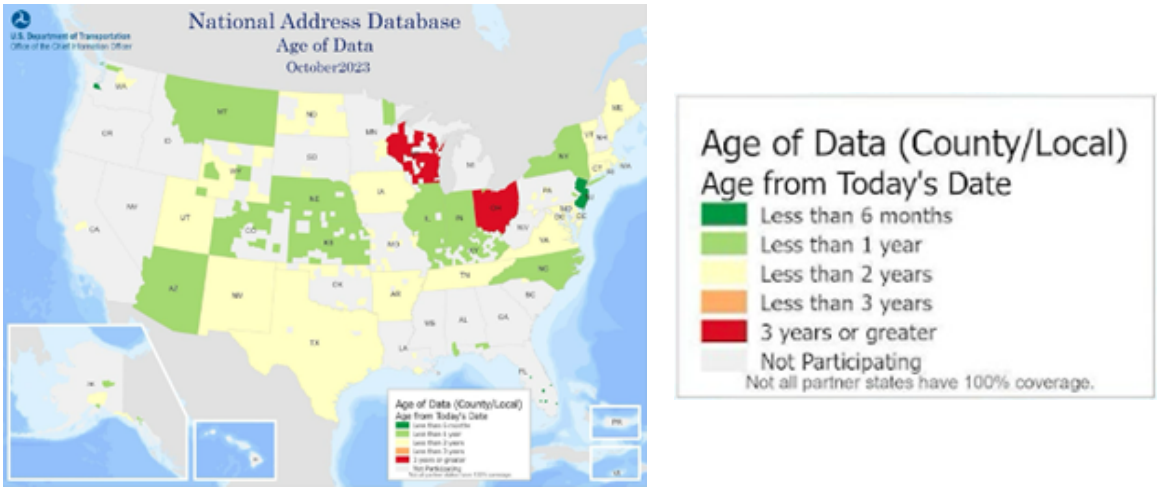


Figure Address-4. Age of Data, as of October 2023.

The theme co-chairs have promoted partnerships primarily via informational presentations at professional association conferences (most notably NSGIC, URISA, and NENA), GIS software user conferences (Esri), and the FGDC National Geospatial Advisory Council (NGAC) meetings.

Assessment:
As of the end of 2023, the NAD data partnership network includes 42 of the 56 state-level jurisdictions in the United States (50 states, five territories, and the District of Columbia), and 47 local data partners. The theme lead agencies, advised by the Subcommittee, have developed and proven procedures for aggregating data from all partners into the NAD, and updated the NAD through fifteen versions over the past six years. They have proven that the procedures are workable at a scale of tens of millions of records, updated more or less quarterly.

The challenge now is twofold:
1. Expand the network to include all 56 state-level jurisdictions, or, if no state-level partner can be found, to seek out local partners to fill in the gaps.
2. Encourage each of the partners to achieve full and current coverage within their jurisdictions.

Key obstacles to expansion include:
1. Seven states are prohibited by state law or policy from sharing their address data.
2. At least sixteen states and territories have no program for state-wide address data aggregation.

Recommendations:
1. For states where state law or policy blocks data sharing, the Subcommittee should ask the NAD Strategies Subgroup to inquire via non-federal members of the Subcommittee, which specific state law prohibits address data sharing, and whether

release of address data to the NAD might conform to the that state's law (e.g., NAD is not intended to support commercial uses; and it includes no personal information). Case studies given in the 2022 NAD Strategies Subgroup White Paper could be used as a starting point for this work.

2. For states with no address aggregation programs, the Subcommittee should seek regional agencies or professional association networks as local partners from which a state-wide address dataset could be assembled for submission to the NAD.

3. The Subcommittee should consider partnering with federal agencies that assign addresses, if they assign addresses within federal facilities independently of local address authorities (e.g. military bases, national parks, etc.), or if they maintain address lists for offices and facilities that they operate.

II.E. Data Made Available for Public Use

Scope: Ensure that the public has free and open access Address Theme information and NAD data products and services, in particular via the GeoPlatform.

GDA Requirements

1. *"The goals of the National Spatial Data Infrastructure are to (1) ensure… (C) free and open access for the public to geospatial data, information, and interpretive products, in accordance with Office of Management and Budget Circular A–130, or any successor thereto;" (GDA 2804(1)(C))*
2. *"[The lead covered agencies shall] provide leadership and facilitate the development and implementation of a plan for nationwide population of the National Geospatial Data Asset data theme, which shall …(iv) identify needs relating … the GeoPlatform;" (GDA 2805(b)(3)(B)(iv)*
3. *"The lead covered agencies shall]— … (v) coordinate with the GeoPlatform; (GDA 2805(b)(3)(E)(v)*
4. *"[The lead covered agencies shall] publish maps or comparable graphics online (in accordance with the mapping conventions specified by the Committee) showing the extent and status of the National Geospatial Data Asset data themes for which the covered agency is a lead covered agency;" (GDA 2805(b)(3)(E)(iii)*

Subcommittee Charter Scope and Objectives

1. *"The primary objective of the Address Subcommittee is to develop and document a sustainable process and necessary content to gather, maintain, and make publicly available address related national geospatial data assets." (Objective #1)*
2. *Coordination: Coordinate among tribal, federal, state, county, and local governments as well as non-profit organizations and commercial vendors to make spatially referenced national address data freely available. (Objective #3)*
3. *Facilitate the public availability of, and access to, national address data and associated metadata. (Scope #4)*

Status and Background

- **NAD Webpage and Metadata**. USDOT hosts a NAD webpage from which the entire NAD can be downloaded in file geodatabase or comma-delimited format. Users must download the entire file; the website does not allow users to define and download subsets of the data. The site also provides the database schema, and information on the purpose and context of the NAD, the extent of its coverage, and the age of the data.
- **Address Subcommittee Records**. Address Subcommittee meetings are open to the public, and participation is encouraged for both federal and non-federal stakeholders. Subcommittee records are published on the FGDC Address Subcommittee webpage, with links to meeting minutes for 2016-2021, as are all reports of the Subcommittee and its subgroups. Plans and reports required by the Geospatial Data Act of 2018, including those of the Address Theme Lead Agencies, are posted separately, on the FGDC's Geospatial Data Act webpage.
- **NAD Web Feature Service**. NAD address point data are published to a web feature service via ArcGIS Online, as a visualization that shows address points nationwide. USDOT reported that the web feature service recorded 965,000 hits in October 2023. Not tracked are the number of unique users, nor the uses for the downloaded data.
- **GeoPlatform**. The GeoPlatform includes NGDA Address Theme pages, which provide NAD metadata (ISO standard 19115 compliant), links to the USDOT and FGDC webpages, and various older Subcommittee documents. NAD data is not currently (as of the end of 2023) published to the GeoPlatform due to a data-harvesting mechanism error that affects many data owners.

Assessment:
The Address Subcommittee has made the NAD data publicly available, but users must download the entire database. Having basic GIS analysis tools available on the NAD and GeoPlatform websites to create selections and export only the selected records, would make the data more user-friendly.

As of the end 2023, the GeoPlatform and FGDC web pages are not up-to-date and not functioning as intended as a clearinghouse.

Recommendation:
Developing tools to allow data users to define and download subsets of the data should be a priority if widespread adoption of the NAD is to be achieved.

II.F. Data Standards and Metadata

Scope: The use and development of address data standards; their coordination with standards established by other standards organizations; and the definition and maintenance of metadata for Address Theme data assets.

GDA Requirements

1. *"[The lead covered agencies shall] provide leadership and facilitate the development and implementation of geospatial data standards for the National Geospatial Data Asset data theme, with a particular emphasis on a data content standard for the National Geospatial Data Asset data theme, including by— (i) assessing existing standards; (ii) identifying anticipated or needed data standards; and (iii) developing a plan to originate and implement needed standards with relevant community and international practices (I) in accordance with Office of Management and Budget Circular A–119, or any successor thereto; and (II) consistent with or as a part of the plan described in subparagraph (B);" (GDA 2805(b)(3)(A)*

2. *"[The lead covered agencies shall] provide leadership and facilitate the development and implementation of a plan for nationwide population of the National Geospatial Data Asset data theme, which shall … (iv) identify needs relating to standards, metadata for geospatial data within the National Geospatial Data Asset data theme, and the GeoPlatform;" (GDA 2805(b)(3)(B)*

Subcommittee Charter Scope and Objectives

"Support the use, coordination, and development of standards established by federal, national, and international standards organizations such as the FGDC, American National Standards Institute (ANSI), the International Organization of Standardization (ISO), National Emergency Number Association (NENA), and the Open Geospatial Consortium (OGC)." (Scope #5)

Status and Background

Existing Address Data Standards. Three recognized standards-issuing bodies have issued US address data standards: USPS, FGDC, and NENA.

- USPS Publication 28 is a specification for standardizing USPS delivery addresses and formatting mailing labels. More of a presentation standard than a data standard, Publication 28 has changed little in the past twenty years, and it was a foundational reference document in the drafting of the FGDC and NENA standards.
- The FGDC United States Thoroughfare, Landmark, and Postal Address Data Standard provides a complete set of data items, data classes, and data quality measures needed for a multi-purpose address repository, and an XML model for address data exchange.
- The NENA (CLDXFv1) and GIS Data Model standards define the data items needed for useful exchange of data about address points, centerlines, places, and emergency service boundaries within NG9-1-1 systems. By intent, the NENA standards incorporate many, but not all, of the data items in the FGDC standard.

NAD Data Schemas: Implementations of Standards. There have been two NAD data schemas. NADv1 was developed quickly to provide a basis for the initial NAD pilot program that concluded in September 2016. It remained in use through 2022. NADv2, adopted by the Subcommittee in 2022, is based on a detailed review of NADv1 against

the FGDC and NENA address standards, in the context of the NAD purpose, scope, and required capabilities. USPS Publication 28 was reviewed regarding the postal data items.

The NAD data schema is not a standard. It is an implementation of the standards. The schemas apply the NENA and FGDC standards (and the USPS standard, for postal elements) to a particular business purpose, within a particular computing environment. The schemas are closely aligned with the NENA and FGDC standards, utilizing both most of the time (because they are mostly the same), and one or the other for a minority of NAD variables. The NAD schema implements the standards, adapted as needed for NAD purposes.

FGDC Address Data Standard Maintenance. Census, advised by the Subcommittee, is responsible for maintaining the FGDC address standard. The FGDC withdrew the endorsement of all geospatial standards so that they could be re-evaluated under the terms of the GDA. The FGDC has longstanding intentions of updating all of its endorsed geospatial data standards, including the FGDC address standard, but procedures and timelines for doing so have not been announced as of the end of 2023.

The Subcommittee has created the Address Standard Maintenance Subgroup, which has collected and reviewed proposed changes to the FGDC address standard. These changes will be reviewed by the Subcommittee and forwarded to the FGDC when the FGDC provides procedures for doing so.

NAD Metadata. NAD records include some record-level metadata items (NAD Data Provider, Data Set ID, Address Lifecycle Status, Address Start/End/Last Revision Date). For the NAD dataset as a whole, the NAD data schema is published on the USDOT NAD webpage. The schema is augmented by the complete data content requirements and state-level workflow documents published on the FGDC Address Subcommittee webpage. Some additional dataset metadata is published on the homepage of the NAD Web Feature Service.

The USDOT NAD webpage includes maps and text showing the participation, NAD data processing status, and age of data by state. Data partners are not asked about the coverage completeness within each coverage area submitted.

Complete NAD metadata, compliant with the ISO 19115 (Geographic Metadata) standard, has been compiled for publication to the GeoPlatform. Publication will occur when GeoPlatform uploading issues have been resolved.

Assessment:

Implementation of Existing Standards. The Subcommittee has not needed to develop any new standards in order to specify NAD data content. NAD data specifications are in close alignment with existing standards, adapting and extending the standards as needed to achieve the purposes of the NAD.

FGDC Standard Updating and Maintenance. The Address Standards Maintenance Subgroup is reviewing proposed changes to the FGDC standard. When the FGDC

announces procedures for updating its geospatial standards, the subgroup will forward its recommendations to the Subcommittee for review, approval, and submission to the FGDC.

NAD Metadata. NAD metadata and Address Subcommittee records are complete and current. However, the FGDC Subcommittee webpage and GeoPlatform repository are incomplete and out of date.

Completeness/Currency Index for NAD Data. NAD metadata does not include any indicator of how complete the NAD coverage is.

Recommendations:

1. Subcommittee webpage and the GeoPlatform repository should be brought current so that the metadata and Subcommittee records are publicly available and the NAD is fully discoverable.
2. A simple completeness/currency index is needed, to track progress toward a more complete and current NAD.

III. NAD Development

Scope: NAD system infrastructure, data content and data architecture, business processes and workflows, and applications and services.

Introduction. A database program requires, in addition to governance, a system infrastructure, data content and database architecture, business processes, and applications and services. This section evaluates the current NAD system and operations in those terms, and some limitations that may constrain future development. Section IV considers more fully whether the existing system will support the operations needed to meet Address Theme requirements.

III.A. NAD System Architecture

Scope: NAD system infrastructure includes the hardware, software, and network components of the system, and the roles, policies, and procedures for managing and securing them.

Status and Background

The NAD System infrastructure is provided by the USDOT Office of the Chief Information Officer. The NAD operating system, network configurations, operations, and cybersecurity policies, as well as the roles and procedures for managing them, must conform to federal and departmental IT policies and procedures. These matters are outside the scope of the Address Subcommittee, so they are not evaluated as part of this assessment.

As of the end of 2023, USDOT operates the GIS software infrastructure to maintain and host the NAD. USDOT is using PC's running a Windows 10 operating system, ArcGIS Pro 3.1.5 and FME 2022.2.1.0. The data itself is not hosted internally at USDOT, and there

is no direct interface from USDOT systems to the NAD. Instead, the feature service of the NAD data is hosted in ArcGIS Online and the zipped downloads (via the USDOT website) are processed through Amazon Web Services S3.

Assessment: The system infrastructure supports current operations. Section IV considers whether it will support operations needed to meet Address Theme requirements.

III.B. NAD Data and Data Architecture

Scope: NAD Data and Data Architecture includes the data stored and organized in the GIS, as well as the data models, policies, and rules that govern how that data is integrated, organized, stored, maintained, and used.

GDA Requirement

"[The lead covered agencies shall] provide leadership and facilitate the development and implementation of a plan for nationwide population of the National Geospatial Data Asset data theme …" (GDA 2805(b)(3)(B)

Subcommittee Charter Scope and Objective

"*The primary objective of the Address Subcommittee is to develop and document a sustainable process and necessary content to gather, maintain, and make publicly available address related national geospatial data assets." (Objective #1)*

Status and Background

The FGDC Address Theme includes one National Geospatial Data Asset Dataset: the National Address Database (NAD).

As of the end of 2023, the NAD included 76.8M records, up from 24.6M records in late 2017. The NAD records cover 18 states completely and parts of 24 more. Data from most partners is updated every year or two.

The USPS data set includes approximately 148 million delivery addresses nationwide. (excluding about 19 million PO Boxes). The USPS address data set differs from the NAD dataset in some important respects, but it provides a rough gauge of the number of address records that the NAD might include if it covered the country completely. By that measure, the NAD dataset includes roughly half of the nation's addresses.

The Address Subcommittee adopted the *Content Requirements for the National Address Database (NAD*) in August 2022. The report states the scope and purpose of the NAD, and the specific capabilities needed to achieve the purpose. The requirements report defines and describes the data elements that comprise the address (address number, street name, landmark name, subaddresses, place and state name elements), and address attributes including the unique address record ID, map point and map coordinates, address authority, and record-level metadata. The data items include the attributes needed to support the required capabilities. The complete data schema is posted on the USDOT NAD webpage.

The data are organized in a flat-file structure: one large table, with one record for each address record. Flat-file schemas are conceptually simple, but they do not scale up well. At a certain point they become operationally inefficient: data values are repeated in record after record, which increases the storage size of the database and the time needed for processing records.

Assessment:

1. During the assessment period, the NAD has been expanded to include 76.8 million records from 42 state-level data partners.
2. NAD data requirements are well-defined and incorporated into database operations.
3. As the number of NAD records increases, the NAD team should consider preparing to migrate to a relational data structure.

III.C. NAD Business Processes and Workflows

Scope: The processes and workflows used in aggregating, updating, managing, and publishing NAD data.

GDA Requirement

"[The lead covered agencies shall] provide leadership and facilitate the development and implementation of a plan for nationwide population of the National Geospatial Data Asset data theme …" (GDA 2805(b)(3)(B)

Subcommittee Charter Scope and Objective

"*The primary objective of the Address Subcommittee is to develop and document a sustainable process and necessary content to gather, maintain, and make publicly available address related national geospatial data assets." (Objective #1)*

Status and Background

State-level Data Import/QC/Update Processes. Local address authorities submit their data to the state GIO or other agency for review and aggregation (or the USDOT directly, in the absence of a state aggregator). The state (or USDOT) conducts a five-phase review to trap errors: initial schema review, conformance, validation, aggregation, and final feedback/corrections. The validation categories include spatial, schema, data, and anomalies. States are encouraged to follow the workflow diagram with the option to combine or skip certain steps. The process is documented by an Address Workflow Validations matrix and flow charts.

Federal-level Data Import/QC/Update Processes. The details of the federal level processes are still being defined. USDOT maintains an FTP site for address data uploads which makes uploading data submissions convenient for NAD partners.

Data is populated as the stakeholders submit their updates. As of October 2023, the age of most NAD records was 6-24 months old.

The current federal update process uses complete data replacement, not incremental data replacement. Upon receipt of an update file from a given data partner, the NAD ETL Developer deletes all prior records from that partner and substitutes the completely new records dataset. This includes records that have not changed since the last update. An Incremental update process, in which only the changed records are updated, is not currently used.

NAD operations have developed as ad hoc routines to receive data in multiple formats and to apply an evolving suite of QA/QC tests. Records that fail the tests are reported to the original data providers for their review. Processes include using ETL tools for importing submitted data and generating QA/QC data reports.

Data Publication Processes. The NAD is published for download from the USDOT website in both file geodatabase (.gdb) and .CSV formats. New NAD data releases are published more or less quarterly.

Users must download the entire dataset. The NAD portal does not allow users to define or download subsets of the NAD.

NAD data are published to a web feature service that shows the NAD address points (i.e., the NAD Viewer). Users can click on a point and read the address. A raster view shows the density of NAD address points.

NAD data has been published to the GeoPlatform (as required by the GDA), but technical issues have prevented successful publication recently. Publication to the GeoPlatform will resume when the technical issues are resolved.

Assessment:

1. NAD business processes for data submission and review are flexible within the limits of the schema. Maintenance and operation of the NAD has been consistent and responsive to partners' needs and issues.
2. The current complete data replacement method of updating, although easier to implement, is less efficient than the incremental data replacement method.
3. The inability to download subsets of the NAD effectively precludes NAD use by those who cannot download the entire 76M-record NAD data file.

Recommendations:

1. Identity and implement process efficiencies to increase data throughput as the number of records and frequency of updates grows.
2. To increase public use of the NAD, provide tools that allow users to select and download subsets of the NAD. This capability would be particularly useful for defining addresses within disaster or emergency relief areas, both during a crisis (notification and evacuation) and post-crisis (filing damage claims).

III.D. NAD Applications and Services

Scope: GIS applications, services, and interfaces are created to support business tasks, operations, and analyses, and GIS interaction with other systems. Generally, they are not created until the production database design is fully defined.

Status and Background
The NAD web feature service, published via ArcGIS Online, has been in service since 2021. No other applications or services have been developed.

Assessment:
The NAD web feature service is a basic data viewer, allowing the user to click on a point and view the address. A point density display is also provided. State-by-state subsets of NAD data can be downloaded, but only if the user has GIS software.

IV. Address Theme Resources

IV.A. Staffing, Procurements, and Funding

Scope: The personnel, procurements, and funding needed to develop the NAD and achieve the goals and purposes of the Address Theme.

GDA Requirements

1. *"The lead covered agencies for a National Geospatial Data Asset data theme shall be responsible for ensuring the coordinated management of the data, supporting resources (including technology and personnel), and related services and products of the National Geospatial Data Asset data theme." (GDA 2805(b)(2)*
2. *"[The lead covered agencies shall] provide leadership and facilitate the development and implementation of a plan for nationwide population of the National Geospatial Data Asset data theme, which shall … (iii) address human and financial resource needs; … (GDA 2805(b)(3)(B)*

Status and Background

Staffing. The Subcommittee and its subgroups are led by Census and USDOT staff. No federal FTE is assigned to work full-time on Subcommittee work. Other committee members and stakeholders participate as volunteers.

NAD database development, maintenance, and day-to-day operations are done entirely by one ETL Developer, who is funded and hired by USDOT under a year-to-year contract covering up to three years.

Procurements. No procurements are currently planned beyond continued funding for the NAD ETL Developer position.

Funding. The NAD is currently administered by USDOT. To date, USDOT has provided all direct funding and system infrastructure. USDOT has funded the NAD contract position using National 911 program funds. No other direct financial costs are incurred. No additional NAD funding requests are under discussion at this time.

Assessment:
As of the end of 2023, the NAD contains roughly half the nation's addresses. Data partners are providing updates, in most cases, every year or two. To be useful in everyday operations for a broad cross-section of stakeholders, the NAD should provide closer to 100% coverage with updates at least quarterly. Scaling up, however, would increase the resources needed for NAD operations:

- If the NAD provided close to 100% coverage, instead of roughly half, the number of address data records to be processed for each quarterly release would roughly double.
- If NAD data partners submitted updates every quarter, instead of every 1-2 years, the NAD operations would have to process that volume of data 4-8 times more frequently— to simplify the discussion, let's take the midpoint and say 6 times more frequently.
- Taken together, if the NAD were issuing data releases every three months for close to 100% of the nation's addresses, its ETL operations would have to scale up by a factor of twelve.
- As the NAD becomes more complete and current, NAD data will become useful for a broader range of purposes, and the NAD would be expected to offer a richer array of products and services. As ETL operations scale up, customer service operations will also Additional capacity would be required to support the anticipated user demand for a broader array of NAD products and services.

The current level of NAD staffing and workflows cannot support the operations required for a complete, current Address Theme NGDA. Scaling up current operations will require substantial additional resources. In deciding whether and when to provide those resources, the lead covered agencies would be choosing from among four options:

1. Add staff (keep doing the same thing with more people);
2. Change current data structures and processes to make them more efficient (and more complex). More sophisticated processes and architecture would require staff with more specialized skills, and during some phases, specialized professional consulting support beyond what is provided by on-site staff. Possible examples:
   - Replace wholesale data updates with incremental data updates.
   - Replace FTP-based file exchange methods with web services.
   - Replace the flat file exchange structure with a relational exchange structure (to minimize redundancy in data transmittals).
3. Continue existing operations indefinitely, at current levels of staffing, funding, and usage, in support of a NAD that is half-complete and out-of-date; or,
4. Discontinue the NAD and abandon federal leadership of the Address Theme.

In making their choice, the lead agencies will ultimately decide whether the NAD will become a long-term operating-budget program or continue as a year-to-year project.

Recommendations: Commitment to a program will require a clear plan for a scaled-up system architecture and staffing to manage it. The plan should be based on four analyses:

1. Organizational context – A description of the organizational structure, the purpose of the NAD, and it's IT environment. This is all well-settled, but it provides background for the analyses that follow.
2. NAD business use case analysis – The business use cases that the NAD is intended to support; and the benefits of those uses.
3. NAD GIS architecture requirements analysis – The technical assumptions and requirements for the GIS infrastructure, data, process, and application architectures needed to support the business requirements. This in turn provides the basis for the financial requirements analysis, detailed system design, and staffing estimates.
4. NAD financial requirements analysis – the financial resources needed to meet the business and architectural requirements, including year-by-year costs and funding sources, staffing requirements and hiring timelines, and major procurements.

The four analyses will—if the lead agencies choose to proceed—provide a sound basis for a strategic plan (including the funding and staffing request), an implementation plan, and the technical design for a scaled-up NAD. Given the lead time required by federal funding and procurement cycles, the analyses and planning should begin now.

V. Assessment

Sections II, III, and IV provide the background and current status of different aspects of the Address Theme, with assessments and recommendations for each. Section V evaluates the theme as a whole, in terms of the seven criteria given for the COGO theme assessments: capacity, condition, funding, future need, operation and maintenance, public use, and resilience. Section VI then synthesizes the assessments into one overall evaluation and grade.

V.A. Address Theme Assessment Considerations

The Address Theme is a Work in Progress. Several conditions require that the Address Theme be evaluated as a work in progress, not as a fully operational data theme:

1. Work on the Address Theme began in 2015, years after work on the other themes was started.
2. No non-restricted core dataset exists, either within the federal government or elsewhere, to provide a basis for creating the Address Theme NGDA dataset(s). The two national address datasets within the federal government (Census and USPS), by federal law, cannot be shared outside of the organizations or with the public.
3. There is no central authority or registry of United States addresses. Addresses are created, revised, and retired by thousands of local governments, each acting independently.
4. The federal Address Theme, unlike any other theme, requires the construction of a

data asset custom-built for the NGDA. Other theme subcommittees provide governance for data theme assets that are managed by specific federal agencies in the course of their operations; only the Address Subcommittee has taken on the technical challenge of building and maintaining an enterprise-level spatial database, in addition to its governance responsibilities.

5. Creation of the National Geospatial Data Asset (NGDA) Dataset depends on voluntary data provision and/or aggregation from local to state to federal agencies. The Address Theme has had to create, from scratch, partnerships and procedures for aggregating address data from dozens of partners. No other NGDA dataset asset relies on such multilevel coordination.
6. There are areas within some states and territories where addresses have never been assigned. Some states and territories have no program for aggregating addresses statewide, and some states prohibit sharing address data as a matter of law or policy.

For all these reasons, the Address Theme is not evaluated against the expectations for a mature theme, whose data assets are largely complete, widely used, and managed within a fully operational database, with ongoing maintenance and enhancements.

Instead, the Address Theme is evaluated as a data governance and database implementation program that is still under construction. The assessment is based on progress towards completion since the beginning of the NAD pilot project (FY2015-FY2023), not on whether completion has been achieved.

End Goal Envisioned for the Address Theme. A judgment about progress toward completion requires a vision of what constitutes "completion". The clearest vision statement to date for the Address Subcommittee is found in the statement of scope and purpose given in the NAD content report:

"The National Address Database shall provide, in a single, authoritative, publicly available spatial database, all United States addresses, along with their coordinate locations, metadata, and other attributes…" (FGDC, *Content Requirements for the National Address Database (NAD).* August 10, 2022, p. 19)

In this assessment, the above vision statement is extended by adding some operational metrics that are implicit in the statement, in the requirements of the GDA, and in the Address Subcommittee charter. When the NAD is complete, it will:

1. Aggregate address data from any or all of 50 states, five territories, and DC that are willing to provide their data voluntarily, or, if no state-level partner is found, local governments within them.
2. Accept updates from data partners as frequently as they wish to provide them.
3. Publish updates at least quarterly to the public.
4. Provide data and metadata products that serve the everyday needs of federal agencies and the public in ways that do not duplicate what is already available via commercial services.

5. Integrate address data and metadata with other NGDA themes via the GeoPlatform.

V.B. Address Theme Assessment

1. Capacity: ***The theme's ability to meet current and future demands.***

The Address Theme, lead covered agencies and theme co-chairs have, in the past six years, provided committed leadership and established a solid foundation of governance policy and data management procedures to support continued progress toward full achievement of Theme goals. Regular Subcommittee meetings provide a forum where stakeholders can agree on Address Theme policies and priorities. Important among these have been the data content requirements and the workflow definitions that underpin NAD data, metadata, and processes.

During this time the Address Theme leads have expanded the partnership network to include 42 state-level partners and 47 local partners. The NAD has grown to include 76.8M records (about half the nation's addresses), updated every year or two. The USDOT, as NAD custodian, has published 15 data releases for public download, and has published a web feature service for data viewing.

The Address Theme stakeholders have demonstrated the administrative and technical practicality of the local-state-federal aggregation chain to create a national address dataset. The results confirm that the policies and priorities to date provide a sound basis for future work.

These achievements, as substantial as they are, cannot be said to meet current and future demands. A database that contains only half of the nation's addresses does not constitute a nationwide dataset and updates every 1-2 years is not particularly timely. The NAD is still under construction and very much a work in progress. Much remains to be done to expand the partnership network, increase the frequency of data updates, make the update processes more efficient, and define NAD products and services that are useful to both federal and non-federal stakeholders.

2. Condition: ***The existing or near-term condition of the Framework themes as an integrated whole.***

Both the FGDC address data standard and the NAD data schema were created to support data integration across themes, applications, and data users throughout the nation.

The address standard incorporates references, either normative or informative, to over 40 other standards (see Part 6). Appendix I shows that the address standard is compatible with all eight parts of the FGDC Geographic Information Framework Data Content Standard except certain details of the Transportation Standard. Finally, the FGDC address standard includes attributes for relating addresses to transportation networks and to real property parcels.

The FGDC Standard is closely aligned with the NENA address data standards (CLDXFv1 and the GIS Data Model). By intent, the NENA standards incorporate many, but not all, of the data items in the FGDC standard.

The NAD data schemas (v1 and v2) implement the FGDC and NENA standards. The schemas are closely aligned with the NENA and FGDC standards (and the USPS standard, for postal elements), adapting and extending them as needed for NAD purposes.

3. Funding: ***The funding capability of the Framework.***

Funding has sufficed to develop the NAD to its current state. Near-term funding for current operations appears stable, but funding is on a year-to-year basis. There is no dedicated federal funding for NAD development and operations.

4. Future Need: ***Whether future funding prospects will be able to meet the need.***

Current operations are not adequate to support a complete, current, nationwide address data set, and the operations and staffing that would entail. Currently there is no commitment from the lead agencies to provide additional funding for scaled-up operations, and no discussion within the theme Subcommittee about undertaking any planning studies to ascertain the level of support required for a complete, current, nationwide address data set.

5. Operations and Maintenance: ***The ability of key lead organizations to develop and maintain the Framework and to adopt new technology, procedures, and standards.***

The lead agencies are large federal government agencies with experience in developing, maintaining, and disseminating large public data sets. Census maintains a nationwide address file to support the decennial census and ongoing surveys. Census also invented the topological road centerline data structure and expanded it to cover the nation, again in support of the decennial census and ongoing surveys. Both agencies and their theme leads are committed to the successful creation of the Address Theme and its NGDA.

Their abilities are constrained by the lack of funding needed to scale up current operations to support a complete, current, and accessible NAD. Lack of staffing constrains outreach to potential new data partners. Lack of funds and specialized enterprise GIS technical staff constrains the workflow analysis and system analysis needed to increase process efficiency, and the incorporation of applications and services for more flexible data access.

6. Public Use: ***The Framework's ability to provide data resources that meet the everyday needs of organizations.***

Provision of data resources requires a policy commitment to public access, and the IT infrastructure to support delivery services. The principle of public access is written into the GDA and the Subcommittee charter, and it has the full support of the theme lead agencies. The NAD is housed within the federal government enterprise computing

system, which has the enterprise architecture and scale to support high-volume provision of large data sets.

The GDA makes clear that the GeoPlatform is expected to provide the point of access for NGDA theme data. As of the end of 2023, NAD data and metadata were not available via the GeoPlatform, and documentation of Subcommittee activities and policies was a few years out of date. Because the scope of this assessment did not extend to any review of the GeoPlatform, the assessment cannot offer any insight as to why that is the case or how it might be remedied.

Under the circumstances, the theme lead agencies have posted NAD data for download from a DOT webpage, and published the NAD to a web feature service that allows viewing but requires GIS software for downloading. Delivery is otherwise restricted to those who can download the entire 76M-record NAD data file. Currently the incomplete coverage and out-of-date data make the NAD of minimal use for everyday needs.

Public use would be improved by

1. Continuing the ongoing progress toward more complete and timely NAD data.
2. Providing tools that allow users to select and download subsets of the NAD.
3. Publishing NAD data to the Geoplatform to put it into context of other NGDA themes.

7. Resilience: ***The ability of the geospatial community to participate in development of the Framework and to contribute to its sustainability as a long-term asset of value for the nation.***

The lead agencies and theme leads place a high priority on participation from all sectors of the Address Theme community. The NAD consists entirely of records provided voluntarily by state and local government data partners. Address Subcommittee meetings include participants from federal, state, local, and private sectors.

VI. Assessment and Grade

THEME GRADE: B
Adequate for now, needs attention for future completion.

Based on the assessment in Section V, this grade reflects the substantial progress made during the assessment period, and the substantial challenges remaining before the Address Theme provides a complete, current, nationwide address database.

Address Data Theme Work Group

Framework Evaluators	Federal Liaisons
Kathrine Cargo, GISP, Team Lead, Orleans Parish Communications District, LA	Matthew Zimolzak, Address Theme co-Chair, Census Bureau
Christopher Ard, GISP, City of New Orleans, LA	Mara Kaminowitz, Address Theme co-Chair, US Dept of Transportation
Craig Fargione, GISP, New York State Office of Information Technology Services, NY	
Rachel Marquez, GISP, PMP, County of Los Angeles, CA	
Evaristo Ramos, GISP, City of Brownsville, TX	
Ed Wells, GISP, Retired	

Reference Documents

Note: Sources are grouped by type, and listed chronologically within each group. URLs are current as of September 6, 2024.

FGDC, Address Subcommittee, and Related Documents

1. National Geospatial Advisory Committee. *The Need for a National Address Database*. December 2012. 11pp. Posted at: *https://www.fgdc.gov/ngac/meetings/december-2012/NGAC%20National%20Address%20Database%20Paper.pdf*
2. National Geospatial Advisory Committee. *The Need for a National Address Database – Use Cases*. December 2014. 21pp. Posted at: *https://www.fgdc.gov/ngac/meetings/december-2014/ngac-national-address-database-use-case-paper-december-2014.pdf*
3. Government Accountability Office. GEOSPATIAL DATA - Progress Needed on Identifying Expenditures, Building and Utilizing a Data Infrastructure, and Reducing Duplicative Efforts. Report to Congressional Requesters, February, 2015. 99pp. (see especially pp. 1-2, 13-15, 56-65, 72, and 88-89). Posted at: *https://www.gao.gov/products/GAO-15-193*
4. U.S. Department of Transportation. *National Address Database Summit Report*. Authored by Applied Geographics. June 2015. 49pp. Posted at: *https://www.transportation.gov/sites/dot.gov/files/docs/NADSummitReport_Final.pdf*
5. U.S. Department of Transportation (USDOT). *National Address Database Pilot Project Findings Report*. Prepared by AppGeo. September 20, 2016. 51 pp. [See pp 10-16, 31, 41-48, and 51 for the NAD pilot schema, version 1]. Posted at: *https://www.fgdc.gov/topics/national-address-database/nad-pilot-project-final-report.pdf*
6. U.S. Office of Management and Budget. "*OMB Supplemental Guidance – Appendix E – NGDA Data Themes, Definitions, and Lead Agencies*". March 24, 2017. 2 pp. Posted at:

https://www.fgdc.gov/policyandplanning/a-16/appendixe/20170324-ngda-themes-fgdc-sc-revised-appendixe.pdf

7. U.S. Federal Geographic Data Committee. *FGDC Address Subcommittee Charter*. May 2017. 4pp. Posted at: https://www.fgdc.gov/organization/working-groups-subcommittees/address-sc/fgdc-address-subcommittee-charter-may-2017.pdf
8. Address Subcommittee of the U.S. Federal Geographic Data Committee. "*Meeting Materials*". Meeting Notes for Address Subcommittee meetings, December 2016 - December 2021. Posted at: https://www.fgdc.gov/organization/working-groups-subcommittees/address-sc/index_html
9. U.S. Census Bureau and U.S Department of Transportation. *National Address Database Federal User Requirements Workshop – February 21, 2017 – Washington D.C. - Final Report*. January 19, 2018. Posted at: https://www.fgdc.gov/topics/national-address-database/nad-federal-user-requirements-final-report-v1.pdf
10. U.S. Department of Transportation. "National Address Database Schema". Version 2. April 2018. 6pp. Posted at: https://www.transportation.gov/sites/dot.gov/files/docs/mission/gis/national-address-database/308816/nad-schema-v2.pdf
11. Address Subcommittee of the U.S. Federal Geographic Data Committee. *Address Theme Strategic Plan FY2019 through FY2021*. September 1, 2019. 7pp. Posted at: https://www.fgdc.gov/organization/working-groups-subcommittees/address-sc/index_html
12. Address Subcommittee of the U.S. Federal Geographic Data Committee. "*NAD State Address Point Data Workflow Process Chart v. 1.6*". October 2020. Diagram, 2pp. Posted at: https://www.fgdc.gov/organization/working-groups-subcommittees/address-sc/nad-draft-state-workflow-v1-6.pdf
13. Address Subcommittee of the U.S. Federal Geographic Data Committee. *"NAD State Address Point Data Workflow Process Companion Textual Description Document v. 1.4"*. October 2020. Text document, 2pp. Posted at: https://www.fgdc.gov/organization/working-groups-subcommittees/address-sc/nad-state-address-point-data-workflow-v1-4.pdf
14. Address Subcommittee of the U.S. Federal Geographic Data Committee. *Content Requirements for the National Address Database (NAD)*. August 8, 2022. 67pp. Posted at: https://www.fgdc.gov/organization/working-groups-subcommittees/address-sc/220810-nad-content-requirements-approved.pdf
15. Address Subcommittee of the U.S. Federal Geographic Data Committee, and National States Geographic Information Council. *Addresses for the Nation - Pathways from Restricted Data to Open Data*. August 2022. 8 pp. Posted at: https://www.fgdc.gov/organization/working-groups-subcommittees/address-sc/nad-public-domain-white-paper-final.pdf
16. U.S. Department of Transportation Office of the Chief Information Officer. *National Address Database Schema*. April 17, 2023 (Version 3). PDF. 37pp. Posted at: https://www.transportation.gov/sites/dot.gov/files/2023-07/NAD_Schema_202304.pdf

NAD Web Feature Service

1. Published via FGDC GeoPlatform NGDA Address Community Theme page: *https://ngda-address-geoplatform.hub.arcgis.com/apps/2c27531e71b94d48b1a4e12207e7f2c3/explore*

Websites: Address Subcommittee, NAD, and GeoPlatform Hub

1. **NAD:** U.S. Department of Transportation. "National Address Database". USDOT Webpage. Includes links to the current NAD data release and NAD data schema, and NAD data release. *https://www.transportation.gov/gis/national-address-database*
2. **Address Subcommittee:** Address Subcommittee of the U.S. Federal Geographic Data Committee. "Address Subcommittee". Includes links to Address Subcommittee documents and meeting notes. *https://www.fgdc.gov/organization/working-groups-subcommittees/address-sc/index_html*
3. **GeoPlatform Hub:** U.S. Federal Geographic Data Committee. "NGDA Address Theme". Includes a link to the NAD web feature service. *https://ngda-address-geoplatform.hub.arcgis.com/*

Address Data Standards: USPS, FGDC, NENA

Note: Versions cited are the versions used in drafting the 2022 NAD content requirement.

1. United States Postal Service. Publication 28 - Postal Addressing Standards. June 2020. 218 pp. Earlier versions date back to the 1970's or before. Earlier versions are not available online. Current (October 2023) version posted at: *https://pe.usps.com/text/pub28/*
2. U.S. Federal Geographic Data Committee. United States Thoroughfare, Landmark, and Postal Address Data Standard. FGDC-STD-016-2011 (Endorsed February 9, 2011). Posted at: *https://www.fgdc.gov/standards/projects/address-data*
3. National Emergency Number Association (NENA). NENA Next Generation 9-1-1 (NG9-1-1) United States Civic Location Data Exchange Format (CLDXF) Standard. NENA-STA-004.1.1-2014, March 23, 2014. 127 pp. Posted at: *https://cdn.ymaws.com/www.nena.org/resource/resmgr/Standards/NENA-STA-004.1.1-2014_CLDXF.pdf*
4. National Emergency Number Association (NENA). NENA Standard for NG9-1-1 GIS Data Model. NENA-STA-006.1.1-2020, February 18, 2020. 106 pp. Posted at: *https://cdn.ymaws.com/www.nena.org/resource/resmgr/standards/nena-sta-006.2-2022_ng9-1-1_.pdf*

Geospatial Data Act of 2018

United States Code, Title 43—PUBLIC LANDS, Chapter 46: Geospatial Data (43 U.S. Code 46). Enacted as H.R. 302, Subtitle F, Sections 751 – 759 (Public Law 115-254),

October 5, 2018. Posted at: *https://www.fgdc.gov/gda/43-usc-ch-46-geospatial-data-geospatial-data-act.pdf*

National States Geographic Information Council (NSGIC) State Geospatial Maturity Assessments

Every other year NSGIC asks each of the 50 states and DC to self-report on coverage and management practices for core spatial data themes, including addresses. This review did not attempt to review state data assets or operations, but the NSGIC assessments provide a valuable overview of state address data resources. The assessments are posted at: https://nsgic.org/initiatives/geospatial-maturity-assessment/

II. Cadastral Data Theme

Executive Summary

While some progress has been made in the six-year span since since the 2018 NSDI Assessment, when the cadastral data theme was assigned a C-, the lack of progress toward creating a comprehensive national parcel database of public and private land warrants keeping the grade as C-. The federal government has been dedicating resources to managing cadastral data for public lands and improved coordination across federal agencies. However, the federal government has done very little to incorporate public and private land cadastral data to assemble a complete parcel fabric for the country. The geospatial community at large must continue to advocate for coordinated efforts across all levels of government to establish a nationwide, comprehensive, accessible, and well-maintained cadastral theme.

Cadastral Theme Grade: C-

Requires Attention

Description of the Framework

Theme Definition

The cadastral theme is defined as, "past, current, and future rights and interests in real property including the spatial information necessary to describe geographic extents. Rights and interests are benefits or enjoyment in real property that can be conveyed, transferred, or otherwise allocated to another for economic remuneration. Rights and interests are recorded in land record documents. The spatial information necessary to describe geographic extents includes surveys and legal description frameworks such as the Public Land Survey System, as well as parcel-by-parcel surveys and descriptions. It does not include Federal government or military facilities."

Introduction to the Theme

Rights and Interest in the American Dream

Property ownership has been at the heart of American Democracy from the beginning and remains a fundamental part of how local government is able to function and support community needs. The local property tax continues to be a primary source of local government funding, with property parcels and their records management remaining a mostly local responsibility.

This tax becomes an annual lightning rod of interest for obvious reasons. County Courthouses and Land Offices have always been open to the public too, because it was important to assure whoever wanted to examine the records to check that assessments were fair across a community, sharing the load so that everyone participated in financially supporting common community needs. Roads, schools, and public safety being the common top items funded by local property taxes.

It was deemed so important that these records be above reproach, that it was typical to have a checks and balances system where multiple elected officials participated in managing the annual assessment rolls of property ownership. Annual certification was a serious official undertaking with consequences for errors or omissions. As these records management tasks have been automated, the checks and balances aren't as obvious, but statutes and regulations are still in place to audit for completion, correctness and fairness. A key component in local property assessment is the annual taxpayer review and protest processes, requiring that local property records remain open and accessible to the public.

Local municipalities and utilities are also daily users of property information to manage their operations and assets in a community. Recognizing that parcels and property information is a valuable resource beyond merely assessment functions, parcel level information is a fundamental underpinning of information for communities in our locally focused democracy. Viewing, analyzing and comparing the information in this theme is undeniably critical to the democratic process of ensuring fair and equitable taxation.

Paying for Your Schooling and Much More

The assessor is often recognized as the steward or authoritative source for land records data for both government agencies and the private sector. Property data or cadastral data is often resold to financial, insurance and real estate agencies for modeling markets or other means of manipulation.

Non-assessment functions of government agencies may also rely on cadastral data for property taxation and local funding sources may provide a locational means for distribution of school funding or other budgeted special social programs. This data along with other supplemental data sources may be utilized to assess the impact they have on a particular geographical area.

Cadastral maps are essential for local governments to efficiently and effectively identify, list and value property for property tax purposes. Location identification attributes, such as address or parcel identification, provide a unique identifier for joining additional data collected by the assessor and to visualize geographical relationships. Cadastral maps also provide efficiency in understanding proximity to other phenomena and are utilized within other government entities such as planning, engineering, and environmental management. A national data system would allow for the standardization of data sources to compare and contrast locational impacts on both government and non-government phenomena. To sum it up appropriately, municipal and county governments rely heavily on the revenue generated from property assessment and that function is driven by parcel data.

According to a 2023 National Center for Education Statistics report, thirty-seven percent of elementary and secondary public school revenues across the US were from local sources, with only eight percent coming from the federal government. In some states, the reliance on local revenues, namely the local property tax, is much greater. For example, the local property tax accounts for more than fifty percent of revenue for public schools in New Hampshire and Connecticut. Here, the local property tax provides funding for

budget items like teacher salaries, building and equipment maintenance, and projects such as building new schools. Although not all states fund their public schools in exactly the same manner, the responsibility of K-12 education falls upon the states, with many heavily relying on the local property tax to fill in the funding shortfalls. The importance of the local property tax is apparent considering the public school enrollment rate was over forty-nine percent in 2021. This means that public schools across the US will need to rely on a consistent and reliable source of funding - local property tax. The majority of public education funding comes from local sources.

A Geographic Measure of the U.S. Economy

Today we live in a society driven by data. Whether for an industrial prospect asking questions on a state level, or a small community dealing with a commercial developer, we need information now. The old adage "Knowledge is Power" has never been more true in our world of split second decision-making and fast paced business development. Every expansion, relocation, or new start-up factors in real estate location. The quicker an economic development prospect can be handed information the more likely that community will get to the next level in the economic development process. The ability to respond rapidly with high quality information may make the difference in whether a prospect chooses to locate in a community, bringing jobs and commerce, or whether that community is passed over for the next community who has their information resources readily available. Cadastral information is the data driving those decisions.

The necessities of site characteristics such as power, water and transportation access are typical items used in site selection or expansion, however other factors at play, including administrative boundaries such as taxing districts and the configuration of the individual tax parcel itself, frames many business decisions. Real estate parcel data effectively becomes a digital billboard allowing expansion, relocation, and site selection decision makers to preview what communities have to offer.

It is indisputable that no other component of the nation's geospatial framework is more closely linked to the economic prosperity of the United States. Out of all of the themes of the NSDI, a real estate parcel is the only one immediately measurable by a sales price. No other framework theme measures the geography that is bought or sold.

Considering commercial real estate alone from the "Economic Impacts of Commercial Real Estate, 2023 Edition" highlights include:

- Commercial real estate development supported 15.1 million American jobs in 2022 (a measure of both new and existing jobs).
- Commercial real estate development contributed $2.3 trillion to the U.S. GDP.
- Commercial real estate development generated $831.8 billion in salaries and wages.
- There were 926 million square feet of commercial real estate space built in 2022, with capacity to house 1.9 million new workers with a total estimated annual payroll of $153 billion.

For all these reasons cited above, the lack of a standardized, comprehensive and accessible view of the nation's real property is recognized as harmful. Property ownership was a fundamental underpinning of the U.S. democracy from the beginning, indeed a prerequisite to participate as a voter until 1856, when North Carolina was the last state to remove property ownership as a requirement to vote.

The cadastral data theme represents a major economic contributor to local economies - it is the only framework theme bought and sold. Most parcel data are locally originated and managed. The value of these lands is the source of local public education serving our national interest. This theme maps the unit of geography more closely tied to jobs and economic prosperity than any other. It is regrettable our nation has not yet fully developed the theme that is an official record of public and private rights and interests in its vast lands. We must digitize the cadastral data theme in today's data-driven society.

Lead Agency and Current Activities

The Bureau of Land Management (BLM) is the lead agency for the Cadastral theme. BLM and the FGDC Cadastral Subcommittee provide government-wide leadership for cadastral data coordination that is carried out under the policy guidance and oversight of the Federal Geographic Data Committee.

Under the National Geospatial Data Asset (NGDA) program's concept of shared portfolio management, the FGDC created a comprehensive listing of cadastral elements under federal authority. This guides BLM's stewardship by identifying 20 different cadastral datasets (Table Cadastral-1) managed by nine different agencies: the Bureau of Land Management, the Bureau of Ocean Energy Management (BOEM), the Army Corps of Engineers (USACE), the Department of Defense (DOD) Acquisition, Technology, and Logistics (AT&L), the Bureau of Indian Affairs (BIA), the National Parks Service (NPS), the Fish and Wildlife Service (FWS), the Forest Service (USFS), and the USGS.

Table Cadastral-1. Bureau of Land Management (BLM) Dataset Stewardship.
Table continued on following page.

Theme NGDA Datasets	NGDA Agency
Administrative Boundaries of National Park System	DOI - NPS
Army Corps of Engineers Civil Works Land Data	DOD - USACE
BIA Indian Lands Dataset (Indian Lands of the United States)	DOI -BIA
BLM National Public Land Survey System Polygons	DOI - BLM
BLM National Surface Management Agency: Area Polygons, Withdrawal Area Polygons, and Special Public Purpose Withdrawal Area Polygons	DOI - BLM
Department of Defense Land Parcels and Sites	DOD - AT&L

Table Cadastral-1, *continued*. Bureau of Land Management (BLM) Dataset Stewardship.

Theme NGDA Datasets	NGDA Agency
FS National Forest Dataset (US Forest Service Proclaimed Forests)	USDA - USFS
FWS Interest	DOI - FWS
Outer Continental Shelf Active Renewable Energy Leases	DOI - BOEM
Outer Continental Shelf Lease Blocks - Alaska Region NAD83	DOI-BOEM
Outer Continental Shelf Lease Blocks - Atlantic Region NAD83	DOI-BOEM
Outer Continental Shelf Lease Blocks - Gulf of Mexico Region NAD27	DOI-BOEM
Outer Continental Shelf Lease Blocks - Pacific Region - West Coast NAD83	DOI-BOEM
Outer Continental Shelf Official Protraction Diagrams - Alaska Region NAD 83	DOI-BOEM
Outer Continental Shelf Official Protraction Diagrams - Atlantic Region NAD 83	DOI-BOEM
Outer Continental Shelf Official Protraction Diagrams - Pacific Region - West Coast NAD 83	DOI-BOEM
Outer Continental Shelf Official Protraction Diagrams And Lease Maps - Gulf Of Mexico Region NAD27	DOI-BOEM
Outer Continental Shelf Block Aliquots - Atlantic Region NAD83	DOI-BOEM
Protected Areas Database of the United States (PAD-US)	DOI - USGS

Since the last report, the BLM has shown improvement in coordinating with other federal agencies to reduce data duplication and providing better access to the data. The older GeoPlatform site was retired, with a theme-based Hub site taking its place. The BLM has been working with BOEM to reduce silos of data and aggregate them for easier use. The FGDC will be releasing their new Strategic Plan this year, which may shed light on where they will take this theme and others next. The area where BLM has exercised its authority best is in the role of standards development. That leadership has been essential in the progress of the cadastral framework.

Absent from the federal structure is any component representing the rights and interest of privately held lands. Those interested in a national fabric of parcel data lament that the federal government has not done its best to foster a national theme. The opposite circumstance may also be true. Federal lands along with state lands are exempt from the real estate assessment process, so there may be many instances where the state and federal real property assets are not mapped in the local databases because they contribute limited value to the local government function of assessment.

The Federal Land Asset Inventory Reform (FLAIR) Act of 2021 is a legislative success,

acknowledging the need to produce and maintain better cadastral data. Unfortunately, this piece of legislation is an unfunded mandate. In order for the BLM and other federal agencies to effectively coordinate with state, tribal, and local government and efficiently incorporate parcel transactions on non-federal lands into a true, national cadastral database, federal dollars must be obligated.

Collaboration and Partnerships

As reported in the NSDI Report Card of 2018, federal agencies have come together to make progress when it comes to the USGS Protected Areas Database (PAD-US) as well as work undertaken by the BOEM to better map offshore development. While these represent a significant investment of resources, they do not go far enough or demonstrate the vision to build a national parcel fabric of public and private lands.

The PAD-US geodatabase model can be revised to accommodate federal parcels that do not specifically share the "protected" designation. The geodatabase model also accommodates non-federal data, and the participation of non-federal partners in this effort addresses the recommendation stated in the report card that "local stewards" be involved. It represents a good start and a model for what could be expanded to include ownership information for all lands.

The federal government has two directions for future collaboration and partnership opportunities. One is to partner with states and tribals to build or prop up state and tribal parcel programs so that all US states, tribes and territories have the means in place to coordinate digital parcel data creation at the local level, with those data rolled up to the state level on a routine basis. This would fill in the gaps for a national private parcel database that would be publicly available. The other is to provide the BLM with adequate resources to build a truly national inventory of all real property to include public and private parcels. Such an effort would require not only financial and technical resources, but also close collaboration with states and tribes to coordinate the data pipeline. Securing a Congressional appropriation for the FLAIR Act would go a long way to foster collaboration and partnership to build the data pipeline properly.

Standards

The Cadastral Subcommittee, created by the FGDC, was the first to create and publish a data content standard for a Framework data theme. The intent of the standard is to support the automation and integration of publicly available data by defining common domains, attributes, or elements that are used in land ownership documents. This standardization ensures that the data is accessible and usable not only by various levels of government but also by the private sector. This 2008 standard is available at: https://www.fgdc.gov/standards/projects/cadastral/cadastral-data-standard-v1-4.pdf.

Additionally, in 2012, the members of the Cadastral Subcommittee released the Cadastral NSDI Reference Document. This document was pivotal as it established a framework for the core content of cadastre data, presenting it as a publication standard. By defining a set of minimum content criteria, it provided clarity and direction for state and local entities regarding the essential components their cadastral data should aim to include. It

is available at: https://www.fgdc.gov/standards/projects/cadastral/cadastral-nsdi-reference-document.pdf.

The International Association of Assessing Officers (IAAO) has the greatest influence over local governments in the assessment world. Assessment offices are considered the authoritative source for cadastral information. The association fosters education, technical standards, consulting services and many other resources for the property valuation and tax policy community. They adopted the "Standard on Digital Cadastral Maps and Parcel Identifiers-2015" (https://www.iaao.org/media/standards/Standard_Digital_Cadastral_Maps_2015.pdf).

This standard provides specific guidance to local governments on many aspects of parcel map conversion, best practices, and specifically data content. While this is not a federal standard its influence is significant over the local cadastral maintenance.

Even though these standards haven't seen recent updates, they remain crucial as they offer foundational guidance that is still applicable today. It is noteworthy that the International Association of Assessing Officers (IAAO) is presently working on updating the Digital Cadastral Map Standard, with an anticipated release in 2025. This update will likely further enhance the standard's relevance and usefulness in modern geospatial data management practices.

Statewide Programs and Standards

Despite the slow evolution of federal standards, various states have proactively initiated statewide programs to develop comprehensive cadastral databases while establishing consistent standards for data management. Numerous states have enacted legislation to create a geospatial information office and appoint a Geospatial Information Officer (GIO) to oversee the governance and curation of statewide geospatial data. These initiatives frequently include provisions for transparency, making data accessible through open data portals and thoroughly documenting the metadata utilized in data curation.

The maturity and advancement of these programs vary across states, reflecting a growing recognition of the importance and diverse applications of cadastral data collection. States like Montana and Minnesota exemplify high standards for data maintenance, with publicly available data schemas ensuring stringent data consistency. Additionally, some states, such as Indiana, enable counties and local communities to contribute cadastral data to a central repository, either as-is or with mandatory data fields, such as parcel identifiers, to ensure uniformity.

Conversely, other states, like Utah, are exploring standardization but do not yet mandate county-level data uploads. The extensive maintenance of cadastral data across the nation suggests that in the coming years, states may increasingly adopt standardized data protocols. This progression could enable federal entities, such as the FGDC, to leverage state-level cadastral data, presenting it in a nationally recognized standard format.

Estimate of Theme Completeness

Since our last national assessment, the total volume of digitized tax parcel polygons has

continued to grow. The National States Geographic Information Council (NSGIC) recently completed their Geospatial Maturity Assessment (GMA) of the states (NSGIC 2023), and a key indicator of state spatial data infrastructure maturity is in the cadastral framework. This assessment provides the best insight on the completeness of this framework theme.

States were asked to identify where digital tax parcel data existed at the local level. The graphics below depict the area where states responded Yes, or No to that question. Note: The States of Alabama and Nevada did not provide a response on these questions.

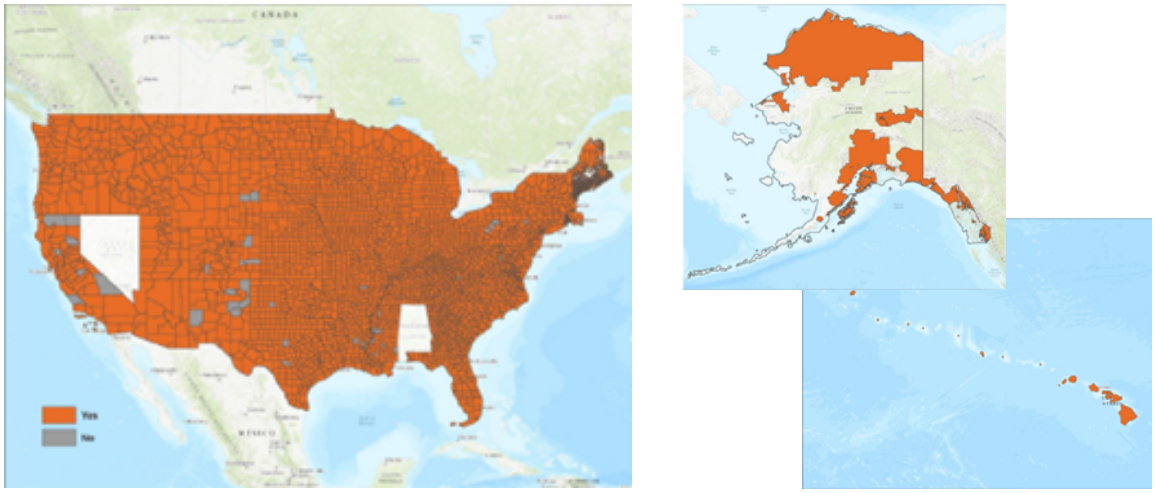


Figure Cadastral-1. Existence of digital tax parcel data. Note: the States of Nevada and Alabama did not provide information. *Data source: Geospatial Maturity Assessment, NSGIC, 2023.*

From the 2015 report card, "It is estimated that there are approximately 150 million parcels that define the privately owned property in the United States and another 8 to 10 million that represent public lands." The commercial data provider Regrid indicates they have 157 million parcel polygons in their product archive, which tracks with prior estimates (Regrid April 2024 Product Report).

State and local governments have continued to push local real estate tax assessment towards increasing the level of technical expertise in fairly and equitably valuing real estate. Most of these are standards-based approaches, and increasingly those approaches have integrated GIS technologies into their processes and workflows. With this progression the parcel GIS solution providers have developed targeted routines that no longer require a GIS analyst with exhaustive GIS skill sets. The impact of adopting these targeted workflows, along with web-based GIS, has lowered the barrier to accessing and using GIS capabilities in even the smallest of local government offices. This impact has had an overall effect on the need to complete and maintain parcel GIS data. The result being digital parcel conversion progress has slowly continued one jurisdiction at a time. This progress has incrementally grown the overall total amount of digital parcel data.

The NSGIC 2023 GMA had only 7 states that did not respond to having coordinated

parcel aggregation programs. It is worth noting this theme may achieve large geographic coverage but will always remain in a state of continual maintenance. Tax parcel data is among the most dynamically changing components of national geospatial data assets. The 2023 NSGIC GMA results show 9 states with no program for developing or maintaining parcel data. Thirty-three states reported having a systematic program in place to collect this data from local government, 28 having a state designated steward for this layer; 22 have the data publicly accessible without restriction, and 32 report the data is available in a standardized format. Each of these metrics show increases from the 2018 report.

The counties where digital parcel data exist represent a total parcel count of 146,372,780 parcels, which equates to 97% of parcels in counties where GIS conversion is taking place. That figure is up from 82% in the 2015 assessment. This is not to say that 97% of parcels in the U.S. are mapped, but rather are located in counties where they are GIS ready and likely to be mapped.

The number of local jurisdictions that have digital tax parcel data has increased. The number of states that are rolling-up this data for integration and publication has increased. The volume is not the limiting rubric for raising the grade on this theme. A national spatial data infrastructure theme must be graded on both completeness and accessibility.

Accessibility of Data

With over 50% of the parcels in the nation that are maintained by local governments now not only in digital form, but being 'rolled up' into statewide databases, it seems appropriate to revisit the mechanics by which the federal government might access local property information.

These states join many others already engaged in rolling up and aggregating parcel data to then be published for consumption through State GIS data clearinghouses. Assuming this trend will continue, there are numerous advantages of using this data rather than harvesting local government working files accessible on the internet. Indeed, this work isn't complete, but the trend has progressed rather quickly over the last two years and may be a more reliable resource for several reasons.

States are rolling up local property data to serve some state functions more efficiently than dealing directly with each local assessment office that is maintaining property data, so they too have similar criteria to what the National Academy of Science, Mapping Science Committee identified as guiding principles for NSDI development (NRC 2007):

- Data should be widely available. These statewide roll ups will often be in the form of an annual 'certified' assessment roll of all the properties in a state. States will be looking to normalize the local data, perhaps a distilled version as well that isn't just for assessment and taxation purposes.

- Accessing spatial data should be easy. There are often state standards for local assessment data to follow, and as data is received state aggregators will also need to

somehow normalize the various schemas so that it is more readily used for state functions that cross jurisdictional lines. Rather than duplicate that effort at a federal agency level, it would be advisable to use these statewide spatial databases that have been through some level of authenticity, normalization, and even certification. Even though not current daily, if indeed that level of need existed, the only way is to work directly with the local jurisdictions to assure the federal need is getting correct and complete data at that point in time.

- The NSDI should be flexible and not dependent on current technology, data, or organizational structures. The processes that states would be using in their aggregation of local data are independent activities in each state at this point. There are also many interested parties that have interest in seeing the above criteria followed to assure continuing access to this valuable data for local, regional, multi-state as well as federal needs. The organizational structures that would be the steward of this periodically rolled-up database are just being identified, but a common theme is that it is an abridged version of the public property record for a wide range of public, government and commercial users. Only dealing with 50 entities rather than 3,000 to 4,000 to acquire this piece of the NSDI would seem preferable from a data quality perspective as well as being more efficient.

- The NSDI should be a foundation to foster new applications, services, and industries. Certainly, by dovetailing with a progressive new resource containing cadastral data normalized into a single, authoritative source used by others at a local, regional, and state level for perhaps similar governmental functions has benefits beyond the perceived needs seen today. Property parcels, basic ownership and land use information is a cornerstone of our democracy from the beginning. Initially, property ownership was a requirement for voting, and now many uses beyond local assessment where these databases have been traditionally developed and maintained.

Also seen as a positive reflection of this trend is research summarizing what's been reported directly from jurisdictions indicating substantial progress in direct accessibility at the local level. With 48 states reporting, we found that 56% of jurisdictions* have open parcel data (Download or Feature API). 33% are only available internally (State government access only, Image API, or Parcel Viewer), and 11% are not available (either not in a digital format or not shared with State government and the public). Overall accessibility of the theme has improved.

* *Jurisdictions: Nevada and Alabama not reporting. Base of Counties totaling 3,138 in 48 States except Maine, Rhode Island, and Alaska. Includes the District of Columbia; OR municipalities: Maine and Rhode Island: 570 municipalities total; OR US Census 2020 Census Blocks- Alaska: 28,568 blocks.*

Authority, Governance, and Management of the Theme

Governance for this strategic asset is federated much like other aspects of the Framework. Under the FGDC structure, the BLM has responsibility for this theme. They have used their role to establish standards and improve the skeleton of the cadastral theme through

their leadership on the Public Land Survey System. They do not, however, have funding appropriations from Congress for state and local data, nor the authority over state or local entities that are charged with stewardship of the cadastral theme at the primary transaction level to create a collaborative effort. These limitations are the main contributors that are preventing a national aggregation initiative.

Conversely, the transaction level of this theme, the buying, selling, and subdividing of the private lands, are governed at the local level. This is especially concerning considering land acquisitions and disposals of federal and state lands that impact the accuracy of cadastral data. When such transactions occur in silos, no one's data are correct. The complete picture of the fabric rests with these producers. Our nation's system of land tenure is recorded at that local level for the public good by the recorders of deeds, and then mapped for discovery and equitable valuation by the Assessors who perform the *ad valorem* assessment process as their primary responsibility. The other level of governance over the theme is at the state level where the state has a regulatory role in the oversight of the *ad valorem process*. Typically, the state provides some guidance, and this may include standards on the content and structure of information associated with real estate records used in the assessment process. The connection between local and state level is mandated, thus creating this collaborative effort.

As stated, the coordination of this theme between the state and local governments continues to improve. However, the coordination between federal and state levels is only marginally coordinated. The state roll-up initiatives outlined earlier should be taken into consideration as a valuable improvement from the standpoint of several key criteria and would elevate this assessment of the cadastre. It is further recommended that the state organizations that are leading these efforts be contacted, and some effort extended to advance that cause to the benefit of the state aggregators, stewards, and the lead federal agencies. A national approach must be established for this national theme for the greater public good.

Cadastral Database Assessment

Incremental progress has occurred within states, yet no national program exists to create a sustainable and equitable funding program for the development and maintenance of parcel data. This framework category requires attention because significant geographic areas of the nation still lack local parcel data. These areas have not made the leap to convert the paper-based tax maps to a digital structure of polygons representing the tax parcels. Despite numerous uses of local cadastral data by the federal government, there is no recognizable federal incentive to increase local parcel conversion. Thus, for the nation to achieve substantial progress for this theme at this point in time, state and local leaders must continue to find a way on their own.

Users can find Public Land Survey System (PLSS) data, federal lands and protected areas through portals assembled by the BLM, the Federal Lands Working Group, and others. Users cannot, however, find a single point of aggregation, distribution or viewing of both public and private lands. A consistent integrated network for this theme is not in place across the U.S, despite the passage of the FLAIR Act of 2021.

To be fair, there are many pieces of foundational activity that assist state and local government parcel conversion. The BLM facilitated and/or completed the standardization of PLSS for all 30 PLSS States in fiscal year 2016. Since that time, as documented by the NSGIC GMA, states have continued to improve their programs to provide better precision and management of control points. The Cadastral Subcommittee of the FGDC has a Strategic Plan in place to continue improvements that will enhance the theme for both public and private lands.

Part of the strategic plan suggests that federal agencies do not have the authority to collect or maintain parcel data on privately managed lands. And while this may be true, it is a fact that many federal agencies need a comprehensive view of the cadastral fabric.

Simply consider how access to consistent and widely available local parcel data could significantly enhance the efficiency of federal agencies in providing relief to citizens during national disasters and other emergencies. Knowing who owns what and where creates significant efficiencies when deciding who needs what help and where.

Cadastral Theme Grade and Recommendations

The committee assigned a grade of C- for the Cadastral Theme. The absence of a national cadastral database remains the most significant issue at hand. Government entities have the capability to address this challenge even with current limitations.

The private sector has developed product lines for parcel data that respond to use cases in many sectors. These are commendable outcomes when considering the large number of private sector decision makers in economic development, insurance, or finance whose needs demand data that is nationally consistent and available. However, it is probable that some federal agencies have procured licenses to these same commercial sources for any number of applications such as law enforcement, disaster response, broadband analysis, and others. This begs the question: might those federal procurements have been better invested in standing up a nationally consistent and publicly accessible baseline of parcel data collected directly from the authoritative local and state government sources.

The 2023 NSGIC GMA shows an increase in state-coordinated parcel aggregation programs. All forty-eight states that reported have digital parcel data available. Of these, thirty-two report that parcel data is available in a standardized format. This data can be a starting point and federal funding could efficiently be allocated to those states and others trying to build out their own databases. Rather than passively purchasing private data, the federal government can collaborate with its states to proactively build an authoritative national cadastral database benefiting all.

In the period between 2022 and 2023 there have been 204 Federal Disaster Declarations recorded by the Federal Emergency Management Agency. It is certain the response and recovery activities for many of these disasters would benefit from access to a cross-jurisdictional view of parcel information. This would undoubtedly be true for mitigation activities as well. When such important matters are at stake, our nation must commit to assembling a publicly accessible, complete view of the parcel fabric, ideally derived from the local government sources that create the parcel data.

Finally, it must be pointed out that economic opportunity is lost for those areas where the cadastral data doesn't exist or is largely incomplete. Those areas are at a competitive disadvantage when it comes to community and economic development work that fuels job growth, economic diversity, and prosperity for local economies. Open access to digital parcel data is key to creating and maintaining economic success across the nation and to compete worldwide.

Cadastral Data Theme Work Group

Framework Evaluators	Federal Liaison
Christine Stinchcomb, Theme Lead, IAAO	Dominica VanKoten, BLM
Dan Fasteen, IAAO	
Ed Crane, URISA	
Katherine Kiyanitsa, NSGIC	
Karen Rogers, NSGIC	
Shelby Johnson, NSGIC	
Daniel Cypert, IAAO	
Michael Safarty, IAAO	

III. Elevation Data Theme

Executive Summary

An assigned grade of A- was given for the Elevation Theme. The theme is primarily supported by the nationwide topographic elevation data resulting from the Department of the Interior's U.S. Geological Survey (USGS) 3D Elevation Program (3DEP) and Bathymetry data resulting from the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) National Bathymetric Source (NBS) project.

USGS is responsible for nation-wide elevation data, and to-date USGS has contracted for acquisition of lidar data for 94.7% of the United States. NOAA has continued its buildout of the NBS to cover the U.S. Atlantic, Gulf, and Caribbean Regions. The NBS is an intensive effort to create, integrate and maintain authoritative, high-resolution bathymetry composed of the best available data. However, according to the 3D Nation Elevation Requirements and Benefits Study (3D Nation Study) performed by Dewberry on behalf of USGS and NOAA (Dewberry 2022), more progress is needed on a National Bathymetry dataset including coverage of the Great Lakes and Inland rivers and streams.

The USGS and NOAA actively engage the public by making data available over the internet through the GeoPlatform (https://www.geoplatform.gov/), The National Map (https://www.usgs.gov/the-national-map-data-delivery/), and the Bathymetric Data Viewer (https://www.ncei.noaa.gov/maps/bathymetry/), among other services and portals. USGS and NOAA data are also accessible on the Registry of Open Data on Amazon Web Services (AWS) (https://registry.opendata.aws/).

The results from the Coalition of Geospatial Organization's (COGO) 2023 survey that focused on elevation data resulted in generally fewer than100 respondents per question. As a result, multiple other sources were reviewed for the preparation of this report. These included the 2021 and 2023 National Geospatial Data Asset (NGDA) Theme Annual Performance Report and Self-Assessment for Elevation Theme Overall, the 3D Nation Study, and the 3D Elevation Program Subcommittee report of June 2023 developed by a subcommittee of the National Geospatial Advisory Committee (NGAC), along with other documents. Note that there was not an independent assessment of the National Bathymetric Source project identified. In both the 2023 USGS and NOAA self-assessments of the Geospatial Data Act (GDA), compliance in all categories was marked as "making progress towards expectations." USGS has continued to work its partnership funding model effectively and according to USGS, progress towards the goal to complete a nationwide baseline is due in large part to community-wide partner investments.

The summary in the NGAC 3DEP report sums up the status of the inland topographic portion of the theme as stated in the report: "The Subcommittee has concluded that 3DEP has successfully advanced toward its initial goal of full high-accuracy elevation coverage of the Nation, helping to address many of the requirements and benefits as described in the National Enhanced Elevation Assessment (2012) and later expanded upon in the 3D Nation Elevation Requirements and Benefits Study (Dewberry 2022) (referred to

hereafter as the "3D Nation Study"), including U.S. topographic and inland, nearshore, and offshore bathymetric 3D elevation data requirements and benefits. The 3DEP data acquisition model and its effective use have established standard process protocols, including methods that encourage the program to continuously adapt to technological and service improvements" (NGAC 2023).

The grade of A- recognizes excellent progress and leadership towards completion of topography and bathymetry, as well as data distribution. However, the USGS goal of complete coverage of 3DEP data for the Nation within eight years has not been met. The current program is in its ninth year and is still not 100% complete. NOAA is at 48% completion. While data sharing and access was ranked high across users, they also identified gaps in sub theme dataset coverage and the majority were not aware of efforts to identify, validate, and advance best practices. Also, respondents indicated adequate resources are not being invested to identify and test innovative methods and technologies of collecting and producing elevation data and the respondents indicated that more progress needs to be made to enact a robust and stable funding plan for this theme.

Elevation Theme Grade: A-

Fit for the Future

DESCRIPTION OF THE FRAMEWORK

An Introduction to the Theme

Elevation is the measured vertical position of the earth's surface and other landscape or bathymetric features relative to a reference datum, typically related to sea level. These points normally describe bare earth positions but may also describe the top surface of buildings and other objects, vegetation structure, or submerged objects. The components of the Elevation Theme are Topographic data from the 3D Elevation Program (3DEP) 3D Elevation Program | U.S. Geological Survey and Bathymetry from NOAA. The 3DEP data are generally derived from Light Detection and Ranging (lidar) or Interferometric Synthetic Aperture Radar (IfSAR) that represent the three dimensional features of over-land terrain.

The term "bathymetry" originally referred to the ocean's depth relative to sea level, but now it generally means the depths and shapes of underwater terrain. Bathymetric mapping is typically conducted through acoustic (sonar) mapping, or topographic bathymetric (topo-bathy) LiDAR. Elevation data can be stored as a three-dimensional array or as a continuous surface such as a raster, triangulated irregular network, or contours. Elevation data may also be represented in other derivative forms such as slope, aspect, ridge and drainage lines, and shaded relief. A graphic illustration of how the topographic and bathymetric components of the Elevation Theme dovetail at the coast is shown below:

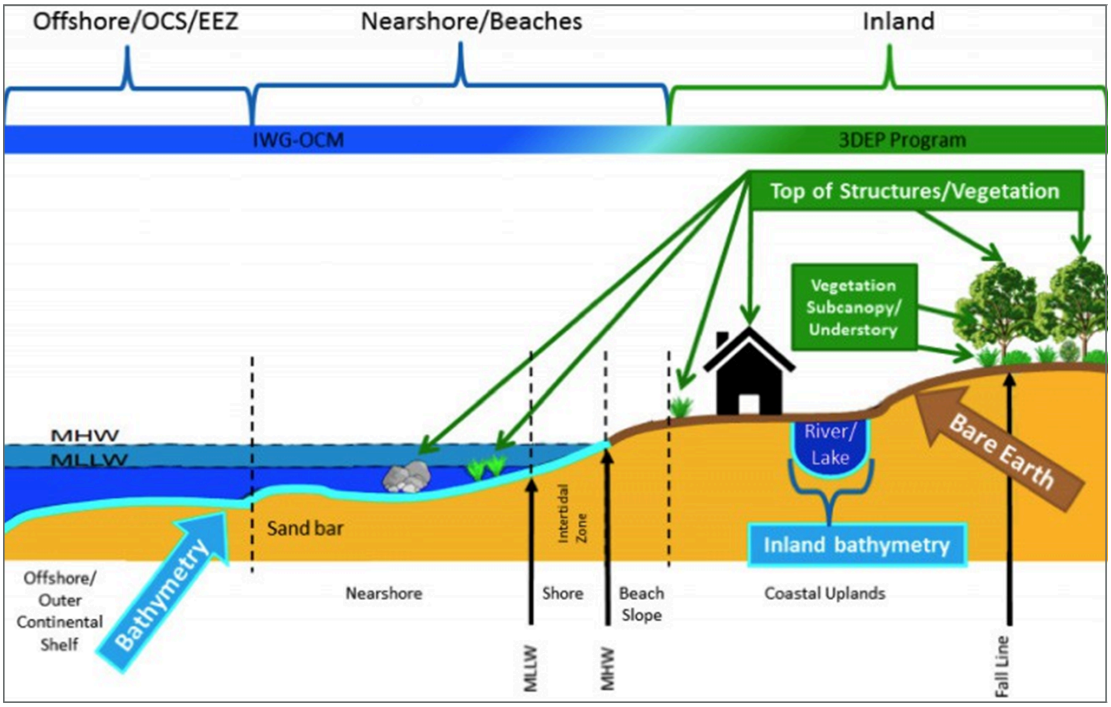


Figure Elevation-1. How the topographic and bathymetric components of the Elevation Theme connect at the coast. *Source: USGS.*

The definition above, while descriptive, lacks context for why elevation data is so very important to our nation. The Elevation Theme team recognizes that the acquisition and management of quality elevation data is essential to put actionable geospatial data in the hands of decision-makers to inform decisions in such high-risk areas as emergency planning, climate adaptation and resilience, economic investment, infrastructure development, and habitat protection.

In September 2022, the 3D Nation Study was published (Dewberry 2022), and the report described three overall primary benefit types:

1. Operational Benefits, which include time savings, cost savings or cost reductions.
2. Customer Service Benefits, which include value added to products or services, improved response or timeliness, and improved customer experience.
3. Societal Benefits, which include education or outreach; environmental benefits; and public safety, including life and property.

According to the 3D Nation Study, an analysis of the results showed that an improved national elevation program has the potential to generate $13.5 billion in new benefits in the categories listed above each year once fully operational. Although not used here, the offshore bathymetry amounts were likely under-counted. The following tables from the report summarize the benefits of the source data elements and emphasize the importance of the theme.

Table Elevation-1. Summary of Reported Future Annual Dollar Benefits by Geography Type. *Data Source: Table 84, Dewberry 2022.*

Geography Type	Total Reported Future Annual Benefits
Inland Topography	$9.99B
Inland Bathymetry	$0.86B
Nearshore Bathymetry	$2.55B
Offshore Bathymetry	$0.16B
Total	$13.56B

Table Elevation-2. Summary of Reported Future Annual Dollar Benefits by Organization Type. *Data Source: Table 85, Dewberry 2022.*

Organization Type	Total Reported Future Annual Benefits
Federal agencies	$5.84B
State, regional, county, local, and tribal government	$7.68B
Not-for-profit and private entities	$0.04B
Total	$13.56B

Over the last few years, USGS has begun the transition to a 3D National Topography Model (3DNTM). The 3DNTM is a new USGS initiative aimed at embracing the inherent relationship between the Earth's surface and the water that interacts with it. The initiative updates and integrates USGS elevation and bathymetry data to model the Nation in 3D.

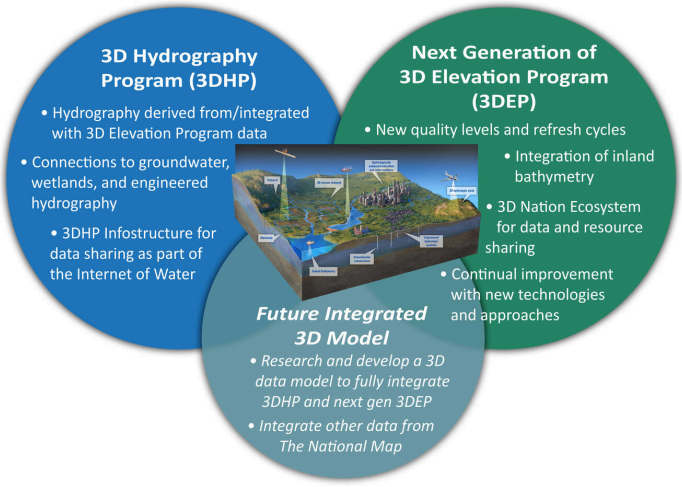


Figure Elevation-2. The 3D National Topography Model (3DNTM). *Source: USGS.*

The transition to this integrated approach to create and manage elevation and hydrography data will result in quality data that are updated more frequently. The

3DNTM provides the terrestrial component of the USGS and NOAA shared vision of a 3D Nation to build an elevation foundation.

According to USGS, the next generation 3DEP component of the 3DNTM calls for a shorter collection cycle and repeat coverages of higher quality elevation data for the U.S. and its territories. While the initial collection of 3DEP lidar data provides an important baseline reference, the addition of multiple repeat topographic lidar coverage significantly expands analysis capabilities. The new data, when compared to the baseline 3DEP data, will support assessments of landscape change because of construction, landslides, lava flows, surface mining, sinkholes, and shoreline erosion along with a host of other applications necessary for a more resilient environment and economy.

With the roll out of this program, the Elevation Theme becomes the foundational data for hydrography as well as transitioning to a next generation data set. This is graphically represented below. It is important to note that the annual cost of the 8-year 3DEP baseline is $146Million per year while the annual cost of next gen 3DEP with a 5 year CONUS refresh is projected to be $259Million per year.

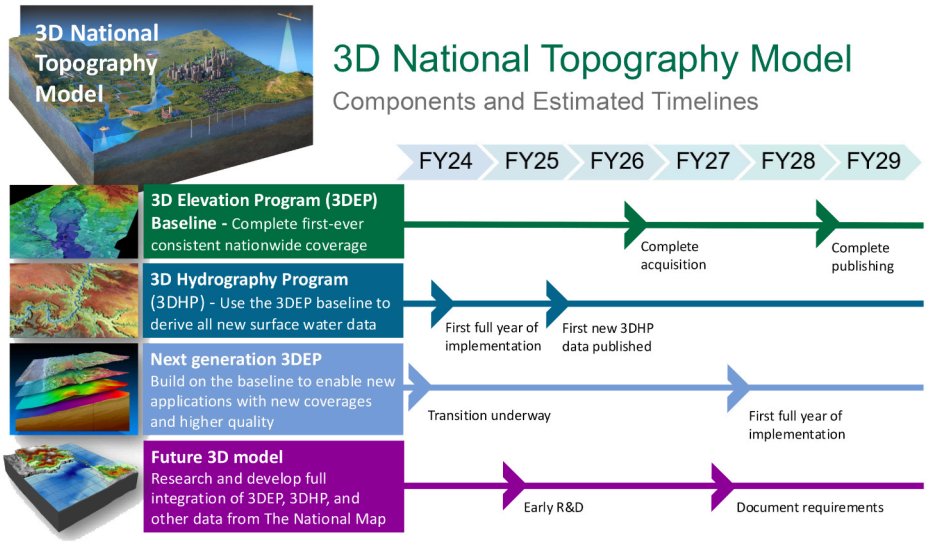


Figure Elevation-3. A progression between the 3DEP Baseline to the 3D National Topography Model. *Source: USGS.*

The Lead Agency, Governance, and Theme Elements

The Elevation Theme has two theme leads: USGS is the lead agency for terrestrial topography and inland bathymetry through the 3DEP, and NOAA is the lead agency for offshore bathymetry through the Interagency Working Group - Ocean and Coastal Mapping (IWG-OCM). The 3DEP Working Group is an active and key governance group for coordinating terrestrial elevation data. The IWG-OCM is a working group of the National Science and Technology Council (NSTC) Subcommittee on Ocean Science and Technology (SOST), and also reports to the Ocean Science and Technology (OST) Subcommittee of the Ocean Policy Committee (OPC) via the National Ocean Mapping, Exploration, and Characterization (NOMEC) Council. SOST serves as the lead

interagency entity for Federal coordination on ocean science and technology. The IWG-OCM came into existence in 2006 to "facilitate the coordination of ocean and coastal mapping activities and avoid duplicating mapping activities across the Federal sector as well as with State, industry, academic and non-governmental mapping interests" (National Ocean and Coastal Mapping Strategic Action Plan 2009). The IWG-OCM, established in law by the Ocean and Coastal Mapping Integration Act of 2009, also represents the ocean and coastal mapping aspects of elevation on the Federal Geographic Data Committee's 3D Nation Elevation Subcommittee. Thus the overall structure and interface to the FGDC is shown below:

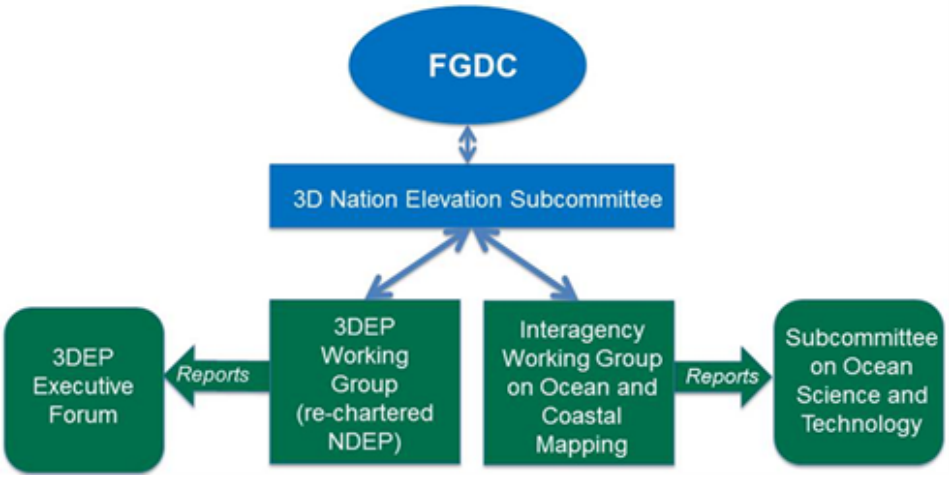


Figure Elevation-4. Governance connecting 3DEP with the FGDC. *Source: USGS.*

Governance occurs in several ways. With the implementation of Public Law 116-323, a subcommittee to NGAC was established. This created a new governance that was lacking per the 2018 COGO assessment. The 3D National Elevation Subcommittee has a requirement to provide a report every two years to the Secretary of Interior and 3D Federal Interagency Coordinating Committee. The results of the first report are referenced in the Executive Summary. The GDA Section 2805(b)(3)(E)(I) requires annual performance reports to be submitted to the Federal Geographic Data Committee (FGDC) that document "the activities relating to and implementation of the NGDA data theme, including progress in achieving the requirements under subparagraphs (A), (B), (C), and (D)" of Section 2805(b)(3). This report also evaluates the compliance of activities with the National Spatial Data Infrastructure (NSDI) Strategic Plan.

The 3DEP Executive Forum was a collaborative effort among federal agencies tasked with managing and coordinating the 3DEP initiative. The Forum played a crucial role in overseeing the implementation of the 3DEP program, coordinating resources, setting priorities, and ensuring collaboration among participating agencies. Per Public Law 116-323, a new governance structure called the 3D Elevation Federal Interagency Coordinating Committee was established and will replace the 3DEP Executive Forum. The group will begin meeting in June 2024. The Theme and agency points of contact listed below are maintained per the A-16 requirements.

Table Elevation-3. Elevation Theme Contacts. *Source: 2023 Lead Covered Agency NGDA Theme Annual Performance Report and Self-Assessment for Elevation Theme.*

Theme Leads	Brian C. Hadley, U.S. Department of the Interior, U.S. Geological Survey Meredith Washington, U.S. Department of Commerce, National Oceanic and Atmospheric Administration
Executive Theme Champions	Dr. Michael Tischler, U.S. Department of the Interior, U.S. Geological Survey Rear Admiral Benjamin K. Evans. U. S. Department of Commerce, National Oceanic and Atmospheric Administration

Table Elevation-4. Elevation-specific Geospatial Data Assets and the Respective Federal Agencies Responsible for Each. *Source: 2023 Lead Covered Agency NGDA Theme Annual Performance Report and Self-Assessment for Elevation Theme.*

NGDAID	Elevation Theme NGDA Datasets	Agency
37	U.S. Coastal Lidar Elevation Data - Including The Great Lakes And Territories, 1996 - Present	U.S. Department of Commerce, National Oceanic and Atmospheric Administration
39	Global Multi-Resolution Terrain Elevation Data - National Geospatial Data Asset (NGDA)	U.S. Department of the Interior, U.S. Geological Survey
40	Lidar Point Cloud - USGS National Map 3DEP Downloadable Data Collection	U.S. Department of the Interior, U.S. Geological Survey
41	MultiBeam Bathymetry Database (MBBDB)	U.S. Department of Commerce, National Oceanic and Atmospheric Administration
42	1/3rd arc-second Digital Elevation Models (DEMs) - USGS National Map 3DEP Downloadable Data Collection	U.S. Department of the Interior, U.S. Geological Survey
43	National Flood Hazard Layer (NFHL)	U.S. Department of Homeland Security, Federal Emergency Management Agency
44	Marine Trackline Geophysical Database	U.S. Department of Commerce, National Oceanic and Atmospheric Administration
45	NOS Hydrographic Surveys Collection	U.S. Department of Commerce, National Oceanic and Atmospheric Administration
46	Shuttle Radar Topography Mission 1 Arc-Second Digital Terrain Elevation Data - Global - National Geospatial Data Asset (NGDA)	U.S. Department of the Interior, U.S. Geological Survey
184	1 meter Digital Elevation Models (DEMs) - USGS National Map 3DEP Downloadable Data Collection	U.S. Department of the Interior, U.S. Geological Survey
185	5 Meter Alaska Digital Elevation Models (DEMs) - USGS National Map 3DEP Downloadable Data Collection	U.S. Department of the Interior, U.S. Geological Survey
199	Continuously Updated Digital Elevation Model (CUDEM) - 1/9 Arc-Second Resolution Bathymetric-Topographic Tiles	U.S. Department of Commerce, National Oceanic and Atmospheric Administration
200	Continuously Updated Digital Elevation Model (CUDEM) - 1/3 Arc-Second Resolution Bathymetric-Topographic Tiles	U.S. Department of Commerce, National Oceanic and Atmospheric Administration

Collaboration and Partnerships

The 3DEP is managed by the USGS, with collaboration, support, and cost-sharing with many other federal, state, and local entities. The 3DEP resides as a program within the USGS National Geospatial Program (NGP). The NGP recently announced a new process for finding and selecting partnerships beginning in FY 2024. The revised and streamlined structure is called the 3DNTM Data Collaboration Announcement (DCA). The DCA replaces the Broad Agency Announcement (BAA) and includes data acquisition partnerships for the 3DEP and the 3D Hydrography Program (3DHP). The DCA is a publicly accessible process for partnership opportunities to cooperatively acquire high resolution 3D elevation data and 3D hydrography data. Since the first BAA in FY15, the occasional online virtual meetings offer an opportunity for stewards to receive information, get assistance with technical tasks, ask questions, and provide feedback on 3DEP program development. Additionally, states are assigned a dedicated National Map Liaison at the USGS to assist with questions. USGS also has a cooperative agreement with the National States Geographic Information Council (NSGIC) to engage and support state and local governments for 3DEP. NSGIC hosts regular meetings that provide a forum for information exchange, data acquisition best practices, use cases and 3DEP education.

The 3D Nation Study, led by DOC-NOAA and DOI-USGS, was completed in FY23 to document national requirements for improved topographic and bathymetric elevation data, estimate the costs and benefits of meeting these requirements, and evaluate multiple national enhanced program implementation strategies. This study included needs of 45 Federal agencies; all 50 states and six territories; and a sampling of local, Tribal, private, and non-profit organizations. Based on the results of the 3D Nation Study, USGS designed a plan for the next generation of 3DEP with a shorter collection cycle and refreshed coverages of higher quality elevation data for the U.S. and its territories.

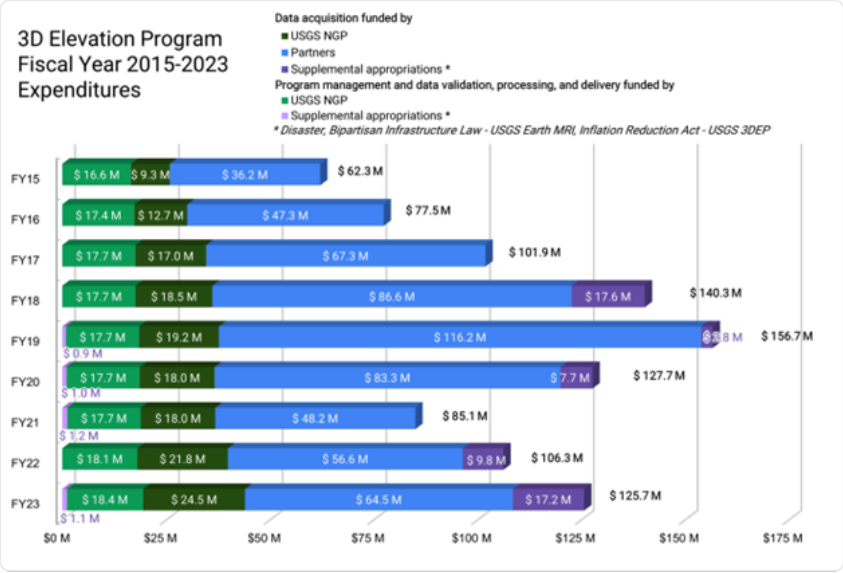


Figure Elevation-5. 3D Elevation Program Fiscal Year 2015-2023 Expenditures. *Source: USGS.*

Standards

The USGS standards and specifications define the requirements to ensure that all products and data prepared by the USGS under the NGP are consistent in accuracy, structure, format, style, and content. NGP standards and specifications are available through The National Map website (https://www.usgs.gov/ngp-standards-and-specifications/3d-elevation-program-standards-and-specifications). The Lidar Base Specification (LBS) is the source of requirements for collections under the 3DEP. The latest version of the specification is LBS 2024 rev. A, released in January 2024. USGS also participated in the American Society of Photogrammetry and Remote Sensing (ASPRS) airborne lidar committee, which helped lead the publication of the new 2nd Edition of the ASPRS Positional Accuracy Standards for Digital Geospatial Data.,

The U.S. Army Corps of Engineers (USACE), the U.S. Navy, NOAA and USGS all participate in setting standards and specifications for airborne bathymetric lidar for coastal, lake and riverine applications. The group participates as part of a forum that make up the Joint Airborne Lidar Bathymetry Technical Center of Expertise (JALBTCX). JALBTCX has enabled the agencies to work together, and with academia and the private sector to discuss requirements, develop the technology, coordinate and collaborate on data acquisition, improve processing techniques, and standardize data stewardship. They have created a body of knowledge called Blue Book II (https://hdl.handle.net/1813/58722). This is a history gained in airborne lidar bathymetry sensor design, testing, evaluation, signal processing, uncertainty estimation, and data exploitation for end-user requirements. The bathymetric lidar specification established a standard specification document that can also be used to acquire data through contracts, enabling additional consistency across federal and state geospatial agencies that procure bathymetric lidar data.

The Hydrographic Survey Specifications and Deliverables document Hydrographic Survey Specifications and Deliverables (https://oceanbestpractices.org) contains the technical specifications for hydrographic survey data submitted to the Office of Coast Survey. It represents NOAA's implementation of the International Hydrographic Organization standards for hydrographic survey and product specifications. Coast Survey is proud to announce the launch of the new Hydrographic Survey Specifications and Deliverables for 2024, the largest overhaul of the document in more than 20 years.

Estimate of Theme Completeness

In FY2023, DOI-USGS, in partnership with federal, state, local, and Tribal partners, contracted for acquisition of lidar data that increased nationwide coverage of 3DEP data available or in progress from 89.5% to 94.7% of the Nation. The map below was published on the USGS website on April 17, 2024.

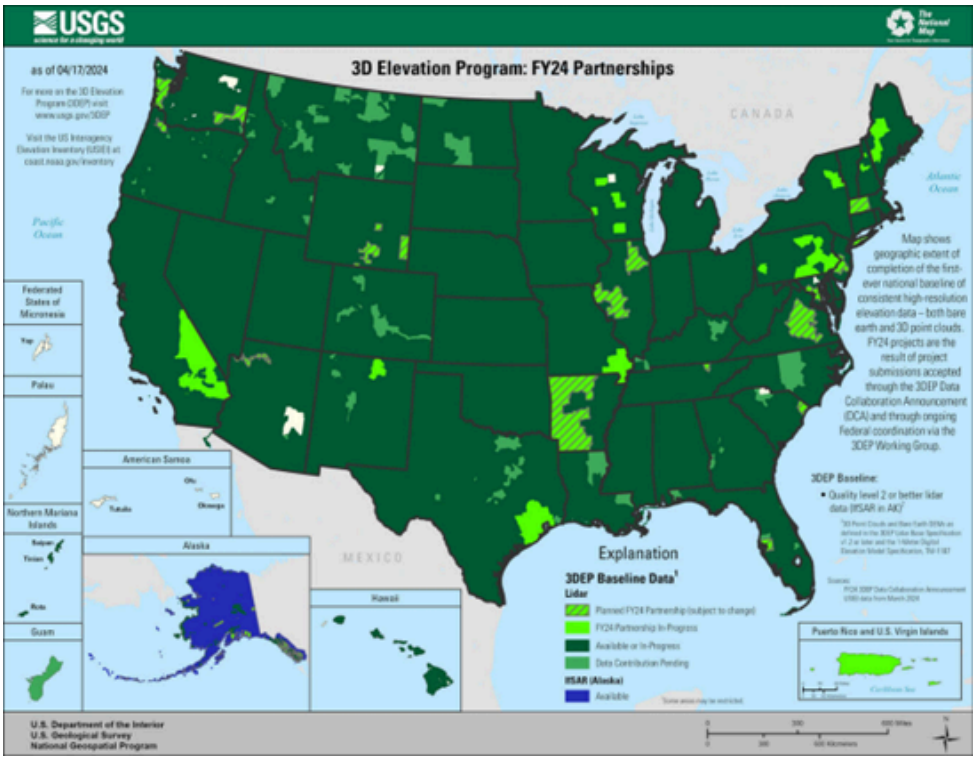


Figure Elevation-6. 3D Elevation Programs indicated by FY24 Partnerships. *Source: USGS. April 17, 2024.*

Completion is now above 95%. Approaching complete 3DEP coverage of the U.S. is a significant achievement for the inland topography portion of the theme.

Offshore Bathymetry is driven by the Presidential Memorandum, the "National Strategy for Ocean Mapping, Exploring, and Characterizing the United States Exclusive Economic Zone" (NOMEC Strategy) released on June 9, 2020. The NOMEC Strategy proposes ambitious goals to completely map the seafloor within the outer boundary of the United State Exclusive Economic Zone (EEZ); explore and characterize priority areas; and leverage the expertise and resources of multi-sector partnerships. Over the course of 2023, NOAA continued its buildout of the NBS to cover the U.S. Atlantic, Gulf, and Caribbean Regions. The NBS is an intensive effort to create, integrate and maintain authoritative, high-resolution bathymetry composed of the best available data. However, there is still significant work to be done. A map from NOAA showing bathymetry coverage and gaps as of January 2024 is shown below. Currently only 52% of the minimum requirements for mapping the EEZ have been met (up from 48% in 2022). Full bottom coverage of the EEZ is still a long way off at the current rate of acquisition.

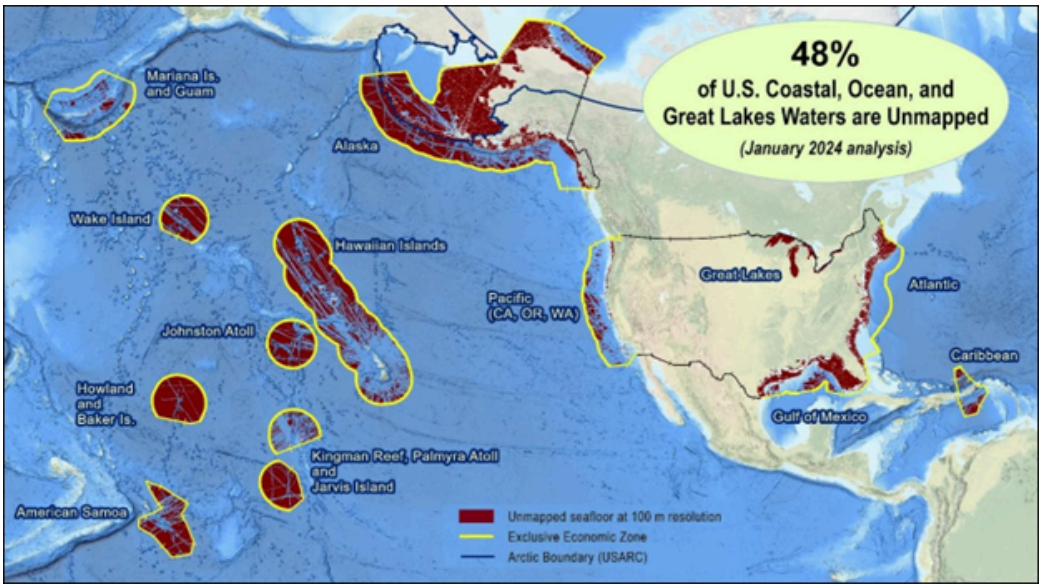


Figure Elevation-7. Status of Seafloor Mapping Within U.S. Waters, January 2024.
Source: Integrated Ocean & Coastal Mapping, NOAA.

Accessibility of Data

Over 4.9 petabytes of Elevation data were delivered and 154 million LPC downloads by DOI-USGS via The National Map for calendar year 2023. These figures do not include data accessed through other channels such as the Amazon Web Services (AWS) Public Dataset or portals such as MS Planet and Open Topography. There are many sources of data.

Multiple Federal, State, university, and nonprofit entities support various portals, collaboration sites and inventories with significant overlap and often duplicated data sets. Often users find it hard to identify which source of data to use. Some examples of the numerous portals, collaboration sites, and inventories are:

- United States Interagency Elevation Inventory (NOAA): https://coast.noaa.gov/inventory/
- The National Map (USGS): https://viewer.nationalmap.gov/basic/
- Flood Map Service Center (FEMA): https://msc.fema.gov/portal
- Geoplatform.gov (FGDC): https://www.geoplat-form.gov/
- Data.gov (GDA): https://www.data.gov/
- OpenTopography (UCSD/NSF): https://opentopography.org/
- Oregon LiDAR Consortium (DOGAMI): https://gis.dogami.oregon.gov/maps/LiDARviewer/
- Virginia GIS Clearinghouse (VGIN): https://vgin.maps.arcgis.com/home/index.html
- Alaska Elevation Portal (State of Alaska): https://elevation.alaska.gov/
- NGS Data Explorer (NOAA): https://www.ngs.noaa.gov/NGSDataExplorer/

- OPUS Shared Solutions (NOAA): https://www.ngs.noaa.gov/opusmap/
- Bathymetric Data Viewer (NOAA/NCEI): https://www.ncei.noaa.gov/maps/bathymetry/
- Global Multi-Resolution Topography Data Synthesis: https://www.gmrt.org/
- National Bathymetric Source Program, https://www.nauticalcharts.noaa.gov/learn/nbs.html
- NOAA National Bathymetric Source Data, via AWS: https://registry.opendata.aws/noaa-bathymetry/
- Bathymetric Coverage Report - U.S. Waters: https://gis.charttools.noaa.gov/bathy-coverage-report/
- NOAA's BlueTopo: https://nauticalcharts.noaa.gov/data/bluetopo.html
- NOAA's BlueTopo,via nowCOAST: https://nowcoast.noaa.gov/

Elevation Theme General Assessment

Grading Scale	
Points	Grade
97-100	A/A+
93-96	A
90-92	A-
87-89	B+
83-86	B
80-82	B-
77-79	C+
73-76	C
70-72	C-
67-69	D+
63-66	D
60-62	D-
<60	F

For this review, a traditional grading scale is shown in the table to the right. Rather than start from the bottom and assign points for every possible element, the decision was made to start at the top and subtract points where an assessed incompletion or deviation existed. Several sources besides the COGO survey were used to assign a score. Starting with a score of 100, an amount of 0-10 was subtracted based on meeting the GDA requirements under USC 43 Sections 2805(b)(3)(A)-(D). The previous 2018 COGO Elevation report was incorporated into the narrative where appropriate and relevant. The NSGIC 2023 Geospatial Maturity Assessment (GMA), the GDA-2023 Lead Covered Agency NGDA Theme Annual Performance Report, and Self-Assessment for Elevation Theme from USGS, the 3D Nation Study, and various other publications were used as input to the scoring process.

It is worth noting that the of Geospatial Organizations (COGO) survey had fewer respondents than anticipated; the sample size of those participating in the Elevation Theme was small and may not be representative of the nation's user base. Although there were a limited number of respondents, the NSDI survey illustrated that the Elevation Theme usage had changed since 2018. Most respondents (44%) were users. The most used datasets were the 1-meter DEM 60%, followed by lidar point clouds 54%. (There could be more than one answer). In 2018 the top two datasets were TopoMaps and USGS DEM/NED.

A. Geospatial Data Standards -Score delta -0- . As discussed in the prior section of this report, standards exist and are evolving for both inland topography and bathymetric data sets. The Standards are accessible if working with the agencies and technologies involved are part of normal a person's work. However, for the general public they may not be easy to find. In the COGO NSDI question related to this standard "Are you aware

of efforts to Identify, validate, and advance best practices to ensure that the A-16 Elevation Theme datasets you use, and related meaningful data can be easily integrated and used" 41% responded "no." As in the 2018 report, a recommendation is to continue to address the data accessibility and claims of duplicate authoritative sources. This should help eliminate confusion within the user community, and a perception of federal agencies creating redundant data.

B. Nationwide Population of NGDA Datasets - Score Delta -5. Discussed in the section of Estimated Theme Completeness, USGS is almost complete with the first Nationwide Inland Topographic 3D data set. The next generation data requirements will be challenging as 49% of the respondents need data updated every 3 years or more frequently. "The greatest number of respondents reported a requirement for 3D inland topographic data to be updated every 4-5 years (44%). The next most frequently reported requirement is for 3D inland topographic data to be updated every 2-3 years (22%). Note that 75% of respondents require an update frequency higher than the 8-year cycle goal currently used for the 3DEP." The chart below shows the current age of data which clearly outlines the problem of data currency when the requirement is 5 years or less to maximize the return on investment.

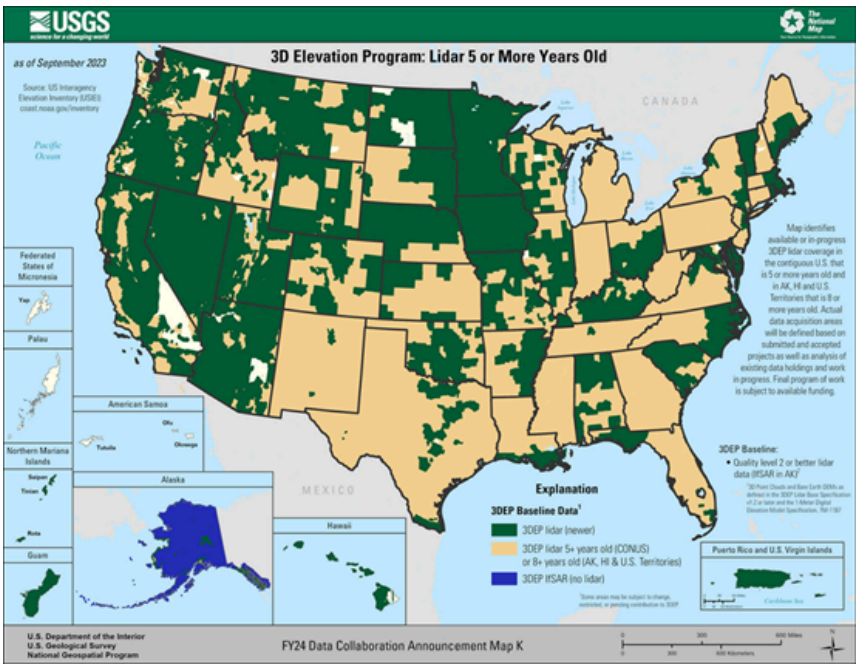


Figure Elevation-8. 3D Elevation Program: Lidar 5 or More Years Old. *Source: USGS.*

For Bathymetry, the update cycle and need vary depending on the type of bathymetry. The COGO assessment in 2018 and 2023 did not address bathymetry and the NSGIC GMA did not either. User expressed update requirements for Inland, Nearshore, and Offshore Bathymetry are all different in the 3D Nation Study. Overall, the level of existing data is different for these three areas. For this element, one point is subtracted for inland topography and four points are subtracted for Bathymetry.

C. Establish Goals That Support the NSDI Strategic Plan -Score delta -4. The goals of the 2020-2024 NSDI Strategic Plan are:

- Goal 1—Implement the National Geospatial Policy and Governance Framework as Defined by the Geospatial Data Act and Related Statutes and Policies
- Goal 2—Advance the Maturity of, Accelerate the Acquisition of, and Expand the Sources of National Geospatial Data Assets (NGDA) To Ensure That They Are Findable, Accessible, Interoperable, and Reusable
- Goal 3—Ensure Open Standards-Based Interoperability To Enable Geospatial Shared Services.
- Goal 4—Enable and Promote Collaborative Governance and Partnerships To Meet National Needs, Priorities, and Circumstances

Also stated in the NSDI strategic plan is development of a project plan outlining how the goals and objectives will be achieved. The project plan should include:

- Milestones
- Timelines
- Responsible parties
- Performance metrics
- Identification of resources available to achieve the objectives

Throughout this document there are many references showing how USGS and NOAA are meeting or making progress in meeting the objectives of the NSDI strategic plan with one exception. Despite efforts to support 3DEP through partnerships (about 64% of the program is funded by partners), funding overall has lagged behind what is needed to meet the needs of the user community. There are well documented benefits for investing in the Elevation Data theme and industry has moved forward to support acceleration of acquisition of the theme data sets. Industry has also successfully lobbied for more funding.

However as shown in example below, the Presidential Budget continues to request less funding than appropriated in the prior year (Table Elevation-5). This occurred in both FY24 and FY25. Congress increased the FY24 requested amount of $36 million with an appropriation of $42.9 million for 3DEP. It is unclear if that will be repeated in FY25. The score of -4 reflects the continued funding shortfall.

Table Elevation-5. Budget Shortfalls for 3DEP in Recent Years. *Source: USGS.*

Core Science Systems National Geospatial Program							
Core Science Systems $ in thousands	2023 Actual	2024 Annualized CR	2025 Fixed Costs	2025 Internal Transfers (+/-)	2025 Program Changes (+/-)	2025 President's Budget	Change from 2024 Annualized CR (+/-)
National Geospatial Program	93,650	93,650	+1,065	0	-8,468	86,247	-7,403
3D Elevation Program (3DEP)	[42,905]	[42,905]	[0]	[0]	-6,250	[36,655]	[-6,250]
Alaska Mapping and Map Modernization	[10,000]	[10,000]	[0]	[0]	-2,278	[7,722]	[-2,278]
3D National Topography Model (3DNTM)/3D Hydrography Component	[500]	[500]	[0]	[0]	+1,000	[1,500]	[+1,000]
Digital Surface Models	[3,000]	[3,000]	[0]	[0]	-3,000	[0]	[-3,000]
Baseline Capacity - 2024 Fixed Costs	[0]	[0]	[0]	[0]	+2,060	[2,060]	[+2,060]
FTE	*212*	*212*	*0*	*0*	+2	*214*	+2

D. Addressing User Needs -Score Delta -1. The GeoPlatform gives any knowledgeable user access to all the elements of geospatial data such as metadata, services, applications, and tools. The question referencing this element in the COGO NSDI Survey was "Are you aware of efforts to increase awareness and broaden the use of the type A-16 Elevation Theme data set you use, including efforts to publish, discover, integrate, promote, visualize, analyze, and disseminate A-16 Elevation Theme data? (Yes / No)." The responses came in roughly 50/50 with a very slight edge to a "No" answer.

Reviewing the NSGIC GMA report, the following conclusions were made. With the advancements/progress in data production and maturity of the USGS 3DEP: *"Over half (52%) of the states indicated that the data is accessible through an API and an additional 17 states (34%) make the data available via download. Finally, data stewardship remained the same from 2021 at a rate of 70%."*

Both responses refer to Inland Topography (3DEP) only. The situation becomes more complex when dealing with both Topography and Bathymetry. NOAA publishes the Digital Coast Data Access Viewer (https://coast.noaa.gov/dataviewer/#/). The NOAA site (https://www.ncei.noaa.gov/maps/bathymetry/) contains a bathymetry viewer with DEM data. The National Centers for Environmental Information (NCEI) provides high-resolution coastal digital elevation models (DEMs) from bathymetric data and integrates the bathymetric data with land surface height data (topographic data) available from other federal agencies. A coastal DEM depicts Earth's land surface and seafloor in an integrated digital map of a coastal region. NOAA also has the BlueTopo site for bathymetric survey data (https://www.nauticalcharts.noaa.gov/data/bluetopo.html).

USGS has a viewer (https://topotools.cr.usgs.gov/topobathy_viewer/), and a search for keywords such as "bathymetry" AND "topography" in an online USGS data catalog (https://data.usgs.gov) will return many hundreds of results.

Overall, the existing data are available and accessible through multiple websites. A very few pull the topographic information and bathymetric information together. The issue remains a lack of complete data sets of current data to populate these sites. The score of -1 reflects this issue.

The overall score of 90 reflects the letter grade of an A-. Although a lot has been accomplished since the 2018 COGO assessment, an improvement in funding leading to more current and complete data sets is required to obtain the full value of this theme.

Elevation Data Theme Working Group

Framework Evaluators	Federal Liaisons
John Copple, MAPPS: Author	Vicki Lukas, USGS
Sue Hoegberg, MAPPS: Principal Editor	Ashley Chappell, NOAA
Michael Shillenn, MAPPS: Reviewer	
Mark Safran, MAPPS: Reviewer	

IV. Geodetic Control Data Theme

Executive Summary

The Geodetic Control Data Theme continues to be adequate to meet current needs but will need some improvement for the future need. Thus it is assigned a grade of A-, as it was in 2018 as well. Based on our assessment of the data available at the time of this report, the National Geodetic Survey (NGS) is following the Blueprints it laid out for modernizing the National Spatial Reference System (NSRS) with a planned rollout for testing and feedback in mid-2025. It is anticipated that accurate, interoperable, and accessible geodetic data are and will continue to be available in an enhanced environment with backward compatibility to previous datums and reference frames from suitable tools. The mission of NGS will remain the same for the foreseeable future. NGS continues to define, maintain, and provide access to the NSRS. The NSRS provides a consistent coordinate system that defines latitude, longitude, height, scale, gravity, and orientation throughout the United States and its territories. It is strongly recommended that the National Geospatial Advisory Committee (NGAC) advocate to the Federal Geographic Data Committee (FGDC) for inclusion of terms such as interoperability, accuracy, and access for all U.S. geospatial data in FGDC Strategic and Implementation documents as well as any updates for other documents such as the OMB Circular A-16. This language would help clarify the need to appropriately access geodetic control and reference frames for all U.S. geospatial data to abide by the F.A.I.R. principles and ensure the best results and synergy for the U.S. government and other stakeholders. COGO recommends coordinating a national plan between US agencies maintaining geodetic infrastructure for input into future NSDI Strategic and Implementation Plans. COGO asks the NGAC to recommend the FGDC re-establish the Federal Geodetic Control Subcommittee (FGCS) to ensure a robust means of communicating with the broader geospatial community reliant on geodetic control and the NSRS. To improve overall resiliency of access to the NSRS, COGO recommends eliminating the 70 km rule to increase the NOAA Continuously Operating Reference Stations (CORS) Network (NCN). To further enhance resiliency, COGO recommends appropriately funded resilient receivers be installed at Foundation CORS stations to provide integrity. Resilience includes increasing the protection of the NSRS, which greatly benefits many facets of our society, in the face of external threats to its operation. COGO recommends the restoration of funding lost through budgetary attrition over the past seven years (approximately 3.3% of overall budget). COGO further recommends that this budget line be expanded to meet expected high demand to meet near-future public and private geospatial requirements for cm-level accurate activities. This includes autonomous traffic on the water, land and air that will expand the U.S. economy and improve the overall resilience of this critical infrastructure.

Geodetic Control Theme Grade: A-

Nearly Fit for the Future

Description of the Framework

An Introduction to the Theme

The NSRS forms the critical geodetic control, infrastructure and systems underpinning the U.S. National Spatial Data Infrastructure (NSDI) and enables a common understanding of location within the United States using geospatial coordinates positions. The NSRS provides the means for tying all geospatial features to common, national geometric and physical coordinate systems. The NSRS provides common geodetic coordinates to enable stacking disparate geospatial data to obtain a synergy and improved tools for geospatial users such as coastal and emergency planners. According to the Geospatial Data Act of 2018, OMB Circular A-16, National Geospatial Data Assets (NGDAs) are intended to be sufficiently complete, current, and accessible to support the critical business and mission requirements of the Federal Government, its partners and stakeholders. This includes Geodetic Control that comprise the four NGDAs in the Geodetic Control Theme. The NGDAs must be internally consistent for providing access to the NSRS. However, they are more critical in that they underpin geospatial data in all U.S. geospatial, including other NGDAs. There will likely be new tools available in the future, which may change NGDAs. However, the core mission of defining, maintaining and providing access to the NSRS will continue. This Theme and any relevant NGDAs will continue to evolve to meet future needs and capabilities.

The Theme Definition

Four NGDAs comprise the Geodetic Control Theme: passive marks, CORS, airborne gravity, and geoid height models. Each of these are discussed more fully below, but a brief description is provided here. Passive marks provide the traditional means of accessing the NSRS through fixed survey markers that provide starting points of known horizontal, vertical or gravity coordinates. This method of establishing geodetic control yields highly accurate positions, but requires users to begin and end surveys at marks of known location and traverse sometimes significant distances to a target work area. When NGS modernizes the NSRS, users will begin their surveys with measurements of signals broadcast from Global Navigation Satellite Systems (GNSS) such as the Global Positioning System (GPS). Positions determined through this method are calculated with respect to the NOAA Continuously Operating Reference Station (CORS) network (NCN). High accuracy surveys will be adjusted with the NCN and with passive marks. These starting measurements can be observed directly at a work site and can sometimes save long traverses to tie to passive control. Positioning accuracies with this new method are somewhat less than with current techniques but will likely be good to about (+/-) an inch. Airborne gravity data are combined with gravity from global gravity models, satellite gravity missions, gravity inferred from satellite altimetry, and current holdings of terrestrial and marine gravity measurements to define a highly accurate model of the Earth's geopotential in U.S. regions. Gravity predicted from this geopotential model will be significantly improved over our current methods and will be used to accurately estimate surface gravity at any location. Geoid height models provide a transformation from geometric coordinates obtained using GNSS/CORS to physical heights that better model the flow of water. All four of these datasets contribute to obtaining geodetic

coordinates in the NSRS and are thus NGDAs in the Geodetic Control theme. The modernized NSRS is planned for public release in 2025 for Beta testing and will change how users get geodetic control and will replace the current reference systems with more modern and accurate reference systems. The NSRS will continue to provide a common system for establishing coordinates for all U.S. geospatial data that is consistent, interoperable and accurate internationally and nationally.

Lead Agency and Current Activities

National Oceanic and Atmospheric Administration's (NOAA's) NGS is the lead federal agency for this data theme. NGS provided information about their efforts with this theme and is included herein. NGS will still define, maintain, and provide access to the modernized NSRS and will incorporate modern models, tools, and methods for its access.

Outreach has already begun in a series of bilateral meetings between NGS and other federal agencies involved in geodetic applications with extensive geospatial data holdings. These include coordination with US Army Corps of Engineers for levee and dredging efforts, coordination with US Geological Survey stream gauging and 3D Elevation Program's DEMs, and the National Aeronautics and Space Administration for development of a national deformation model to capture vertical and horizontal land motions.

While the FGDC has yet to formally re-establish the FGCS, NGS continues to hold annual meetings for the broader US government on progress towards the modernized NSRS with its new reference frames and tools for access. This outreach and education effort continues in the form of webinars, online training, videos, courses of instruction and many other media. NGS recognizes the need to ensure stakeholders inside the government and outside the government are prepared and best positioned to take advantage of the modernized NSRS to maintain their existing geospatial data and to follow appropriate SOPs for collecting additional data using geodetic control.

- *COGO recommends to the NGAC for further recommendation to the FGDC that the FGCS be formally re-established.*

NGS closely coordinates with the Federal Geographic Data Committee (FGDC) at multiple levels to ensure that the NSRS is appropriately reflected in FGDC planning documents and subsequent Departmental planning documents. NGS has been working to ensure language in the update to the NSDI Strategic Plan will reflect the need for US geospatial data to be interoperable, accurate and accessible. NGS is planning to include clear language on the recommended use of the NSRS to define the geodetic coordinates of geospatial data in the subsequent NSDI Implementation Plan (IP). The NSDI IP will begin development during Summer 2024 and will be in force from 2025-2034. Additionally, NGS has been working to have explicit language in the update to the OMB Circular A-16 to likewise reflect the recommended use of the NSRS in defining US geospatial data.

- *COGO recommends to the NGAC and for further consideration by the FGDC that the impending NSDI Strategic Plan include language specifying the need for accuracy, interoperability, and accessibility of geospatial data. The best means for obtaining all three of these would be through the use of the NSRS, so possibly such language could also be given in the NSDI Strategic Plan update.*

These efforts and recommendations are supported by US Census as the lead US representative to the United Nations committee of experts on Global Geospatial Information Management (UN-GGIM), which functions much like the FGDC but at a global scale. Much of the language adopted in the GDA and FGDC guidance comes from UN-GGIM resolutions and documents. Hence, NGS has been active at the global level to ensure that our national compliance in implementing the NSRS will be consistent with international norms and agreements. NGS has membership on the UN-GGIM Subcommittee of Geodesy that is developing international frameworks that will stipulate how countries must adopt the International Terrestrial Reference System (ITRS) as the basis for their national reference systems (i.e., the NSRS for the U.S.). NGS participates actively in both the International Organization for Standardization (ISO) and Open Geospatial Consortium (OGC) to have a hand in developing appropriate international geospatial standards. NGS remains active with NASA in managing geospatial data that feed the development of the International Association of Geodesy (IAG) models that, in turn, feed the ITRS. It is this ITRS to which NGS is aligning the NSRS to meet requirements in the GDA and UN resolutions. Through these meetings and liaisons, NGS is working to ensure that any specific implementation issues are addressed over the next few years and that the modernized NSRS will meet all international commitments and agreements while serving as the most accurate and interoperable means of coordinating geospatial data in the U.S.

NGS continues to engage with the public through publications on the progress to NSRS modernization work by providing a quarterly newsletter, called the NSRS Modernization Newsletter. Each issue reports on high-level projects, identifying their start, progress and completion as appropriate - and more recently - the planned roll-out of the modernized NSRS. Additionally, NGS sends out broad public announcements and provides information and education through the NGS webpages.

In the next four subsections, each of the four NGDA's will be covered in more detail to amplify upon activities that have occurred in the past four years plus the expectation of near term activities related to the roll out of the modernized NSRS. The four NGDAs are required to be maintained in such a way to be Findable, Accessible, Interoperable and Reusable (F.A.I.R.). To that end, they are made available both through Data.gov and Geoplatform.gov. The Geodetic Control Theme and each of the four NGDA's can be found on Geoplatform.gov.

1. Geodetic Control Information on Passive Marks: Horizontal and Vertical Geodetic Control Data. Currently, the NSRS can be accessed via existing information on survey marks (such as permanent brass markers installed in the ground) which is publicly available in the NGS Integrated Database (NGS IDB). This positioning method we term

as using "passive" geodetic control as positioning is based upon coordinates established at survey marks. These survey marks have defined accurate horizontal and vertical coordinates in the North American Datum of 1983 (NAD 83) and North American Vertical Datum of 1988 (NAVD 88), respectively. NAVD 88 is comprised of a network of approximately 800,000 marks spread across the country through Canada and into Alaska. While NAVD 88 was not adopted in Canada, geodetic control was obtained to transit through to Alaska. Because traditional vertical datums are tied to tide gauges, Guam, the Commonwealth of Northern Mariana Islands, American Samoa, Puerto Rico, and the US Virgin Islands all have their own vertical datums tied to their respective master tide stations. Figure 1 highlights the partial extent of NAVD 88. Not shown are additional lines through Canada that connect to Alaska. Note also that NAVD 88 was on official datum only in the Conterminous U.S. and Alaska - not in Canada and Mexico. Note that each mark is both a marker in the ground with a unique identification and a value in the NGS Integrated Database, which can be obtained by users. With the known coordinates, traditional leveling connects from the bench mark to a work area.

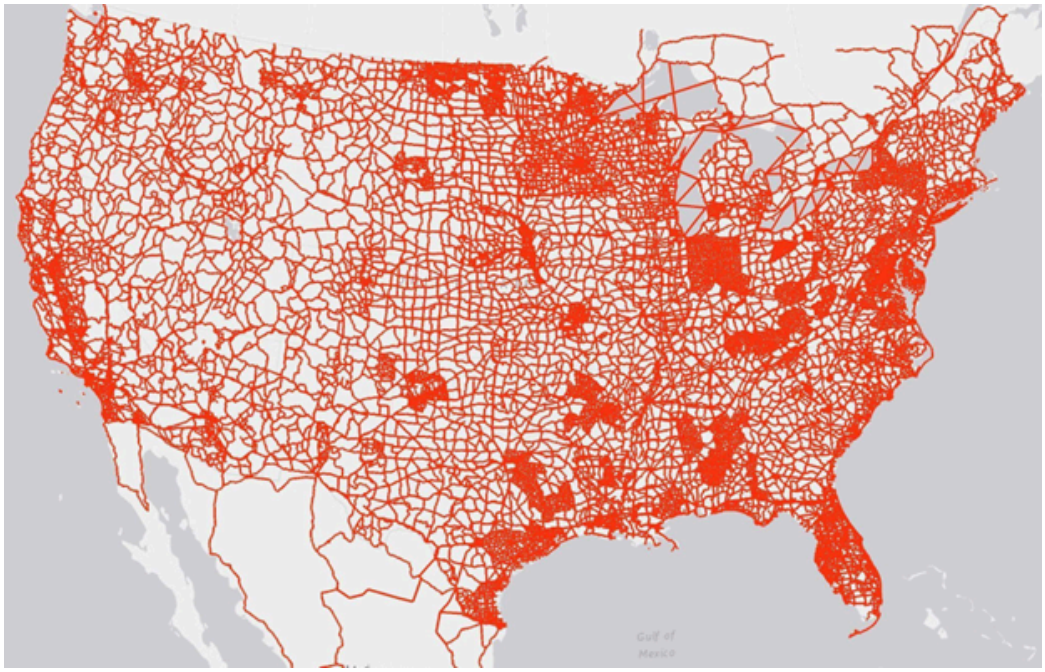


Figure Geodetic-1. Partial vertical control network used in NAVD 88. Additional lines run through Canada to Alaska, but NAVD 88 is an authoritative vertical datum only in the Conterminous U.S. and Alaska. *Source: NOAA.*

The vertical network was realized by leveling from one point to the next. Horizontal control was traditionally determined by turning angles and triangulating - using geometry to transfer coordinates. This method was significantly updated in the 1990's with the adoption and use of GPS to determine geodetic coordinates. The North American Datum of 1983 (NAD 83) is the horizontal and geometric control datum for the United States, Canada, Mexico, and Central America. NAD 83 was released in 1986.

Current tools such as the Online Positioning User Service (OPUS) connect NCN's CORS to a rover GPS at a work area. Rovers still set up on horizontal geodetic control survey marks to obtain the tie to NAD 83. There are significantly fewer NAD 83 survey marks - only about 272,000 as shown in the original NAD 83 control network in Figure Geodetic-2.

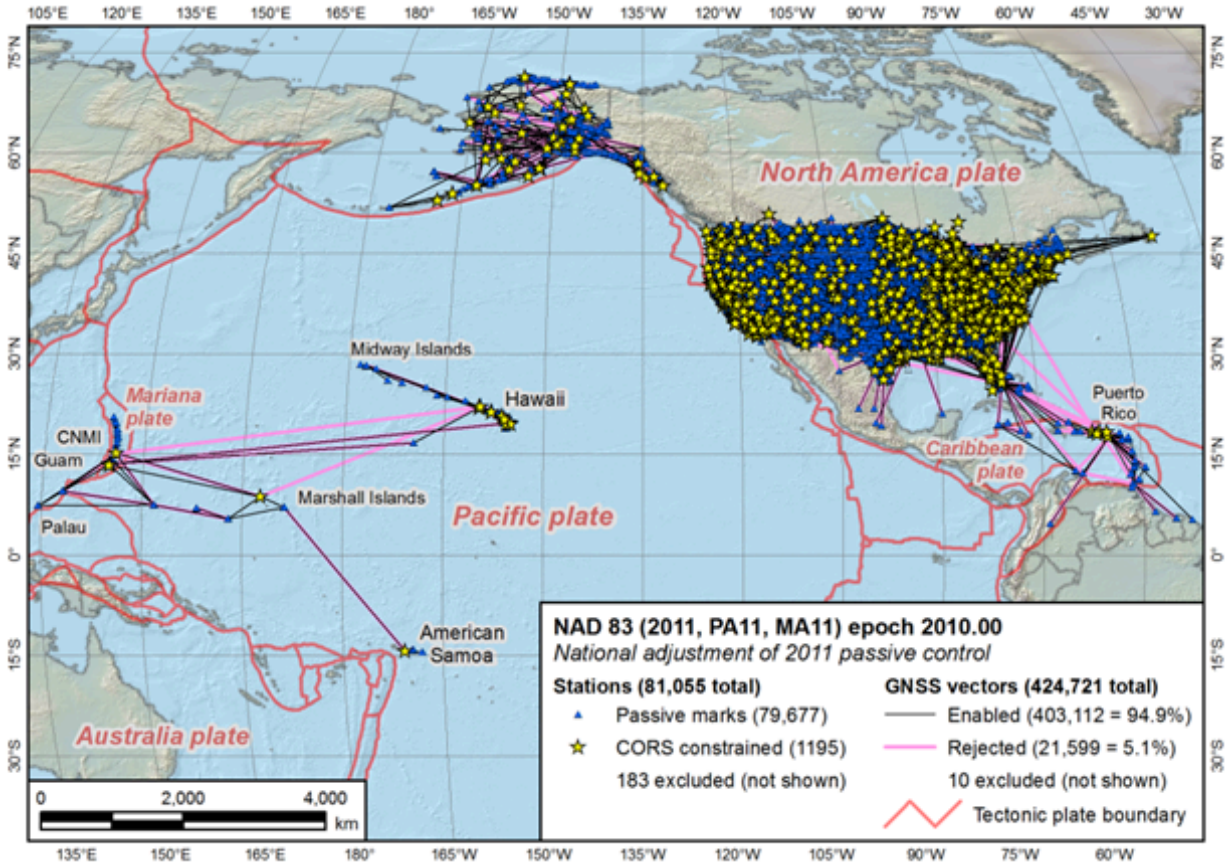


Figure Geodetic-2. Survey control network for the most recent realization of NAD 83 (GNSS-only). *Source: NOAA.*

In the modernized NSRS, primary access to positioning will be provided via GNSS measurements tied to the NOAA CORS Network (NCN), and we term this "active" geodetic control. Passive control as a method of accessing the NSRS will accede to active control in the modernized NSRS. However, passive control will still continue to prove invaluable. Surveyors and engineers will continue to use survey marks to constrain positions and to execute their work. Passive markers define cadastral surveys and are integral to legal boundary definition. Real Time Kinematic Network (RTN) users typically check their observations each day by a measurement on a known passive control mark. Additionally, passive markers can help assess deformation over time, such as after an earthquake in California or Alaska or over a longer period of time monitoring glacial isostatic adjustment in the Great Lakes region. Remotely sensed signals from space, such as Interferometric Synthetic Aperture Radar (InSAR), provide a means of determining topographic deformation from space. However, such remotely sensed data

must be calibrated and validated. Occupations by Campaign GNSS/GPS on passive survey marks provide in situ measurements for this work. Passive control can also be used adjacent to active control (a CORS, for example) as a geometric reference point (GRPs). GRPs would aid in the recovery of a station should there be a loss to the equipment for the active control. Finally, survey marks are resilient to GPS interference because they are passive. They are marks in the Earth with known coordinates and can provide access to the NSRS. While the modernized NSRS will focus on the use of active control and such tools as OPUS to provide users coordinates, passive control will continue to provide a complementary role indefinitely into the future.

NGS receives, validates, and curates survey data and makes available electronic datasheets for all geodetic and geospatial users. These data are largely stable with new additions being validated to maintain the internal integrity and reliability for both NAD 83 and NAVD 88. The data in this NGDA are very mature and stable.

2. Continuously Operating Reference Stations (CORS). The NOAA CORS Network (NCN) currently serves as the primary tool for accessing the NSRS for NAD 83 and for the modernized NSRS from 2025 onwards. It is a collaborative effort of more than 200 federal, state, academic, and private organizations, providing publicly accessible GPS/GNSS data from over 2000 CORS. These CORS, with 98% ownership and maintenance by NCN partners, support post-processed positioning activities across the United States and its territories. As of March 08, 2024, the largest portion of the NCN is made up of 37 state departments of transportation and surveying, and 60 local governments which collectively contribute more than 1200 stations (approximately 42% of the whole NCN). This is followed by 38 colleges, universities, and research organizations which contribute 661 stations (approx. 23%). Meanwhile, less than 20 US federal agencies contribute 596 stations (approx. 21%), 53 private industry partners with 306 stations (approx. 23%), and 16 foreign government partners contribute 76 stations (approx. 3%).

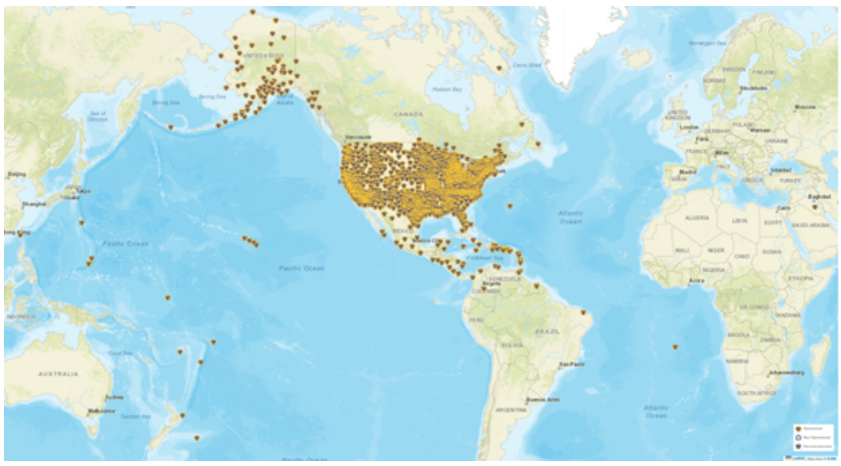


Figure Geodetic-3. NOAA CORS Network provides nearly 2000 active control stations for access to the NSRS. *Source: NGS, 2024 (https://geodesy.noaa.gov/CORS/ for info and https://arcg.is/18fWq8 for data).*

These data are collected and curated by NGS. Analysts maintain data logs on changes and issues with all of the CORS, and data are analyzed for potential defects. Additionally, the signals from the satellites to the receivers are used to develop orbital models to describe the path of the GNSS satellites. This orbital analysis helps to refine the post-processing of user data to enable the horizontal and vertical accuracies at +/- one inch. The CORS data provide the primary datasets for accessing the NSRS for users that collect rover GNSS observations in their work area.

In turn, NGS works with NASA to contribute this data into a global effort to develop international models. NGS is an Analysis Center for the International GNSS Service - a function of the International Association of Geodesy. These data feed into global modeling that is used to refine and update the models in the International Terrestrial Reference System. The most recent model was the International Terrestrial Reference Frame of 2020 (ITRF2020). The modernized NSRS will be built on ITRF2020, so NGS efforts over the preceding years ensured that the NSRS will be closely tied to the techniques, which are labor intensive and prohibitively expensive to repeat. NGS is investigating modernized astro-geodetic approaches to conduct Deflection of Vertical (DoV) observations with accuracy comparable to leveling observations with denser measurements along a profile line.

While this network of stations in the NCN is quite extensive, it needs to be expanded further to provide enhanced access to the NSRS. In the Assessment section below, discussion focuses on the restriction of NCN station spacing to 70 km or more. This necessarily limits the ability to include new stations to provide greater access and decreases the overall resilience of the NSRS access. Additionally, NCN stations may be subject to interference from intentional or unintentional noise. Having additional stations will better detect and mitigate these sources of interference and enhance resilience of the overall network. Given the critical nature of these stations underpinning access to the NSRS, a coordinated national plan is necessary and should involve all US Agencies maintaining geodetic infrastructure.

- *COGO recommends that the 70 km rule be eliminated and that additional stations be incorporated into the NCN that will include more stations in RTNs, State DOT operations, other government agencies and other organizations.*
- *COGO also recommends the NCN, FCORS and all related support be sufficiently resourced to ensure the viability of this critical infrastructure. COGO recommends that these efforts be a part of a national plan coordinating geodetic infrastructure, associated R&D and operations and that this be incorporated into the broader NSDI implementation plan.*

3. Geoid Height Models. As part of the NSRS modernization, NGS will release the GEOID2022, a gravity-based geopotential surface t hat is tide-free and is referenced to the Geodetic Reference System 1980 ellipsoid (Figure Geodetic-4).

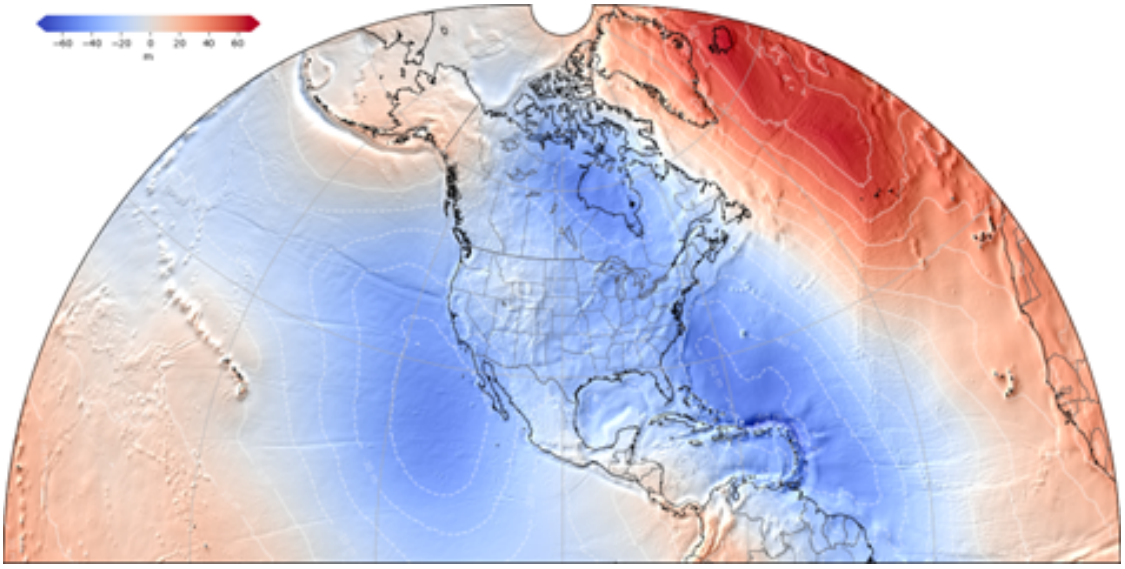


Figure Geodetic-4. Height relationships between the static geoid (GEOID2022) layer and the Geodetic Reference System 1980 (GRS1980) ellipsoid in meters. *Source: NOAA.*

It covers three regions: the North America–Pacific region, Guam and Northern Mariana Islands, and American Samoa. Considering climate scale changes, in addition to a static model (defined as static geoid), an annual change layer was also developed to allow the user to correct the static model over time (Figure 5), also known as the dynamic geoid. The geoid layers are used in many applications, such as defining water flow direction, initiating coastal models that predict tides and extreme events (e.g., flooding and inundation), and in digital navigation systems on land, air and space.

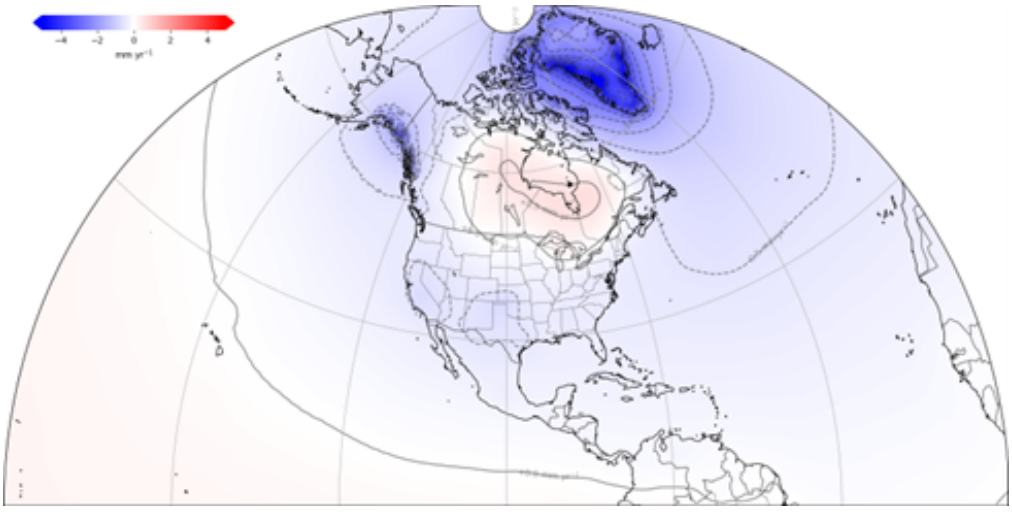


Figure Geodetic-5. Annual change in the height (mm per year) of the geopotential surface with respect to the static geoid. *Source: NOAA.*

Geoid models and associated Deflections of the Vertical models are maintained by NGS. NGS has developed transformations between the existing reference frames of the current NSRS - NAVD 88 and NAD 83. Geoid height models were developed that blended both data from the passive control with a geoid model determined from gravity data only. These hybrid models culminated in the last version shown in Figure 6 - GEOID18, which will be the last such model pending the modernized NSRS implementing GEOID2022.

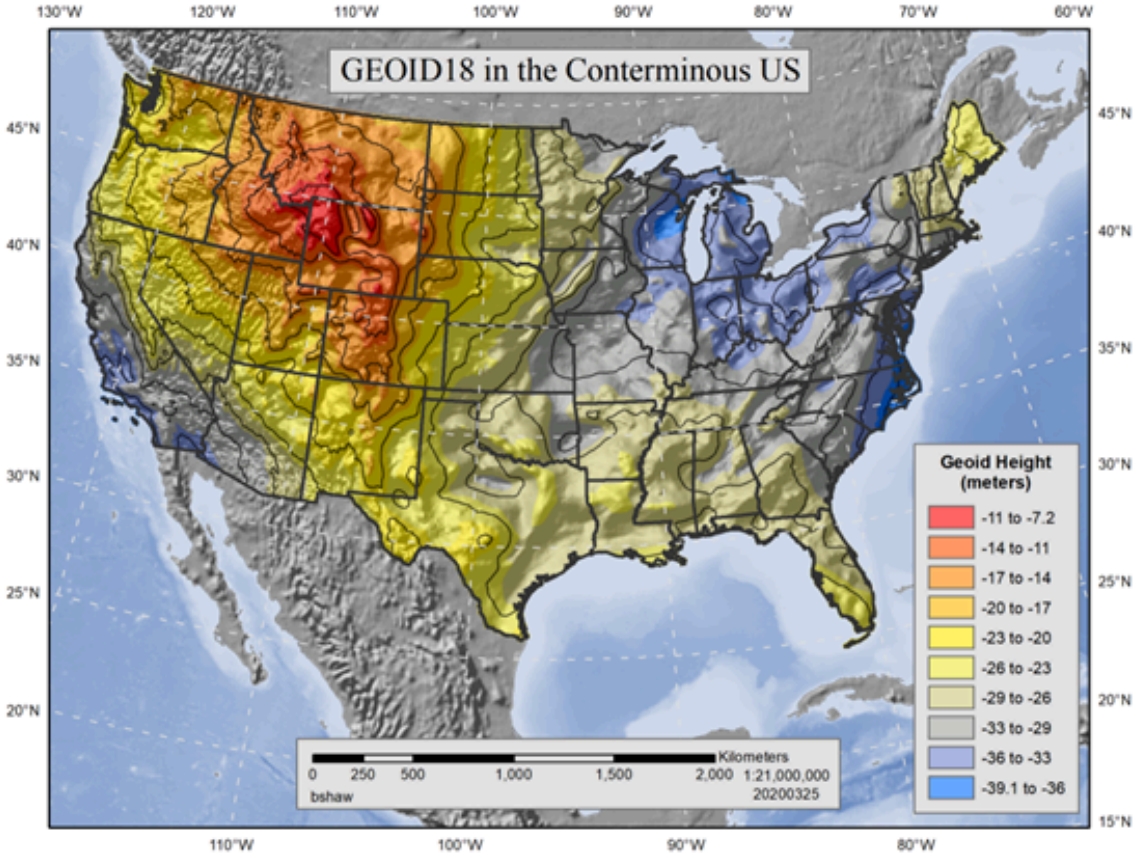


Figure Geodetic-6. GEOID18 for the U.S. transforms between NAD 83 and NAVD 88. Similar models exist for other regions. GEOID18 is only valid inside the U.S. land areas, where passive control are located. *Source: NOAA.*

4. Airborne Gravity Data. In 2023, NGS completed a monumental 15-year airborne gravity campaign with coverage over the entire United States and its territories (Puerto Rico, US Virgin Islands, American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands). This completes the first objective of the Gravity for the Redefinition of the American Vertical Datum (GRAV-D) project, a high-resolution "snapshot" of the gravity field in the US and its territories. GRAV-D objective 2, a low-resolution "movie" of the gravity field is also underway and named the Geoid Monitoring Service (GeMS). The purpose of GeMS is to monitor changes in the gravity field over time which will allow NGS to model how the geoid is changing with respect to time.

The status of the GRAV-D project can be seen in Figure 7. Green represents blocks (geographic regions) where data and metadata beta products are available, and blue represents blocks where data is being processed or being prepared for publication. GRAV-D beta products for the green blocks are available on the NGS website (https://www.ngs.noaa.gov/GRAV-D/data_products.shtml). All of the GRAV-D airborne gravity data has been processed and is being prepared for publication as a final data set.

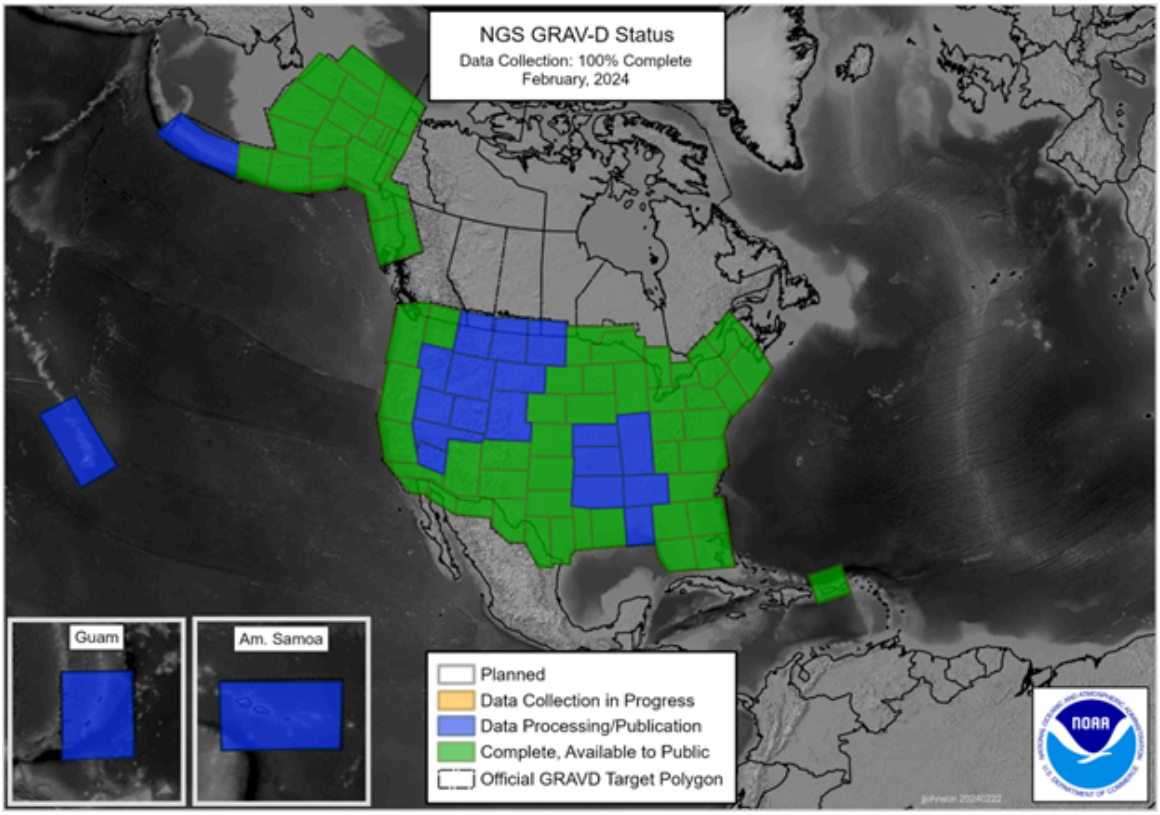


Figure Geodetic-7. GRAV-D data blocks. All data collection is complete. Green blocks are published as beta data products. All processing is complete; however, the blue blocks have not been published yet. *Source: NOAA.*

The complete gravity disturbance grid for the entire GRAV-D airborne gravity dataset can also be considered (Figure 8). The GRAV-D data set will be one of the foundational data sets used by scientists at NGS as they build the products and services related to the modernized vertical datum, the North American-Pacific Geopotential Datum of 2022 (NAPGD2022). This includes the modeling of both the gridded reference surface, GEOID2022, and also the gridded surface gravity model, GRAV2022, along with other NAPGD2022 products.

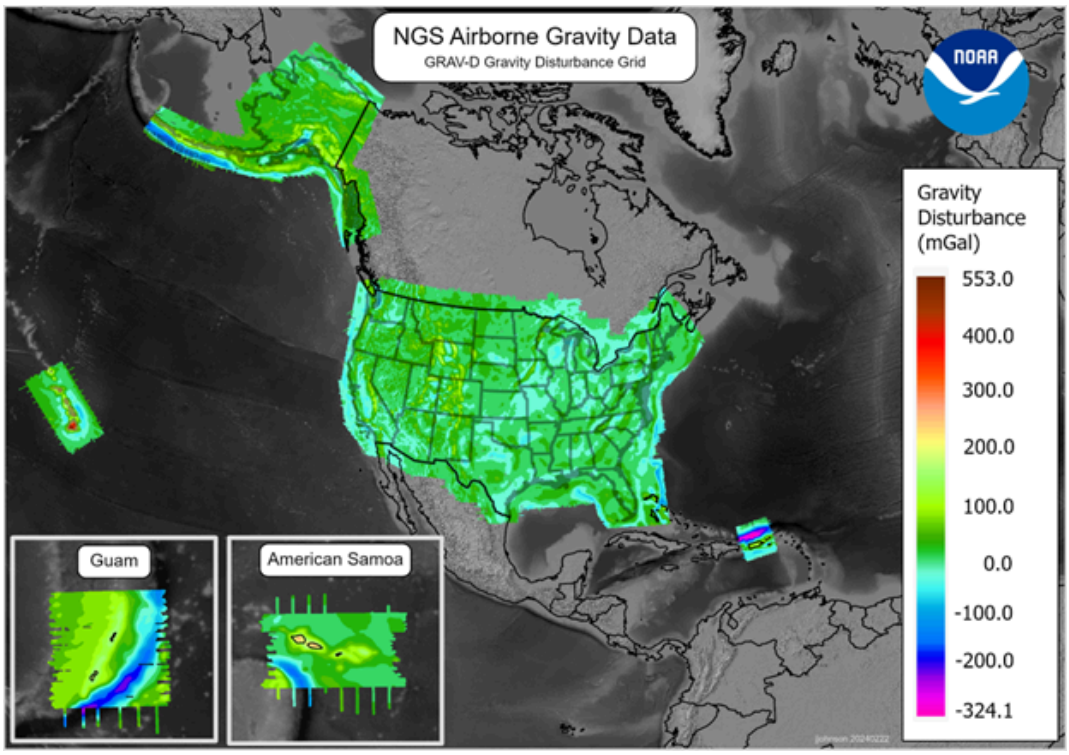


Figure Geodetic-8. Gravity disturbance grid for the complete GRAV-D data set. Units in milliGal (mGal). *Source: NOAA.*

Collaborations and Partnerships

NGS is a founding member of the Geodesy Community of Practice (CoP). NASA, NGA, USGS and NOAA/NGS form the core membership as the owners of the critical national geodetic infrastructure. Bilateral and joint collaboration occurs between all four. NGS works with NGA as the final refinements to airborne gravity data as a part of the GRAV-D project. An MOA exists between NGS and NGA to facilitate continued airborne gravity collections in regions adjacent to the United States (e.g., Canada). NGS collaborates closely with NASA in developing and maintaining GNSS data in support of the ITRS. NASA and NGS are exploring additional areas of interest involving InSAR data for deformation model determination. This last effort also involves USGS in the creation of a national deformation model describing expected Vertical Land Motion (VLM) and Horizontal Land Motion (HLM) that are relevant for landslides, coastal inundation, and other potential disasters. NGS collaborates with USGS in refining the datums for 3DEP DEM's and with NOAA's Office of Coast Survey to ensure these datasets meld at the shoreline in the NSRS. VLM, elevation models and inundation will improve the resilience of coastal communities as well as inland communities adjacent to rivers and lakes. NGS works with both USGS and USACE to ensure that water level measurements are also in the NSRS. This further ensures the accurate translation of

flooding into adjacent lands. It also enables USACE to provide cost-effective planning for dredging and levee-building necessary to mitigate flood risks and shoaling.

NGS also collaborated with local (governmental, commercial, and academic) partners throughout the GRAV-D project. Partners willing to support airborne or terrestrial surveys or monitor local variations in the gravity field are a critical component of GRAV-D (https://geodesy.noaa.gov/GRAV-D/).

Although this part does not discuss non-geodetic control points, such as Public Land Survey System points, local government control points, project control points for public and private projects, aerial-photo control points, and so on, it can be used as a model for effective collaboration and partnership to enhance services to users. There are strategic opportunities between COGO and NGS specifically with support in outreach and communication efforts and feedback for stakeholder concerns. When the update to the NSRS rolls out, there will still be individuals and groups that were unaware of the coming change. As such, there may be unanticipated consequences to those groups from the new NSRS. Minimizing this impact by ensuring the broadest outreach is a significant goal for NGS. COGO members can assist by relaying communication and outreach efforts to as many stakeholders as possible. If concerns are expressed and mitigated before the roll out, then implementation of the new NSRS will be that much more successful.

The most significant obstacles in a successful rollout of the modernized NSRS include both data collection and collaboration. Data collection is primarily limited on the physical side by the vast area that must be surveyed. The Gravity for the Redefinition of the American Vertical Datum (GRAV-D) Project as a part of the NGS Gravity Program completed data collections in 2023. These data are being processed and incorporated into gravity field products in collaboration with the DoD's National Geospatial-Intelligence Agency (NGA). NGA will be rolling out a new global model in 2024 that will incorporate most of the GRAV-D data. NGA will continue to work with NGS to develop a more comprehensive gravity field model now that GRAV-D data have been collected. Rollout of the beta version of OPUS positioning tools that will provide coordinates and accuracies in the new NSRS is slated for mid-2025. Additional collaboration is needed and largely happening between NGS and NASA for coordinating Global Navigation Satellite Systems (GNSS) infrastructure, gravity collection and products, and digital elevation models. Collaborations between NGA and NGS as well as NGS and NASA are fairly strong as all have vested interests in collaborating.

However, collaboration with other federal agencies to develop models and techniques which assist in their implementation might not be as robust. This is in large part due to turnover of personnel and lack of expertise in other federal agencies on how to change the geodetic infrastructure that underlies their products and services. Finally, some NGS products require international collaboration. The reference frames for the Caribbean and the Pacific span regions where NGS must have additional information to properly develop a model. Hence, agreements with other countries may be required. This may involve the State Department and slow the process of development.

A final consideration is that the modernized NSRS will account for time dependency of positions. In principle, this is a sound approach as it would better account for how a location may have moved over time and better align observations from different periods of time for comparisons. NGS plans to provide official positions at the epoch of observation and infer coordinates at the epoch of the last national adjustment. NGS will develop the tools and provide training, but how readily this will be adopted by the user community is unknown. NGS will also remain ready to collaborate with the user community to implement the modernized NSRS, but NGS must account for a broad range of skills and adaptability. An important aspect of NGS' modernization plan is the development of a new State Plane Coordinate System (SPCS). This third generation of SPCS covers all U.S. states and territories, and is being developed in coordination with state, tribal, and other stakeholders in local government and the private sector. It also includes special use zones that span multiple states or offshore regions (such as the Navajo Nation and the Gulf of Mexico, respectively). The new State Plane system (SPCS2022) is a dataset of definitions, which we will provide to our customers and partners in a variety of ways. This includes using standardized data formats and publicly accessible databases, such as the International Organization for Standardization (ISO) Geodetic Registry and the European Petroleum Survey Group (EPSG) Geodetic Parameter Dataset widely used by commercial software developers. Most of the SPCS2022 zones were designed by the stakeholders themselves, with guidance from NGS. Because of that level of participation and engagement, NGS expects that the modernized State Plane system will significantly enhance the desire of the user community to adopt the modernized NSRS.

NGS will provide digital transformations under ISO 19111 to help the GIS community adapt to the new NSRS. These transformations will be maintained in an ISO-sponsored geodetic registry and will also be available through the NGS website as models and the underlying interpolation algorithms. The surveying community will have available the same transformations; however, the existence of paper records in legacy datums will require digitizing to upgrade. On the plus side, robust, map-grade transformations already exist in geometric coordinates and a similar set is being developed for physical height transformations. Additionally, models are being developed that will explain any expected movement over time (e.g., plate rotation) so that data collected at different epochs could be transformed to common epoch for comparison for long term projects. A robust collection campaign is in progress to obtain sufficient GPS on bench marks to improve the new realization of the reference frame with the previous. Additionally, NGS is working with its counterparts in Canada and Mexico to ensure continuity of the NSRS across the borders.

As noted above, NGS is also working with Canada and Mexico to ensure continuity over the border as well as to facilitate any transnational activities. This is a part of the broader United Nations Global Geospatial Information Management (UN-GGIM) activities that the United States has agreed to support. UN-GGIM stipulates that nations should adopt common, international models and standards of use.

Further, one of the primary objectives of NGS has been the development of a complete

educational portfolio, with ready-to-teach training units for teachers at the elementary through university level.

Regional Geodetic Advisors serve as liaisons between NGS and our public, academic, and private sector constituents within their assigned regions, to ensure all territories are covered. Regional Advisors provide expert guidance to constituents who manage geospatial activities that are tied to the National Spatial Reference System (NSRS). Geodetic Advisors serve as the subject matter experts to regional geodetic issues and collaborate internally across NGS and NOAA to further the mission of the organizations. This transition to a regional program is particularly important, as NGS executes the plans to replace the North American Datum of 1983 (NAD 83) and the North American Vertical Datum of 1988 (NAVD 88) by 2022, when our Gravity for the Redefinition of the American Vertical Datum (GRAV-D) project will be completed. During this period of change, every state will need the direct support and technical assistance provided by their Regional Advisor.

Finally, it should be noted that NGS Regional Advisors interface with the state and - to some extent - local governmental organizations. NGS Regional Advisors attend professional meetings and conduct workshops and training sessions. They will continue to provide outreach and education of the planned rollout and usage of the new NSRS in 2025 and after. They remain NGS's robust forward presence in outreach and communication. NGS staff also attend many meetings at the national level to ensure broader educational outreach. NGS plans to continue to provide remote access to educational materials through meetings, trainings and webinars.

NGS is engaged with multiple agencies and groups primarily through contacts in the FGCS but also with other federal agencies. The most direct interactions are with NASA and NGA. NASA has groups related to geometric infrastructure (GNSS sites), gravity field modeling (GRACE Follow-On), and digital elevation models. All of these are essential to NGS to update the NSRS. NASA's interest in GNSS infrastructure is to ensure that the U.S. is providing and leading scientific efforts to develop the International Terrestrial Reference Frame (ITRF). In turn, NGS is interested in using these same sites as the backbone network for defining the NSRS in the U.S. These sites will be designated as Foundation CORS (FCORS) and provide the main ties to ITRF in the U.S. NGS will also seek to work with NSF and other private groups to ensure that either by direct ownership or proxy, NGS will have a robust network of FCORS distributed around all U.S. states and territories to guarantee access to the NSRS in case voluntary contributions from regular CORS ceases for any reason. There will also necessarily be agreements made with U.S. neighbors Canada and Mexico, the Caribbean states, South Central and South American states, and countries in the Asia-Pacific region to develop coordinated models for those regions. All of this is stipulated under the tenets of the UN-GGIM agreements to adopt ITRF models implemented as regionally densified reference systems and an eventual International Height Reference Frame (IHRF).

- *COGO recommends that the FCORS be made as resilient as possible to ensure the integrity of access to the NSRS in the presence of signal interference or other extreme*

circumstances. COGO further recommends that other NCN stations be made similarly resilient where feasible.

For the latter part, NGS collaborates with both NGA and NASA to develop a highly accurate geopotential datum. NGS has been steadily collecting data through GRAV-D but will be building this into a larger Gravity Program to ensure that the final products remain updated and consistent with the planned IHRF. This also has required collaboration to ensure continuity throughout the region and across international borders.

Standards

When the GDA was passed, all FGDC standards were revoked. Nevertheless, NGS continues to rely upon previously established standards as a mechanism for continuing to deliver the NSRS. NGS continues membership in national (ANSI/INCITS) and international (ISO, OGC) organizations to ensure that the updates to such standards will not disrupt the reliable access to the NSRS nor plans for the modernized NSRS. It is expected in the near future that the FGDC Standards Working Group will start to re-establish requirements, starting with more fundamental standards such as ISO 19111 and ISO 19115.

NGS will continue to meet these requirements for the NGDAs, since the NGDAs are geospatial data in their own right. However, these data also serve to underpin all other geospatial data sets. As such the adoption of the NSRS along with appropriate SOP's for accessing the NSRS should be deemed essential for all U.S. geospatial data. This will best ensure the interoperability and accuracy for all data. NGS will be required to adhere to ISO 19161 that provides a link between the NSRS and the ITRS. This will ensure that U.S. geospatial data are interoperable with other geospatial data sets from around the world.

In the meantime, NGS continues to follow the previously established standards developed as SOPs to achieve accuracy. The FGCS of the FGDC was established to promote standards of accuracy and currentness in geodetic data financed in whole or part by Federal funds; to exchange information on technological improvements for acquiring geodetic data; to encourage the Federal and non-Federal communities to identify and adopt standards and specifications for geodetic data; and to collect and process the requirements of Federal and non-Federal organizations for geodetic data. The lead agency responsible for the coordination, management, and dissemination of geodetic data is the Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, National Geodetic Survey:

- Geographic Information Framework Data Content Standard, Part 4: Geodetic Control (2008)
- Geospatial Positioning Accuracy Standards, Part 1: Reporting Methodology (1998)
- Geospatial Positioning Accuracy Standards, Part 2: Standards for Geodetic

Networks (1999)

- Geospatial Positioning Accuracy Standards, Part 3: National Standard for Spatial Data Accuracy (1998)
- Geospatial Positioning Accuracy Standards, Part 4: Architecture, Engineering, Construction, and Facilities Management (2002)
- Geospatial Positioning Accuracy Standards, Part 5: Standards for Nautical Charting Hydrographic Surveys (2005)
- Geographic information - Geodetic codes and parameters (ISO) (2010)

Estimate of Theme Completeness

Previous reports relied upon Lifecycle Maturity Assessments (LMA) to determine theme completeness. With the advent of the GDA, LMA's were discontinued. Annual Lead Covered Agency (LCA) reports were instead submitted and biennial Inspector General audits completed to verify completeness or progress towards. The Geodetic Control Theme is marked as "Progress Towards" completion for all of the past four years. Given the impending nature of the NSRS Modernization, it was not deemed feasible to mark anything complete. Further, no standards have yet been designated by the FGDC Standards Working Group, so no compliance can be demonstrated. As noted above in the Standards section, this will change in the near future when the FGDC adopts specific standards. Additionally, a Geodetic Control Theme Strategic Plan (separate from the NGS Strategic Plan), will be developed to codify the roadmap for activities over the next five-year cycle. Implementation Plans will also be created to capture annual activities.

For this report, the four NGDA's are complete and stable based on the previous information. Passive control continues to have data added and additions are vetted to ensure integrity with other existing passive control. The airborne gravity collection phase of the GRAV-D project is complete. Additional data may be collected in cooperation with NGA, but these are supplementary data. The NOAA CORS Network is largely stable with additions and removals as deemed necessary to support the overall network. Geoid-Height models and related Deflection-of-the-Vertical models are likewise nearly complete - being built from existing terrestrial and satellite gravity data and the recently completed GRAV-D project. All four NGDA's are complete but will require maintenance to ensure future integrity. All four datasets are promulgated through Data.gov to the Geoplatform.gov where they are maintained to ensure the data are F.A.I.R.-compliant.

Accessibility of Data

NGS products and services are available from the NOAA website as well as from the NSDI Clearinghouse and other government portals. The four NGDAs are required to be maintained in such a means as to be Findable, Accessible, Interoperable and Reusable (F.A.I.R.). To that end, they are made available both through Data.gov and Geoplatform.gov. The Geodetic Control Theme and each of the four NGDA's can be found on https://Geoplatform.gov.

Authority, Governance, and Management of the Theme

NGS is an agency within NOAA, which is part of the Department of Commerce. NGS provides the framework for all positioning activities in the Nation. The foundational elements of latitude, longitude, elevation, shoreline information impact a wide range of important activities. The NGS, our Nation's first civilian scientific agency, was established by President Thomas Jefferson in 1807 as the Survey of the Coast. Its mission was, and still is, to survey the U.S. coastline and create nautical charts of the coast to help increase maritime safety. As the nation grew westward surveys of the U.S. interior began. In 1878 the agency was given a new name, the U.S. Coast and Geodetic Survey (USC&GS), which it maintained until 1970. In 1970 a reorganization created the National Oceanic and Atmospheric Administration (NOAA) and the National Ocean Service (NOS) was created as a line office of NOAA. To acknowledge the geodetic portion of the NOAA mission, the part of NOS responsible for geodetic functions was named the National Geodetic Survey.

The specific programmatic authorities (statutes or Executive Orders) for collecting, maintaining, using, and disseminating the information NGS Products and Services Authorities include:

- 5 U.S.C. § 301 authorizes the operations of an executive agency, including the creation, custodianship, maintenance and distribution of records
- 15 U.S.C. 1501 et. seq -15 U.S.C. § 1512 is an Organic Law which confers general powers and duties authority to executive agencies, vesting jurisdiction and control of departments, bureaus, offices and branches
- 44 U.S.C. 3101 -Presidential Memorandum: Promoting Economic Competitiveness While Safeguarding Privacy, Civil Rights, and Civil Liberties in Domestic Use of Unmanned Aircraft Systems (Feb. 15, 2015); National Marine Sanctuaries Act
- 16 U.S.C. 1431 et seq.; Marine Debris Act
- 33 U.S.C. 1951 et seq.; Coast and Geodetic Survey Act
- 33 U.S.C. 883a et seq.; Coastal Zone Management Act
- 16 U.S.C. 1451 et seq.; Coral Reef Conservation Act
- 16 U.S.C. 6401 et seq.; National Historic Preservation Act
- 16 U.S.C. 470 et seq.; Ocean Pollution Act
- 33 U.S.C. 2701 et seq.; Comprehensive Environmental Response, Compensation and Liability Act
- 42 U.S.C. 9601 et seq.; Clean Water Act,
- 33 U.S.C. 1251; 47 CFR parts 80, 87, and 95. The system is also authorized by the U.S. Office of Management & Budget (OMB) Circular A–130; the Magnuson-Stevens Fishery Conservation and Management Act
- 16 U.S.C. 1801 et seq. (Magnuson-Stevens Act); High Seas Fishing Compliance

Act of 1995

- 16 U.S.C. 5501 et seq.; International Fisheries Regulations: Vessels of the United States Fishing in Colombian Treaty Waters
- 50 CFR 300.120; the FAA Modernization and Reform Act of 2012 (Pub. L. 112–95); the American Fisheries Act, Title II, Public Law 105–277; the Atlantic Coastal Fisheries Cooperative Management Act of 1993
- 16 U.S.C. 5101–5108, as amended 1996; the Tuna Conventions Act of 1950
- 16 U.S.C. 951–961; the Atlantic Tunas Convention Authorization Act
- 16 U.S.C. Chapter 16A; the Northern Pacific Halibut Act of 1982
- 16 U.S.C. 773 et seq. (Halibut Act), the Antarctic Marine Living Resources Convention Act of 1984
- 16 U.S.C. 2431–2444; the Marine Mammal Protection Act
- 16 U.S.C. 1361; and the Debt Collection Improvement Act, 31 U.S.C. 7701. Version Number: 01-2021 7
- Federal Preparedness Circular (FPC) 65, July 26, 1999
- Executive Order 12065, 12656 -E-Government Act of 2002 (Pub. L. 107–347) Section 204; Davis-Bacon and Related Acts
- 40 U.S.C. 3141–3148 40 U.S.C. 276a; 29 CFR parts 1, 3, 5, 6 and 7; Section 5 of the Digital Accountability and Transparency Act (DATA Act), Public Law 113–101. DAO 210-110; Executive Order 12564; Public Law 100-71, dated July 11

Geodetic Control Assessment

1. Capacity: *the Framework's capacity to meet current and future demands.*

NGS's strategic plan calls for millimeter-level accurate positioning, with a strong reliance upon the use of GNSS. This reliance upon GNSS, with a heavy leaning toward GPS for at least 5 more years, means that any threat to GPS is a threat to the NGS mission. Other GNSS constellations could eventually serve as a backup to GPS, though the goal would be to use all GNSS constellations interoperably first, only relying on them independently as backups to one another as threats arise. The M-PAGES tool processes multi-GNSS signals and remains viable for some of the NGS tools. M-PAGES is not expected to be fully invested into all tools by the final roll-out of the modernized NSRS. Further, the passive control network of survey marks can serve as a secondary method of access to the NSRS and as a partial backup to GPS should any threats arise. Additional future research into complementary Positioning-Navigation-Timing (PNT) techniques will be explored to mitigate the reliance on GNSS and to provide geospatial information in GNSS-denied areas (e.g., underground).

2. Condition: *The existing or near-term condition of the Framework themes as an integrated whole.*

Modernization of the National Spatial Reference System (NSRS) is scheduled to be

released for Beta testing in 2025. The National Geodetic Survey (NGS) has finalized certain key decisions in replacement of the three NAD 83 reference frames, and in the replacement of various vertical datums of the National Spatial Reference System. Four plate-fixed terrestrial reference frames are being implemented. These Reference Frames are North American Terrestrial Reference Frame of 2022 (NATRF2022), Pacific Terrestrial Reference Frame of 2022 (PATRF2022), Marianna Terrestrial Reference Frame of 2022 (MATRF2022), and Caribbean Terrestrial Reference Frame of 2022 (CATRF2022). These frames will be accessed using the CORS NGDA. Additional collaboration with Canada ensures that NATRF will be realized in both the U.S. and Canada as a common North American datum - a true replacement for NAD 83. Collaboration also exists with Asia-Pacific countries for PATRF/MATRF, and with other countries in the Americas for CATRF.

An Alpha version of the GEOID2022 already exists and will replace all vertical datums in the U.S. and territories. It consists of one main grid spanning a quarter of the planet centered on the mainland U.S. and covering Canada and Mexico as well. Smaller grids cover Guam and the Commonwealth of Northern Mariana Islands as well as American Samoa. The two smaller grids are developed in a manner consistent with the larger grid to ensure a consistent and accurate vertical datum in all areas.

Development of the geoid models required development of a more accurate gravity grid, which now provides gravity values everywhere. In this manner this Theme's datasets will serve in the near future to provide access to the modernized NSRS for all U.S. citizens equitably, accurately and with complete interoperability between geospatial data sets.

3. Funding: *the funding capability of the Framework.*

Federal Government Funding from FY 2017 to FY2024 was reviewed, based on the NOAA Annual Blue Book Budget Data. NGS funding is contained within the NOAA parent agency - National Ocean Service (NOS) for the category "Navigation, Observations and Positioning (NOP)". The NGS portion of this budget category is approximately 20% of this category budget but cannot be further refined.

Each proposed fiscal year budget is prepared by the NOAA budgeting authority using the previous year's FY approved budget, and "adding to the base" (ATB) to come with the proposed budget for the next fiscal year. The proposed budget goes to the OMB where the President's Office adds to or subtracts from the agency's proposed budget. Congress then adjusts the budget numbers after that. The growth or shrinking of the actual Congressionally approved budget for "Navigation, Observations and Positioning" is best computed by measuring the changes in the approved category budget for the previous fiscal year, indicated in the Budget Table below.

Table Geodetic-1. Budget Table for NOAA/NOS Navigation, Observations, and Positioning (NOP), Fiscal Years 2017-2025.

Fiscal Year	Congress Enacted ($ Thousands)	% Change actual Adding to the Base (ATB)	% Change Consumer Price Index (CPI)
2025			
2024	184,702	0.0	3.5
2023	184,702	13.7	3.4
2022	162,500	1.8	6.5
2021	159,613	0.1	7.0
2020	159,456	1.9	1.4
2019	156,467	5.7	2.3
2018	147,998	-0.5	1.9
2017			
	Total	22.7	26.0
	Average	3.2	3.7
	Std. Deviation	5.0	2.2
	Total Net Change to Effective Budget over Past 7 Years	-3.3	

In the 2017-March 2024 time frame the US Consumer Price Index (CPI) has increased an average 3.7% . The data indicate that increases in the NOP budget are lagging inflation in general and not accounting for personnel pay increases, or any expansion of the geodetic control program to improve the NSDI. The average yearly ATB of 3.2% masks a problem with consistency of ATB. There was a 13.7% FY23 ATB joined by 3 years of near 0% ATB. Actual reductions in NGS personnel during this period (from retirements) ultimately reduced the resiliency of the geodetic control programs to improve the NSDI.

- *COGO recommends that the net loss of 3.3% in the Navigation, Observations and Positioning budget line be restored and maintained in the future to meet Framework needs covered in the other parts of this Section (A-B, D-G). COGO further recommends that this Funding be appropriately expanded to meet NSDI requirements related to the adoption of the Framework for all U.S. Government geospatial data as well as anticipated use in other public and private organizations.*

4. Future Need: *Whether future-funding prospects will be able to meet the need.*

The NSDI Report Card of 2018 noted NGS has provided a clear road map forward with the contemplated implementation of the new datum in 2022. While this date slipped due to a number of factors, the expected roll-out discussed in this report is 2025. This is based on the fact that most data are collected, models and tools are nearing completion, and outreach efforts have begun. It is anticipated that accurate, interoperable, and accessible

geodetic data are and will continue to be available in an enhanced environment. Additionally, a number of tools and improved models will be generated after 2025 based on available resources.

This includes Artificial Intelligence to aid in CORS station analysis, which will lead to a well-resourced expansion of the NCN. This would better integrate stations from other organizations such as RTN providers. Additionally, future processing software requirements will better enable usage of other GNSS as well as GPS III signals to further refine positioning and navigation - potentially with Precise Point Positioning (PPP). Significant Proliferated Low Earth Orbit (PLEO) satellites are also coming online (e.g., Starlink), which may offer additional positioning signals to help build alternatives to traditional GNSS. These PLEO would lead to enhanced resilience of the positioning and navigation systems. Ground based augmentation systems (GBAS) can further improve the accuracy of positioning and navigation in a real-time mode. These GBAS systems would be akin to WAAS at airports, but sited in transportation infrastructure to support autonomous vehicles on the ground, air and on the water. Development of version 2.0 for the Intra-Frame Deformation Model (IFDM) is intended to use InSAR calibrated against NCN stations. Integrating the remotely sensed data will provide a more coherent means of moving observations from an observation epoch to a reference epoch, leading to greater confidence in positioning results. Alongside this would be mapping the change in the geopotential field or the dynamic, time-varying geoid that will serve as the new vertical datum. These changes must be mapped and modeled to provide better estimates of water flow for flood mitigation efforts.

5. Operation and Maintenance: ***The ability of key lead organizations to develop and maintain the Framework and to adopt new technology, procedures, and standards.***

NGS is updating the NSRS to a more easily maintained and accessed model that meets the future needs of federal, state and local governments as well as private organizations. These models will ensure that the Geodetic Control Theme and Framework will be well maintained using new technology such as positioning signals from other GNSS, deformation models such as the IFDM and physical heights based on a geoid model. All these new technologies and procedures will be coordinated with neighboring Canada, Mexico and the Caribbean region, as well as the broader international community. The current paradigm of accessing geodetic control via passive monumentation is costly to maintain and is inconsistent with international plans for updates that have been adopted by the U.S. through participation in UN-GGIM, IAG and ISO. The aim is to provide an accessible NSRS via easily obtained GNSS, processed online, and closely tied to other physical heights and gravity field products. The NSRS will then have 3-D velocity models to describe the expected changes over time. This should account for physical changes that make the old datums obsolete, such as subsidence in Louisiana or glacial isostatic adjustment in the Great Lakes region. It further avoids having to maintain a million bench marks that would have to be revisited often to ensure their integrity and accuracy.

6. Public Use: ***The Framework's ability to provide data resources that meet the everyday needs of organizations and the general public, and to provide data resources that meet the need to respond to public safety incidents, natural disasters, and other emergencies.***

With the impending release of the modernized NSRS in 2025, continued outreach and education are planned through more geospatial summits, webinars, presentations at conferences (scientific and professional), publication of papers in scientific and trade journals, and industry-specific meetings. A major focus of this effort will be through NGS Regional Advisors who are at the forefront of interactions with state, county and private institutions. However, NGS is also actively engaged with other government agencies through activities within the FGCS and FGDC. NGS is also working closely with USGS to adopt the new datums throughout their national stream gauge network, ensuring seamless water level data connections across watersheds and into the coastal zone to help with flood prediction and protection.

AAGS and NSPS sent out a questionnaire to supplement the categories in this assessment and received 108-117 responses, which have been included in the report. The NSPS/ AAGS polling questions included:

Question 9. Which organization will you primarily look for to provide information on NSRS modernization?	
A. NGS online webinars	37.61%
B. NGS Regional advisors online or in-person presentations	17.95%
C. NSPS online presentations	4.27%
D. State Geodetic Organizations	8.55%
E. State Surveying Society	16.24%
F. GNSS Equipment Dealer	6.84%
G. Other	5.13%
H. No answer	3.41%

A total of 59.83% of responses directly rely on NGS resources to learn how to incorporate NSRS modernization. But the other non-NGS organizations who can provide training and resources rely on NGS as their primary source of NSRS modernization.

Question 10. How prepared is your firm for NSRS modernization with Low Distortion Projections (LDPS)?	
A. Well prepared, have attended seminars on the topic.	24.79%
B. Somewhat prepared, attended seminars but waiting for the product to initiate.	41.86%
C. Heard about it but have not attended seminars on the topic.	18.8%
D. What is NSRS modernization? Never heard of it.	11.11%
E. No answer.	3.42%

Only 24.79% of responses are well prepared for NSRS modernization at this time.

Question 11. NGS is currently in the process of creating preliminary designs for the State Plane Coordinate System of 2022 (SPCS2022) zones. How familiar are you with how the State Plane Coordinate System (SPCS) for your State will change as part of the NSRS modernization?	
A. I am familiar with them and use them.	35.9%
B. I am familiar with them but have not used them yet.	33.35%
C. I am not familiar with them but understand State Plane Coordinate Zones will change with the release of the Modernized NSRS.	22.22%
D. I am not familiar with them.	5.98%
E. No answer	2.56%

69.23% of responses are familiar with modernization of state plane coordinates and half of this group is using them at this time.

7. **Resilience:** *The ability of the geospatial community to participate in development of the Framework and to contribute to its sustainability as a long-term asset of value for the nation.*

NGS will help the GIS community adapt to the new NSRS by providing digital transformations under ISO 19111. These transformations will be maintained in an ISO-sponsored geodetic registry and will also be available through the NGS website as models and the underlying interpolation algorithms. Tools are being developed to help with the map-grade transformations suitable for a bulk of geospatial data sets. For those requiring increased accuracy, guidelines for the use of OPUS will provide the means for obtaining the desired accuracy. These guidelines or SOPs will be akin to the Bluebook in that accuracy will be achieved through procedure. Additionally, models are being developed that will explain any expected movement over time (e.g. plate rotation or

deformation) so that data collected at different epochs could be transformed to common epoch for comparison for long term projects.

- *As we anticipate the launch of the new National Spatial Reference System (NSRS) in 2025, COGO recommends and emphasizes the critical need for implementing a comprehensive national action plan that starts with the geodetic control theme. This interagency plan should guarantee the establishment of a robust geodetic control framework, which forms the backbone of our spatial referencing. To ensure its resilience and effectiveness, a meticulous approach akin to a "SWOT" analysis should be adopted to uncover any hidden or visible gaps, weaknesses, and potential threats in the geodetic control workflows. This investigative analysis will be instrumental in understanding the robustness of our positioning infrastructure and how it cascades down from the global to the national and eventually local implementation of geodetic controls.*

It is imperative to acknowledge and address potential hidden threats that may undermine the United States' autonomy in defining and maintaining the NSRS. One such concern is the U.S. dependence on the global ITRF, which could limit our control over the geodetic framework and our ability to respond independently to the international community's changes.

It is of utmost importance that we take proactive steps to safeguard the applications that rely on the geodetic control framework. These applications, often overlooked, are integral to numerous services that greatly benefit our society. However, if we fail to address the potential threats, there is a real risk that the quality and reliability of these applications could deteriorate, leading to a significant loss of benefits. Therefore, the implementation of the national action plan must include strategic measures to strengthen our geodetic control theme and ensure the enduring independence and accuracy of the NSRS. The potential consequences of inaction are too grave to ignore.

Assessment Categories Specific to Geodetic Control

In this section we include an assessment of five additional categories specific to geodetic control: A. CORS Coverage, B. OPUS-RS Ellipsoid Height 1-Hour Data Coverage, C. Passive Control Coverage, and D. RTN Service. Based on these four elements, we established rubrics for each and assigned state-by-state grades (**Table Geodetic-6**). To supplement our analysis, AAGS and NSPS sent out a questionnaire to supplement the categories and received 108-117 responses, which have been included in the report. The first two questions related to the population of respondents, their professional associations and job role.

Question 1. What is your organization's role in creating and managing geodetic control?	
A. Data Creator - Owner/Authority (Creates, procures geodetic control data)	29.91%
B. Manager/Custodian (Manages geodetic control database for an organization/operation)	3.42%
C. Data Aggregator (Collects geodetic control data from multiple sources)	5.98%
D. User (Uses data directly - visualization, geo-searches, analysis; does not collect data and does not manage system)	47.86%
E. Vendor/Consultant (Provides products or services to geodetic control data managers or users)	5.13%
F. Other / None of the above.	7.69%

Question 2. Which geospatial organization(s) do you belong to (choose all that apply):	
A. National Society of Professional Surveyors (NSPS)	65.81%
B. American Association for Geodetic Surveying (AAGS)	11.11%
C. State Surveying Society	66.67%
D. American Society of Civil Engineers (ASCE)	12.82%
E. American Society for Photogrammetry and Remote Sensing (ASPRS)	12.82%
F. American Geophysical Society (AGU)	2.56%
G. Other	16.24%
H. None	13.68%
I. No answer	1.70%

A. CORS Coverage

As of March 8, 2024, the NCN has a total of 2878 stations. Among these, 1750 stations (approximately 61% of the total NCN) actively provide RINEX data in the last 30 days and are classified as Operational stations. There are 166 stations that have not been providing data in the last 30 consecutive days and are classified as Non-Operational. Additionally, NGS has temporarily suspended data ingestion from 12 stations with known issues. The station providers and NGS's Geodetic Infrastructure branch are collaborating to identify reasonable solutions for these stations. A total of 950 stations are classified Decommissioned from which NGS has permanently stopped ingesting data.

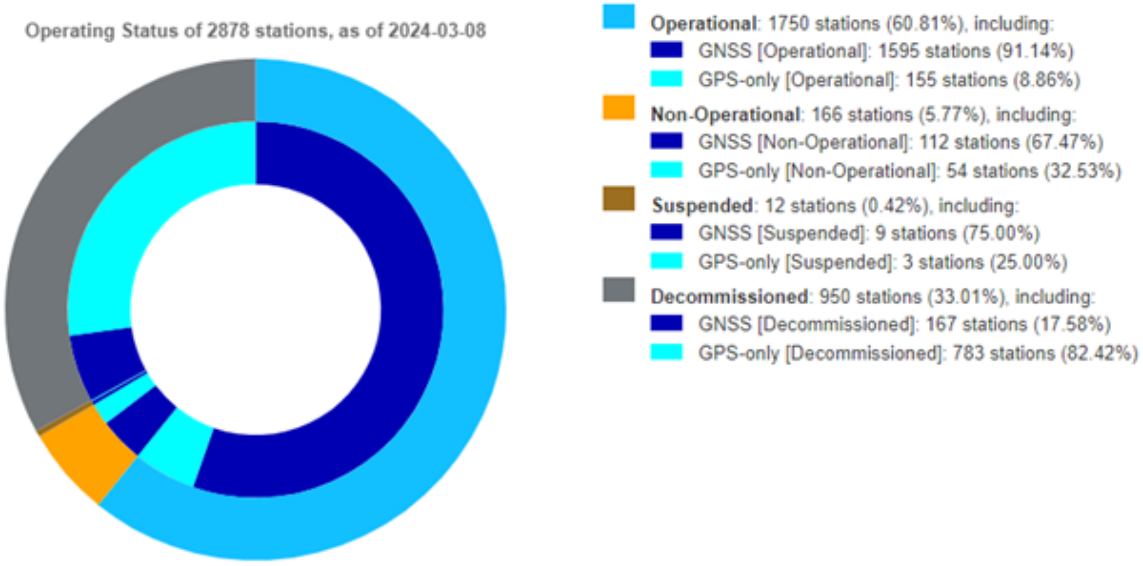


Figure Geodetic-9. The NCN based on operating status and the satellite constellation observed at each station. *Source: NOAA.*

The classification of NCN stations by operating status is illustrated in Figure 9. Among 1750 Operational stations, 1595 stations or 91.14% of Operational stations, are actively tracking multiple satellite constellations. Within this group, 871 stations (approximate 49.77%) are tracking GPS+GLONASS+Galileo constellations, 693 stations (39.60%) are tracking GPS+GLONASS, and a few stations are also tracking Beidou and regional constellations such as QZSS.

As shown in this figure, there are 155 Operational stations (approx. 8.86% of 1750 Operational stations) providing GPS-only observations. The majority of these GPS-only stations are over 10 years old. The oldest and most remarkable station is UNAVCO's SEDR located in Washington state, which has been in operation for 26 years and remains stable and functional.

The assessment of the NCN coverage for each state's total surface area, including federal, non-federal, and water bodies, is conducted using NGS CORS data and the USDA-NRCS National Resources Inventory data. Only NCN stations classified as Operational on March 8, 2024, within each state were considered. It is important to acknowledge that these grades may not accurately represent the CORS coverage of currently operational CORS within a given state. For instance, while approximately 150 CORS are operated by the Washington State Reference Network (WSRN) in the Washington (WA) area, only 60 of them are currently integrated into the NCN. In accordance with the NGS guidelines from 2018, new CORS are recommended to be located no closer than 70 km (~43 miles) from an existing CORS, indicating a coterminous coverage of half this distance (21.5 miles). The resulting surface area coverage is 1450 square miles, considered an average indicator of sufficiency for this assessment.

Figure Geodetic-10 illustrates the geographic contribution of NCN's operational stations with the 35-km coverage. The NCN stations are concentrated along the coastlines due to their location and the importance of the ports, shipping, and transportation infrastructure. The network is heavily congested in states such as Tennessee, Missouri, Indiana, and Michigan due to their infrastructure and economic importance. On the other hand, the network is sparse in the mid-western states such as in Montana, Wyoming, North Dakota, and South Dakota, as well as in Alaska due to their lower population density and less infrastructure.

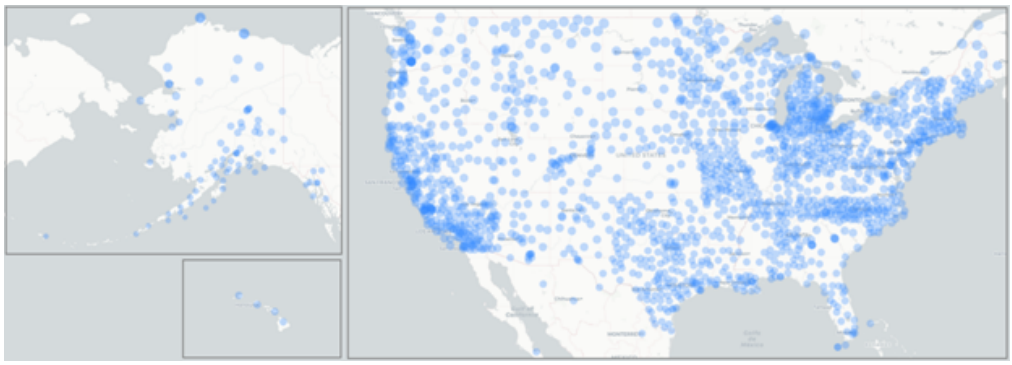


Figure Geodetic-10. Coverage extending 35 kilometers around Operational CORS in the United States, as of March 8, 2024. *Source: NOAA.*

Table Geodetic-2. Rubric for CORS coverage grades on a state-by-state basis (see Table Geodetic-6 below).

Grade	Square Miles of Coverage
A	< 500
B	< 800

The NSPS/AAGS polling questions included the question below on CORS density. 72.65% of responses have satisfactory or better CORS spacing.

Question 3. Rate the CORS density in your state only.	
A. Excellent (40 miles spacing)	27.35%
B. Good (50 miles spacing)	23.08%
C. Satisfactory (60 miles spacing)	22.22 %
D. Fair (80 miles spacing)	9.4%
E. Unsatisfactory (100+ miles spacing)	10.26%
F. No answer	7.69%

Member organizations report a robust use of GNSS Receivers. About 10% of member responses report not using GNSS receivers at all. This group must rely on passive monuments for geodetic control at this time, or do not need to use GNSS equipment in their work.

Question 7. Which GNSS signals do you process normally?	
A. GPS + GLONASS + GALILEO + BEIDOU	41.03%
B. GPS + GLONASS + GALILEO	21.37%
C. GPS + GLONASS	19.66%
D. GPS only	11.97%
E. None	2.5%
F. No answer	3.41%

Question 8. What year of purchase is the oldest GNSS equipment you regularly operate?	
A. 2020 and newer	23.93%
B. 2010 - 2019	54.7%
C. 2000 - 2009	15.38%
D. 1990 - 1999	0.85%
E. No answer	5.14%

Over 80% of responses report processing multi-constellation signals and over 40% responses report processing with BEIDOU signals. It is important for CORS stations to collect GNSS signals from all acceptable data sources. 78.63% of responses utilize more modern GNSS receivers.

B. OPUS-RS Ellipsoid Height 1-Hour Data Coverage

Subjective graphical assessment of the availability and coverage of rapid static processing of 1-hour ellipsoid height data was conducted using the NGS OPUS Map: https://www.ngs.noaa.gov/OPUSI/Plots/Gmap/OPUSRS_sigmap.shtml.

Compared to horizontal positioning, ellipsoid height positioning is the best indicator of position integrity. For instance, high accuracy GPS ellipsoid heights will always generate high accuracy GPS horizontal positioning whereas high accuracy horizontal positioning will not always generate high accuracy GPS ellipsoid heights. Rapid-static processing of OPUS solutions is an indicator of efficiency and ability to meet future needs.

Table Geodetic-3. Ellipsoid Height 1-Hour Data Coverage. Rubric for OPUS-RS coverage on a state-by-state basis (see **Table Geodetic-6 below**).

Grade	Coverage
A	**100%**
B	**98%**
C	**95%**

C. Passive Control Coverage

The coverage and distribution of passive monuments used for geodetic control for each state's non-federal developed and rural surface area (excluding water bodies) was assessed using NGS CORS data and the USDA-NRCS National Resources Inventory

data. Passive control is less critical to the NSRS modernization efforts, because of the shift to active control (e.g., NCN and OPUS). Hence, these data no longer will be maintained, but will still serve to help redundancy checks for future positioning needs.

Table Geodetic-4. Rubric used for Passive Control Coverage on a state-by-state basis (see Table Geodetic-6 below).

Grade	Square Miles of Coverage
A	< 2
B	< 10
C	< 20+

Question 12. How much do you rely on NGS passive marks for geodetic control?	
A. I only use GNSS via RTNs and the NOAA CORS Network (NCN) for geodetic control and do not rely on passive marks	23.93%
B. I primarily use GNSS RTNs and the NCN and use passive marks only for backup.	42.74%
C. I use RTNs and NCN but tie into passive marks for historical reference.	7.69%
D. I rely on passive marks where RTNs and NCN are not accessible.	12.72%
E. No answer.	7.69%

Only 13% of respondents rely on passive monuments and do not use RTNs or NCN.

D. RTN Services

Real Time Network (RTN) Services are real time GNSS coordinate determinations with corrections from a base station. They are provided to GNSS receivers in the field to provide usable geodetic based coordinates in near real time, avoiding time consuming post-processing in an office. It is a pervasive and productive tool used in many industries. The access and availability to GNSS users is an indicator of accelerating geodetic network services nationally.

The breakdown of RTN users by industry in North Carolina, for example, is as follows:

- 27% Surveying/Engineering
- 26% Construction
- 19% Agriculture
- 16% Service Sector
- 7% Government
- 5% Utility

RTN Service is reliant on CORS Density, Cell Phone Service availability and speed, and an organization willing to create the RTN base station and network. RTN providers can be state or local governments, universities, private vendors or even large corporations. RTN providers can provide services for a fee or can be free. Multiple RTN Services can provide overlapping geographic service areas in more developed states, offering various levels of RTN service quality.

For this NSDI Assessment, a simple set of four criteria was used to evaluate RTN Services for the state-by-state assessment.

1. Is there at least one RTN available in the State?
2. Do the base stations cover at least 90% of the State with minimum coverage?
3. Are the base stations, in whole or in part, elements of the national NGS CORS system?
4. Are the base stations, in whole or in part, multi-constellation and/or receiving modernized GPS frequencies (L1C, L2C, L5)?

Grades for how effectively each state can provide RTN services to users (see Table Geodetic-6 below) if these four criteria can be measured on a state-by-state basis.

Table Geodetic-5. Elements of RTN Quality. Rubric for RTN quality on a state-by-state basis (see Table Geodetic-6 below).

Grade	RTN Service
A	All 4 Criteria Met
B	3 Criteria Met
C	2 Criteria Met
D	1 Criterion Met
F	No Criteria Met

Because RTN Services are provided by many individual providers, public and private, there is no national organization which measures and evaluates RTN services. Cell phone provider coverage is also subject to private telecommunications infrastructure which has not been evaluated for the quality of its RTN capabilities nationally. Individual RTN Services providers do not always create an accepted CORS station as their RTN base station, although some do. Therefore, it would not be possible at this time to use to grade RTN Services.

The single measurable component of RTN services which can and has been measured is CORS Coverage, which directly affects the quality of the RTN Service provided. All RTN Services rely on the CORS network as their geodetic foundation for further densification of geodetic quality coordinate products for users. It is recommended that the grading of RTN Services on a state by state basis use the existing scoring from Table Geodetic-1 CORS Coverage.

Question 4. How do you typically access RTN Services in your state?	
A. RTN Service	44.44%
B. RTK Service	30.77%
C. Radio Setup	2.56%
D. None	17.09%
E. No answer	5.13%

Question 5. Who provides the RTN Service you use?	
A. Free Public / Quasi Public RTN	34.19%
B. Fee-Based Public / Quasi Public RTN	18.8%
C. Your Own RTN	5.98%
D. None	11.97%
E. No answer	5.98%

Over 75% of respondents use some kind of RTN service. 17% of respondents do not use any RTN Service. There are a variety of public and private RTN services available, sometimes with overlapping areas of service.

In the Table below, the grades for the four criteria are provided on a state-by-state basis. A final overall grade was given for each state (the last column) and for each category (the last row). The overall evaluation of these measured elements was assigned a grade of B.

Table Geodetic-6. State-by-State Assessment of Geodetic Control Quality. Rubrics for these individual criteria are presented in their respective sections, above.

State	CORS Coverage Rating	OPUS-RS Coverage Rating	Passive Control	RTN Service Rating	Overall Rating
Alabama	B	A	C	B	B
Alaska	B	B	C	B	B
Arizona	B	B	B	B	B
Arkansas	B	A	C	B	B
California	B	A	B	B	A-
Colorado	B	A	C	B	B
Connecticut	A	A	B	A	A-
Delaware	A	B	B	A	A-
Florida	B	B	A	B	B+
Georgia	B	A	C	B	B
Hawaii	A	B	B	A	A-
Idaho	B	B	C	B	B

Table Geodetic-6, *continued*. State-by-State Assessment of Geodetic Control Quality. Rubrics for these individual criteria are presented in their respective sections, above.

State	CORS Coverage Rating	OPUS-RS Coverage Rating	Passive Control Rating	RTN Service Rating	Overall Rating
Illinois	B	A	B	B	B+
Indiana	B	A	C	B	B
Iowa	B	A	C	B	B
Kansas	B	B	C	B	B
Kentucky	B	A	C	B	B
Louisiana	B	A	B	B	B+
Maine	B	B	C	B	B
Maryland	A	A	A	A	A-
Massachusetts	A	B	B	A	A-
Michigan	B	A	B	B	B+
Minnesota	B	B	B	B	B
Mississippi	B	A	C	B	B
Missouri	B	A	C	B	B
Montana	B	A	C	B	B
Nebraska	B	B	C	B	B
Nevada	B	B	C	B	B
New Hampshire	B	A	C	B	B
New Jersey	A	B	A	A	A-
New Mexico	B	B	C	B	B
New York	B	A	B	B	B+
North Carolina	A	B	B	A	A-
North Dakota	B	B	C	B	B
Ohio	B	A	B	B	B+
Oklahoma	B	A	C	B	B
Oregon	B	A	C	B	B
Pennsylvania	B	A	B	B	B+
Rhode Island	A	B	A	A	A
South Carolina	B	B	B	B	B
South Dakota	B	B	C	B	B
Tennessee	B	A	C	B	B
Texas	B	B	C	B	B
Utah	B	A	C	B	B
Vermont	B	A	B	B	B+
Virginia	B	A	B	B	B+
Washington	B	B	B	B	B
West Virginia	B	A	C	B	B
Wyoming	B	A	C	B	B
Average Element Letter Grade, 2024	**B**	**A-**	**B-**	**B**	**B**

Geodetic Control Working Group

Framework Evaluators	Federal Liaisons
John Doody, Theme Lead, AAGS & NSPS	Daniel Roman, NOAA
Dave Zilkoski, AAGS & NSPS	Juliana Blackwell, NOAA
Thomas Meyer, AAGS & NSPS	Daniel Gilliins, NOAA
	Vicki Childers, NOAA
	Shachak Pe'eri, NOAA
	Giovanni Sella, NOAA
	Colin Becker, NOAA
	John Galetzka, NOAA
	Jeffery Johnson, NOAA
	Ira Sellars, NOAA
	Michael Dennis, NOAA
	Philippe Hensel, NOAA
	Dru Smith, NOAA
	Jacob Heck, NOAA

V. Governmental Units, and Administrative and Statistical Boundaries Data Theme

Executive Summary

The domain of the Governmental Units, and Administrative and Statistical Boundaries Theme (Governmental Units Theme) is the set of boundaries for geopolitical and electoral geographical divisions of the U.S., including the nation's international, state, local, tribal, and territorial boundaries. The data theme is an integral part of the U.S. Census Bureau's activities, supporting the nation's Decennial Census, and forms an important context for nearly all legislative, judicial, and executive functions of government at the national, state, and local levels. As such, it has been a core NSDI Framework data theme since its inception. The Census Bureau, as the steward of this data theme, has successfully managed a complex update process with many state and local partners, and is now planning strategically for the future. While some uncertainties exist in future directions of the NSDI, this data theme remains well-managed, actively evolving around emerging standards, and is fit for the nation's future.

Governmental Units Theme Grade: A-

Fit for the Future

Description of the Framework

Introduction to the Theme

Governmental Units are the boundaries and names of government service and management areas at all levels of government. For the purposes of this assessment, Governmental Units are defined here - and in more detail below - as:

> *The geopolitical divisions of the U.S. including international and tribal boundaries, states and territorial boundaries, state divisions, typically counties and their equivalents, county divisions including cities, villages towns and minor civil divisions, and election geography.*

As noted in previous assessments, this framework assessment on Governmental Units excludes statistical divisions including those defined for statistical aggregation, census blocks and tracts, administrative boundaries defined for internal agency resource allocation, and other miscellaneous service areas such as emergency response zones or municipal service districts.

The Governmental Units Theme has benefited greatly from the Census Bureau's stewardship, investment, outreach and extensive coordination activities. Governmental Units are an integral part of the work products at the Census Bureau, supporting economic, election, and demographic statistics and geographies. The Census Bureau invests heavily in boundary data quality by supporting annual updates from local, state, and tribal governments, and implementing data content and quality standards, through programs such as the Boundary Quality Project. The data produced through this effort is publishing several times a year, and offering public web services.

Governmental Units are essential for defining and depicting boundaries throughout the United States. Their effects are far reaching, and impact all strata of society, from government administrators to individual homeowners. By delineating the spatial extent of legal jurisdictions, and thus the spatial extent of governance and laws, everyday life is dramatically impacted by the spatial lines drawn by geographers and cartographers. Crossing a governmental unit boundary can result in changes to laws, regulations, and administrative oversight. New speed limits, different tax rates, and changes to liquor and tobacco laws are common. An example case from just over a decade ago, cited in the 2018 report, highlights the importance of precise, accurate, and comprehensive geospatial data of Governmental Units.

As a result of a boundary resurvey of the North and South Carolina state line, a gasoline and fireworks business on the state line in South Carolina was found to be located in North Carolina where fireworks sales are illegal. Details of this boundary resurvey are documented by the South Carolina Revenue and Fiscal Affairs Office (South Carolina, n.d.). Inaccuracies of mere meters can have a massive financial impact on individuals and businesses should they end up on the wrong side of an imprecise demarcation. As noted by the Revenue and Fiscal Affairs Office, the intent of the boundary resurvey was:

> "*to avoid a litigious dispute, such as occurred between South Carolina and Georgia regarding their boundary in the Lower Savannah River area. This contentious dispute cost the state $10 million and 26 years of litigation and negotiation, that involved the U.S. Supreme Court and Congress, to resolve 25 miles of boundary.*"

Boundaries shifts at the state level are uncommon in the modern era, with resurveys and adjustments only authorized by the Supreme Court or in agreement between states with the consent of Congress (See §5.19 of "Manual of Survey Instructions," https://www.cadastral.com/73manl-1.htm). Permanent, verifiable boundaries are essential for governance at all administrative levels of government.

Governmental Units provide the basis of the size, shape, and organization of places in the U.S. Examples of the uses and applications for Governmental Units include the following:

- Governance
- Election management
- Area of interest or map orientation
- Navigation and search and rescue
- Addressing (both addressing authority and address search and orientation)
- Real estate tax rates and collection
- Unique identification of places, and
- Allocation of Title 1 funding for school districts

A quote from both previous assessments on Governmental Units (Bossler et al., 2015; Freundschuh et al., 2018) remains true:

> *"When the USGS published The National Map Customer Requirements Findings from Interviews and Surveys in 2009, the need for civil boundaries and Federal and Native American lands were ranked in the top ten of data requirements."*

Theme Definition

The previous 2015 and 2018 reports on the Governmental Units Theme provide a useful summary of theme, much of which is echoed below. The current FY2025-2027 draft Strategic Plan for the Government Units Theme provides additional information on how the theme will develop in the future, and is recommended when it becomes public. Generally, the mandate of the Governmental Units Theme definition remains unchanged from prior years reports. In both the 2015 and 2018 NSDI report cards, the Governmental Units Theme included the following:

- Governmental Units — These data describe, by a consistent set of rules and semantic definitions, the official boundaries of federal, state, local, and tribal governments as reported/certified to the U.S. Census Bureau by responsible officials of each government for purposes of reporting the nation's official statistics.
- International Boundaries —International boundary data sets include both textual information to describe, and the cartographic data to depict, both land and maritime international boundaries, other lines of separation, limits, zones, enclaves, exclaves, and special areas between states and dependencies.
- Marine Boundaries — Marine boundaries depict offshore waters and seabeds over which the U.S. has sovereignty and jurisdiction.
- Additional definitions are provided by the Federal Geographic Data Committee (FGDC) Sub-committee on Cultural and Demographic Data (SCDD) including the following for governmental and administrative units:

  > *"A governmental unit is a geographic area with legally defined boundaries established under Federal, Tribal, State, or local law, and with the authority to elect or appoint officials and raise revenues through taxes."*
  >
  > *"An administrative unit is a geographic area established by rule or regulation of a legislative, executive, or judicial governmental authority, a non-profit organization, or private industry for the execution of some function. A statistical unit is a geographic area defined for the collection, tabulation, and/or publication of demographic, and/or other statistical data."*

COGO's 2015 and 2018 NSDI assessments of this theme describe an expanded portfolio management approach with Governmental Units including administrative and statistical boundaries, encompassing 70 separate datasets. A September 2024 search of data.gov (https://catalog.data.gov/dataset) using "Governmental Units" as a search criterion returned 2,792 data sets (down from 3,098 in 2018). A similar search of the National

Geospatial Data Asset Datasets site returned 34 datasets for "Governmental Units, and Administrative and Statistical Boundaries" (down from 39 in August 2018).

As noted below in comments about the Governmental Unit Theme's Capacity, the currently maintained Census Bureau Governmental Units Theme is comprised of 34 Individual National Geospatial Data Asset datasets available through the associated Geoplatform.gov NGDA Theme Page (https://ngda-gov-units-geoplatform.hub.arcgis.com/). This large collection of Governmental Units datasets is a subset of the even larger 171 NGDA datasets. This demonstrates the need to include "Governmental Units" as a federal data metadata keyword term.

As with previous assessments, statistical and administrative areas are not part of this evaluation, nor are the U.S. international boundary data sets as they are integrated into the Census Bureau's voluminous data sets. As a way of establishing broader context for the voluminous geospatial data curated by the Census Bureau, a recent count of national-level features within the 2020 Census Data https://www.census.gov/geographies/reference-files/time-series/geo/tallies.html), yields the following tallies:

- 85,528 Census Tracts
- 242,747 Block Groups
- 8,180,866 Blocks
- 32,188 Places
- 392 Metropolitan Statistical Areas
- 441 Congressional Districts
- 158,444 Voting Districts
- 13,292 School Districts, and
- 33,791 Zip Code Tabulation Areas

Each of these features has complex border geometry associated with it, and is available for download through the data portals managed by the Census Bureau, as well as through data.gov. As noted above, this assessment and previous assessments limited the scope significantly to those layers described above.

The emerging FY 2025-2027 Governmental Units, and Administrative and Statistical Boundaries Theme Strategic Plan notes active work by the Census Bureau with the International Boundary Commission, the International Boundary and Water Commission, and many other federal, state, and tribal agencies, working groups and stakeholders with an interest in the definition of the Governmental Units Theme and associated boundaries. This strategic plan, currently in draft form, provides a helpful review of the theme's evolution, components, and areas of focus over the past several decades.

Election geography was not addressed specifically in either the 2015 or 2018 report cards, and is also excluded here. The concepts and applications defining and maintaining election geography are beyond the scope of this evaluation as they can have varying interpretations depending on the level of government, governing statutes, and

applications or uses for the data. In the years since the prior report, election precincts became important during the 2020 redistricting process. The definition of election geography is impacted by various authorities and laws, both state and local. However, aggregation of precinct data and precinct areas are not part of the Office of Management and Budget (OMB) Circular A-16 responsibility or definition.

Thus, with these revisions and for the purposes of this evaluation, the Governmental Units Theme is defined as:

> *"The geopolitical divisions of the U.S. including international and tribal boundaries, states and territorial boundaries, state divisions, typically counties and their equivalents, county divisions including cities, villages towns and minor civil divisions, and election geography*."

Lead Agency and Current Activities

The Geospatial Data Act of 2018 (GDA) identifies the role of covered agencies in managing NSDI framework data themes and requires OMB to update previous Circular A-16 guidance to further define the roles and responsibilities of these agencies, in their role as data stewards. The Census Bureau continues its role as the lead covered agency for the Governmental Units data theme and is responsible for "ensuring the coordinated management of the data, supporting resources (including technology and personnel), and related services and products of the National Geospatial Data Asset data theme."

Section 2808 of the GDA enumerates the responsibilities of the Census Bureau in relation to the Governmental Units Theme. These include the development of strategy for advancing the theme, sharing the theme with federal and non-federal users, promoting integration of the theme's geospatial data with all other sources, using relevant geospatial data standards, and coordinating with other federal agencies, including state, local, and tribal governments. Additional budgetary, reporting, and auditing requirements are established as well.

The GDA has served as an important event for the FGDC and stewardship of all NSDI data themes, as it outlines the responsibilities of the FGDC in developing and managing the National Spatial Data Infrastructure (NSDI). The NSDI is more than the just the geospatial data reviewed in this report. It also includes the

> *"technology, policies, criteria, standards, and employees necessary to promote geospatial data sharing throughout the federal, tribal, state, and local governments, and the private sector (including nonprofit organizations and institutions of higher education."* (Advancement of the National Spatial Data Infrastructure, https://www.fgdc.gov/nsdi/nsdi.html).

The FGDC's release of the 2025-2035 strategic plan, and its impact on the broad goals of the NSDI, is highly anticipated. Attention should be paid to key areas mentioned in this and other chapters about the developing geospatial metadata standards that will have a large impact on the availability and interoperability of the Governmental Units data theme.

Collaboration and Partnerships

The Census Bureau has an extensive funded and staffed program that focuses on developing agreements for data sharing, data maintenance, and submissions to the Boundary Annexation Survey (BAS). More so than many of the other Framework Data Themes discussed in this report, the Governmental Units Theme requires a complex series of partnerships and collaborations with other entities to gather foundational data. These entities include other federal agencies, as well as state, local, and tribal governments, with the more intensive collaborations at the local levels where the majority of boundary changes take place. The Cadastral Data Theme in this report has a similar dynamic, with complex multi-scale data collection programs.

The Boundary Annexation Survey is one of the key programs for updating Governmental Units data as it provides an annual mechanism for tribal, state, and local governments to check and review the Census Bureau's boundary data and provide updates, frequently in digital format. In its descriptive flyer of the BAS program (https://www2.census.gov/geo/pdfs/partnerships/bas/BAS-Flyer.pdf), the Census Bureau's explains the nature of the program, below.

> *"Through BAS, governments can report legal boundary changes, such as annexations and de-annexations; legal status changes, such as incorporations and disincorporations; and small corrections to spatially incorrect boundaries. Governments can update boundaries, features, and landmarks for:*
>
> - Federally recognized tribes with a reservation or off-reservation trust lands
> - States
> - Counties or county equivalents, such as boroughs or parishes
> - Incorporated places, such as cities, towns, boroughs, and villages
> - Minor civil divisions, such as towns and townships
> - Consolidated cities
> - Census Designated Places (CDPs)

The BAS is a complex and voluntary process, and while it has been successful, it is an area of significant risk, due to the possible complications posed by newly adopted standards and data formats, as well as the inherently complex digital submissions processes. The presence of several technical tools for facilitating the exchange of information is useful. The Census provides the BAS Partnership Toolbox, Geographic Update Partnership Software (GUPS), and where necessary, a manual annotation process using paper maps and other documents.

Another key collaboration supporting the Governmental Units Framework data theme is the National Boundaries Group (NBG), a working group co-lead by USGS and Census staff, who "*coordinate boundary information sharing among federal, state, local, tribal, and private organizations*." The goals of the NBG, outlined in their associated Geoplatform.gov portal, are:

- Creating an open exchange of information about boundary data
- Assuring availability of, and public access to, boundary data and associated

metadata from distributed databases

- Investigating, evaluating, promoting, and implementing new technologies to improve boundary accuracy and integration
- Supporting coordination and standards goals, and objectives established by federal, national and international standards organizations

Extensive meeting minutes, updates, presentations exist that document the significant level of collaboration between USGS and Census to support this Framework data theme, with participation and input from a constellation of other federal agencies. Many of these are available at the National Boundary Group's Work Group page (https://ngda-gov-units-geoplatform.hub.arcgis.com/pages/national-boundaries-group) and this list of the federal agencies that participate in the NBG (https://www.fgdc.gov/organization/working-groupssubcommittees/nbg/nbg-participating-agencies.pdf).

Standards

Since COGO's 2018 NSDI report, the FGDC has prioritized the testing, adoption, and establishment of national and global standards, including standards for metadata, data cataloging, data search and discovery, geospatial service data, web application interoperability, and data quality. The GDA requires lead covered agencies to develop and implement standards consistent with relevant community and international practices. The Census Bureau has participated in this process and with FGDC is exploring new standards based on the widely used Data Catalog Vocabulary, v.3.0. The goal of this standard is echoed in the Federal Data Chief Officer Council's FAIRness project (https://github.com/DOI-DO/dcat-us/wiki), which seeks to have data be Findable, Accessible, Interoperable, and Reusable. Census staff are knowledgeable about this effort and actively engaged in the implementation of the project principles, which will be essential in the furtherance of standards for the Governmental Units Theme.

Census staff are also actively aware of the requirement in the GDA to achieve complete compliance with FGDC adopted standards within a five-year window, or risk the loss of funding. Due to the current and former Census leadership at several levels of FGDC and NGAC, the awareness of standards, adoption schedules, and convergence with standards of other groups, notably United Nations Integrated Geospatial Information Framework (UN-IGIF, https://ggim.un.org/UN-IGIF/), the Governmental Units data theme is in very good shape with regards to standards. Where possible, convergence with European and United Nations data standards would increase the interoperability and capabilities of federal, state, local, and tribal governments. Additionally, the Census Bureau has active metadata production workflows to comply with ISO 19115-1, ISO 19115-3 metadata standards adopted by FGDC and used by other agencies such as HUD and BLM. The Census Bureau also submits annual reports to the National Institute of Standards and Technology (NIST) to summarize agency activities undertaken to comply with the provisions of OMB Circular A-119 (https://www.whitehouse.gov/wp-content/uploads/2017/11/Circular-119-1.pdf) which "establishes policies on Federal use and

development of voluntary consensus standards and on conformity assessment activities."

Theme Completeness

The Census Bureau's data collectively provides coverage for the U.S, States, Territories, Counties (state divisions), County Subdivisions (incorporated and unincorporated areas), and Legislative Districts for the U.S. Congress and State legislatures. As indicated, the Census Bureau has responsibility for Governmental Units and serves as a national steward for these data sets.

Maintaining a complete and accurate inventory of Governmental Units is essential for Census activity, facilitating the aggregation and generation of accurate statistical estimates and counts from the decennial census and surveys. While the combined datasets are national in geographic coverage, the timeliness of the data is challenging due to the increasingly complex process of data update. The Census Bureau's Boundary and Annexation Survey program is national in scope and voluntary in participation, but essential for managing boundary changes, particularly at the local level, where the vast majority of boundary changes occur. As noted in COGO's 2018 report,

> *"no other Federal agency collects these data nor is there a standard collection of this information at the state level. The Census Bureau's BAS is a unique survey providing a standard result for use by federal, state, local, and tribal governments and by commercial, private, and public organizations."*

The growing complexity of online tools and digital submissions used for the BAS process makes this an important area for the Governmental Units data theme.

Accessibility of Data

Since the 2018 report, the Census Bureau has updated their web interface for accessing and downloading their Governmental Units GIS data, and re-organized their website. The Census Bureau's signature governmental unit data product is their TIGER/Line data, which cover an extensive range of Governmental Units across geographic scales, including county subdivisions, counties, states, and national borders. Shapefiles are also available for the Census Bureau's statistical aggregation units (census blocks, block groups, and statistical areas), as well as for consolidated cities, state legislative districts, and school districts. As in 2018, the TIGERweb portal (Figure 1) contains the most recent updates of the Census Bureau's TIGER/Line data, available for download as shapefiles or geodatabases. Additionally, the site provides access to their Representational State Transfer (REST) Services, and Web Map Service (WMS). Users can navigate the data either through a web interface, or directly through the FTB archive, the latter of which includes data in both shapefile and KML formats.

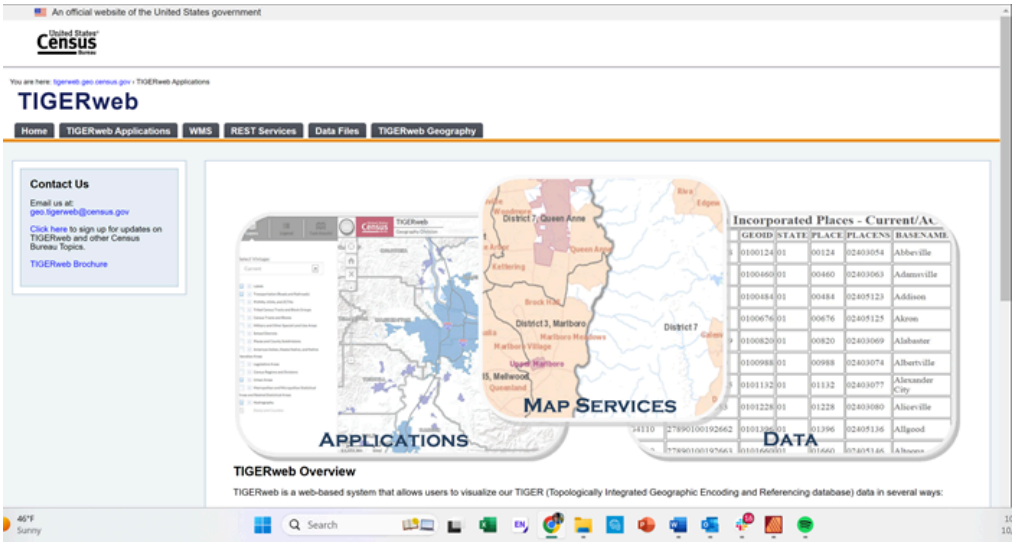


Figure GovtUnits-1. TIGERweb, available at https://tigerweb.geo.census.gov/tigerwebmain/TIGERweb_main.html. *Source: U.S. Census.*

In addition to their existing TIGERweb portal, TIGER/Line shapefile data can also be accessed through the Census Bureau's mapping files site (Figure 2). Compared to the existing TIGERweb portal, the Census Bureau's Mapping Data site requires more clicks to navigate, and locating individual pages can prove a challenge, as the landing page does not provide a comprehensive overview of the resources available on the website. Notably, a link to the page in which shapefiles for TIGER/Line data can be downloaded is not present on the landing page.

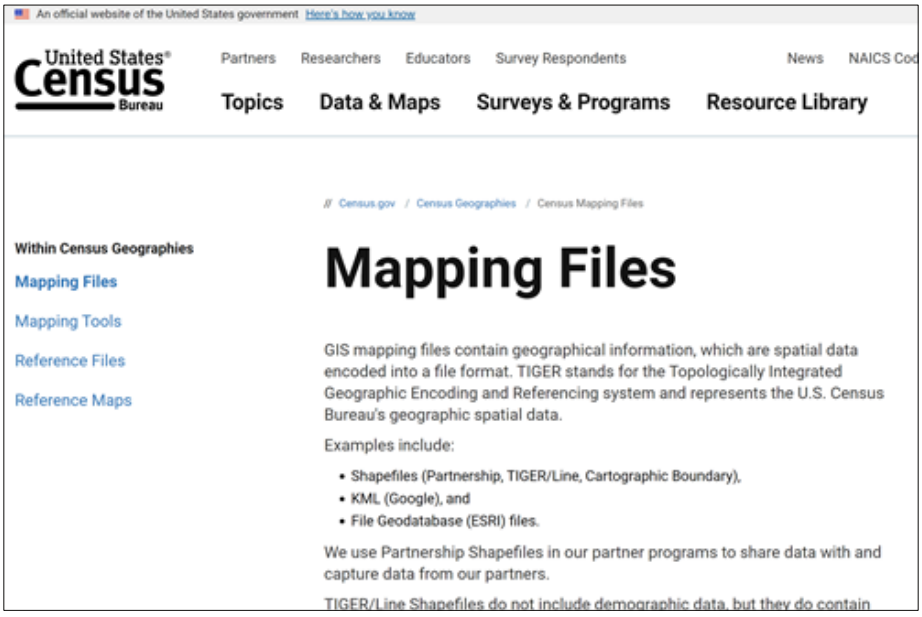


Figure GovtUnits-2. The Mapping Files landing page, available at https://www.census.gov/geographies/mapping-files.html. *Source: U.S. Census.*

Authority, Governance, and Management of the Theme

The Federal Office of Management and Budget Circular A-16 provides direction to federal agencies that produce spatial data, and establishes the authority and guidance under which the NSDI is developed and managed by the Federal Geographic Data Committee (FGDC). The Census Bureau has been and continues to be the steward for the Governmental Units, with responsibilities as the covered agency, defined in the 2018 National Geospatial Data Act, §2805. The U.S. Census Bureau is responsible for the theme's strategic plan, implantation plan, development, use, sharing and dissemination. Additionally, Census coordinates with other federal agencies as well as state, local, and tribal governments. The quality of the Governmental Units Theme is dependent on the continuous update of the MAF/TIGER System which is the major operational function of the Geography Division of the Census Bureau.

The Governmental Units Assessment

The following assessment is organized according to standard criteria used in previous COGO reports. The status of the theme based on each criterion was drawn from interviews and information gleaned from Census Bureau and FGDC documents, presentations, and reports.

1. Capacity: ***The framework's capacity to meet current and future demands.***

The currently maintained Census Bureau Governmental Units Theme is comprised of 34 Individual National Geospatial Data Asset datasets available through the associated Geoplatform.gov NGDA Theme Page (https://ngda-gov-units-geoplatform.hub.arcgis.com/). This large collection of Governmental Units datasets is a subset of the even larger 171 NGDA datasets. The Governmental Units NGDA datasets and over-arching Framework data theme have been developed through the extensive collaborations and partnerships noted above. The 34 NGDA datasets provide identification, description, and delineation of all incorporated places, counties (and county equivalents, such as independent cities), states, and territories of the U.S. This data layer is both complete and well-maintained. As such, it meets the current needs, and will meet future needs if the trajectory does not change.

2. Funding: ***The funding capability of the Framework.***

The Governmental Units Framework Data Theme supports a constitutionally mandated decennial census, as well as providing the important geographic context for a majority of the executive, legislative, and judicial activities of government on the federal, state, and local levels. At present, the funding seems relatively secure in supporting the necessary staffing and technical resources required to produce the creation, maintenance, and publication needs for the data sets of this theme. However, this does not constitute an absolute guarantee of future funding; political consequences stemming from disagreements over census enumeration of immigrant groups has raised some concerns, along with the more routine concerns about government cutbacks, hiring freezes, and resource reductions.

3. Future Needs: ***Whether funding prospects will be able to meet future needs.***

While it is impossible to predict the future with any certainty, funding seems relatively stable for the present. Staffing and resources are adequate to support the activities related to this data theme and the associated missions of the Census Bureau. A key to future needs being met is the continued participation of the Census Bureau's Geography Division Chief and Federal Theme Leads, who are actively involved and leading NSDI efforts within the FGDC community.

The complexity of the digital submissions process for updating the theme should be carefully monitored to ensure that voluntary compliance with the data updates continues at a level necessary to ensure the theme maintains its high quality. While digital submission processes can reduce some types of error and be timelier and more efficient, they can also lead to a drop in participation due to complexity and perceived difficulty.

4. Operation and Maintenance: ***The ability of key lead organizations to develop and maintain the Framework and to adopt new technology, procedures, and standards.***

The Census Bureau has had the long-term benefit of engaged leadership, particularly in the Geography Division, which is a critical part of the creation, maintenance, and publishing of this data theme. This leadership is coupled with a history of successfully adopting new technology and standards. Tools for digital data submissions and updates are helpful, and can accommodate a wide variety of data input formats. A continued focus on staff recruitment and training is essential to keep the operation and maintenance of this data theme in good shape. Currently, the 34 production datasets that comprise the Governmental Units Theme include several million features, including more than five million polygons and over 1 billion line segments. Datasets of this size are inherently complex to create, maintain, and publish, requiring significant planning and resources. Careful consideration should be made to any significant changes in format or content, or in the implementation of emerging standards. So far, the operation and maintenance of the data theme has been satisfactory, and is likely to remain so.

5. Public Use: ***The Framework's ability to provide data resources that meet the everyday needs of organizations and the general public, and to provide data resources that meet the need to respond to public safety incidents, natural disasters, and other emergencies.***

As described in the accessibility section of this report, this data theme is widely available through the Census Bureau's own web portal, and through geoplatform.gov, data.gov, and a number of other data portals that use the metadata records from Census.gov to facilitate search and discovery. The Governmental Units data is available in a variety of different GIS formats that can be used in a variety of different software systems. The data for this theme is a foundation for mapping, analysis, and a large proportion of other government activity.

6. Resilience: ***The ability of the geospatial community to participate in development of the Framework and to contribute to its sustainability as a long-term asset of value for the nation.***

The long-term resilience of this data theme is tied directly to the success of the annual Boundary Annexation Survey, and other voluntary activities that provide critical updates. Similar to the Cadastral Framework Data Theme discussed in this report, the

majority of important changes are recorded locally. With this in mind, the resilience of this theme may become a direct by-product of the usability of the digital submission tools and the management of this process by Census Bureau personnel. Another matter entirely is the success of the publication and dissemination of the geospatial data associated with the data themes, managed by FGDC leadership. While problems with the Geoplatform may be discussed elsewhere in this report, the specific resilience of this theme will be more directly tied to the success of the Census Bureau's partnerships and collaborations.

Overall Assessment of the Governmental Units Data Theme

A clear observation of the Framework Evaluators responsible for this chapter is the good fortune to have the current and former leadership responsible for this theme directly engaged with the highest levels of leadership at FGDC and NGAC. This will continue to benefit the users of the Governmental Units Theme, as it lessens the possible impacts of changes in standards, formats, or dissemination mechanisms, which are largely the responsibility of FGDC leadership. The Census Bureau has made significant process since the 2015 COGO report, and has made additional further progress in the last six years. The consolidated BAS reporting and data collection processes are a key, as is successful relationships with other federal agencies and working groups, such as the National Boundaries Group. Cautious attention should be paid to the complexity of the BAS processes and digital submissions, which has an impact on the level of voluntary compliance. The degree to which the BAS processes could be partially automated has not been assessed by the Framework Evaluators, but should be explored.

The Governmental Units theme is complete and well-maintained. It is built on partnerships and collaboration with authoritative state, local, and tribal governments. It is adequately funded, and easily accessed. Adoption and implementation of new standards adopted by FGDC, including metadata standards to facilitate interoperability and search, is underway. Convergence with frameworks and standards adopted by international partners is encouraged, particularly UN-GGIM / IGIF.

In the opinion of the Framework Evaluators and Reviewers, the Governmental Units Theme is FIT FOR THE FUTURE, with a GRADE of A-.

Government Units Data Theme Work Group

Framework Evaluators and Reviewers	Federal Liaisons
Matt Rice, Theme Lead, CaGIS	Dierdre Bevington-Attardi, Census Bureau
Joel Conti, CaGIS	
Keith Clarke, CaGIS	
Nathan Burtch, George Mason University	
Katharine Perkin, CaGIS	

The 2024 Framework Evaluators thank the previous 2018 Framework Evaluators for their comprehensive work that formed the starting point for this assessment. Some of the relevant, useful text of that assessment is contained in this assessment. They are Nancy von Meyer, and Hunter Key, both affiliated with URISA.

VI. Hydrography Data Theme

Executive Summary

The U.S. Geological Survey (USGS) has begun a transition from the National Hydrography Dataset (NHD) to a new 3D Hydrography Program (3DHP), as the surface water mapping component of the new 3D National Topography Model (3DNTM). This next generation of surface water mapping under the new 3DHP will incorporate the most relevant and impactful components of the existing NHD with greatly improved spatial accuracy; thus, it will provide better support for hydrologic modeling and accounting.

For this review, the COGO Hydrography Theme team evaluated the transition state of hydrography data for the nation and the 3DHP implementation to date. The previous 2018 COGO Hydrography report was incorporated into the narrative where appropriate and relevant. Additionally, results from two community surveys were considered: the National Spatial Data Infrastructure (NSDI) survey conducted by COGO, and the National States Geographic Information Council (NSGIC) 2023 Geospatial Maturity Assessment (GMA). Also considered is the report for the GDA - 2023 Lead Covered Agency NGDA Theme Annual Performance Report and Self-Assessment for Water – Inland Theme from USGS.

The transition from NHD to 3DHP is a necessary step for the advancement of hydrography systems. Recommendations for improvement of the hydrography theme are primarily focused on communication and funding. Addressing communication gaps, improving user awareness, fostering collaboration, and developing a comprehensive funding strategy are critical components for the successful and sustainable implementation of 3DHP.

Hydrography Theme Grade: B-

Adequate for Now

DESCRIPTION OF THE FRAMEWORK

An Introduction to the Theme

Hydrography data is critical in decision making across jurisdictions and disciplines. As with other data themes, many users need hydrographic features as reference or base map data. These data have also assisted with monitoring water quality and availability, agriculture, flood risk management, environmental health, land suitability, wildlife management and coastal processes, among many others. OMB Circular No. A 16 of August 19, 2002, Supplemental Guidance (November 10, 2010) listed Hydrography as a framework layer theme of the National Spatial Data Infrastructure (NSDI) and assigned responsibility to the Department of Interior, United States Geological Survey. The National Geospatial Data Asset (NGDA) hydrography theme was changed when the

FGDC published A-16 supplemental guidance Appendix E - NGDA Data Themes, Definitions & Lead Agencies on August 19th, 2011, and revised the original list of 34 NSDI Data Themes to 16 National Geospatial Data Asset (NGDA). The "Water - Inland" theme name change took place and hydrography was listed as one of the data sets. The Water-Inland Theme contains more than just hydrography as shown below in a table from the January 19, 2024 2023 Lead Covered Agency NGDA Theme Annual Performance Report and Self-Assessment for Water – Inland Theme.

Table Hydrography-1. Multiple NGDA datasets exist for the Water-Inland Theme. This assessment report is only focused on hydrography (NGDAID 159).

NGDAID	Water – Inland Theme NGDA Datasets	Agency
159	National Hydrography Dataset (NHD) - USGS National Map Downloadable Data Collection	U.S. Department of the Interior, U.S. Geological Survey
160	National Inventory of Dams	U.S. Department of Defense, U.S. Army Corps of Engineers
161	National Levee Database	U.S. Department of Defense, U.S. Army Corps of Engineers
162	USFWS National Wetlands Inventory	U.S. Department of the Interior, U.S. Fish and Wildlife Service
163	Watershed Boundary Dataset (WBD) - USGS National Map Downloadable Data Collection	U.S. Department of the Interior, U.S. Geological Survey

Historically, the NSDI Hydrography Data Framework was based on an approach developed for the EPA and the USGS. This approach resulted in the Watershed Boundary Dataset (WBD), the National Hydrography Dataset (NHD) and the NHDPlus; the NHDPlus includes additional hydrographic features at a higher resolution. Nationwide, the NHD has become increasingly complex and inconsistent in its accuracy across regions. Leveraging the results of the 2016 Hydrography Requirements and Benefits Study (HRBS) that indicated a modernized 3D-enabled hydrography program could provide up to $1.14 billion annually in benefits if all user requirements were met, the U.S. Geological Survey (USGS) has begun the transition to a new 3D Hydrography Program (3DHP), as the surface water mapping component of the new 3D National Topography Model (3DNTM).

The 3DNTM is a new USGS initiative aimed at embracing the inherent relationship between the Earth's surface and the water that interacts with it. The initiative updates and integrates USGS elevation and hydrography data to model the Nation in 3D. The transition to this integrated approach to create and manage elevation and hydrography data will result in higher quality data that are updated more frequently. The 3DNTM provides the terrestrial component of the USGS and National Oceanic and Atmospheric Administration (NOAA) shared vision of a 3D Nation to build an elevation foundation.

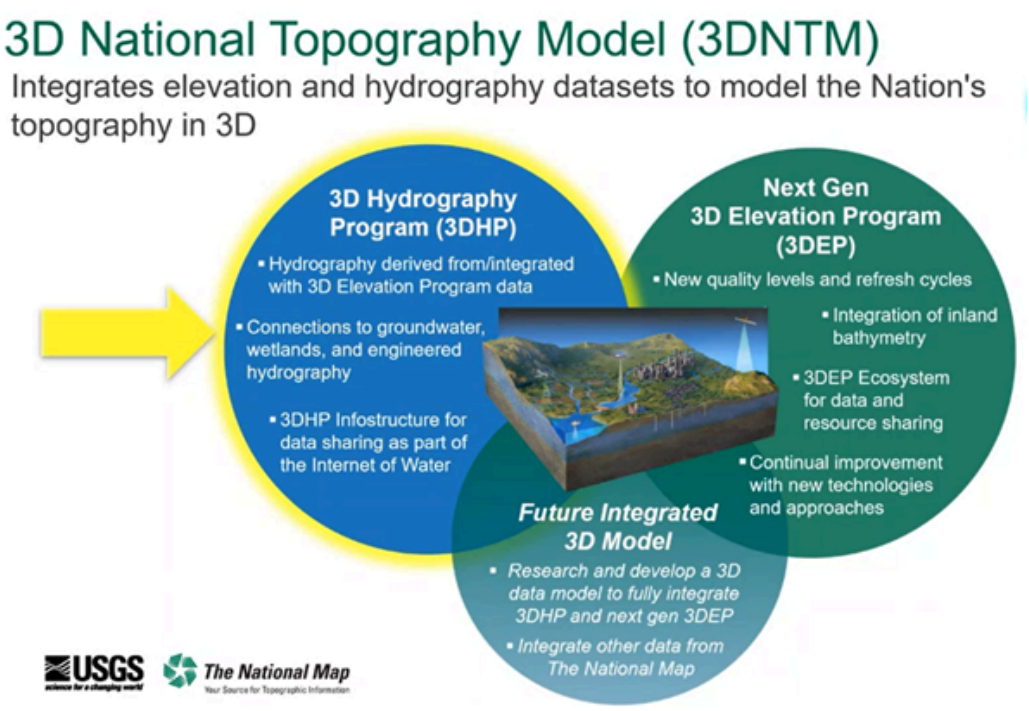


Figure Hydrography-1. The 3DNTM initiative recognizes the inherent relationship between the Earth's surface and the water that interacts with it. The initiative updates and integrates USGS elevation and hydrography data to model the Nation in 3D. *Source: USGS.*

In describing the 3D Hydrography Program (https://www.usgs.gov/3DHP), the USGS states, "The 3DHP will significantly improve the level of detail, currency, and content of hydrography data by deriving (1) three-dimensional (3D) stream network datasets and watersheds from high-quality 3D Elevation Program (3DEP) data and (2) other elevation derivatives to support applications like hydrologic and hydraulic modeling. The 3DHP will improve the ability to track information related to water as it moves through the hydrologic cycle by connecting surface-water features traditionally represented in the National Hydrography Dataset (NHD) to data about wetlands, engineered hydrologic systems, and groundwater; it will also improve the attribution of important hydrologic characteristics like streamflow permanence."

In September 2022, a new report on 3D nation elevation was published (Dewberry 2022), and a substantial portion defines the requirements for inland bathymetry and related products as input to the 3DHP. However, it does not reach a conclusion, stating *"There has been very little inland bathymetry collected and made publicly available to date. USGS has collected data for a few pilot projects and U.S. Army Corps of Engineers (USACE) has collected data in some navigable waters, but overall, very little data are available. 17% of the respondents said the data they need are not available; 26% report using navigation charts as the source of inland bathymetry rather than a digital elevation model (DEM)."*

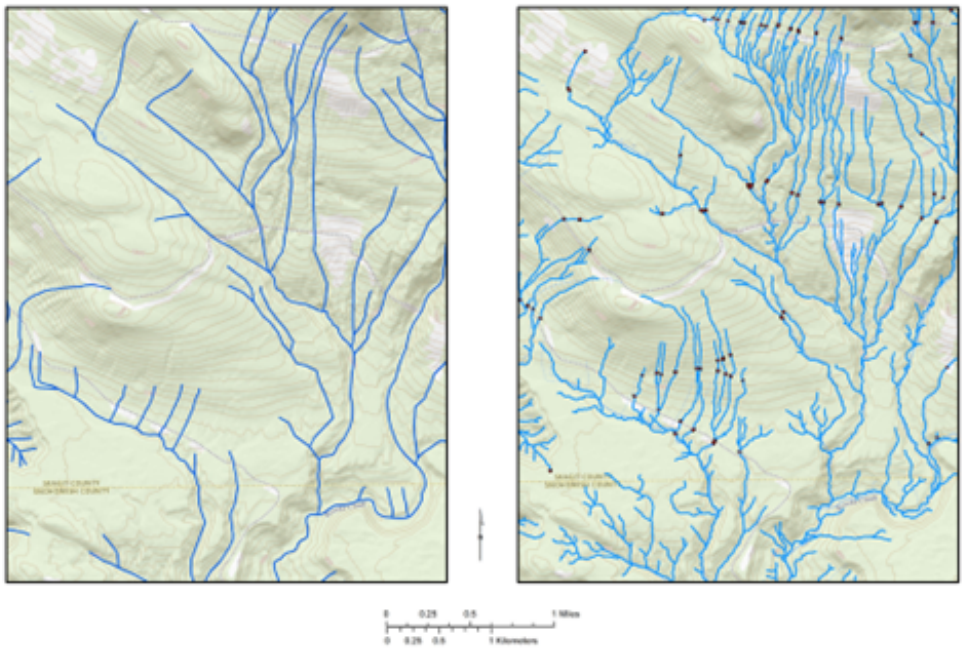


Figure Hydrology-2. Improved alignment is possible in the 3D Hydrography Program by deriving hydrography data from high-quality 3DEP elevation data. *Source: USGS.*

This next generation of surface water mapping under the new 3DHP will incorporate the most relevant and impactful components of the existing NHD with greatly improved spatial accuracy; thus, it will provide better support for hydrologic modeling and accounting. This approach will create a standardized specification for EDH that replaces the NHD and will serve as a single best source of hydrography location information.

With the roll out of this new program, this theme is in transition. The maintenance and active updates of the traditional data products, the National Hydrography Dataset (NHD), Watershed Boundary Dataset (WBD) and the NHDPlus High Resolution (NHDPlus HR), have been phased out. Static versions of these datasets will be available while the 3DHP data is being developed.

Theme Definition and Lead Agency

The National Geospatial Data Asset (NGDA) Water - Inland Theme is defined as Interior hydrologic features and characteristics, including classification, measurements, location, and extent. Includes aquifers, watersheds, wetlands, navigation, water quality, water quantity, and groundwater information (https://ngda-water-inland-geoplatform.hub.arcgis.com/). Theme Lead Agencies designated under OMB Circular A-16 are the U.S. Geological Survey and the U.S. Fish and Wildlife Service. These agencies are responsible under USC 43 Sec 2805(b)(2) for … "ensuring the coordinated management of the data, supporting resources, and related services and products of the National Geospatial Data Asset data theme." As indicated earlier, this Assessment report will focus only on NGDAID 159 (National Hydrography Dataset) rather than other datasets that are included within this Theme (see Table Hydrography-1)

Collaboration and Partnerships

3DHP is managed by the USGS, with collaboration, support, and cost-sharing with many other federal, state, and local entities. 3DHP is one part of a new USGS initiative, the 3D National Topography Model (3DNTM), which integrates elevation and hydrography to support scientific requirements and data driven decision making. The 3DNTM Data Collaboration Announcement (DCA) is a publicly accessible process for partnership opportunities to cooperatively acquire high resolution 3D elevation and hydrography data.

The USGS communicates with partners through monthly Hydrography community calls. These online virtual meetings offer an opportunity for stewards to receive information, get assistance with technical tasks, ask questions, and provide feedback on 3DHP program development. Additionally, states are assigned a dedicated National Map Liaison at the USGS to assist with questions.

USGS also has a cooperative agreement with the National States Geographic Information Council (NSGIC) to engage and support state and local governments in the derivation of a 3D stream network. NSGIC hosts regular meetings that provide a forum for information exchange, data acquisition best practices, use cases and 3DHP education.

Standards

The available 3DHP products consist of data from the National Hydrography Dataset (NHD) and hydrography derived from elevation, stored in a common data model. USGS has already created detailed specifications for 3DHP found in their Standards and Specifications document, and the Representation, Extraction, Attribution, and Delineation (READ) Rules. These two documents form the specifications for contractors to meet when creating Elevation Derived Hydrography for 3DHP.

The legacy NHD data integrated into the current 3DHP products relied on the Geographic Information Framework Data Content Standard. The standard was endorsed in 2008 as FGDC-STD-014-2008, and hydrography is one of the parts of the standard. According to the standards document, the goal of the hydrography part of the Framework Data Content Standard is to provide common definitions and syntax to enable collaborative development, use, and exchange of hydrography data.

Estimate of Theme Completeness

Inland hydrography data development for the nation is currently in transition. The previous approach to data development and maintenance through the NHD, NHDPlus high resolution, and the WBD has been phased out and these datasets, while still available, are no longer being maintained. NHD and NHDPlus attribution and associated tables became overly complex. As a result, data access and usefulness subsequently became challenging for the end user and the state stewards responsible for maintaining the data.

3DHP solves this dilemma through minimizing the complexity of the core schema while providing the mechanism for the end user to join their relevant complex information to

the framework by location. In the 2023 GDA self-assessment report, USGS describes this transition, "In FY2023 USGS completed development of the National Hydrography Dataset (NHD) and NHDPlus High-Resolution (NHDPlus HR). USGS completed 9,487 user-submitted corrections to the NHD before publishing the final products. NHD data were then converted to the new 3D Hydrography Program (3DHP) data model. Steward editing of the Watershed Boundary Dataset (WBD) was frozen; during FY2024 the USGS will make some final improvements to the WBD in anticipation of a final version to be published in late FY2024. USGS also expanded partnership opportunities for State, local, Tribal, and other entities to collect 3D hydrography data through the 3D National Topography Model (3DNTM) Data Collaboration Announcement (https://usgs.gov/3dntm/dca). During FY23 USGS contracted for 88,000 square miles of new hydrography data in Alaska, and 47,000 square miles of new hydrography data in CONUS."

With the transition to 3DHP, the geometry and selected attribute information from these datasets has been utilized to establish a baseline. 3DHP data development and methodology is currently being piloted in several states. Not enough time has elapsed for the 3DHP to be effectively evaluated for completeness.

Accessibility of Data

NHD data sets are readily available for download at 1:24,000-scale and 1:100,000-scale nation- wide from the USGS. NHD data sets, including the WBD, are part of the National Map and multiple web-based map services are available. The NHDPlus (1:100,000-scale) and the NHDPlus HR (1:24,000-scale) are currently available for download or consumption via web mapping services.

The downloadable data, feature rules, data models, user guide, and further information are available (https://nhd.usgs.gov/). The NHD is also accessible through the Geoplatform.gov Dataset Search (https://geoplatform.gov), as well as through various state-maintained websites and web mapping services. It is important to note, that these products have been retired and there is no mechanism to ingest updates.

For current data consumers, the web mapping services are difficult to use, and performance is lacking. The scale dependency necessary to depict features is less than optimal for the end user. As this service is not feature based, end users are unable to extract features for their area of interest. Until 3DHP data products are available and modernized for larger regions of the nation, local, regional and state entities will continue to utilize their local hydrology data, which in many cases, is built from the NHD data products.

Authority, Governance, and Management of the Theme

Theme Lead Agencies designated for hydrography is the U.S. Geological Survey. This agency is responsible under USC 43 Sec 2805(b)(2) for …"ensuring the coordinated management of the data, supporting resources, and related services and products of the National Geospatial Data Asset data theme." The National Spatial Data Infrastructure Strategic Plan 2021–2024 sets the following goals:

- Goal 1: Implement the National Geospatial Policy and Governance Framework as Defined by the Geospatial Data Act and Related Statutes and Policies
- Goal 2: Advance the Maturity of, Accelerate the Acquisition of, and Expand the Sources of National Geospatial Data Assets to Ensure that they are Findable, Accessible, Interoperable, and Reusable
- Goal 3: Ensure Open Standards-Based Operability to Enable Geospatial Shared Services
- Goal 4: Enable and Promote Collaborative Governance and Partnerships to Meet National Needs, Priorities, and Circumstances

Authority and implementation of the hydrography framework at the national level is the responsibility of the theme leads as previously discussed. Governance and management of this theme in its maturity is intended to be collaborative, through partnerships with other federal agencies, state and local organizations and the private sector. Participation and commitments among all partners are key to a robust national hydrography resource.

One goal that is not stated nor addressed in the Geospatial Data Act is funding. All the efforts required must have funding to be accomplished. Our assessment is that funding requests by the current administration are lacking and further there is no funding authorization for the theme. Lessons learned from the Elevation theme included having authorization and oversight for the theme, an amount of budget equal to the authorization requested in the President's Budget request, and support from partners advocating for appropriations. As shown in an excerpt from the Budget Justifications and Performance Information Fiscal Year 2025, the Administration does not appear to be requesting sufficient funds to credibly start the 3DHP program with 7 states having submitted DCA funding requests per a briefing from USGS in the summer of 2023. According to the briefing, DCA requests were as follows: 11 Project submissions in 7 states, Total Project Value: $18.9M, Requesting from USGS: $7.5M, Partner contribution: $11.4M. However, in the President’s Budget request, only $1.5 million was requested for the program (Table Hydrography-2).

Table Hydrography-2. Actual and anticipated funding for the National Geospatial Program, FY 2023 - 2025.

Core Science Systems National Geospatial Program							
Core Science Systems $ in thousands	2023 Actual	2024 Annualized CR	2025 Fixed Costs	2025 Internal Transfers (+/-)	2025 Program Changes (+/-)	2025 President's Budget	Change from 2024 Annualized CR (+/-)
National Geospatial Program	93,650	93,650	+1,065	0	-8,468	86,247	-7,403
3D Elevation Program (3DEP)	[42,905]	[42,905]	[0]	[0]	-6,250	[36,655]	[-6,250]
Alaska Mapping and Map Modernization	[10,000]	[10,000]	[0]	[0]	-2,278	[7,722]	[-2,278]
3D National Topography Model (3DNTM)/3D Hydrography Component	[500]	[500]	[0]	[0]	+1,000	[1,500]	[+1,000]
Digital Surface Models	[3,000]	[3,000]	[0]	[0]	-3,000	[0]	[-3,000]
Baseline Capacity - 2024 Fixed Costs	[0]	[0]	[0]	[0]	+2,060	[2,060]	[+2,060]
FTE	*212*	*212*	*0*	*0*	+2	*214*	+2

Hydrography Theme General Assessment

For this review, the COGO Hydrography Theme team evaluated the transition state of hydrography data for the nation and the 3DHP implementation to date. The previous 2018 COGO Hydrography report was incorporated into the narrative where appropriate and relevant. Additionally, results from two community surveys were considered: the National Spatial Data Infrastructure (NSDI) survey conducted by COGO, and the National States Geographic Information Council (NSGIC) 2023 Geospatial Maturity Assessment (GMA). Also considered is the report for the GDA- 2023 Lead Covered Agency NGDA Theme Annual Performance Report and Self-Assessment for Water – Inland Theme from USGS. It is worth noting that the NSDI survey had fewer respondents than anticipated; the sample size of those participating in the hydrography theme was small and may not be representative of the nation's user base as a whole. That said, some of the trends when evaluated in conjunction with the NSGIC GMA results were informative and are worth including in this assessment.

The NSDI survey illustrated that the NHD was a successful program and was perceived as on a path to improvement but had limitations; 75% of respondents currently use the NHD and 50% of respondents indicated that the NHD meets 80% or greater of their hydrography data needs. The majority of respondents identified that they also use non-

NHD hydrography data sets to meet their business needs. Despite numerous presentations to NSGIC members, policy groups like the Western States Water Council and Interstate Commission on Water Policy, professional groups like the American Water Resources Association and the Association of Fish and Wildlife Agencies, and state and regional geospatial organizations, almost half of respondents were unaware of the transition to 3DHP and the majority of respondents (even if they were aware of 3DHP) were unsure if the available data would meet their needs while 3DHP matures and higher resolution data becomes available.

The NSGIC GMA provides a summary of geospatial initiatives, capabilities, and issues within and across state governments. For this evaluation, the GMA Hydrography Theme was not graded because of the transition to 3DHP. States were still surveyed on the NHD and their experience of 3DHP to date. The NSGIC GMA survey was conducted in June of 2023 and 47 states participated.

The GMA results were similar to the NSDI survey in that 75% of states indicated that they were currently utilizing the NHD. Fifty percent expressed satisfaction with its hydrographic capabilities. The survey illustrated that there are still challenges with nationwide adoption of the NHD with only 12% of respondents contributing to updates more than once a year and many still relying on non-NHD hydrography data sources. 90% of states believe that 3DHP will better meet their hydrography needs once implemented.

They also indicated that the transition process has been challenging in the following areas:

- **Communication and Awareness**: Poor communication with stewards and partners during the transition has resulted in frustration and confusion among users. A significant portion (41%) was unaware of the transition, and only 23% of those aware found it meeting their needs.
- **State Preparedness and Decision-Making**: Despite the challenges, 72% of states are preparing to transition to 3DHP. The decision-making process, based on specifications rather than a defined process, has raised concerns, with the transition favoring the use of USGS-GPSC private contractors.
- **End User Support and Collaboration:** While 3DHP is considered a great solution, it lacks the strong end-user support enjoyed by NHD. Cross-agency collaboration, among federal entities like USFW and EPA has been active, however, adoption has been slow due to resource and management challenges, hindering progress.
- **Overall Program Funding**: While there are well-documented cost benefits associated with 3DHP, sustainable funding remains a substantial concern. While USGS is working diligently to identify and organize resources to support the vision of the 3DHP, current appropriations specifically for 3DHP do not indicate that there is a commitment to funding state implementation and cost sharing opportunities to build out the program at scale.

The GDA report dated January 19, 2024, is the most recent assessment from USGS. In the report the evaluation against Geospatial Data Act requirements was evaluated as "Made progress towards expectations" for all elements.

The transition from NHD to 3DHP is a necessary step for the advancement of hydrography systems. Recommendations for improvement of the hydrography theme are primarily focused on communication and funding. Addressing communication gaps, improving user awareness, fostering collaboration, and developing a comprehensive funding strategy are critical components for the successful and sustainable implementation of 3DHP.

The Grade for this theme is a B-; due to the transition to 3DHP, the evaluation team did not change the previous grade received in 2018.

Hydrography Data Theme Working Group

Framework Evaluators	Federal Liaisons
Jenna Leveille, Theme Lead, NSGIC	Vicki Lukas, USGS
John Copple, MAPPS	Stephen Aichele, USGS
Joshua Greenberg, WA Dept of Ecology	Megan Lang, USFWS

VII. Orthoimagery Data Theme

Executive Summary

The National Spatial Data Infrastructure (NSDI) is defined as a shared national vision of the technology, policies, criteria, standards, and employees necessary to promote geospatial data sharing and integration, and the NSDI portfolio consists of a core set of National Geospatial Data Assets (NGDAs) datasets. The Lead Covered Agency NGDA Theme Annual Performance Report and Self-Assessment for Imagery Themes for FY2020, FY2021, FY2022 and FY2023 are available at GDA Lead Covered Agency Theme Reports — Federal Geographic Data Committee (fgdc.gov) and have been referenced throughout this assessment. It is important to note that there is currently an inconsistency in the description of this theme. The NSDI theme in OMB Circular 16 uses *Orthoimagery* as the theme description and the NGDA uses *Imagery* as the NGDA theme description. This can lead to some confusion in the reporting process.

The Orthoimagery/Imagery Data Theme is a highly valued component of the NSDI, providing a rich set of georeferenced and orthorectified images that have supported a wide range of stakeholders for many decades. The Theme has evolved and matured, benefiting from advances in technology, as well as focused investments at both the Federal and State level. The Theme's lead agencies, with support from the FGDC National Digital Orthoimagery Program (NDOP) Subcommittee, have been instrumental in helping to advance the Theme. The Federal community and State and local organizations should be commended for their efforts to archive and enable open access to their National Geospatial Data Assets. The user community should continue focusing on free and open government imagery augmented by an increasingly robust commercial satellites industry.

In 2023, the Coalition of Geospatial Organizations (COGO) distributed a survey to a broad community of NSDI producers and users, to provide a better understanding of the current state of the NSDI Framework data themes. For the purposes of the survey, the term orthoimagery was used and the orthoimagery database was defined as follows:

"The orthoimagery theme consists of georeferenced images of the Earth's surface, which have been collected via aerial or space-based platforms in near-Earth orbit. Orthoimagery is prepared through orthorectification to remove image displacements and distortions, allowing orthoimages use as base maps for digital mapping and analyses among other uses. A digital orthoimage is an aerial or satellite image with the geometric qualities of a map. The assessment considered the NSDI Imagery Theme data sets that are available in the public domain. In addition, this assessment also includes imagery collected by States. This COGO assessment excludes proprietary and licensed imagery."

Survey respondents defined their role as: Data Creators (25%), Managers/Custodians (14%), Data Aggregators (8%), Users (44%), Vendor/Consultant (3%) and Other (5%). Their input was taken into account in this evaluation of Orthoimagery/Imagery. Total respondents to this theme were about 150 individuals.

54% of the responders use Openly Accessible and freely available orthoimagery, in addition, Openly Accessible and freely available orthoimagery is used Routinely (several times per week) by 71% of the responders. High-resolution local source publicly available orthoimagery data was used by 50% of the responders with National Agriculture Imagery Program (NAIP) orthoimagery data in second place used by 21% of the responders.

Orthoimagery Theme Grade: B

Adequate for Now

Description of the Framework

Introduction to the Theme

In 2017, the Federal Geographic Data Committee (FGDC) released the "National Spatial Data Infrastructure Strategic Framework", which highlighted the Orthoimagery Data Theme as a cornerstone of the National Spatial Data Infrastructure (NSDI). This theme provides a valuable collection of georeferenced images that have served a wide range of stakeholders for many years. Over time, the theme has advanced significantly, benefiting from technological progress and targeted investments at both the Federal and State levels. Key agencies such as the US Geological Survey (USGS), the US Department of Agriculture (USDA), the National Oceanic and Atmospheric Administration (NOAA), as well as State and local organizations, have played crucial roles in advancing the theme, with support from the National Digital Orthoimagery Program (NDOP).

These efforts have enabled the archiving and open access to imagery assets, ensuring that users have access to high-quality, non-proprietary imagery within the public domain. Some Federal and State agencies are considering or have moved towards licensed imagery products, which could impact the accessibility of imagery data for users. Some Federal and State agencies are considering or have moved towards licensed imagery products, which could impact the accessibility of imagery data for users. In 2019, USDA did consider the licensing approach but did not then, nor in any more current years, favor that suggestion.

It is imperative for the user community to remain engaged and advocate for ongoing access to non-proprietary and non-licensed imagery. The Coalition of Geospatial Organizations (COGO) has recognized the changing role of government in the geospatial ecosystem and has highlighted the progress made by the FGDC community in driving initiatives such as the National Geospatial Platform (GeoPlatform.gov), the Geospatial Interoperability Reference Architecture (GIRA), and the enhancement of the National Geospatial Data Asset (NGDA) portfolio management process.

The importance of orthoimagery is evident from various reports, including the USGS publication "The National Map Customer Requirements: Findings from Interviews and Surveys" (Sugarbaker et al., 2009) which identified orthoimagery as one of the top data sets needed to support geospatial activities, as well as the 2017 economic valuation of Landsat imagery that indicated $3.45 billion in benefits (Straub et al. 2019). Orthoimagery, created through a process known as orthorectification, provides a map-

like quality that is essential for digital mapping and analysis. This assessment focuses on the NGDA Imagery Theme data sets available in the public domain, excluding proprietary and licensed imagery, and includes imagery collected by States.

In summary, the Orthoimagery Data Theme is a critical component of the NSDI, supported by dedicated agencies and organizations. Continued advocacy and engagement from the user community are vital to ensuring ongoing access to high-quality imagery data.

Theme Definition

The "imagery theme" consists of georeferenced images of the Earth's surface, which have been collected via aerial or space-based platforms. Orthoimagery is prepared through a geometric correction process known as orthorectification to remove image displacements due to relief and sensor characteristics, and supporting applications such as land cover and land change mapping, natural resource management, agricultural monitoring, water quality and availability studies, and natural hazards mitigation.

This assessment considers the 10 NGDA Imagery Theme data sets that are available in the public domain (Table Orthoimagery-1). This COGO assessment excludes proprietary and licensed imagery.

Table Orthoimagery-1. Imagery Theme National Geospatial Data Assets. All are at the Federal Jurisdiction level.

Dataset	NGDA Lead Agency
Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)	USGS
High Resolution Orthoimagery Collection - Historical	USGS
Landsat 1-5 Multi-Spectral Scanner Collection 2 Level-1	USGS
Landsat 4-5 Thematic Mapper Collection 2 Level-1	USGS
Landsat 7 Enhanced Thematic Mapper Plus Collection 2 Level-1	USGS
Landsat 8-9 Operational Land Imagery and Thermal Infrared Sensor Collection 2 Level-1	USGS
Moderate Resolution Imaging Spectroradiometer (MODIS) Aqua	USGS
Moderate Resolution Imaging Spectroradiometer (MODIS) Terra	USGS
National Agriculture Imagery Program (NAIP) Imagery	FPAC
NOAA Coastal Mapping Remote Sensing Data	NOAA

Lead Agency and Current Activities

According to Office of Management and Budget (OMB) Supplemental Guidance – Appendix E – National Geospatial Data Assets (NGDA) Data Themes, Definitions, and Lead Agencies Updated March 24, 2017, the following Federal departments are defined

as lead agencies for the Imagery Theme:

- Dept. of Agriculture, Farm Production and Conservation Business Center (FPAC-BC) Primary Point of Contact: David Davis USDA / FPAC-BC
- Dept. of the Interior, U.S. Geological Survey (USGS) Primary Point of Contact: Greg Snyder DOI/ USGS/National Land Imaging Program

The National Digital Orthoimagery Program (NDOP) is a subcommittee of the Federal Geographic Data Committee (FGDC). NDOP is "an activity of the U.S. Government responsible for managing and coordinating overhead imagery and applications to support the operational needs of civil government in the United States" (FGDC, n.d.2).

Collaboration and Partnerships

The NDOP Subcommittee is responsible for developing, promoting, and executing coordinated strategies to determine the needs for and approaches to acquire imagery data for Federal agencies. Partnerships can include Federal and non-Federal organizations. Primary members of the NDOP Subcommittee are shown in Table Orthoimagery-2. Additional agencies typically participate in NDOP activities and meetings. Non-profit organizations representing State, local, regional and tribal governments may be added with the consensus of NDOP Subcommittee representatives. Although non-Federal participants may engage in NDOP Subcommittee discussions and offer information and opinions, their participation is limited to a non-voting role.

Governmental bodies and commercial industry provide essential imaging capabilities that augment Federal imagery, such as high-resolution commercial satellite imagery. NDOP works with the National States Geographic Information Council (NSGIC) to coordinate Federal and State agency imagery needs and establish data collection partnerships.

Table Orthoimagery-2. Members of the FY 2023 NDOP Steering Committee. *Table is continued on the next page.*

Dept of Agriculture, Farm Production and Conservation Business Center (FPAC-BC)	David Davis	US Environmental Protection Agency (EPA)	David Williams
Dept of Agriculture, US Forest Service (USFS)	Everett Hinkley	US Geological Survey, National Geospatial Program	Gita Urban-Mathieux
Dept of the Interior, Fish and Wildlife Service (FWS)	Matthew Bobo	Dept of the Interior, Bureau of Land Management (BLM)	Chris Cole

Table Orthoimagery-2, *continued*. Members of the FY 2023 NDOP Steering Committee.

Dept of Homeland Security (DHS), Federal Emergency Management Agency (FEMA)	Paul Rooney	US Dept of Commerce, National Oceanic and Atmospheric Administration	Erik Hund
National States Geographic Information Council (NSGIC)	Rick Kelson	National Park Service	Jennifer Haack Gaynor
US Department of Commerce, Census Bureau	Peter Reid		

Standards

Numerous national and international standards and protocols pertain to objects or phenomena that are directly or indirectly associated with a location(s) on the Earth. Standards help facilitate reliable, consistent access, discovery and sharing of data, metadata and services between providers and among users. The FGDC Goal 3 of the NSDI Strategic Plan 2021-2024 is to Ensure Open Standards-Based Interoperability to Enable Geospatial Shared Services.

The FGDC Subcommittee of Base Cartographic Data (SBCD) submitted a draft Standard for Digital Orthoimagery to the FGDC Standards Working Group over two decades ago (1996). Since that time, several related efforts have successfully been completed, including:

- Content Standard for Remote Sensing Swath Data (1999)
- Geospatial Positioning Accuracy Standards Part 3: National Standard for Spatial Data Accuracy (FGDC-STD-007.3-1998)
- Content Standards for Digital Orthoimagery by FGDC (1999)
- Content Standard for Digital Geospatial Metadata: Extensions for Remote Sensing Metadata (2002)
- OpenGIS® Sensor Observation Service Interface Standard, version 1.0.0 (2010)
- ISO 19115 – 2: Geographic information - Metadata - Part 2: Extensions for imagery and gridded data, GeoTIFF Revision 1.0

Subsequent to the 2018 Report Card, the American Society for Photogrammetry and Remote Sensing (ASPRS) has published both digital and hardcopy versions of the ASPRS Positional Accuracy Standards for Digital Geospatial Data (2024) Edition 2, Version 2.

(www.asprs.org (ASPRS 2023). USGS has already created the revision process and text. As of January 25, 2024, this has not yet been incorporated into the NAIP requirements but is planned to be done in time for the 2024 NAIP acquisition.

Industry trends continue to shift from onsite geospatial data storage and processing to cloud-based services. Public entities, operating at U.S. Federal, State, municipal, and tribal levels, and private or international entities are customizing services for different users. For imagery products and services, three primary bodies (FGDC, OGC, and ISO) propose, test, and establish the standards to ensure interoperability across all users.

These trends are evident among the various programs and management systems and services resident in the United States. All these data and services are coming from different sensors on different platforms and are being accessed and/or converted through interoperable interfaces. These are discovered and shared through Open Geospatial Consortium (OGC) standards, such as Web Map Service (WMS), Web Feature Service (WFS), Catalog Service for the Web (WSC), WMTS (Web Mapping Tile Service), Sensor Model Language (SensorML), Sensor Planning Service (SPS), Sensor Observation Service (SOS), and others.

The Digital Object Identifier (DOI) (based on the ISO 26324 standard) continues to gain traction to provide a permanent and unique digital identification for images, digital or film-based. The 2018 Report Card Assessment referenced that NASA in the Earth Observing System Data and Information System (EOSDIS) have already adopted DOI. Currently all data released through USGS on servers owned by, or managed under contract to, the Bureau must be assigned a DOI generated by the USGS Asset Identifier Service (AIS); DOIs created using this tool are registered to DataCite.org. USGS data that are published on Federal servers managed by other agencies may be assigned a DOI managed by the hosting agency, if required as a condition for publishing the data; otherwise, a USGS DOI should be assigned to these data using the USGS DOI Creation Tool. The Data Management Plan should specify where the final data will be published; if another Federal agency will publish the USGS data, the Plan should also stipulate which agency will assign and manage the DOI during the anticipated lifecycle of the data. The USGS Asset Identifier Service uses DOI to make their research more Findable, Accessible, Interoperable, and Reusable (FAIR) (USGS 2023).

Rapid innovations in platform, sensor, and hosting technologies have lowered the cost of imagery acquisition and access. However, these rapid changes often outpace the ability of organizations such as FGDC, OGC, and ISO to promulgate and maintain relevant standards. Current federal and international standards for orthoimagery must be continuously evaluated and updated to ensure relevance and usability. Several organizations are developing standards on the use of “emerging technologies” that need to be integrated with other geospatial data and services, such as imagery collected with Uncrewed Aircraft Systems (UAS), crowd-sourcing platforms (e.g. social media), and other technologies.

Significant progress has been made to address standards that promote imagery harmonization, integration, and calibration. For example, after becoming the first

recipient of the Committee on Earth Observation Satellites (CEOS) endorsement for CEOS Analysis Ready Data (CEOS-ARD)-compliant products with Landsat Collection 2 Level-2 surface reflectance and surface temperature products, and now custom U.S.-based ARD product in 2023, the USGS has continued its leadership position across the international community with movement toward making CEOS-ARD a recognized standard through robust engagement with the International Organization for Standardization (ISO) and the Open Geospatial Consortium (OGC). The CEOS internationally recognized certification applies to satellite data that have been processed to a minimum set of requirements and organized into a structure that allows for immediate analysis with minimum user effort and interoperability both through time and with other datasets. Bringing this product certification approach to ISO/OGC will greatly enhance commercial partnerships and drive interoperability with USGS and other space agency product offerings. While co-leading the CEOS Land Surface Imaging Virtual Constellation (LSI-VC) and Vice-Chairing the CEOS Working Group on Information Systems and Services (WGISS), the USGS played a critical role in preparing a CEOS Interoperability Framework Roadmap. This Framework and its implementation will not only further drive interoperability with CEOS-ARD products but will also extend interoperability into vocabulary/semantics, architecture, interface/accessibility, quality, and policy. Finally, the imagery theme continues to inform future Landsat satellite systems with active user engagement on a scale never realized during the history of the Landsat program.

There are also interagency efforts, to include participation of international, academic, and industry organizations, focused on sensor data characterization, calibration, data processing, and uncertainty quantification. The Joint Agency Commercial Imagery Evaluation effort performs and makes available data quality assessments and hosts broadly attended workshops (https://www.usgs.gov/calval/data-quality-assessment).

Needs of Community Users

Civil agencies including NDOP member agencies have provided requirements to the USGS National Land Imaging (NLI) Program, as part of the USGS/ NASA Sustainable Land Imaging (SLI) Program including Landsat-9 follow-on mission – Landsat Next, formulation. Landsat Next plans to offer more than twice of number of spectral bands compared to Landsat 8/9, higher spatial resolution of 10/20m for visible to short-wave infrared and 60m thermal infrared bands, and higher temporal revisit at 6 days (https://www.usgs.gov/landsat-missions/landsat-next). While requirements were primarily collected from Landsat and other moderate resolution projects and applications, a sub-portion of these requirements included higher resolution needs as potential enhancements to current moderate resolution systems. This activity is part of a larger, ongoing effort to help optimize investments in land imaging technology and products that better meet user needs in support of Landsat and other missions and national Earth observation assessments. The effort supports the U.S. Group on Earth Observation (USGEO) national planning process, for which the USGS/ NLI serves as Vice-Chair alongside NASA and NOAA. NLI provides data and analyses to USGEO to help optimize Federal investments in Earth observing technology and products to better

understand and address user needs across a broad range of uses and applications, both scientific and geospatial in nature. The NLI is supporting other NDOP Federal Agency members to assist their organizations in defining future capabilities and user needs across this broad range of applications, including imagery collection systems.

A significant amount of orthoimagery is collected at the local, regional, and State levels through-out the United States. While High Resolution Orthoimagery collection is not one of the NSDI/NGDA themes, the NAIP program is included in the Geospatial Maturity Assessment. There is value in following up on the community user need for High Resolution Orthoimagery.

The results from the COGO 2023 survey show that when asked "What kinds of publicly available orthoimagery data do you use?" 50% of the 149 responders to this question use High-resolution orthoimagery from a local source, 21% use NAIP orthoimagery, 15% use other orthoimagery and 13% use satellite orthoimagery. Of the 150 responders, 129 skipped the survey question when asked an additional question to specify which dataset they used. In addition, when asked the follow-up question "What resolution(s) of publicly available orthoimagery data do you use?" 27% of the 145 responders to this question use 7 cm resolution, 25% use 15 cm resolution, 18% use 30 cm resolution, 7% use 60 cm resolution, 10% use 1m resolution, and 11% responded "other." When asked to specify the resolution 134 responders skipped the question. When asked the question, "How frequently do you need publicly available orthoimagery data updated?" 48% of the 147 responders answered annually, 31% answered every three years. While it is apparent that the survey for orthoimagery needs to be improved to allow more flexible responses, it also appears that there is a need for high resolution local orthoimagery collected in a 1–3 year cycle.

As reported in the 2018 Report Card, an analysis of NSGIC's 2015 Geospatial Maturity Assessment (GMA) showed that 28 states had achieved a "level of completion," from 96% to 100%. Five states had between 26% and 74% coverage (Freundschuh et al., 2018). According to the NSGIC 2023 Geospatial Maturity Assessment State-level orthoimagery programs, leaf-off orthoimagery shows steady improvement, while leaf-on programs show a reduction in buy-up efforts. Conclusions from the NSGIC 2023 Geospatial Maturity Assessment: Orthoimagery includes both leaf-on and leaf-off products and both are important to users of geospatial data in the states. The leaf-on product serves interests such as agriculture and forestry while leaf-off serves tax assessors and the emergency response community, among others. Statewide coverage is important, and the frequency of update is critical, particularly for areas that are growing and/or changing. The orthoimagery layer was scored separately for leaf-on and leaf-off products. Scoring was primarily based on the following individual criteria (1) frequency of update; (2) resolution; (3) completeness or coverage, and (4) accessibility. The NAIP program is the foundation used for scoring the leaf-on products. NAIP is a federal program; it is not something that the states need to fund on a regular basis unless a state wishes to buy-up to a 6-inch product or by adding the fourth band of imagery to the delivered product (NSGIC 2023).

Orthoimagery Leaf-off Theme Summary (State-Led Theme): In 2023, 45 states plus the District of Columbia completed the leaf-off and leaf-on portions of the NSGIC survey compared to 47 states in 2021. Nevada, New Hampshire, New Mexico, South Dakota, and West Virginia did not submit a survey. Of the 45 responses, well over 69% (31 responses) have statewide coverage. This is up from 29 states in 2021. Of the remaining states 16% (7 states) have some coverage and another 15% (8 states) have no coverage. Of the 8 states with no coverage, 4 are Western states that typically focus on leaf-on coverage due to the high percentage of coniferous forest, 2 states (Alaska and Hawaii) have challenging flying conditions that make leaf-off imagery collection difficult and the remaining 2 states did not collect imagery this cycle. Of the 37 states with leaf-off imagery programs, about two-thirds update the imagery frequently (within a 5-year period) with just one-third taking 6 or more years to update the coverage. Almost 80% of the states buy up to higher resolutions (1 foot to 3 inches) and most states make the imagery available to users via download. Most states have identified data stewards, and most have dedicated funding. Fewer have a business plan but more have local participation. Both have slight increases over 2021 (NSGIC 2023).

Final grades for leaf-off suggest that about 70% of the states score a B or better (an increase of 10% from 2021) and that result jumps to higher if you drop the Western states and states without programs. This suggests that many states are successfully implementing a leaf-off orthoimagery program. Compared to 2021, there has been continued improvement in participation and the quality of the data in the leaf-off imagery program. Fewer states responded in 2023, Indiana moved from N/A in 2019 to a letter grade of B in 2021 and the following states plus the District of Columbia completed the NSGIC survey for leaf-on in 2021 that did not complete it in 2019: Alaska, California, Connecticut, Maine, Maryland, Rhode Island, South Carolina, and South Dakota (NSGIC 2023).

Orthoimagery Leaf-on Theme Summary (Federal-Led Theme): Of the 46 responses, almost all have statewide leaf-on coverage provided through NAIP. Of the remaining states 2 had less than 80% coverage. Only five states (down from 10 in 2019) participate in the buy-up program NAIP offers. Most of the states enjoy a 2 to 3-year update which correlates to the NAIP update cycle. Only 2 states have updates after 3 years or more while 5 states receive annual updates. Almost all states make this public domain data available to their users via download, however three states license the data, while three states restrict access and two states do not make it accessible. These numbers are up from 2019. Most states have identified data stewards and the states with dedicated funding are those with the buy-up programs. The number of states with business plans and local buy up is extremely low; but that is not surprising given that NAIP is a federal program. Final grades for leaf-on reveal that only 8 states receive an 'A' grade, much lower than leaf-off. However, just over 50% score in the 'B' range. The grading suggests that if a state does minimal work, they will get a statewide leaf-on product via NAIP and a 'B' for a grade. States that participate in the program via buy ups receive the 'A' grades. Additionally, a state that restricts access to the data or does not have a regular buy-up schedule received a lower grade (NSGIC 2023).

Estimate of Theme Completeness

To estimate the "completeness" of the Nation's imagery, one must consider numerous factors including the business requirements behind individual NDOP agency imagery programs. The spatial, spectral, radiometric and temporal resolution requirements of individual imagery programs vary widely (e.g. NOAA Coastal Mapping vs. NAIP vs. the Landsat program), uniquely determining the measure of completeness.

The NAIP program has progressively increased the imagery resolution (GSD), geographic coverage (including some non-CONUS areas), and frequency (two-year cycle) over the continental U.S. and applicable non-CONUS areas. The NAIP GeoHub provides Comprehensive coverage listings by state and year.

According to the 2023 Lead Covered Agency NGDA Theme Annual Performance Report and Self-Assessment for Imagery Theme dated January 19, 2024 (FGDC 2024) since the launch of Landsat 1 in 1972, the Landsat mission satellites, a partnership between NASA and USGS has produced more than 10 million images of Earth's surface. This 52-year record—the longest continuous global record of the Earth's natural and human-induced surface change—is unmatched in quality, detail, and coverage, and provides a unique and valuable resource for people in a wide variety of professions. The Landsat Next mission, currently in formulation, will be far more capable than Landsat's 8 and 9 combined, meeting the evolving needs of users. These needs were rigorously documented by the USGS, to include improved spectral, spatial, and temporal detail that is critical for identifying and characterizing land surface change in areas of the world most vulnerable to climate change, while sustaining continuity with the 52-year archive. Landsat Next is in the Phase A stage of development since FY2023. Phase A activities included final refinement of draft science requirements, illustration of Landsat Next science benefits, support for the Landsat Next instrument suite request for proposal, and ground system studies, all of which are keeping Landsat Next development on schedule in Phase A.

The following image is from the Landsat-Earth Observation Satellites fact sheet which was revised August 24, 2022.

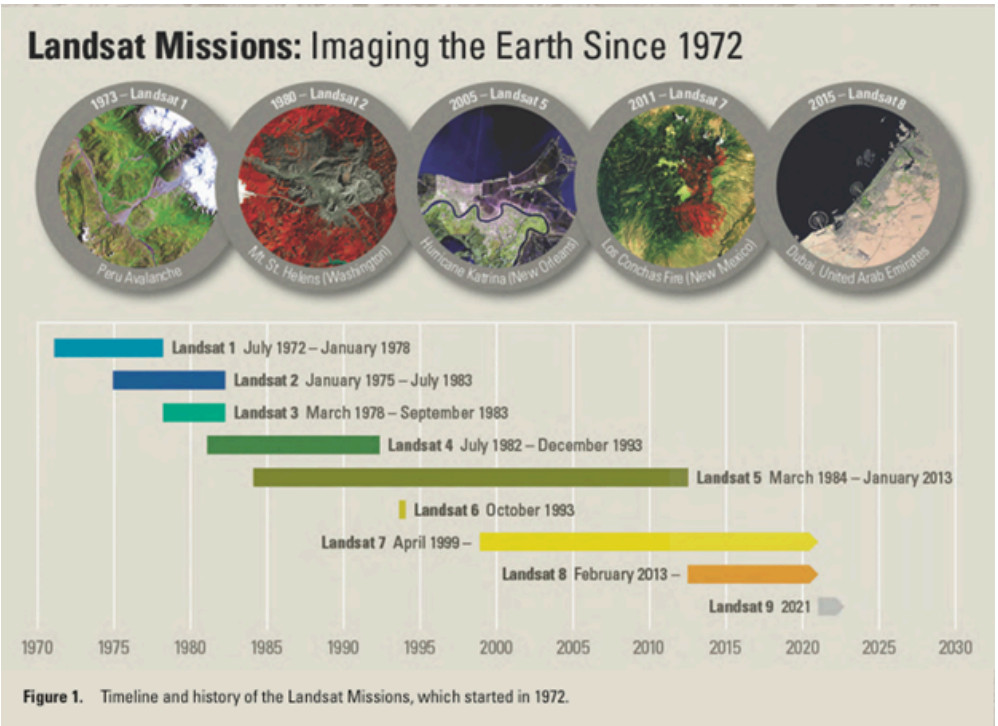


Figure Orthoimagery-1. Timeline and history of the Landsat Missions. *Source: USGS.*

Accessibility of Data

For this report, data accessibility is defined as data that can be freely downloaded, is consistent with Open Data policies, and/or available at the cost of reproduction. Metadata (information about the data) must also be readily available; without it, data maybe unusable or easily misunderstood and misused.

The Geospatial Platform is a cross-agency collaborative effort and Shared Service that embodies the principles and spirit of Open Government, emphasizing government-to-citizen communication, accountability, and transparency. In 2020, GeoPlatform.gov, operating under the authority of the Geospatial Data Act of 2018, transformed to establish its primary role: to discover geospatial data assets with special emphasis as the authorized source for all the official National Geospatial Data Assets (NGDAs) across 18 Data themes as guided by the U.S Federal Geographic Data Committee (FGDC) .

- **Data Services** - The GeoPlatform delivers trusted, nationally consistent, authoritative geographically enriched social, economic, environmental and other data for understanding and decision making.
- **Applications and Tools** - The GeoPlatform provides a suite of applications and tools for integrating, synthesizing, analyzing, problem-solving and visualizing geographically enriched data to accelerate understanding and decision-making.
- **Shared Services** - The GeoPlatform provides shared hosting infrastructure that allows agencies to publish their geospatial data, applications, and tools in a secure cloud-computing environment at a low cost.

The USGS EROS Archive-Aerial Photography-High Resolution Orthoimagery Dataset (HRO) houses the High Resolution Orthoimagery Collection-Historical dataset for the NGDA imagery theme. An overview of the data describes this dataset as digital images of orthorectified aerial photographs with a pixel resolution of 1-meter or finer from across the United States (2000-2016) (USGS 2018).

Innovations in data collected with UAS, cloud computing, web services, and licensed imagery products are altering how imagery is procured, delivered, and consumed. This has put pressure on orthoimagery program managers to justify the cost of keeping imagery in the public domain. The National Geospatial Advisory Committee (NGAC) noted in their report *Landsat in the Cloud* from May 2022 that "Over the past decade, a rapidly growing number of companies and public entities have migrated their operations to commercial clouds, motivated by factors of resiliency, scale and economics. They have also been motivated by "network effects": as more users themselves move to the cloud, sharing and large-scale analysis of data is easier. In the cloud environment, it is possible to pass a "pointer" to the data rather than copying it from place to place, making it even more attractive for new users to adopt use of the cloud. Commercial cloud providers offer servers, storage, and virtual desktops, along with a plethora of pre-build services that reduce the amount of unique development required and speed time-to-operation, or time-to-market for commercial firms" (NGAC 2022).

Authority, Governance, and Management of the Theme

After COGO's 2018 Report Card, the FGDC released the National Spatial Data Infrastructure Strategic Plan 2021-2024 (FGDC 2020). The GDA includes a set of overarching goals for the NSDI. These goals, which were addressed in the plan, may be summarized as follows:

- Ensure that geospatial data comply with privacy policies and statutes;
- Protect personally identifiable information from disclosure;
- Enhance the accuracy of statistical information;
- Promote free and open access to geospatial data, information, and interpretive products;
- Protect proprietary interests related to licensed information and data; Promote interoperability and sharing capabilities of Federal information systems and data; and
- Advance a global spatial data infrastructure and development of international geospatial data in accordance with voluntary consensus standards.

Intergovernmental and cross-sector collaboration is a key success factor in the development of the NSDI. The substantive and ongoing consultation between Federal, State, Tribal, and local governments—as well as with other sectors—will help lead to more effective and resilient relationships and policies. The Strategic goals and objectives focus on four critical components to accelerate the development of the NSDI: 1) policy and governance, 2) data, 3) shared services, and 4) partnerships (FGDC 2020).

Since the last COGO Report Card, lead agencies for Imagery (USDA's Farm Protection and Conservaton (FPAC) and USGS) have updated the National Geospatial Datasets discoverable through the GeoPlatform. Efforts to improve data access include placing Landsat in the cloud and in FY23 there were 20.2 billion accesses via Commercial Cloud and 113.5 million products distributed via downloads. The dramatic increase in accesses was also facilitated by the conversion to Analysis Ready Data (ARD) which permitted downloading small specifically located data tiles rather than full Landsat scenes.

Acquisition Platforms

Acquisition platforms listed in the 2018 Report Card included satellites, planes, helicopters, and uncrewed aircraft systems (UAS). As of the writing of the current report, these remain the primary acquisition platforms used for acquiring source imagery for production of orthoimagery. However, since the last report, there have been changes within these categories of platforms, including new subcategories, broadened use, and new application areas.

An emerging subcategory of acquisition platforms is small satellites. While a key motivator for small satellites is the lower costs (including substantially lower launch costs), a major advantage to the user community is high temporal frequency imagery acquisition, enabled by fleets of dozens to hundreds of small satellites. This high frequency capability is especially beneficial for emergency response applications, real-time decision support, and other applications that require near-real time data.

Another category of platform that has seen substantially increased use for orthoimagery generation since the last NSDI assessment is UAS. It might seem that UAS have a relatively minor role to play in orthoimagery acquisition over large spatial extents (e.g., regional to national coverage), UAS are proving increasingly important for rapid deployment and acquisition of extremely high spatial resolution data (often resolutions on the order of a few centimeters), and applications, such as urgent or time-sensitive response. New categories of UAS have emerged, such as hybrid UAS that provide vertical takeoff and landing (VTOL) and change to a fixed-wing configuration in flight. It is important to note that some of the limitations with respect to use of UAS for imagery acquisition over large spatial extents are more regulatory than technological. FAA Part 107 (or, more formally, Part 107 of Title 14 of the Code of Federal Regulations: 14 CFR Part 107) restricts UAS operations to within visual line of sight (VLOS) without a waiver. However, as regulations are revised, there may be potential for beyond visual line of sight (BVLOS) operations (e.g., FAA, 2002), which would substantially increase the utility of UAS for orthoimagery production for larger spatial extents.

In between UAS and satellites (in terms of altitude, costs, and coverage) in the spectrum of acquisition platforms are crewed aircraft, including airplanes and helicopters. While both UAS and satellites have encroached on the domain of crewed aircraft for imagery acquisition, it remains the case that crewed aircraft are the primary platform for county-wide to statewide imagery acquisition programs that generate periodic, high-resolution (≤ 0.5-m) imagery. We foresee these same trends continuing over the next five years: namely, for UAS and satellites to fill increasingly larger roles in imagery acquisition, but

for crewed aircraft to remain the most prevalent platforms for regional- to national-level coverage orthoimagery programs.

Orthoimagery Theme Assessment

1. Capacity: ***The Framework's capacity to meet current and future demands.***

The FGDC's Imagery Theme planning documents reflect a continuing commitment to enhancements of key Imagery Theme NGDA data sets and programs to address requirements of Federal, State, local and tribal government users, subject to funding constraints. Regarding the Landsat program, the emerging requirements for Landsat, identified by non-Federal customers, indicated needs for enhanced revisit and improved spatial resolution (FAA, 2022). In addition, in June 2017, the USGS National Land Imaging program office - then Land Remote Sensing program office - issued a request for information from the land imaging community for user requirements for future Landsat systems (USGS 2017). NASA issued a Landsat Next request for information in 2020 to seek improved community input to Landsat Next draft science requirements and mission architecture. These and others inputs received, such as the the Landsat Science Team, the Landsat Advisory Group of the National Geospatial Advisory Committee, AmericaView, the Decadal Survey, and international cooperators are providing community input to augment broad Federal civil requirements collection efforts, contributing to a diversity of input to inform the Landsat Next mission. Landsat Next is part of the NASA / USGS Sustainable Land Imaging Program and is the follow-up mission to Landsat 9 launched in 2021.

In the 2018 COGO Report Card (Freundschuh et al., 2018), concern was expressed regarding the future of the NAIP program. Threats to funding then jeopardized future acquisition efforts. However, NAIP funding has improved since the 2018 time period, even though it is still not a line item nor a fully funded program. Delays and shortfalls regularly occur with FPAC and the NAIP funding partner agencies. Greater funding stability is needed to ensure adequate data collections and continued vendor capacity. Talk of moving to a vendor-based image service and eliminating the public domain status of NAIP has largely stopped. The program has been able to maintain a two-year cycle for several years now and should continue with that schedule for the foreseeable future.

Partnerships with state or non-federal agencies have increased, with the resolution of some of the contracting regulations. These state partnerships however may have different calendar years, funding requirements, and so forth that can make partnerships difficult.

The NAIP program together with the 3DEP elevation program are working on a second pilot evaluation for dual sensor / simultaneous acquisition of imagery and lidar. This could lower costs and increase acquisition but does have numerous technical and programmatic hurdles. With more cameras and systems coming online and ongoing government agencies coordination this appears to be promising.

ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) is a cooperative mission of NASA and Japan, flying on Terra, a satellite launched in

December 1999, acquiring visible, shortwave infrared and thermal data from February 2000, as part of NASA's Earth Observing System (EOS). All ASTER data is freely available (https://asterweb.jpl.nasa.gov/data.asp).

MODIS (MODerate-resolution Imaging Spectroradiometer) is a sensor launched into Earth orbit by NASA in 1999 on board the Terra Satellite, according to a descending orbit (north to south in the morning), and in 2002 on board the Aqua satellite, according to an ascending orbit (south to north in the afternoon). The data are openly available (https://modis.gsfc.nasa.gov/data/), but in three areas the MODIS products can be improved:

1) by making most products available at 250-meter spatial resolution,

2) by doing a daily repeat, and

3) by developing a standardized protocol for the metadata regarding every MODIS product.

With the proposed decommissioning of MODIS Terra and Aqua satellites in 2025, the full suite of land products (MODIS Collections 6.1) will not be available past 2025 for imaging and mapping purposes (USGS 2021). These land products are now being produced using VIIRS (Visible Infrared Imaging Radiometer Suite) inputs (Román et al., 2024).

VIIRS, the next generation optical sensor and the successor to MODIS, was launched onboard the Suomi National Polar-Orbiting Partnership (Suomi NPP) spacecraft in 2011. Other VIIRS instruments that are currently operational are onboard NOAA-20 (launched in 2017) and NOAA-21 (launched in 2022). VIIRS provides moderate resolution imaging capabilities complementary to MODIS that ensure continuity of global coverage at coarse resolution (375m to 750m). The VIIRS datasets are openly accessible from NOAA (https://ncc.nesdis.noaa.gov/VIIRS/). Nevertheless, like MODIS products, there is a need to generate the daily VIIRS products at a higher resolution than 375m.

NOAA's Coastal Mapping Program acquires aerial imagery along 95,000 miles of U.S. coastline to support NOAA's Coastal Mapping Program and NOAA's Emergency Response Imagery requirements. Since 2009, orthorectified digital imagery has been made available through NOAA's Digital Coast (https://coast.noaa.gov/digitalcoast/) in order to increase support for multiple uses of the data as outlined in NOAA's Integrated Ocean and Coastal Mapping Initiative (https://iocm.noaa.gov/). Emergency Response Imagery is available at National Geodetic Survey - Emergency Response Imagery Index (https://storms.ngs.noaa.gov/).

2. Condition: ***The existing or near-term condition of the Framework themes as an integrated whole.***

Prior to the enactment of the GDA, the FGDC conducted Lifecycle Maturity Assessments (LMA) based on the A-16 Supplemental Guidance Stages of the Geospatial Lifecycle.4 As described in the FY2020 LCA NGDA Theme Reports, these assessments were conducted in 2015 and 2017 and resultant Theme LMA Summary Reports and Dashboards were made available online through GeoPlatform.gov. While the LMA process was put on hold following the enactment of the GDA, it is seen as a key component moving forward. Following the release of the updated OMB Circular A-16, the FGDC will analyze that

guidance and evaluate the LMA process for adoption and use to capture the lifecycle information from agencies and dataset managers. The LMA process could be used to dynamically augment these GDA annual reports and will also be analyzed as part of developing and implementing the plan for nationwide population of the NGDA data themes (core datasets) (FGDC 2024). The 2018 COGO Report Card used the 2017 NGDA lifecycle maturity assessment to provide some insights, based on user input, comparing the feedback of the assessed maturation to the optimized standard relative to specific lifecycle stages of the NGDA theme datasets (Freundschuh et al., 2018).

The former 133 Cities imagery provided higher resolution aerial imagery (15-30cm) for national urban areas. With the cancellation of the 133 Cities program, the NAIP imagery has in large part been able to provide similar data. The standard GSD of 30-60cm and two-year cycle for NAIP is comparable to 133 Cities. 15cm imagery is available through commercial imagery service for the same coverage as NAIP. The 20+ years of the NAIP program together with multiple agencies partnering with the funding has enabled consistent, high-resolution imagery for not only the 133 Cities urban area but also the entire statewide coverage. The NAIP imagery is available through USDA USDA:NRCS: Geospatial Data Gateway:Home and other imagery services as well as the actual digital data in DOQQ or Compressed County Mosaic formats.

In 2022, the National Reconnaissance Office awarded a contract to purchase commercial satellite imagery from several U.S. companies including BlackSky, Maxar Technologies, and Planet Labs. It is a 10-year contract providing satellite imagery to intelligence, defense, and federal civil agencies (FGDC 2023).

3. Funding: ***The funding capability of the Framework.***

The Farm Production and Conservation (FPAC) includes the Farm Service Agency (FSA), the Natural Resources Conservation Service (NRCS), and the Risk Management Agency (RMA), aligned with the FPAC Business Center. (Note the common representation on the NDOP Subcommittee in the table above.) FPAC funding with those partner agencies has been supporting the two-year NAIP cycle. Nevertheless, the shift to digital delivery over the past few years has been accompanied by the notable increase of imagery data and users but with budget constraints. A new revenue model could provide more stability for annual acquisitions, which are anticipated to grow rapidly. This would allow for technology and management improvements to benefit the supplier and user communities with capacity growth and delivery times (NGAC 2024).

Subsequent to the previous NSDI Report Cards, the partnership between NASA and USGS was Congressionally funded to complete the design for and September 2021 launch of the now successfully-operational Landsat 9. In December 2022, NASA and USGS proposed Landsat Next, expected to provide nearly 15 times more data that Landsat 9. As noted by the Congressional Research Service in November 2023 (https://crsreports.congress.gov/product/pdf/IN/IN12281), for FY24 NASA requested $95.7 million in funds to initiate Landsat Next and USGS requested an increase of $12 million over FY23 for its Sustainable Land Imaging Program for the Landsat Next ground system development. However, USGS funding was only increased $3.15M by Congress, well

short of the $12M requested (which was taken directly from USGS National Land Imaging science research and investigation funding therefore weakens the overall Imagery theme). As updated in the CRS on 28 June 2024, in the FY2025 budget submission, the USGS requested an increase of $8.9 M over FY2024 funding of $94.5 M for Landsat Next ground system development. That funding is required for the anticipated 2031 launch and operational date without impacting the Landsat data continuity and the entire sustainability mission (USGS 2024).

The ASTER and MODIS sensors remain operational on the Terra platform. The Terra platform, far exceeding its mission design life, has drifted in orbit, with exit from the nominal constellation in the early 2020s. Orbital, viewing angle and programmatic ends to the mission are expected in mid-2020s. As a result, the geospatial community in the United States can count on imagery from ASTER and MODIS from 2000 to early 2020s and on VIIRS imagery from 2020 onwards.

4. Future Need: ***Whether future-funding prospects will be able to meet the need.***

In the previous description of the "Condition of the Theme," this evaluation noted that users of orthoimagery are frequently identifying expanded uses of the various data sets and articulating both the benefits and the shortfalls that must be considered as future strategic objectives and implementation plans are prepared for NGDA imagery programs.

The 2023 Lead Covered Agency NGDA Theme Annual Performance Report and Self-Assessment for Imagery Theme reported a summary of accomplishments the imagery theme made in FY2023. Among the accomplishments, the following address the progress made on evaluating future imagery/orthoimagery needs.

The National Agricultural Imagery Program (NAIP) has continued on a two-year acquisition cycle. The number of states flown varies each year due to the different sizes of each state but averages approximately 50% of the area each year. The ground sample distance of the delivered imagery products continues to improve. The standard deliverable has been 60 cm for several years, with many states now delivering at 30 cm. Users consider NAIP to be particularly useful but worry about future accessibility. Their on-going experience shows that NAIP outperforms its cloud coverage specification, enabling some low-cost change detection and feature extraction tasks for an end user needing relatively high-resolution images. Continuation of the NAIP program, with reliable accessibility is most desirable. Higher resolution and improved temporal collections for the phenology throughout the growing season were seen as future needs in the previous COGO assessment.

The U.S. Group on Earth Observations (USGEO) Satellite Needs cycle initiated in 2022 and completed in 2023, assessed civil agency needs for satellite data and products that could be supported by NASA and partner agencies. The process allows Federal departments and agencies to communicate their Earth observation requests for satellite-based Earth observation data and information products to agencies with Earth observing capabilities. Information gathered during this process is used to inform NASA and

potentially other agency decisions on future sensors placed into orbit, new data products, and new data delivery strategies. The 2022 cycle identified needs for higher resolution data, lower latency access, training in the use of cloud technology, and potential activities related to enhanced land and atmospheric products and water quality information (USGEO 2022).

The U.S Department of Agriculture (USDA) is participating in an ongoing pilot project with USGS to 12 Imagery Theme – LCA NGDA Theme Report FY2023 - to evaluate methods, coordination, technologies, and data for dual sensor / simultaneous acquisition of aerial imagery and lidar elevation data that meet both NAIP and 3D Elevation Program (3DEP) requirements. This new development could result in lower costs and increase acquisitions for both the 3DEP, NAIP, and possibly other programs or datum (FGDC 2024).

5. Public Use: ***The Framework's ability to provide data resources that meet the everyday needs of organizations and the general public, and to provide data resources that meet the need to respond to public safety incidents, natural disasters, and other emergencies.***

During FY2023, the NGDA Themes transitioned from legacy GeoPlatform Theme sites to new Hub-based Theme sites (https://ngda-portfolio-community-geoplatform.hub.arcgis.com/pages/ngda-themes). As part of the transition, the themes established by consensus, the minimum required site content. All eighteen themes were transitioned and updated to reflect this minimum content requirement. Individual themes have the flexibility to publicly display and manage additional information from a variety of sources related to their theme. The new Hub sites provide end users, stakeholders, and partners with a place to find consistent theme-related information and access to NGDA datasets and services.

NAIP imagery is used by nearly every governmental organization at all levels, federal, state, tribal, local, etc. It is also widely used by industries, such as Esri as a base layer. The image layers published by Esri include all NAIP imagery since 2010 and provides access to imagery for each state in 4-bands (RGB and Near Infrared) with the option to display the imagery as Natural Color, Color Infrared, or NDVI showing relative biomass of an area.

Grade of Orthoimagery Theme

This committee assigned a grade of B (Adequate for now) for the orthoimagery theme. The Imagery Theme is in good condition but requires attention. The lead agencies (USGS and FPAC-BC) continue in their efforts since the last COGO report card, including GeoPlatform evaluations and reporting as well as ongoing NGDA program support for NAIP, Landsat, ASTER and MODIS. These efforts have not gone unnoticed. However, there is still a concern that limited Federal funding for imagery programs, such as NAIP, may result in more restrictive data access models as Federal and State agencies consider a move toward licensed imagery products. Based upon the current survey results there is a need for high resolution ortho imagery and the near elimination of the High-Resolution Imagery program, and its removal from the GeoPlatform, continues to represent a clear

threat to the future availability of public-domain high-resolution orthoimagery. Accurate metadata continues to be a critical component in order to facilitate the discovery, integration, and use of imagery. Assigning a grade of B (Adequate for Now) captures the underlying pressures and limitations of some NGDA programs and data sets. As a result, the COGO review committee believes a grade of B is warranted for the Imagery Theme.

Summary and Recommendations

The current NSDI strategic plan will expire in 2024. The FDGC plans to work collaboratively with partners and stakeholders in the geospatial community to develop a new strategy that includes a national vision and goals and objectives for the continued and sustainable development of the NSDI. This will provide an opportunity to provide input into the future direction of the NSDI plan.

It is recommended that the disconnect between the use of the term "orthoimagery" for the NSDI Framework and the use of the term "imagery" in NGDA be resolved.

The COGO Evaluation Team for the NSDI Imagery theme has determined that an overall grade of "B" is warranted for this theme. Programs such as Landsat, ASTER, and MODIS would be in the A- range for their current and near-term future stability, meeting user specified requirements and assessing future requirements. NAIP, although prized by its contributors and users, is confronted by the uncertainty of funding and demands for more phenology opportunities (e.g. leaf-on vs. leaf-off, consistent radiometry, etc.). As Technology evolves, there is an ever-growing need to assess standards, analytics and data management needs for future technological advances.

Although the NSDI, FGDC, GeoPlatform, and the NDOP are focused on acquisition and management of data sets, either primarily or predominantly funded by the Federal government, an assessment of the national condition of an Imagery Theme cannot ignore the disconnect between the vast amount of orthoimagery collected by States and the NGDA imagery theme. Much of that data is freely accessible, is high resolution, and follows the accepted data standards. Whether or not included within the official definition of the NDOP, the Sate collections are invaluable to the NSDI performance.

This Report Card subsection did not evaluate the status of lidar images derived from the intensity values. The process of creating images from vector intensity data requires the exercise of judgment, so this collection is left to the Elevation Theme of the COGO Assessment. However, it is promising that dual sensor / simultaneous acquisition of aerial imagery and lidar elevation data that meet both NAIP and 3D Elevation Program (3DEP) is being evaluated by the USDA. This technology crosses the themes of elevation and orthophotography and should be evaluated in future assessments.

The energized focus of the FGDC and the GeoPlatform efforts since the 2018 evaluation report continues to be pronounced. Preparing strategic and implementation plans for each theme and identifying criteria to measure progress continues to mature. Attention to the needs of customers, as reflected in the LCA NGDA theme annual assessment reports, demonstrates a willingness to design systems, sensors, data sets, and services

that reflect those needs. In addition, the movement to cloud-based storage and systems reflects the data management requirements as imagery/orthoimagery moves to higher resolution. It is recommended that NDOP agencies continue to look beyond the needs of Federal users and consider the requirements of other important constituencies. One valuable asset for this analysis is the Government Services Administration's Digital Analytics Program (DAP). Federal agencies are required to participate in the DAP. These analytics can provide useful information on public-facing federal websites and the availability of data sets. As an example, NOAA Summarizing the Digital Coast Accomplishments Report 2024 (NOAA 2024) Objective 2: Increase Availability of Core Coastal Data Sets listed the following information on data availability:

- 118,000 downloads of custom data in fiscal year 2023, a 27 percent increase since fiscal year 2021;
- 33 trillion lidar points, more than doubling holdings since the start of fiscal year 2021;
- 200 terabytes of imagery, almost quadrupling over this period;
- Improved access to data for typically underserved areas such as Guam, the Northern Mariana Islands, Alaska, and several Great Lakes tribal communities.

The most obvious risk to all geospatial data and services, including imagery/orthoimagery continues to be sufficient funding at all levels. The risk is that imagery becomes less "free and open," creating "walled gardens" that are reflective of a trend toward greater market segmentation within the imagery industry.

The geospatial community should pay close attention to the growth of both cloud-based storage and cloud-based services and processing. The community should stay active in the groups developing the data architectures to facilitate the standards-based integration of the cloud-based data stores and services, continue to demand good metadata, and strongly promote the sharing of non-proprietary and non-licensed imagery with the public.

Orthoimagery Data Theme Working Group

Framework Evaluators
Tonda Shelton, Team Lead, North Carolina Flood Plain Mapping Program
Christopher Parrish, Oregon State University
Roberta Lenczowski, Independent Consultant
Tony Spicci, GIS Certification Institute
Bandana Kar, US Department of Energy
Mark Yacucci, University of Illinois

Members of the Working Group express their thanks to the two federal liaisons for the Orthoimagery program, who provided updated information and key comments during the writing period. They are:

- Greg Snyder, DOI/USGS/National Land Imaging Program
- David Davis, USDA/FPAC-B

VIII. Transportation Data Theme

Executive Summary

The Transportation Data theme is critical to the Nation's geospatial practitioners and decision makers both within and beyond the transportation sector. Programs such as Next Generation 911 (NG911) demand information beyond that which is found within the current data theme. As such it is important to understand not only the needs of the transportation sector but across the spectrum of users that leverage the data. With that in mind, a portion of this assessment focuses on the maturity of a multi-use national transportation road centerline data set with address ranges that can be leveraged across the community of users.

There will continue to be a need within the transportation sector for data being collected from programs such as MAP 21 and the All Roads Network of Linear Referenced Data (ARNOLD) to continue to improve safety and operation of the transportation system. Innovative technologies such as the Internet of Things and autonomous vehicles require continued data development, acquisition, and improvement of transportation data so the public and federal, state, and local agencies can take effective and efficient advantage of these advancements.

While some progress has been and continues to be made, multiple areas need attention and more work to be done. Standards development has essentially been in a holding pattern. Concern remains that workflows are underfunded and understaffed. Workflow coordination needs improvement between federal, state, and local transportation related agencies, as well as potential commercial partners.

Transportation Theme Grade: C

Requires Attention

Description of the Framework

Introduction to the Theme

The National Spatial Data Infrastructure (NSDI) consists of eighteen (18) National Geospatial Data Asset (NGDA) Themes managed by twenty-five (25) Federal agencies. Each theme includes a group of data layers the FGDC's Steering Committee has designated as being National Geospatial Data Assets. The US Department of Transportation (USDOT) Bureau of Transportation Statistics (BTS) serves as the Lead Covered Agency (LCA) and theme lead for the development and maintenance of the geospatial data representing the networks of roads, railroads, air, transit, and inland waterways. The Transportation Theme, established in 2002 as part of the original A-16 themes, consists of fifteen (15) NGDAs (Table Transportation-1). The Transportation Data theme is critical to the Nation's geospatial practitioners and decision makers.

While the US DOT BTS leads the theme, they are not responsible for, nor does the agency

serve as the steward for, all the data defined as part of the theme.

Table Transportation-1. Federal agencies and the National Geospatial Data Assets (NGDA) each agency maintains and supports.

Transportation NGDA	Responsible Covered Agency
Roads - TIGER/Line Shapefile	Department of Commerce - Census Bureau
Ports	Department of Defense - US Army Corps of Engineers
Waterway Locks	
Inland Electronic Navigational Charts	
Navigable Waterway Routes	
Navigable Waterway Nodes	
National Bridge Inventory	USDOT Federal Highway Administration
Transit Stations	USDOT Bureau of Transportation Statistics
Transit Lines	
Intermodal Freight Facilities	
Intermodal Passenger Facilities	
Airports	USDOT Federal Aviation Administration
Runways	
Rail Nodes	USDOT Federal Rail Administration
Rail Lines	

The coordination between these federal agencies to ensure success of the theme can be daunting. Additionally, other entities including federal agencies (e.g., Census TIGER), state and local jurisdictions and tribal entities are providing digitalization of this data for their own purposes. Private sector companies such as HERE, TomTom, Google, Waze, Amazon, Apple, OpenStreetMap, and others created national and global geospatial transportation data to meet the needs of their respective organizations and the public. Variations in data schemas, field naming conventions, and levels of normalization lead to difficulties in sharing and aggregating data from multiple jurisdictions into common theme elements. Overall significant variations in the quality, completeness, and accuracy between local agencies, states, federal, and non-governmental business datasets continue to challenge the transportation theme.

This evaluation reviews the efforts completed and progress made since the 2018 Report Card, at which time the Transportation Data Theme was graded at the C level. The 2018 report card grade reflected the need for further coordination, data governance and integration of the multiple sources of road centerline data (e.g., TIGER, ARNOLD, and privately produced) in use by federal agencies.

Additionally in 2018 the Geospatial Data Act became law providing new requirements for theme leads to address. This assessment reviews the impact of those requirements and the progress since their enactment.

The Theme Definition

Transportation theme data includes both physical and non-physical components representing all modes of travel in the US. Physical components of the transportation

infrastructure include the road, railroad, transit, and waterway networks, and freight, passenger, and airport facilities. Non-physical components are Inland Electronic Navigational Charts (IENC). This foundational set of data not only gives a reference to where we are in the US, but the interconnectedness and characteristics of this important theme provides us a model for how goods and people move from one place to another.

Lead Agency and Current Activities

The U.S. Department of Transportation (USDOT) Bureau of Transportation Statistics (BTS) serves as the lead covered agency (LCA) responsible to facilitate and coordinate the management and development of the Transportation Theme. Partner agencies (Census, Federal Aviation Administration (FAA), Federal Railroad Administration (FRA), US Army Corps of Engineers (USACE) and Federal Highway Administration (FHWA)) within the Transportation Theme community are responsible for managing individual NGDAs. Additionally, there are data theme creators and providers in state, tribal and local governments and the private sector making it difficult to move toward a single set of truth for the data theme.

The passage of the Geospatial Data Act in 2018 provided new guidance and requirements to all NGDA Theme Leads. In September 2022, the USDOT Inspector General developed Report IT2022040 which outlines a summary of the compliance activities and progress toward GDA Transportation Theme requirements (USDOT 2022).

The USDOT's Inspector General's Report concluded that the US DOT has made progress complying with lead covered agency requirements (USDOT 2022). Since the report was issued, the organization published its Geospatial Standards Implementation Plan (GSIP) which identified, assessed, and recommended geospatial data standards for each of its NGDAs. The report also defines a Standards Development Lifecycle for theme data however standards implementation has not yet begun.

Table Transportation-2. Lead covered agency responsibilities and status as assessed by the USDOT Inspector General. ***Table is continued on the next page.***

Responsibility	Description	FY 2020 Status	FY 2022 Status
NGDA Theme Standards	Lead development and implementation of data standards for the transportation theme with emphasis on a data content standard. Before developing new standards, lead agencies must review standards already in use and adopt them if possible.	Did not meet	Partially meets
Theme Plan	Lead the development and implementation of a plan for the nationwide population of the transportation theme.	Partially met	Meets
Establish Goals	Establish goals that support the strategic plan for the NSDI prepared under section 755(c)	On hold	Meets

Table Transportation-2, *continued*. Lead covered agency responsibilities and status as assessed by the USDOT Inspector General.

Responsibility	Description	FY 2020 Status	FY 2022 Status
Information on User Needs	Collect and analyze information from users of transportation theme data regarding users' needs for the data and incorporate these needs into theme related strategies.	Met	Meets
Theme Administration	Establish a theme point of contact, submit annual performance reports, and publish maps and coordinates with GeoPlatform.	Met	Meets

Overall, DOT has made progress as a lead covered agency but has not fully complied with requirements on standards implementation due to a new standards development process developed through FGDC.

Table Transportation-3. Covered agency responsibilities and status as assessed by the USDOT Inspector General. *Table is continued on next page***.**

Responsibility	Description	FY 2020 Status	FY 2022 Status
Strategy	Prepare, implement, maintain, and publish a strategy for advancing geographic information and related geospatial data and activities.	Partially met	Partially meets
Geospatial Data	Collect, maintain, disseminate, and preserve geospatial data.	Met	Meets
Promotion of integration	Promote the integration of geospatial data from all sources.	Met	Meets
Inclusion of geospatial data in agency record schedules	Ensure that data information products and other records created in geospatial data and activities are included on agency record schedules approved by the National Archives and Records Administration (NARA).	Partially met	Partially meets
Allocation of resources	Allocate resources to fulfill the responsibilities of effective geospatial data collection, production, and stewardship.	Partially met	Meets
Use of geospatial data standards	Use the geospatial data standards, including documenting geospatial data with the relevant metadata and making metadata available through the GeoPlatform.	On hold	Meets
Privacy and confidentiality	Protect personal privacy and maintain confidentiality in accordance with Federal policy and law.	Did not meet	Meets

Table Transportation-3, *continued*. Covered agency responsibilities and status as assessed by the USDOT Inspector General.

Responsibility	Description	FY 2020 Status	FY 2022 Status
Data declassification	Participate in determining whether declassified data can contribute to and become a part of the NSDI.	NA	NA
Review of existing geospatial data	Search all sources to determine if existing geospatial data meets the needs of the covered agency before expending funds for geospatial data collection.	Did not meet	Meets
Collection of high-quality data	Ensure that a person receiving Federal funds for geospatial data collection provides high-quality data.	Did not meet	Meets
Appointment of Contact	Appoint a contact to coordinate with the lead covered agencies for collection, acquisition, maintenance, and dissemination of the NGDA data themes used by the covered agency.	Met	Meets

In 2023, the Theme awarded a Geospatial Standards Adoption contract. The contract provides administrative support to the theme and NGDA dataset managers in their efforts to identify and adopt minimum content standards (MCS). The contract will culminate with a plan for the adoption or development of geospatial standards for each NGDA within the theme.

Overall, DOT has made progress as a lead covered agency but has not fully complied with requirements on standards implementation due to a new standards development process developed through FGDC.

While good progress has been made in many areas, the US DOT Inspector General identified the Theme has yet to fully meet three requirements for Covered Agencies:

1. **Geospatial Data Strategy**: It is important to note that since the Inspector's report, DOT issued its GIS Strategic Plan for years 2022 through 2024 and posted it at transportation.gov. DOT is implementing the plan and assesses progress quarterly.
2. **Inclusion of Geospatial Data in Agency Record Schedule**s: GDA requires covered agencies to include data information products in agency record schedules approved by the National Archives and Records Administration (NARA). The Federal Aviation Administration, Federal Transit Administration, Maritime Administration, National Highway Traffic Safety Administration, Office of the Secretary of Transportation, and Pipeline and Hazardous Materials Safety Administration have submitted their information and are waiting for NARA to complete its approval process. Once

approved this requirement will be met.

3. **Promotion of Use of Geospatial Information**: GDA requires covered agencies to use geospatial information to enhance their operations, support decision making, and improve reporting to Congress. The DOT GIS Strategic Plan for fiscal years 2022 through 2024 includes guidance for enhancing operations and established ongoing monitoring for geospatial data, but implementation of those efforts remains to be completed. In the January 2023 report to the FGDC, DOT identified these requirements have been met.

Finally in terms of GDA requirements, USDOT is meeting the requirements for reporting. The agency provides two annual reports to the FGDC and maintains a geospatial data asset inventory.

Since 2022, however, and subsequent to the audit, DOT has indicated they have met each of the requirements identified above by the US DOT Inspector General.

Transportation Theme Strategic Plan and Implementation Plan

The GDA requires the Department to assess and report progress against the Transportation Theme Strategic Plan (TTSP) and the US DOT GIS Strategies yearly. The Transportation Theme of the National Spatial Data Infrastructure Strategic Plan 2021–2024 provides goals and objectives to guide the work of the Transportation Theme Subcommittee.

With input from the Transportation Theme community, and in accordance with the Geospatial Data Act of 2018 (GDA), the USDOT completed a TTSP in 2022. The TTSP also strives to align goals from the TTSP to the NSDI Strategic Plan. As of this writing, the FGDC pans to publish a new NSDI strategic plan by the end of the 2024 calendar year.

As the Transportation Theme Lead, US DOT is responsible for developing a Theme Implementation Plan (TIP) to clarify when and how the relevant parties will accomplish the actions identified in the theme strategic plan. The Transportation Theme Implementation Plan aligns with the four strategic goals the FGDC collaboratively developed for the NSDI Strategic Plan 2021–2024 and assigns objectives and action items to focus efforts on achieving those goals. There are two documents that support the TTSP, the Theme Implementation Plan and the Theme Communications Plan. Current progress and status of the strategic plan goals and objective for 2022-2024 are detailed in the Table Transportation-3 (below).

Table Transportation-4. Current Progress and Status of the Transportation Theme's Strategic Plan Goals and Objectives for 2022 - 2024. *Table continued on next page.*

Goal ID	NSDI Goal		NSDI Subject	Action Items	Due Date and Progress
1	Implement Federal Geospatial Policies and Governance Framework		Policy and Governance	Meet Objectives 1.1 and 1.1.1 - 1.1.7	
Obj. ID	**Transportation Theme Objective**	**GDA Item**	**GDA Subject**	**Action Items**	**Due Date and Progress**
1.1	Coordinate the management of data, supporting resources, and related services and products of the Transportation Theme	2805.b.2	LCA Responsibilities	Addressed by Action ID's 1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5, 1.1.6, 1.1.7	Perpetual
1.1	Lead and facilitate the development and implementation of a plan for nationwide population of the Transportation Theme	2805. b.3.B	Theme Development	Addressed by Action ID's 1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5	Perpetual
1.1	Administer the Transportation Theme according to the GDA	2805. b.3.E	Theme Administration	Addressed by Action ID's 1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5, 1.1.6, 1.1.7	Perpetual
Action ID	**Transportation Theme Action**	**GDA Item**	**GDA Subject**	**Action Items**	**Due Date and Progress**
1.1.1	Establish goals that support the strategic plan for the NSDI prepared under 43 USC Ch. 46, §2804(c) of the GDA	2805. b.3.C	Theme Development	Developed and published the Transportation Theme Strategic Plan	Completed

Table Transportation-4, *continued*. Current Progress and Status of the Transportation Theme's Strategic Plan Goals and Objectives for 2022 - 2024.

Action ID	Transportation Theme Action	GDA Item	GDA Subject	Action Items	Due Date and Progress
1.1.2	Expedite the maturation of the Transportation Theme through the effective implementation of theme strategies.	2805.b.3.B.v	Theme Development	Expedite the maturation of the Theme through effective administration by implementing strategic planning, calculated communications, and deliberate actions. See TSP, CP, and IP for success criteria	Perpetual
1.1.3	Address the human and financial resource needs of the Transportation Theme.	2805.b.3.B.iii	Theme Development	Complete the Human and Financial needs report. Updated 10.8 in the TTSP to reflect the methodology.	Completed May 2022
1.1.4	Identify needs relating to standards, metadata for geospatial data, and the GeoPlatform.	2805.b.3.B.iv	Theme Development	BTS completed the Geospatial Standards Implementation Plan (GSIP) in June of 2023	Completed June 2022

Table Transportation-4, *continued*. Current Progress and Status of the Transportation Theme's Strategic Plan Goals and Objectives for 2022 - 2024.

Action ID	Transportation Theme Action	GDA Item	GDA Subject	Action Items	Due Date and Progress
1.1.5	Lead and facilitate the development of the DOT GIS Strategic Plan by defining the actions CAs will take to meet responsibilities defined in section 2808 of the GDA.	2808.a.1	NGDA Administration	GMO is responsible for administering section 2808 (Covered Agency responsibilities) of the GDA.	Completed March 2022
1.1.6	Submit a performance report to the FGDC, at least annually, that documents the activities relating to and implementation of the National Geospatial Data Asset data theme, including progress in achieving the requirements.	2805. b.3.E.ii.I	Theme Administration	Begin drafting annual reports each December.	Perpetual. Completed for 2020-2023.
1.1.7	Respond to FGDC comments, as appropriate, regarding the summary and evaluation of the performance report.	2805. b.3.E.ii.II	Theme Administration	No comments received from FGDC.	Perpetual. Completed for 2020-2023.
Goal ID	**NSDI Goal**		**NSDI Subject**	**Action Items**	**Due Date and Progress**
2	Mature the Transportation Theme Through Expanded Data Sources and Accelerated Data Acquisition		NGDAs	Meet objectives 2.1 and 2.1.1 – 2.1.3	

Table Transportation-4, *continued*. Current Progress and Status of the Transportation Theme's Strategic Plan Goals and Objectives for 2022 - 2024.

Obj. ID	Transportation Theme Objective	GDA Item	GDA Subject	Action Items	Due Date and Progress
2.1	Lead and facilitate the development and implementation of geospatial data standards for the Transportation Theme, with an emphasis on data content standards.	2805. b.3.A	Geospatial Data Standards	Addressed by action items 2.1.1 and 2.1.2 BTS, working with its contractor, is executing the Geospatial Standards Adoption Plan.	GSIP Completed June 2023 Underway: GSAP Tasks POP: 9/29/2023 – 9/28/2025
2.1.1	Recognizing the development continuum of NGDAs, the USDOT will establish a GSIP consistent with the NSDI.	2805. b.3.A.iii.II	Geospatial Data Standards	BTS completed the GSIP in June 2023.	GSIP Completed June 2023
2.1.2	The GSIP shall assess existing standards.	2805. b.3.A.i	Geospatial Data Standards	BTS completed the GSIP in June 2023..	GSIP Completed June 2023
2.1.2	The GSIP shall identify anticipated or needed data standards	2805. b.3.A.ii	Geospatial Data Standards	BTS completed the GSIP in June 2023.	GSIP Completed June 2023
2.1.2	The GSIP shall detail a process to originate and implement needed standards with relevant community and international practices.	2805. b.3.A.iii	Geospatial Data Standards	BTS completed the GSIP in June 2023. BTS, working with its contractor, is executing the Geospatial Standards Adoption Plan.	GSIP Completed June 2023 Underway: GSAP Tasks POP: 9/29/2023 – 9/28/2025

Table Transportation-4, *continued*. Current Progress and Status of the Transportation Theme's Strategic Plan Goals and Objectives for 2022 - 2024.

Obj. ID	Transportation Theme Objective	GDA Item	GDA Subject	Action Items	Due Date and Progress
2.1.2	The GSIP shall develop needed standards in accordance with OMB Circular A–119, or any successor.	2805. b.3.A.iii. I	Geospatial Data Standards	BTS completed the GSIP in June 2023. BTS, working with its contractor, is executing the Geospatial Standards Adoption Plan	GSIP Completed June 2023 Underway: GSAP Tasks POP: 9/29/2023 – 9/28/2025
2.1.3	Develop procedures to assess data gaps, source gaps, data collection processes, data integration processes, and best practices.	2805. b.3.A	Geospatial Data Standards	BTS completed the GSIP in June 2023. BTS, working with its contractor, is executing the Geospatial Standards Adoption Plan	GSIP Completed June 2023 Underway: GSAP Tasks POP: 9/29/2023 – 9/28/2025
Goal ID	**NSDI Goal**		**NSDI Subject**	**Action Items**	**Due Date and Progress**
3	Promote open standards-based interoperability to enable geospatial shared services		Geospatial Shared Services	Meet objectives 3.1 – 3.1.2	Perpetual
Obj. ID	**Transportation Theme Objective**	**GDA Item**	**GDA Subject**	**Action Items**	**Due Date and Progress**
3.1	Foster the use of the GeoPlatform	2805. b.3.E.iv	Theme Administration	Promoting Theme site on GeoPlatform	GTS site on the GeoPlatform

Table Transportation-4, *continued*. Current Progress and Status of the Transportation Theme's Strategic Plan Goals and Objectives for 2022 - 2024.

Object ID	Transportation Theme Action	GDA Item	GDA Subject	Action Items	Due Date and Progress
3.1	Coordinate with the GeoPlatform	2805. b.3.E.v	Theme Administra-tion	Engaging with the GeoPlatform users' group as needed; Co-chair the GDA Working Group until the end of 2024; Attend monthly Theme Lead Community Meeting	GDAWG meeting. Meetings are held every other month. The GDA Working Group minutes are available from the Department of Interior archives.
Action ID	**Transportation Theme Action**	**GDA Item**	**GDA Subject**	**Action Items**	**Due Date and Progress**
3.1.1	Designate a point of contact within the lead covered agency who shall be responsible for developing, maintaining, coordination relating to, and disseminating data using the GeoPlatform	2805. b.3.E.i	Theme Administra-tion	Dom Menegus is the Point of Contact. Derald Dudley is the Alternate	Updated Theme POCs via email on August 18, 2023
3.1.2	Encourage individuals and entities that are a source of geospatial data or metadata for geospatial data for the Transportation Theme to provide access to such data through the GeoPlatform	2805. b.3.E.iv	Theme Administra-tion	Datasets are accessed via the GeoPlatform	GeoPlatform NGDA Transportation site

Table Transportation-4, *continued*. Current Progress and Status of the Transportation Theme's Strategic Plan Goals and Objectives for 2022 - 2024.

Goal ID	NSDI Goal		NSDI Subject	Action Items	Due Date and Progress
4	Enable and promote collaborative partnerships to meet national needs and priorities for geospatial transportation data.		Collaborative Governance and Partnerships	Meet objectives 4.1 and 4.1.1 – 4.1.5	Perpetual
Obj. ID	**Transportation Theme Objective**	**GDA Item**	**GDA Subject**	**Action Items**	**Due Date and Progress**
4.1	Meet the needs of users of Transportation Theme data	2805. b.3.B.ii	Theme Development	Partnership activities: GTS quarterly meetings, Workshop production, Participation in conferences, research organizations, professional organizations.	Perpetual. GTS site on the GeoPlatform, Partnership Building Activities, Communications Coordinator for TRB's AED40
Action ID	**Transportation Theme Action**	**GDA Item**	**GDA Subject**	**Action Items**	**Due Date and Progress**
4.1.1	Develop partnership programs with States, Indian tribes, institutions of higher education, private sector entities, other Federal agencies, and local governments	2805. b.3.B.i	Theme Development	Partnership activities: GTS quarterly meetings, Workshop production, Participation in conferences, research organizations, professional organizations..	Perpetual. GTS site on the GeoPlatform, Partnership Building Activities, Communications Coordinator for TRB's AED40

Table Transportation-4, *continued*. Current Progress and Status of the Transportation Theme's Strategic Plan Goals and Objectives for 2022 - 2024.

Action ID	Transportation Theme Action	GDA Item	GDA Subject	Action Items	Due Date and Progress
4.1.2	Leverage partnership programs to solicit input on the need and use of transportation data and services.	2805. b.3.B.i	Theme Development	Partnership activities: GTS quarterly meetings, Workshop production, Participation in conferences, research organizations, professional organizations.	Perpetual. GTS site on the GeoPlatform, Partnership Building Activities, Communications Coordinator for TRB's AED40
4.1.3	As necessary, collect and analyze information from users of geospatial data within the Transportation Theme regarding the needs of the users for geospatial data and incorporate the needs of users in strategies relating to the Transportation Theme	2805. b.3.D	User Needs	Partnership activities: GTS quarterly meetings, Workshop production, Participation in conferences, research organizations, professional organizations.	Perpetual. GTS site on the GeoPlatform, Partnership Building Activities, Communications Coordinator for TRB's AED40
4.14	Identify and publish proven practices for the use and application of geospatial data of the LCA	2805. b.3.E.vi	Theme Administration	Developing Theme Strategic Plan template, Theme Implementation Plan, and Communication Plan Templates for the NSDI.	FGDC Theme Lead Working Group is developing the templates.

Table Transportation-4, *continued*. Current Progress and Status of the Transportation Theme's Strategic Plan Goals and Objectives for 2022 - 2024.

Action ID	Transportation Theme Action	GDA Item	GDA Subject	Action Items	Due Date and Progress
4.14, cont.				Developing a study to measure the efficacy of transportation data feeds	.
4.15	Publish maps or comparable graphics online (in accordance with the mapping conventions specified by the FGDC) showing the extent and status of the NGDA data themes for which the CA is an LCA.	2805. b.3.E.iii	Theme Administr-ation	Publish maps, applications, and data via the USDOT Geospatial shared services infrastructure.	BTS Geospatial Application & Map Gallery BTS Open Data Catalog: Data.gov – Federal Open Data: DOT GIS Gallery and Maps GeoPlatform NGDA Communities GeoPlatform Terria Map

As the lead agency, the USDOT in partnership with the Transportation Theme Subcommittee provides annual reports through the FGDC regarding theme progress concerning transportation data-related activities.

Collaboration and Partnerships

Given the multiple institutions involved in partnering in the theme, it is not surprising that the Transportation Theme has identified collaboration as a primary guiding principle. The Theme should be applauded for its work with partners in federal, state,

local, and tribal governments, institutions of higher education, and private sector entities, as well as many professional organizations, boards, committees, and working groups to help the Theme to identify, analyze, and develop community guided data management strategies and policies to help provide for Theme growth and improvement. Identified collaboration includes:

- USDOT
- FAA
- FGDC
- Work Zone Data Working Group
- US Roads Specification Working Group
- Federal Land Roads Working Group
- Federal Trails Working Group
- Intercity Bus Working Group
- Open Street Map
- National States Geographic Information Council (partnership with states)
- American Association of States Highway and Transportation Officials (AASHTO)
- Transportation Research Board
- GIS-T (partnership with states)
- Esri

Standards

Geospatial standards are critical for data sharing and integration and allow for the creation of regional, state and national data sets from multiple sources.

The Geospatial Data Act of 2018 (GDA) requires agencies with theme-specific National Geospatial Data Assets (NGDAs) to implement geospatial data standards within each associated theme under the National Spatial Data Infrastructure. USDOT has designated the Bureau of Transportation Statistics (BTS) as the Transportation Theme Lead and tasked it with developing a Geospatial Standards Implementation Plan (GSIP) to encourage the standardization of NGDAs across the Transportation Theme.

In collaboration with the geospatial transportation community, the BTS developed a process for identifying and assessing existing geospatial standards, developing standards when existing standards are insufficient, and delineation of a detailed workflow to nominate relevant geospatial standards to the FGDC Office of the Secretariat (OS), Executive Committee (EC), and Steering Committee (SC) for endorsement.

The original standards development for the transportation theme consists of the 2008 Framework data exchange standards for the transportation base. This development includes lines and points for air, rail, road, transit, and inland waterways.

Additional standards work for transportation related data themes, continues with standards being created for the following:

- Federal Trail Data Standards (2011)
- Federal Trail GIS Schema (2022)
- Geospatial Positioning Accuracy Standards, Part 4: Architecture, Engineering, Construction, and Facilities Management (2002)
- Intermodal Standard (In progress)
- Draft US Road Specification (In progress)

While these standards were developed in the early 2000's they are no longer relevant due to advancing technology and requirements. Each data set related to this theme will undergo the adoption of an existing standard or the development of a new standard following the new standards process.

Estimate of Theme Completeness

- **Definition**: Complete
- **Strategic Plan**: Completed in 2022
- I**mplementation Plan**: This was developed 2021– 2024 with defined goals and objectives with yearly progress reports.
- **Data sets**: Development of Transportation data continues at all levels of government and the private sector. Federal Highway Administration MAP 21 and ARNOLD programs outline guidance and incentives for local agencies to provide transportation related data to the state and federal agencies. Work remains in integration, aggregation, and sharing of data, standards development and planning for and addressing disruptive technologies.
- **GDA Requirements and Reporting**: DOT made progress complying with lead covered agency requirements. The agency has made progress as a covered agency but has not fully complied with requirements on strategy, records, and use of geospatial information. The DOT provides two annual reports to the FGDC.

Accessibility of Data

A primary goal from the Theme Implementation Plan is to "Facilitate the Sharing of Transportation Geospatial Data." The success of this goal is being measured and met through the providing of web services to the Geospatial Platform, Data.gov, and the National Transportation Atlas Database.

Authority, Governance, and Management of the Theme

Under OMB Circular A-16, US DOT has always been the steward for Framework data relating to transportation. It chairs the Transportation Theme Subcommittee, which is responsible for the coordination of the theme strategic plan, implementation plan, and associated transportation data-related activities among agencies. As the lead agency, US DOT is responsible for establishing mechanisms for the coordinated development, use, sharing, and dissemination of best practices, standards, data and reporting for the theme.

Transportation Data Theme Assessment

While some of the deficiencies from the first assessment are not resolved, some progress

has been and continues to be made. Data is becoming more openly available through web services and APIs. Further embracing web services and APIs presents an opportunity to better obtain and share transportation related data.

The DOT, in partnership with the Transportation Theme Subcommittee, completed the Transportation Theme Strategic Plan and is making progress on the goals and objectives within the plan. The Transportation Implementation Plan was finalized and steps are being taken to complete the objectives.

There are, however, needs for progress in some areas. Standards development has essentially been in a holding pattern for some time while a new process for standards approval has been defined. There needs to be deliberate effort pursued toward additional work in furthering standards development.

Concern remains that workflows are underfunded and understaffed. That jeopardizes keeping multi-modal transportation data current with continuous maintenance or sufficiently accurate across multiple jurisdictions, which often rely upon gasoline/fuel taxes for funding work.

The workflow coordination needs improvement between federal, state, and local transportation related agencies as well as potential commercial partners both in terms of data integration and aggregation. This year's assessment included a survey of geospatial data providers and users to better understand both the opportunities and needs of the geospatial community.

Understanding Community Needs

While it is clear the US DOT and Transportation Theme Subcommittee are making progress, one important question needs to be asked. Does the data produced meet the needs of the geospatial and public communities? To better understand that question as with the other themes, COGO surveyed the community of data producers and users. While the Transportation Theme is made up of sixteen individual data sets, a survey of all sixteen data sets was not practical or possible. Hence, we focused our community assessment on a multi-use road centerline with address ranges. A multi-use road centerline data set would meet more than the needs of just the transportation community. Examples include routing for emergency management, use in a geocoder or to aid in delivery of goods to residents.

To ensure a good understanding of needs and ability to move toward a national multi-use road centerline, COGO surveyed both transportation data providers and users. There was a good mix of respondents.

Table Transportation-5. Percentages of survey respondents in different roles.

Role	Proportion
Data Creator - Owner/Road Authority (creates, modifies road centerline records)	40.5%
Manager/Custodian (manages road centerline database for an organization/operation)	10.3%
Data Aggregator (collects road centerline data from multiple sources)	7.8%
User (uses data directly - visualization, geo-searches, analysis; does not edit and does not manage a system)	32.8%
Vendor/Consultant (provides products or services to road centerline data creators, managers, or users)	2.6%
Other/None of the above	6.0%

Achieving a national multi-use road centerline requires the ability to integrate data into a common standard and format from multiple authoritative sources. While the geospatial community is making progress moving toward standards, survey responses clearly show more work is necessary in both providing and moving toward a multi-use standard for road centerlines.

Table Transportation-6. Road centerlines published to standards.

Survey Response	Proportion
Published to an approved state or national standard and validated to ensure consistency of both geometry and attributes.	38.6%
Published to an approved state or natoinal standard but not validated against that standard to ensure consistency of both geometry and attributes.	27.3%
Not published to a standard nor validated for consistency.	19.3%
Not published to a state or national standard but is validated against another standard or data model for consistency of both geometry and attributes.	14.8%

Road centerline data requires regular updates and maintenance to be a trusted source for users. A road centerline dataset must contain a broad set of attributes that enables it to be leveraged for more than one purpose to truly support multi-use. Eighty three percent (83%) of respondents identified the data they are producing includes a broad set of attributes used for more than one purpose. The remaining respondents identified the data is designed for a specific purpose without additional utility.

The specific program need and use of the data drives frequency updates. For instance, Next Generation 911 recommends updates of 72 hours, while other programs such as US DOT Highway Performance Monitoring System (HPMS) only require annual updates.

The survey results seem to support that approach.

Table Transportation-7. Frequency with which road centerline databases are updated.

Survey Response	Proportion
Weekly, nightly, or near real-time	34.7%
Monthly	12.6%
Quarterly	5.3%
Annually	7.4%
> Every 2 Years	2.1%
Not defined	37.9%

Some attribute elements clearly stand out as a key need. Address ranges are becoming increasingly important especially in the 911 community as the nation moves toward Next Generation 911. Additionally, road centerlines with address ranges are a critical component of geocoding services. Of those who responded in the survey, about 53% of data provided by producers contains address ranges, and 22.4% does not.

Another key aspect of a multi-use road centerline includes whether the geometry contains topology and can be leveraged for routing analysis. Fifty eight percent (58%) of data providers indicated the road centerline data contains topology and connectivity in addition to address ranges to use as a routable network in a GIS.

Currently there is no specific national policy requiring a topologically connected, geospatial road dataset, built for routing or geocoding. It is clear from the community there is a need for one and there should be a call for action to review road centerline and the leverage technology to meet advanced needs of the community (e.g. polygons for roads to support autonomous vehicles).

While a broad base of attributes plays a significant role in how a road centerline data set can be used, other requirements need compliance to achieve a sustainable national multi-purpose road centerline. A national program will need to have a program steward and funding, as well as a solid business plan, data governance, and process to roll up data to a national level. The effect needs workflows to provide consistency of updates, validation, aggregation and sharing of data to ensure users can access quality and current data. Of those who responded to the survey question, 65% indicated that their data gets rolled up to a state or national level, while the other 35% does not.

Table Transportation-8 provides other insights from data producers as to where they are with those activities.

Table Transportation-8. Characteristics of road centerline databases. ***Respondents could choose all that apply.***

Characteristic	Proportion
Steward: There is a designated steward for this data layer.	55.1%
Funding: The program for this data has regular funding for data creation and maintenance.	40.4%
Business plan: A business plan exists for this theme.	15.7%
Sharing: A formal connection or agreement exists with others to allow local government to roll up and make data available.	31.5%
Attributes: The data contains additional attributes associated with road centerlines (e.g., lanes, speeds, address ranges, etc.)	60.7%
Real-time (e.g., Work zone, traffic congestion) or Near real0time road conditions are available.	9.0%
None apply.	16.9%

From the survey of transportation geospatial data providers and users, it appears the community is not currently in a position to provide an authoritative, community-based, high resolution, multi-use road centerline with address ranges that is updated frequently enough to meet the needs of the many programs that would leverage such a dataset.

Opportunities and Considerations

The following are considerations that can be discussed by the DOT, Transportation Theme Subcommittee, and NGDA owners that could have a positive impact on the continued development and utilization of the theme's data sets in the future.

- Several road centerline databases developed and maintained by different federal, state, and local governments, as well as the private sector exist, making integration challenging. The Community should consider partnering together to move toward a dataset with a common geography that:
  - Provides a specification for a set of common attributes that supports a multiuse road centerline.
  - Allows organizations to relate or join additional attribution via primary key or object relationship.
  - Supports spatial and attribute accuracy for routing.
  - Allows for linear referencing of other data elements to the common geography.
- Provide a data governance and workflow model that supports aggregation of the geography and common attribution from multiple sources to a national road centerline database.
- Continued funding will be critical to continued progress. Consider funding as a separate metric that should:

- Provide an assessment of the costs of the current approach for development and maintenance of the multiple road centerlines needed to meet business needs.
- Develop funding models that provide for the development of a common specification, workflow, aggregation, and maintenance costs of achieving a shared multi use national road centerline.

- Deliberately focus an effort to better understand where innovation and emerging technologies such as artificial intelligence might contribute to and improve the ability to develop and integrate data and workflow to better achieve national open shared transportation data.
- Consider an evaluation of current national route networks and augment them to meet the needs of the geospatial community.

Grade of the Transportation Theme

While some of the deficiencies from previous assessments are not resolved, some progress has been and continues to be made. Improvements with coordination between DOT and NSDA owners through the Transportation Subcommittee Coordination Group, with programs such as MAP 21 and ARNOLD, and access to innovative technologies by partnered private agencies has increased the development and utilization of these data sets.

Completion of the Theme Strategic Plan and Implementation Plan are significant accomplishments. It will be important to continue to make and measure progress on goals and objectives defined in each.

As this theme matures, the transportation spatial data community must discuss and act proactively towards disruptive technologies such as the Internet of Things and autonomous vehicles so that these advancements can be taken advantage of effectively and efficiently by federal, state, and local agencies.

For example, DOT has pursued the development of a specification for work zone data that multiple providers are adhering to and sharing data, which is then able to be consumed via web services in navigation systems. Grade for this theme is a C = Requires Attention.

Transportation Data Theme Working Group

Framework Evaluator	Framework Assessment Reviewers	Federal Liaison
Dan Ross, Theme Lead, NSGIC	Richard (Dick) Popp, ASCE	Derald Dudley, USDOT Bureau of Transportation Statistics
	Patrick Whiteford, Arizona Department of Transportation	

References

American Society for Photogrammetry and Remote Sensing (ASPRS). (2023, August 23). *ASPRS Approves Edition 2 of the ASPRS Positional Accuracy Standards for Digital Geospatial Data.* https://www.asprs.org/revisions-to-the-asprs-positional-accuracy-standards-for-geospatial-data-2023.

Bossler, J. D., Cowen, D. J., Geringer, J. E., Lambert, S. C., Moeller, J. J., Rust, T. D., and Welch, R. T. (2015). Report Card on the U.S. National Spatial Data Infrastructure - Compiled for the Coalition of Geospatial Organizations. Available at https://img1.wsimg.com/blobby/go/d03ac9fe-b503-4c13-983d-a7dbdff5c7fd/downloads/2015COGO-report.pdf?ver=1726512277516.

Dewberry Engineers, Inc. (2022). *3D Nation Elevational Requirements and Benefits Study.* Available at https://dewberry.com/docs/default-source/documents/3d-nation-elevation-requirements-and-benefits-study/3d_nation_study_final_report.pdf

Federal Aviation Administration (FAA). (2002). *Unmanned Aircraft Systems Beyond Visual Line of Sight Aviation Rulemaking Committee: Final Report.* Available at https://www.faa.gov/regulations_policies/rulemaking/committees/documents/media/UAS_BVLOS_ARC_FINAL_REPORT_03102022.pdf.

Federal Geographic Data Committee. (n.d.1). Committees, Subcommittees, Workgroups, and Related Communities. https://ngda-imagery-theme-geoplatform.hub.arcgis.com/pages/committees.

Federal Geographic Data Committee. (n.d.2). NGDA Imagery Theme, Standards in Use. https://ngda-imagery-theme-geoplatform.hub.arcgis.com/pages/standards.

Federal Geographic Data Committee. (2020). National Spatial Data Infrastructure Strategic Plan 2021–2024. Reston, Virginia, USA, Federal Geographic Data Committee, 17 p. Available at https://www.fgdc.gov/nsdi-plan/nsdi-strategic-plan-2021-2024.pdf.

Federal Geographic Data Committee. (2023, February 4). 2022 Lead Covered Agency NGDA Theme Annual Performance Report and Self-Assessment for Imagery Theme. https://www.fgdc.gov/gda/gda-lca-theme-reports/fy2022/fy2022-imagery-theme-gda-annual-report.pdf.

Federal Geographic Data Committee. (2024, January 19). 2022 Lead Covered Agency NGDA Theme Annual Performance Report and Self-Assessment for Imagery Theme.

Freundschuh, S. M., Sinton, D. S., and Smith, C. (Eds.). (2018). Second Report Card on the U.S. National Spatial Data Infrastructure. Compiled by the Coalition of Geospatial Organizations. December.

National Geospatial Advisory Council. (2022, May 18-19). NGAC Webinar Meeting. Available at https://www.fgdc.gov/ngac/meetings/may-2022/index_html.

National Geospatial Advisory Council. (2023, June). Assessment of the 3D Elevation Program. Prepared by the 3D Elevation Subcommittee. Available at https://www.fgdc.gov/ngac/meetings/june-2023/ngac-assessment-of-the-3d-elevation-program-june.pdf.

National Geospatial Advisory Council. (2024, April 2-4). The National Agriculture Imagery Program (NAIP). Available at https://www.fgdc.gov/ngac/meetings/april-2024/the-national-agriculture-imagery-program-naip-ngac.pdf.

National Oceanic and Atmospheric Administration. (2024). *Summarizing the Digital Coast Accomplishments Report 2024*. Available at https://coast.noaa.gov/data/digitalcoast/pdf/accomplishments-summary.pdf.

National Research Council. (1993). *Toward a Coordinated Spatial Data Infrastructure for the Nation*. Washington, DC: The National Academies Press. https://doi.org/10.17226/2105.

National Research Council. (2007). *National Land Parcel Data: A Vision for the Future.* Washington, DC: The National Academies Press. https://doi.org/10.17226/11978

National States Geographic Information Council. (2023). Geospatial Maturity Assessment. Available at https://nsgic.org/initiatives/geospatial-maturity-assessment/.

Office of Management and Budget. (2017, March 24). *OMB Supplemental Guidance – Appendix E – NGDA Data Themes, Definitions, and Lead Agencies*. Available at https://www.fgdc.gov/policyandplanning/a-16/appendixe/20170324-ngda-themes-fgdc-sc-revised-appendixe.pdf

Román, M. O., Justice, C., Paynter, I., Boucher, P. B., Devadiga, S., Endsley, A., ... & Wolfe, R. (2024). Continuity between NASA MODIS Collection 6.1 and VIIRS Collection 2 land products. Remote Sensing of Environment, 302, 113963. https://doi.org/10.1016/j.rse.2023.113963.

South Carolina, Revenue and Fiscal Affairs Office. (n.d.). South Carolina - North Carolina Boundary Re-establishment Project (1996-2013). https://rfa.sc.gov/programs-services/geodetic/NC-SC-Boundary

Straub, C.L., Koontz, S.R., and Loomis, J.B. (2019). *Economic valuation of Landsat imagery: U.S. Geological Survey*. Open-File Report 2019–1112, 13 p., https://doi.org/10.3133/ofr20191112.

Sugarbaker, L., Coray, K.E., and Poore, B. (2009). The National Map customer requirements; Findings from interviews and surveys: U.S. Geological Survey Open-File Report 2009–1222, 34 p. plus appendixes A, B, and C. https://doi.org/10.3133/ofr20091222.

United States Department of Transportation. (2022, September 28). *DOT Has Made Progress Meeting the Requirements of the Geospatial Data Act of 2018*. Report IT2022040. Available at https://www.oig.dot.gov/sites/default/files/Geospatial%20Data%20Act%20Final%20Report%20FY%202022%20-%2009-28-22.pdf

United States Geological Survey. (2017, June 15). Request for information for Future Landsat Missions. Available at https://www.usgs.gov/landsat-missions/june-15-2017-request-information-future-landsat-missions.

United States Geological Survey. (2018). USGS EROS Archive - Aerial Photography - High Resolution Orthoimagery (HRO). Available at https://www.usgs.gov/centers/eros/science/usgs-eros-archive-aerial-photography-high-resolution-orthoimagery-hro.

United States Geological Survey. (2021). Terra MODIS Acquisition Plan Through December 2025. Available at https://lpdaac.usgs.gov/news/terra-modis-acquisition-plan-through-december-2025/.

United States Geological Survey. (2023, December 15). Asset Identifier Service (AIS). Available at https://www.usgs.gov/tools/asset-identifier-service-ais.

United States Geological Survey. (2024, March 11). President proposes $1.6 billion FY 2025 budget for USGS. Available at https://www.usgs.gov/news/national-news-release/president-proposes-16-billion-fy-2025-budget-usgs.

United States Group on Earth Observations, Committee on the Environment. (2022). *2022 Annual Report*. Available at https://www.usgeo.gov/uploads/USGEO%20Annual%20Report%202022.pdf.

The Thirteen Member Organizations of the Coalition of Geospatial Organizations (COGO)

American Association for Geodetic Surveying (AAGS)
The American Association for Geodetic Surveying (AAGS) aims to lead the community of geodetic, surveying, and land information data users through the 21st century. This will require AAGS to develop new educational programs, including presentations, seminars, and workshops on topics related to geodetic surveying; and articles and papers that inform the membership of the latest scientific and technological developments and how to implement them in the most cost-effective and efficient manner.

American Association of Geographers (AAG)
The Association of American Geographers (AAG) is a nonprofit scientific and educational society founded in 1904. For more than 100 years the AAG has contributed to the advancement of geography. Its members from more than 60 countries share interests in the theory, methods, and practice of geography, which they cultivate through the AAG's Annual Meeting, scholarly journals, and the online AAG Newsletter.
The AAG promotes discussion among its members and with scholars in related fields, in part through the activities of its affinity groups and more than 60 specialty groups. The meetings and activities of our regional divisions provide the opportunity to network with colleagues.

American Society of Civil Engineers (ASCE) - Geomatics Division
The American Society of Civil Engineers (ASCE) represents more than 145,000 members of the civil engineering profession worldwide and is America's oldest national engineering society. ASCE's mission is to provide essential value to our members and partners, advance civil engineering, and serve the public good. ASCE advances technology, encourages lifelong learning, promotes professionalism and the profession, develops civil engineer leaders, and advocates infrastructure and environmental stewardship.

The purpose of the Geomatics Division is to provide leadership, within the engineering profession, for the acquisition and management of spatial data required as part of scientific, administrative, legal, and technical operations for surveying, cartography, photogrammetry, multi-purpose cadastre, remote sensing, and geographic information systems; to foster the development of policy, guidelines, and specifications; to encourage the advancement of geomatics education; and to foster the dissemination of information.

American Society for Photogrammetry and Remote Sensing (ASPRS)
Founded in 1934, the American Society for Photogrammetry and Remote Sensing (ASPRS) is a scientific association serving thousands of professional members around the world. Our mission is to pro- mote the ethical application of active and passive sensors, the disciplines of photogrammetry, remote sensing, geographic information systems, and other supporting geospatial technologies; to advance the understanding of the geospatial and related sciences; to expand public awareness of the profession; and to promote a

balanced representation of the interests of government, academia, and private enterprise.

Cartography and Geographic Information Society (CAGIS)
The mission of the Cartography and Geographic Information Society is to support research, education, and practice to improve the understanding, creation, analysis, and use of maps and geographic information to support effective decision-making and improve the quality of life. The society serves as a forum for the exchange of original concepts, techniques, approaches, and experiences by those who design, implement, and use cartography, geographical information systems, and related geospatial technologies.

GIS Certification Institute (GISCI)
The GIS Certification Institute (GISCI) is a tax-exempt, not-for-profit organization that provides the geographic information systems (GIS) community with a complete certification program, leading to GISP recognition. GISCI offers participants around the world, from the first early years on the job, until retirement, a positive method of developing value for professionals and employers in the GIS profession. We offer the only industry-wide, internationally recognized, software-agnostic Certification available to geospatial professionals around the world.

International Association of Assessing Officers (IAAO)
IAAO is a nonprofit, educational, and research association. It is a professional membership organization of government assessment officials and others interested in the administration of the property tax. IAAO has a membership of more than 7,400 members worldwide from governmental, business, and academic communities. The mission of IAAO is to promote innovation and excellence in property appraisal, assessment administration, and property tax policy through professional development, education, research, and technical assistance.

Management Association for Private Photogrammetric Surveyors (MAPPS)
The Management Association for Private Photogrammetric Surveyors (MAPPS) is the only national association of firms in the surveying, spatial data, and geographic information systems field in the United States. MAPPS member firms are engaged in surveying, photogrammetry, satellite and airborne remote sensing, aerial photography, hydrography, aerial and satellite image processing, GPS and GIS data collection, and conversion services. Our associate members include firms that provide products and services to our member firms, as well as other firms world-wide. MAPPS' primary objective is to develop strength and unity on matters affecting the interests of its member firms. It is intended to pro- mote a quality, profitable profession, interaction among firms, and advance education, both professional and public. The organization monitors and works to affect legislation that impacts the profession. It is the purpose of MAPPS to promote the business interests of the profession.

National Society of Professional Surveyors (NSPS)
NSPS strives to establish and further common interests, objectives, and political effort that would help bind the surveying profession into a unified body in the United States.

NSPS aims to advance the sciences and disciplines within the profession; enhance the image of the surveying profession in the eyes of the public; build self-esteem and professionalism; encourage cooperation between the public and private practices; establish channels of communication with other societies and assist in the exchange of information on laws, education, professional practice, and other concerns; promote the profession through an active public relations program; advance the protection of public welfare relative to surveying and mapping issues; encourage high standards of ethical and professional behavior; promote public faith and confidence in the profession; support new practical methods of surveying; promote good business practice; monitor national and state laws and regulations; encourage improved higher education curricula for surveyors; and honor persons for service to the public, the surveying profession, and the NSPS Foundation Inc.

National States Geographic Information Council (NSGIC)
NSGIC's mission is to promote statewide geospatial coordination activities in all states and to be an effective advocate for states in national geospatial policy and initiatives, thereby enabling the National Spatial Data Infrastructure (NSDI). The National States Geographic Information Council (NSGIC) is an organization committed to efficient and effective government through the prudent adoption of geospatial information technologies (GIT). Members of NSGIC include senior state geographic information system (GIS) managers and coordinators. Other members include representatives from federal agencies, local government, the private sector, academia, and other professional organizations. A rich and diverse group, the NSGIC membership includes nationally and internationally recognized experts in geospatial information technologies, data creation, and management as well as information technology policy.

University Consortium for Geographic Information Science (UCGIS)
The University Consortium for Geographic Information Science (UCGIS) is a non-profit organization that creates and supports communities of practice for GIScience research, education, and policy endeavors in higher education and with allied institutions. We aim to be the professional hub for the academic GIS community. The UCGIS mission is to advance research in the field of geographic information science; expand and strengthen geographic information science education; advocate policies for the promotion of the ethical use of and access to geographic information and technologies; and build scholarly communities and networks to foster multi-disciplinary GIS research and education.

United States Geospatial Intelligence Foundation (USGIF)
USGIF's purpose is to promote the geospatial intelligence tradecraft and to develop a stronger community of interest between government, industry, academia, professional organizations, and individuals who share a mission focused around the development and application of geospatial intelligence to address national security objectives.

Toward this end, the Foundation shall seek to accomplish the following broad objectives: sponsor, con- duct, and support public discussion groups, panels, lectures and forum, for an interchange of views and the instruction of the public on the topics under review;

publish and distribute educational publications relevant to civic associations, governmental bodies, libraries, schools, universities, and other interested groups; conduct sponsor or promote educational programs including, but not limited to, programs for teachers, administrators, and students; and award scholarships to students at accredited institutions of higher education to pursue geospatial intelligence disciplines.

Urban and Regional Information Systems Association (URISA)

The Urban and Regional Information Systems Association (URISA) is an independent, not-for-profit 501c (3) organization established in 1966. From webinars and workshops to multi-day conferences, URISA presents an abundance of educational programs, offers volunteer GIS expertise through its GIS Corps program, and assists government agencies with benchmarking GIS maturity through its GIS Management Institute.

URISA fosters excellence in GIS through its programs, guiding and supporting GIS professionals throughout their careers. URISA is considered to be the premier organization for the use and integration of spatial information technology to improve the quality of life in urban and regional environments.

Framework Theme Evaluators and FGDC Resource Experts

Framework Theme	Framework Evaluators & Reviewers	FGDC Resource Experts / Federal Liaisons
Address	Christopher Ard, City of New Orleans, LA Kathrine Cargo, Orleans Parish Communication District, LA Craig Fargione, New York State Office of Information Technology Services, NY Rachel Marquez, County of Los Angeles, CA Evaristo Ramos, City of Brownsville, TX Ed Wells, Retired	Matthew Zimolzak, co-Chair, Census Bureau Mara Kaminowitz, co-Chair, US Dept of Transportation
Cadastral	Christine Stinchcomb, IAAO Dan Fasteen, IAAO Ed Crane, URISA Katherine Kiyanitsa, NSGIC Karen Rogers, NSGIC Shelby Johnson, NSGIC Daniel Cypert, IAAO Michael Safarty, IAAO	Dominica VanKoten, BLM
Elevation	John Copple, MAPPS Sue Hoegberg, MAPPS Michael Shillenn, MAPPS Mark Safran, MAPPS	Vicki Lukas, USGS Ashley Chappell, NOAA
Geodetic Control	John Doody, AAGS & NSPS Dave Zilkoski, AAGS & NSPS Thomas Meyer, AAGS & NSPS	Daniel Roman, NOAA Juliana Blackwell, NOAA Daniel Gillins, NOAA Vicki Childers, NOAA Shachak Pe'eri, NOAA Giovanni Sella, NOAA Colin Becker, NOAA John Galetzka, NOAA Jeffery Johnson, NOAA Ira Sellars, NOAA Michael Dennis, NOAA Philippe Hensel, NOAA Dru Smith, NOAA Jacob Heck, NOAA

Framework Theme Evaluators and FGDC Resource Experts

Framework Theme	Framework Evaluators & Reviewers	FGDC Resource Experts / Federal Liaisons
Governmental Units	Matt Rice, Theme Lead, CaGIS Joel Conti, CaGIS Keith Clark, CaGIS Nathan Burtch, George Mason University Katharine Perkin, CaGIS	Dierdre Bevington-Attardi, US Census Bureau
Hydrography	Jenna Leveille, Theme Lead, NSGIC John Copple, MAPPS Joshua Greenberg, WA Dept of Ecology	Vicki Lukas, USGS Stephen Aichele, USGS Megan Lang, USFWS
Orthoimagery	Tonda Shelton, North Carolina Flood Plain Mapping Program Christopher Parrish, Oregon State University Roberta Lenczowski, Independent Consultant Tony Spicci, GIS Certification Institute Bandana Kar, U.S. Department of Energy Mark Yacucci, University of Illinois	Greg Snyder, DOI/USGS/ National Land Imaging Program David Davis, USDA/FPAC-B
Transportation	Dan Ross, NSGIC Richard (Dick) Popp, ASCE Patrick Whiteford, Arizona Department of Transportation	Derald Dudley, USDOT Bureau of Transportation Statistics