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Part A: Strategic Plan

THINK SPATIALLY

GEOGRAPHIC INFORMATION SYSTEMS (GIS)
DEPARTMENT OF TRANSPORTATION
1. Executive Summary

The purpose of DOT’s first GIS Strategic Plan is to examine the current use of Geographic Information Systems (GIS) at DOT and set goals to optimize GIS’ potential. This Strategic Plan is accompanied by an Implementation Plan which provides timelines, tasks and resource requirements. Our vision is: DOT’s GIS brings formerly fragmented geospatial investments together in a hub for innovative data analysis and visualization; geospatial data products help meet DOT’s mission goals and are shared with appropriate stakeholders on a centralized platform.

GIS allows a user to display, analyze, and manipulate data with a spatial component. Geospatial data analysis can be used as a decision support tool, to pinpoint “hot spots” and perform root cause analysis, to allocate staff and resources, and for many other projects which support DOT’s mission. For example, a breakthrough in the Takata airbag failure investigation by NHTSA came when failure locations and environmental conditions were plotted using GIS software. The resulting map showed a clear correlation between failures and areas of high heat and humidity.

The GIS programs in the modes have developed in relative isolation. No DOT-wide GIS budget or set of standards exists. Some of DOT’s modes have developed sophisticated mapping applications, perform advanced geospatial analysis, and allow stakeholders to stream geospatial data via map or feature services. Other modes have spatial data or data that could be spatialized, but not enough knowledge, staff, or funding to stand up a GIS program. The top three obstacles preventing the growth of DOT’s GIS program are

1. Staffing: Most modes using GIS need additional FTEs to perform the work they are tasked with. Modes with spatial data and no GIS staff require FTEs with knowledge of GIS to start a GIS program.
2. Budget: No centralized budget exists for GIS at DOT (apart from the ESRI GIS software ELA, which is paid by OCIO from the Working Capital Fund), and modal spending on GIS is not tracked. The modes are therefore dependent upon finding funding individually. As a result, the modes’ programs vary widely in maturity. No set of data and visualization standards for GIS at DOT currently exists.
3. Awareness: A large percentage of employees at all levels of DOT do not understand what GIS is and how it differs from cartographic mapping. Without this understanding, employees cannot identify data with a spatial component or data that could be spatialized. The “think spatially” logo on the preceding page was developed to assist in raising awareness.

The strategic goals below are presented in further detail in Section 4. When implemented, they will allow GIS to become a hub of analysis and visualization for a data-driven DOT.

1. Mature an Enterprise GIS Program
2. Centralize and Strengthen GIS Governance
3. Leverage Emerging Geospatial Technology
2. Introduction and Vision

As a former Director of the Bureau of Transportation Statistics once noted, transportation is inherently geospatial. DOT is charged with ensuring the “fast, safe, efficient, accessible, and convenient” operation of the transportation systems which move people and resources around our nation. GIS (Geographic Information Systems)\(^1\) enables a user to display, analyze, and manipulate data with a spatial component to understand relationships, patterns, and trends. Geospatial analysis can be used as a decision support tool, to pinpoint “hot spots” and perform root cause analysis, to allocate staff and resources, and for many other activities which support DOT’s mission. The purpose of DOT’s first GIS Strategic Plan is to examine DOT’s current use of GIS and set goals for optimizing GIS’ potential. This Strategic Plan is accompanied by an Implementation Plan which provides details about timelines and resources.

The desired future state of GIS at DOT is captured in our **Vision Statement:**

**DOT’s GIS brings formerly fragmented geospatial investments together in a hub for innovative data analysis and visualization; geospatial data products help meet DOT’s mission goals and are shared with appropriate stakeholders on a centralized platform.**

DOT’s data can make a greater and more immediate impact when shown on a map or viewed in a geospatial application. For example:

- NHTSA was researching Takata airbag failures. Plotting the locations of the failures on a map allowed them to see how airbag failures were clustered in areas of high temperature and high humidity. This helped determine the ultimate cause of the failures.

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\(^1\) An acronym guide is included as Appendix B.
NHTSA’s analysis of airbag failures and areas of high heat and humidity

- FAA deployed GIS in the production of Instrument Flight Rule Enroute navigation charts. In the future, a similar GIS-based, data-driven process will be implemented across the entire Aeronautical Information Services product suite.
- PHMSA used GIS to map pipeline inspection boundaries. The map revealed gaps in inspection coverage which were not apparent in the tabular data.
- FRA uses GIS to overlay rail grade crossings, rail accidents, and automated track inspection locations to provide FRA’s Office of Safety, FRA’s Office of Policy, and FRA’s field inspectors with tools to assist with daily decisions and allocation of resources.
- OST-R needed to locate airports classified as “rural,” which affects taxes applied to airfares. The criteria included number of passengers departing from the airport, the airport’s proximity to other airports, subsidies being received, and connection by paved roads to other airports. The query was being run in an outdated language (FORTRAN) before OST-R optimized the process by using GIS.
OST-R’s GIS analysis identified airports which were eligible for an IRS excise tax.

Certain geospatial problems are shared across DOT. How can an inspector optimize an inspection route? Where do clusters of accidents or vulnerabilities exist? Where are our grant dollars allocated and how do we find out which areas or populations are under-served? Where is the best place to locate our next regional office? Where should we draw our service area boundaries to improve the allocation of available resources?

GIS is the most efficient tool to solve problems like these. Desktop GIS software allows a user to perform analysis on data with a spatial component, such as accident locations, and to create custom maps. Web-based GIS applications can give a dynamic view of a mode’s regulatory assets or mission-related data and allow the user to easily access background layers such as satellite imagery or road maps. These applications are capable of finding the most efficient route between several points, revealing “hot spots,” or modeling past and future states.
A single year of Aviation Safety Inspector activity at FAA’s St. Louis Flight Standards District Office. GIS can be used to optimize inspector routes.

Documents such as [GAO 13-94](http://www.gao.gov/assets/660/650293.pdf), [Executive Order 12906](#), and [OMB Circular A-16](#) state the need for federal agencies to eliminate duplication in geospatial data collection and to include their geospatial data in the National Spatial Data Infrastructure (NSDI). DOT has been specifically cited for lack of a GIS strategy, transportation theme standards or a policy for metadata, and procedures for accessing a data clearinghouse. This Strategic Plan is being written to address those concerns, and to present actions that DOT can take to improve its data analysis and visualization through GIS.

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3. Current State

Who We Are
The U.S. Department of Transportation has approximately 60,000 employees nationwide and an FY16 budget of $94.7 billion. The DOT is organized into 10 modes. Representatives from the following nine modes were interviewed for this project:

- Federal Aviation Administration (FAA)
- Federal Highway Administration (FHWA)
- Federal Motor Carrier Safety Administration (FMCSA)
- Federal Railroad Administration (FRA)
- Federal Transit Administration (FTA)
- Maritime Administration (MARAD)
- National Highway Traffic Safety Administration (NHTSA)
- Pipeline and Hazardous Materials Safety Administration (PHMSA)
- Office of the Secretary of Transportation (OST), including the Office of the Assistant Secretary of Research and Technology (OST-R)

A representative from the Volpe National Transportation Systems Center, which provides support to the DOT and other federal agencies and customers, was also interviewed. The tenth mode, Saint Lawrence Seaway Development Corporation (SLSDC), has mission goals unrelated to GIS and was not interviewed. The interviewees were a mixture of decision makers (supervisors and managers) and hands-on GIS users.

DOT has been using GIS since the mid-1980s. FHWA launched its GIS program at that time, FRA followed in the late 1980s, FAA in the mid-1990s, and PHMSA began its program in the late 1990s. DOT’s GIO was appointed in 2008 (the title GIO was given to the existing Bureau of Transportation Statistics GIS Manager). In 2014, the GIO became a full-time position in OCIO.

Staffing and Software
There are currently 15 FTEs in DOT (excluding FAA) who have GIS-related work as a primary responsibility. At FAA, approximately 137 FTEs are GIS professionals. The table below shows FTEs by mode and evaluates whether the current staffing level is sufficient. The evaluation is based on

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3 Airports: 23; Tech Center: 3; Aviation Safety: 1; Center cartographers: 25 (15 users of Microstation); Aeronautical Information Services: approximately 85 (some users of Microstation). An additional 256 employees at Aeronautical Information Services are classified as GIS users, although they do not use GIS as their primary job function.
interviews with representatives of each mode. Unless annotated, a lack of funding and/or billet, stemming from a lack of leadership support, is hindering the ability to reach optimal staffing levels.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Current number of GIS FTEs</th>
<th>Evaluation of current staffing level</th>
<th>Optimal staffing level to meet strategic goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAA</td>
<td>137</td>
<td>Aeronautical Information Services requires six additional senior(^4) GIS FTEs to serve as SME Project Managers. They will lead future geospatial implementation and modernization efforts.</td>
<td>143</td>
</tr>
<tr>
<td>FHWA</td>
<td>6</td>
<td>The Federal Lands department is understaffed with GIS FTEs; as a result, they cannot conduct requested training or organize geospatial data and metadata. No GIS positions are currently being advertised.</td>
<td>8</td>
</tr>
<tr>
<td>FMCSA</td>
<td>0</td>
<td>The sole GIS FTE position was eliminated. As a result, FMCSA has a need for geospatial analysis but no staff to perform it.</td>
<td>1</td>
</tr>
<tr>
<td>FRA</td>
<td>2</td>
<td>Additional junior FTEs with GIS skills are needed for database and server management and application development. No GIS positions are currently being advertised.</td>
<td>4</td>
</tr>
<tr>
<td>FTA</td>
<td>0</td>
<td>No geospatial work is currently performed given lack of GIS staff. Two FTEs (one junior and one senior) could support data visualization, process optimization, policy decisions, and regulatory activities.</td>
<td>2</td>
</tr>
<tr>
<td>MARAD</td>
<td>0</td>
<td>No requirements for a GIS FTE. MARAD’s limited spatial data could be mapped by a contractor if desired.</td>
<td>0</td>
</tr>
<tr>
<td>NHTSA</td>
<td>1</td>
<td>Current staffing is sufficient.</td>
<td>1</td>
</tr>
<tr>
<td>OST</td>
<td>1</td>
<td>Two GIS FTEs are being advertised later this year.</td>
<td>3</td>
</tr>
<tr>
<td>OST-R</td>
<td>3</td>
<td>Current staffing level is not sufficient. One FTE is being advertised and one or two additional FTEs are needed to perform critical work.</td>
<td>6</td>
</tr>
<tr>
<td>PHMSA</td>
<td>2</td>
<td>One additional junior FTE is needed in order to perform critical work relating to risk assessment and geospatial data processing.</td>
<td>3</td>
</tr>
<tr>
<td>SLSDC</td>
<td>0</td>
<td>No need for GIS FTEs</td>
<td>0</td>
</tr>
</tbody>
</table>

Total existing FTEs 152

Total needed to meet strategic goals 171

ESRI GIS desktop software dominates the market for geospatial data analysis. DOT has a three-year Enterprise License Agreement (ELA) for ESRI GIS software; the ELA expires in September 2018. As of July 2016, non-FAA DOT has approximately 475 ESRI desktop GIS users. With a few exceptions for full-time GIS professionals, these users share 60 concurrent use licenses. This indicates that most are occasional or rare users and that the user base at non-FAA DOT is broad but not deep. FAA has 105 single-use ESRI desktop licenses and 106 concurrent use licenses. At FAA, 235 unique users have used ArcGIS Desktop between July 2015 and July 2016. DOT is charged for support from ESRI based on the number of licenses DOT is using, and during ELA renewal, pricing is negotiated based on the number of licenses installed during the outgoing contract.

Analytical Activities
DOT creates, consumes, analyzes, and provides geospatial data. See Appendix D for a list of GIS-related DOT websites. Highlights of recent GIS use at DOT include:

- The FAA Emergency Operations Network (EON) utilizes GIS to provide up-to-date spatial awareness of all events impacting the National Airspace System (NAS). EON provides a common operating picture that gives emergency planners a near real-time view of current incidents affecting air traffic control, weather movement, and active national security.
- GIS is the foundation for the FAA National Airspace System (NAS) Integrated Status Insight System (NISIS), a tool that is used to mitigate the impact of threats, incidents, and associated security measures on the safety and efficiency of the NAS.
- FAA uses GIS to predict the impact of jamming activities on GPS navigation signals.
- FAA collects and processes airport survey data with the Airports Surveying GIS tool. Survey data that was originally collected on paper is now collected online in a GIS format. The Airports GIS tool is also used by airport authorities to create electronic Airport Layout Plans required for airport certification.
- FHWA collects highway data in linear referenced (LRS) format and hosts several web mapping applications, including HEPGIS, which allows the user to investigate highway and related data, and the All Roads Network Of Linear referenced Data (ARNOLD), which is road data in a geospatial network format. FHWA uses its GIS data to develop asset management policies, help understand freight demands, assess implications for the surface transportation system, and improve freight efficiency. The Freight Analysis Framework (FAF) database assists users in determining geographic relationships between local trade flows and the nation’s overall transportation system. FHWA has developed GIS tools for addressing pedestrian and bicycle safety issues. GIS assists FHWA staff and stakeholders in identifying areas that are underserved by transportation infrastructure, pinpointing appropriate sites for the placement of a roadway or public transit facility, and matching transportation services with demographic and environmental features.
• FMCSA maps truck company locations and uses the data to assign inspectors. Staff also analyze NHTSA’s fatal crash data for patterns.

• FRA displays GIS data related to rail lines and rail facilities on its FRAGIS web mapping application. GIS data is used to perform risk assessment. FRA is currently developing mobile mapping applications and a multimodal freight network geospatial dataset.
NHTSA uses GIS to analyze vehicle crashes, pinpoint crash clusters and common factors, and to disseminate data to its stakeholders.

OST has created geospatial data viewers and products for the Crisis Management Center (CMC). CMC staff brief senior leadership using maps and geospatial products. The Office of Civil Rights is working to integrate GIS with anti-discrimination initiatives and uses GIS to research and plan investigations.

OST-R produces the National Transportation Atlas Database (NTAD) each year. NTAD contains GIS data layers for transportation facilities, transportation networks, and associated infrastructure. Modes contributing data to NTAD include FRA, FAA, and FHWA. NTAD also includes data from other federal agencies such as the U.S. Census, Department of Energy, National Park Service, and the U.S. Army Corps of Engineers. NTAD is available to the public as a feature service, which allows the user to stream NTAD data into their own GIS.

PHMSA collects pipeline data from pipeline operators and displays the data on three web mapping applications, two of which are restricted due to the data’s sensitive nature. GIS is used for emergency response, risk assessment, inspection planning, and to assist research and development.

PHMSA’s “hot spot” map helped management determine potential locations for a new regional office.
Internal DOT documents and mandates related to the use of GIS include:

- A 2014 DOT memorandum which established two DOT-wide policies for geospatial information. The first policy required that DOT modes meet with each other and check the GeoPlatform clearinghouse before acquiring or developing geospatial data in order to avoid duplication. The second policy established guidance and responsibilities for implementing federal requirements for the creation and publication of metadata for geospatial data. Both policies were written in response to GAO 13-94.

- Mode-specific mandates, such as
  - FAA: The External Data Access Initiative (EDAi) increases and improves the public's access to FAA data. The initiative's first phase focused on the release of underlying geospatial data used to create aeronautical charts in open data formats.
  - FAA: The Information Innovation Initiative (i3) provides a roadmap for Aeronautical Information Services to transition from product-centric to information-centric, with the objective of providing aeronautical information as a service. This is a complementary initiative to EDAi.

Role of geospatial products in FAA’s i3 roadmap
FHWA: The Highway Performance Monitoring System and OMB 2125-0028 require states to submit public road geospatial data in linear reference system (LRS) format.

FRA: FAST Act, 49 CFR §234 Subpart F, and 49 CFR §225 define the nation’s rail network and provide grade crossing and rail accident data which is used in their GIS applications.

OST-R: USC 49 §6302, §6303, and §6309 includes a stipulation that OST-R produce the NTAD dataset described above.

PHMSA: 49 CFR §191.29 and §195.61 require pipeline operators to submit geospatial data to the National Pipeline Mapping System (NPMS) program. The Pipeline Safety, Regulatory Certainty, and Job Creation Act of 2011 §60132(a) allows PHMSA to collect geospatial data pertaining to its mission.

Groups and Partnerships

Existing GIS groups at DOT include the Geospatial Coordination Council (GCC), which is comprised of senior-level DOT representatives from each mode. The GCC addresses issues such as GIS-related mandates, procurements, and strategic directions. A GIS Professionals group, comprised of GIS managers, specialists, and analysts in modes other than FAA, was inactive for the past few years but resumed regular meetings in July 2016. The GIS Professionals group is a forum for advanced GIS users to demonstrate GIS projects, discuss common problems, and exchange knowledge. The FAA has a GIS Users Group which is active and meets bimonthly.

DOT actively shares data with partners at all levels of government and appropriate external stakeholders. As a federal partner in the National States Geographic Information Council (NSGIC), DOT maintains relationships with other agencies at all levels of government, allowing DOT to share its geospatial data and consume other agencies’ data. OST-R chairs the Federal Geospatial Data Committee (FGDC), Transportation Subcommittee, whose mission is to “coordinate transportation data-related activities among agencies and establish a mechanism for the coordinated development, use, sharing, and dissemination of best practices, standards and data for transportation.”

The Open Geospatial Consortium (OGC) is a non-governmental group which promotes geospatial interoperability, specifically through the use of open-source GIS code and products. DOT has no official relationship with the OGC but has assisted in developing data standards.

In an online survey of DOT employees, respondents felt DOT was “slightly below average” in its use of GIS compared with other federal agencies. Some modes, such as FAA, FHWA, OST-R, FRA, and PHMSA have dedicated GIS staff and public-facing GIS applications or datamarts. Other modes, such as MARAD and FTA, have an interest in geospatial data analysis and visualization, but no resources to initiate a GIS program. DOT had no full-time GIO (Geospatial Information Officer) or GIS presence at the departmental level until 2014. No centralized budget or governance policy for GIS exists at DOT. Interviewees expressed the opinion that GIS is viewed as a specialty at DOT or as “bells and whistles,” not as a basic utility. Events such as GIS Day, groups such as the GCC, and the interviews conducted for this Strategic Plan revealed that most DOT employees do not understand how GIS can bridge the gap between raw data and decision making. 

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5 See Appendix C for results of the online survey.
data and data-driven geospatial analysis which provides decision support or helps a mode meet its mission goals.
4. Strategic Goals

The three strategic goals listed below capture themes that emerged during the interview and research phases of this project. The Implementation Plan assigns action items to staff and provides estimates of timelines and budgets.

1. Goal: Mature an Enterprise GIS Program

Objectives
- Advance mission goals with geospatial analysis
- Improve communication and awareness related to GIS
- Cultivate a 21st century geospatial workforce
- Fund a mature GIS program

Benefits
- Improved ability to identify vulnerable areas and predict risk before accidents occur
- Optimize routes and internal processes (such as inspection planning) through geospatial network analysis
- Position DOT as a leader in data visualization and analysis by familiarizing the workforce with geospatial concepts and software

Actions

**Advance mission goals with geospatial analysis**
Plan and implement actions so that geospatial data, applications, and analysis can

- Meet mission goals of safety and promoting effective transportation
- Support the Crisis Management Center and the National Response Plan
- Improve data visualization, proving that “safety data makes a greater impact when it’s a picture.” For example, create a mobile GIS application that allows FAA field staff to view, collect, publish, and analyze airport infrastructure data.
- Display DOT investments across the US and reveal under-served areas
- Improve DOT’s use of GIS for risk analysis, with the goal of finding vulnerabilities and hazards before accidents or violations occur
- Locate “hot spots” which may require additional staff or resources
- Support the Secretary’s “ladders of opportunity” agenda
- Facilitate connection of intermodal GIS data
- At FAA, perform dynamic air traffic flow control which incorporates live weather and reallocates airspace boundaries for maximum efficiency
Improve communication and awareness related to GIS

- Develop a communication plan to educate DOT management and non-supervisory employees about GIS.
- Resume quarterly meetings of the GIS Professionals Group (comprised of DOT’s GIS Managers, Analysts, and Specialists). Create a charter document for the group with its purpose, membership, and activities. The group’s mission is to provide a forum for GIS professionals to demonstrate how they are using GIS technology, promote discussion of GIS-related issues, and troubleshoot for each other when needed.
- Designate a GIO in each mode. The modal GIO will generally be a FTE with knowledge of GIS and a grade level of GS 14 or higher. The modal GIO will act as a liaison between DOT’s GIO and current or potential GIS users in the mode.
- Resume an annual GIS Day open house to demonstrate the strategic and analytical possibilities of geospatial data to a wide range of DOT personnel.
- Create an online space for all ArcGIS desktop users. Provide information regarding training, conferences, or networking events.
- Meet with Volpe representatives and develop a strategy to improve usage of Volpe resources.
- Develop a policy at the GIO level which states that new data collection projects must be evaluated for GIS conversion possibilities before the data collection begins. Disseminate this policy to the modal GIOs.
- Review drafts of new regulations, mandates, and requirements for references to geospatial data; ensure they do not cite GIS data which does not exist or which is of poor quality.

Cultivate a 21st century geospatial workforce

- Create and implement plans to train
  - Senior management in GIS capabilities; emphasize level of resources needed
  - Technical users; beginners could start with free ESRI online courses, while advanced users may need training when new versions of GIS software are released, or to become familiar with newer technologies like open-source GIS.
  - Users of web/mobile GIS applications
  - Modes with no current GIS use in basic principles of GIS
  - 5-HELP in GIS software installation and related issues
- Create use cases showing which tool to use for common tasks and distribute documentation to ArcGIS Desktop users

Fund a mature GIS program

- Add federal FTEs as suggested in Section 3 to enable the modes to fully staff their GIS programs.
- Consider elevating the GIO position to an SES level, since all other cabinet level federal departments which have a GIO classify the position as SES.
- At the CIO level, clearly define OCIO’s role in geospatial endeavors and implement a geospatial budget at OCIO level to allocate resources to modes.
- Document how modes are currently spending geospatial funds; allocate additional resources to modes based on their geospatial goals and current level of resources. Communicate to the CIO
that use of GIS is dependent upon stable funding and staff resources as well as GIS software availability.

- Create and fund a budget for the GIO which includes separate allocations for geospatial data production and geospatial data visualization.
- Survey all GIS users to determine whether their hardware and software needs are being met; create a plan to rectify shortfalls.
- Formalize a list and description of “core GIS” staff to align with other specialty staff at DOT and a plan to continue to build DOT’s federal GIS workforce. Create standard position descriptions for GIS Managers, Specialists, and Analysts and work with HR to file them for each mode.
- Add a professional services component to the ESRI ELA which allows DOT staff to task ESRI with specific project responsibilities.

2. Goal: Centralize and Strengthen GIS Governance

Objectives

- Centralize oversight of DOT’s GIS
- Share geospatial data and eliminate duplication
- Standardize geospatial data and applications

Benefits

- Eliminate disparities in the modes’ access to and use of GIS
- Provide easily accessible geospatial data to internal and external stakeholders
- Present a unified portfolio of geospatial applications

Actions

Centralize oversight of DOT’s GIS

- Formally include GIS as part of the DOT IT Enterprise in order to provide more oversight of and communication with the modes.
- Develop content on the DOT Intranet including a GIS data directory (containing map and feature services where available), Modal GIO contact information, URLs for DOT’s GIS applications, and other related resources. Ideally, DOT will have a centralized repository of all GIS data created and maintained by DOT along with the offices designated as responsible for the accuracy, quality, and currency of the data. This will be similar to the NTAD maintained by OST-R, but it would contain all GIS data in DOT (including FAA).
- Designate the GIO as the principal-in-charge on the Enterprise License Agreement (ELA) with ESRI. The FAA will still have autonomy over its license use and will be involved with ELA decisions and negotiations. It is strongly recommended that FAA change the majority of its single-user ESRI licenses to concurrent use in order to reduce license costs.
• Evaluate the benefits of building centralized systems architecture which would improve network performance for DOT’s geospatial applications and facilitate standardizing the applications’ platforms.
• Write a governance policy for the ESRI ELA
• Improve the effectiveness of the GCC by:
  o Reviewing its membership and making changes as needed, with the goal of increased attendance and engagement.
  o Providing educational resources and/or training to members who would like more information about GIS.
  o Sharing decisions made at GCC meetings with technical GIS staff and receiving feedback.
  o Allowing the GCC to provide feedback to the modes on their geospatial programs.

**Share geospatial data and eliminate duplication**
• Create map and feature services to share data internally and externally in real time. When map/feature services are not feasible or desirable, the GIO should create a policy on best practices for sharing GIS data internally at DOT through a dashboard or datamart.
• Work with modal GIOs to document or establish relationships and MOUs with other federal geospatial data providers, such as the Department of Homeland Security, the National Parks Service, and the U.S. Census. The goal is to identify relationship gaps and create a plan to open lines of communication.
• Per OMB Circular A-16 and Executive Order 12906, require that modes examine available geospatial data before embarking upon new geospatial data collection projects, and require modes to share metadata in FGDC format through NTAD.
• Create a toolkit for common geospatial problems at DOT, such as how to optimize routes and how to pinpoint “hot spots.”
• Post all publicly distributable geospatial data owned by DOT on geoplatform.gov, the government-wide geospatial datamart
• Create best practices documentation related to
  • Sharing sensitive or protected geospatial data;
  • Resolving firewall issues which hinder effective data sharing;
  • Standardizing geospatial data production workflow, including a procedure to incorporate feedback when a dataset is modified or improved;
  • Improving requirements analysis and planning stages before beginning geospatial data collection or application development.

**Standardize geospatial data and applications**
• Create best practices documentation related to
  o Network and governance procedures
  o Design of public-facing GIS applications and mobile apps
  o Geospatial data quality
  o Workarounds when web browsers are incompatible with GIS applications
GIS software deployment through 5-HELP, including providing Tier 1 technical support through 5-HELP

- Implement the standards described above to enable seamless sharing of multimodal data
- Document and resolve data gaps
- Review tabular datasets at the modal level for spatialization potential and spatialize those datasets if resources allow

3. Goal: Leverage Emerging Geospatial Technology

Objectives

- Seamlessly import and disseminate geospatial data
- Provide a flexible data processing environment for geospatial web applications which experience variable traffic
- Equip DOT’s workforce with tools to view geospatial data and perform analysis while in the field
- Optimize geospatial application performance

Benefits

- Outdated data on geospatial applications is eliminated when map and feature services are used to stream data layers
- Application outages due to heavy traffic are eliminated
- Mission-critical analysis can occur 24/7, wherever an employee has phone or tablet access
- Updated and standardized geospatial mapping applications provide the performance and interface that users expect

Actions

**Seamlessly import and disseminate geospatial data**

- Eliminate DVD data distribution except where warranted (such as for sensitive datasets where distribution needs to be controlled); disseminate geospatial data through map and feature services

**Provide a flexible data processing environment for geospatial web applications which experience variable traffic**

- Formalize a policy on use of cloud environments for GIS applications and processing

**Equip DOT’s workforce with tools to view geospatial data and perform analysis while in the field**

- Evaluate feasibility of making existing GIS websites mobile-friendly or developing mobile apps
- Discuss and resolve issues related to VPN connections, which can result in loss of productivity for offsite staff
Optimize geospatial application performance

- Evaluate the suitability (including data security) of non-ESRI technologies such as OpenGIS components; add these technologies to the DOT ITSS software list
- Write and distribute an internal policy for use of ArcGIS Online
- If resources are available, set up virtual servers that any mode can use to test new GIS software or tools
- Share knowledge of linear referencing and other “niche” GIS practices or technologies
- Discuss the concept of “story maps” and how DOT can use them to promote awareness of GIS capabilities. For example, FAA could create a story map depicting a typical passenger flight from departure to arrival. Along the way, each element of FAA safety oversight is portrayed: aircrew training, certification, and medical examination; mechanic certification and medical examination; maintenance facility oversight and certification; a rulemaking that institutes free flight.

Cross-cutting Strategic Goals

The FGDC’s National Spatial Data Infrastructure (NSDI) project developed a Strategic Plan in 2013 to “describe the actions the FGDC community will take, in collaboration with partners, to develop and maintain the Nation’s critical geospatial infrastructure.” They identified three Strategic Goals:

1. Develop capabilities for National Shared Services
2. Ensure accountability and effective development and management of federal geospatial resources
3. Convene leadership of the National Geospatial Community

The table below shows the crosswalk between DOT’s and NSDI’s Strategic Goals.

<table>
<thead>
<tr>
<th>NSDI Strategic Goal</th>
<th>DOT GIS Strategic Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Develop capabilities for National Shared Services</td>
<td>• Leverage emerging geospatial technology</td>
</tr>
<tr>
<td>• Ensure accountability and effective development and management of federal geospatial resources</td>
<td>• Centralize and strengthen GIS governance</td>
</tr>
<tr>
<td>• Convene leadership of the National Geospatial Community</td>
<td>• Mature an enterprise GIS program</td>
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</table>
5. Challenges and Opportunities

Resource limitations and other roadblocks can present barriers to achieving the Strategic Goals. DOT's challenges and opportunities can be organized into broad categories.

Challenges

Fragmented investments and duplication of effort
The modes’ geospatial programs have been developed independently and with minimal centralized oversight. This has resulted in

- Widely varying degrees of maturity in modal GIS programs
- Data and effort being duplicated when the modes are unaware of available resources
- Some datasets becoming effectively “invisible” because users and stakeholders don’t know the data exists
- Lack of standardization regarding geospatial data quality, web application tools and interfaces, or symbology. A detaillee has been assigned to OCIO for the purpose of adopting and/or creating standards. These standards will be implemented throughout all modes and will likely be based on FGDC standards. The NIEM (National Information Exchange Model) process is being examined for its appropriateness; it is currently used by the Department of Homeland Security and the Department of Justice.

Closed lines of communication

- Policy makers often do not consult with GIS professionals when making decisions that affect geospatial programs and data. GIS professionals do not meet regularly with senior management to discuss their geospatial programs.
- DOT has a wealth of geospatial data but a scarcity of sophisticated geospatial analysis. This is due to a lack of GIS knowledge or experience among decision makers and technical staff, a lack of FTEs to perform this analysis, and the absence of a dedicated geospatial budget.
- Interviewees noted that the Enterprise License Agreement (ELA) with ESRI lacks transparency and accountability; many questions exist as to the terms of the ELA and acceptable usage. The new ArcGIS Online (AGOL) environment is of interest to several modes but since use can incur costs which are billed to a central DOT account, GIS managers and analysts have been reluctant to use the environment. Better communication is needed from OCIO and the GIO to GIS professionals and users as to acceptable uses of the software and online environment.
- The Geospatial Coordination Council (GCC) was created to serve as a conduit of communication from the GIO to senior management in the modes, and from technical staff in the modes to the GIO and OCIO. However, attendance has been low and interviewees felt the GCC was not functioning at its full potential.
- OST’s role is not clearly defined. Interviewees were unsure whether its role was to increase awareness and promote use of GIS, or to create and enforce standards for geospatial data and products.
The DOT Help Desk (5-HELP) does not have adequate GIS training, resulting in prospective GIS users experiencing problems with getting the software installed or resolving issues.

Lack of sufficient resources
Like other federal agencies, DOT has experienced growth which has outpaced available funding. With the understanding that not all resource issues are surmountable, it should be noted that the following items have prevented DOT from fully realizing the potential of geospatial display and analysis.

- Interest in GIS has outpaced the growth of the GIS workforce. As expressed during the interviews, the modes generally have inadequate GIS staff to perform routine geospatial work and develop new projects or analysis which support mission goals. Four of the DOT modes with spatial data have no specialized GIS staff at all. FAA noted that bringing on new employees has been hampered by hiring freezes, and training existing employees has been hampered by an insufficient budget. Interviewees expressed an opinion that GIS analysts are often perceived as IT staff. As a result, they are often tied up with software and support issues instead of working on sophisticated analysis or using GIS to accomplish mission goals.

- As noted by respondents to the online survey, needs not being met include: IT support and partnerships, hardware and software needs, cloud environments, and data availability, development, and visualization.

- Lack of funding and human capital resources has resulted in DOT being unable to keep pace with geospatial technology. For example, PHMSA’s public-facing GIS viewer recently went offline when DOT’s PIV policy was applied to its server. The viewer was created in 2010 and funds had not been available to update it. The outdated version of ArcGIS Server that was used was not compatible with the PIV policy, causing the entire viewer to go offline. In FMCSA, the only GIS-trained FTE was reassigned and the slot was used for a non-GIS FTE, leaving FMCSA with no GIS expertise on staff.

- Instead of opening federal FTE positions for GIS staff, contractor support is frequently used. Outsourcing GIS work weakens DOT’s long-term GIS knowledge base and shows a lack of desire to grow GIS capabilities.

- Available bandwidth is often not sufficient to satisfy demand for GIS processing and web applications. When a web application has slow performance, the user often loses interest. Slow bandwidth and/or remote connections to ArcGIS desktop licenses result in wasted time.
Opportunities

Wide base of GIS users
- Over 1,300 DOT staff have access to ArcMap desktop GIS software
- Public-facing GIS applications at DOT can average over 1,000 visitors per day
- Hundreds of GIS users have attended GIS Day activities

Demonstrated innovation
- GIS professionals at DOT are already using innovative GIS technology such as OpenGIS, ArcGIS Online, mobile GIS, and linear referencing.

In-house GIS expertise
- The following modes have full-time GIS professional FTEs: OST, OST-R, FAA, FHWA, FRA, and PHMSA (the Volpe Center, which is not a mode but a partner, also has GIS staff).

Mission goals aligned with GIS technology
- Transportation analysis is geospatial by its nature; DOT’s mission goals naturally point to GIS as a tool to achieve them.

Enterprise License Agreement with ESRI
- The ELA with ESRI, the leading producer of GIS desktop software, enables DOT to easily grow its GIS user base. Additionally, the training and development opportunities that accompany the ELA provide resources to help novices learn the basics of GIS.
6. Data and Infrastructure

Current State
DOT has an extensive catalogue of geospatial data which is used by all levels of government, industry, and the public. Data includes:

- The National Transportation Atlas Database (NTAD), distributed by OST-R. It contains GIS data layers for transportation facilities, transportation networks, and associated infrastructure. Some of the data is collected by OST-R (passenger connectivity, border crossings, and freight intermodal facilities) but the majority comes from other government agencies.

![Map of public transit commuters produced by OST-R using data from NTAD](source)

- Safety-critical infrastructure data at all U.S. airports, including runways, navaids, and obstructions, produced and disseminated by FAA.
• All IFR Enroute aeronautical chart data in the national airspace system, produced and disseminated by FAA. All IFR and Visual charts are available as a geospatial pdf or Geo-TIFF. The public instrument flight procedures are in the process of being released in these formats as well.

• FAA office locations and service areas, unstaffed infrastructure locations, Center and Approach Control airspace boundaries, and locations of certificate holders authorized to conduct operations under Title 14 of the Code of Federal Regulations (CFR), produced by FAA.

• Highway and freight data, collected by FHWA and used in the HPMS and ARNOLD web mapping applications. HPMS also includes bridge inventory data, tunnel inventory data, ferry route data, and urban adjusted boundaries.

• Truck company locations and truck accidents, collected by FMCSA

• Vehicular crash and fatal crash locations, collected by NHTSA

• Density and waybill data, Amtrak stations, freight and passenger rail lines, freight stations, grade crossings, and mileposts, collected by FRA and used in their FRAGIS web mapping application

• Gas transmission and hazardous liquid pipeline locations, pipeline-related facilities, accidents, derailments, and oil spill response resources, collected by PHMSA and used in the NPMS web mapping applications

Because no centralized architecture exists, the modes are finding their own solutions to storing and processing geospatial data. Most modes are using physical servers, and some modes are also using virtual machines (cloud-based servers). If physical servers are being used or if the virtual machines are not set up for scalability, performance degradation or interruption can occur when there are spikes in traffic or with large processing operations.

Likewise, because no DOT-wide standards exist for GIS web applications, there is no unified look and feel to DOT’s applications. The modes have used ESRI and/or OpenGIS to build their web mapping applications. The ability to build new applications (either web or mobile) or update existing ones depends upon the mode’s individual budget. Many DOT mapping applications are using outdated software or dated interfaces.

Opportunities

Cloud Environment
The cloud is a network of servers at a remote location which can host data and applications or process data. The benefit to a cloud environment subscription is that the server space used can be scaled up or down as needed. When the Takata airbag recall took place in 2015, NHTSA’s website traffic increased exponentially as car owners looked up their VINs to see if their cars were affected by the recall. NHTSA used a cloud environment to handle the increased traffic with no interruption in website service. A substantial cost savings was realized; the cloud space which cost DOT less than $3,000 per month would have cost $3,000,000 had traditional physical servers been procured.

Two major cloud providers dominate the market: Amazon’s AWS and Microsoft’s Azure. DOT has an ELA with Microsoft and recently obtained an enterprise subscription for Azure. The term of the subscription is one year but it is likely to be renewed along with the ELA for other Microsoft products. The global DOT
Azure account is managed by OCIO: the modes receive their own accounts upon request. The Azure cloud has been vetted as a secure environment for hosting DOT’s sensitive datasets. A detailed governance policy and details on the service catalogue have not been finalized or communicated to the modes, but are expected to be available in FY17. The Common Operating Environment policy from the CIO’s council is currently being followed for decisions about cloud usage. The Associate CIO explained that this has been due to overwhelming interest by the modes, who wanted to begin using the cloud immediately and the decision by the CIO’s office to accommodate that need.

Cloud environments are becoming increasingly popular for DOT’s geospatial operations and applications. The cloud can be used for geospatial data storage, processing, backup, and hosting as well as for geospatial applications. This year, OST-R moved NTAD to the Azure cloud and uses the cloud to host applications, a map gallery, processing, and its production and development environments. NHTSA is considering moving its ArcGIS Server instance to the cloud and will put REST (Representational State Transfer) services in the cloud via BTS’ platform by the end of FY16. FHWA is moving its GIS applications to the cloud over the next year.

**ArcGIS Online**

ArcGIS Online (AGOL) is an online, collaborative web GIS that allows the user to use, create, and share maps, scenes, apps, layers, analytics, and data. A user has access to ready-to-use maps, apps, and ESRI’s secure cloud, where he or she can add items and publish web layers. Currently, OST-R is sharing data on AGOL, PHMSA is setting up an AGOL environment to assist regional offices in making and sharing basic maps, and FAA uses AGOL for certain geocoding operations. FHWA is using AGOL to map access roads into federal lands and traffic counts.

AGOL is part of DOT’s ELA, but most activities expend credits, which are allocated to DOT in a single account. Interviewees said that they have been reluctant to use AGOL extensively because there is no clear guidance as to how many credits each mode is allocated and how many credits specific activities on AGOL consume.

A detailed governance and usage policy for AGOL should be developed by the GIO, working with others in OCIO. It should include the total credits available to each mode and the number of credits common activities consume. The modes should be responsible for purchasing additional credits for their own accounts if they use more than their allocation.

Once these policies are in place, AGOL can benefit DOT in the following ways:

- AGOL is much easier to learn and use than ArcGIS desktop software. Novice GIS users can be empowered to create, modify, and collaborate on visually appealing maps that can help meet mission goals.
- The ability for multiple users to view, edit, and attach files such as videos, pictures, or PDFs to an online map is ideal for modes who have multiple offices across the country. Quickly constructing a map that can be shared and augmented with pictures and reports can assist modes in effectively responding to an accident.
• Although AGOL has the capability to process data and host applications, these activities are not recommended due to the high number of credits needed. Data can be processed with ArcGIS desktop software with no credits expended, and data or applications can be hosted on physical or virtual servers owned by DOT.

Map and Feature Services
Map services (sometimes referred to as Web Map Services or WMS) provide a user with a rendered map distributed online; feature services (sometimes referred to as Web Feature Services or WFS) provide the user with geospatial data streamed online. The main benefit is that both types of services show the user the most current data or maps. The services provide a dynamic view of the dataset and prevent the user from doing analysis on or drawing conclusions from outdated data.

Map and feature services are not widely used by DOT; however, OST-R distributes NTAD as a feature service. FHWA has expressed an interest in using map and feature services. NHTSA uses map and feature services internally only. FAA’s External Data Access Initiative is not yet online but will provide map and feature services.

Centralized GIS Infrastructure
Because web mapping applications are developed and upgraded based on available funding at the modal level, the GIO and OCIO should evaluate options for developing a centralized architecture for DOT’s geospatial data and applications. A centralized infrastructure would enable DOT to

• Ensure that all web mapping applications are running versions of software that are currently supported and approved by DOT
• Upgrade all web mapping applications concurrently
• Provide the modes with equal access to hardware or cloud resources
• Maintain a true development environment, which is often not part of the modes’ GIS architecture due to limited funds. This has resulted in web mapping applications going offline when a patch or policy has been incompatible with an ESRI software component.
• Patch all GIS-related servers at the same time

Ideally, a centralized GIS infrastructure would be funded by OCIO, but cost-sharing among the modes can also be examined.
7. Conclusion

Despite limited resources, DOT’s GIS Managers, Specialists, and Analysts have produced a number of sophisticated and innovative geospatial products and applications. Using GIS, DOT staff have helped meet mission goals and revealed what cannot be discerned with tabular data, providing “a-ha” moments to management and stakeholders.

In order to realize the full potential of GIS, DOT must

- Educate its workforce on what GIS is and how to use it
- Increase staffing and budgetary resources to allow the modes to maintain uniformly mature GIS programs
- Create a centralized GIS directory and geospatial datamart
- Maintain data and visualization standards across all modes

The Implementation Plan which begins on the following page outlines specific actions to take in order to achieve the Strategic Goals. Once we empower our workforce to think spatially, GIS will become a hub of analysis and visualization for a data-driven DOT.
Part B: Implementation Plan

The Implementation Plan provides high-level tasks, timelines, and resource estimates for actions needed to implement the strategic goals. Roles and responsibilities of DOT staff are also included. Although some flexibility can be assumed if budgetary and staffing resources are not available at the levels specified, senior DOT management should understand that the strategic goals will not be accomplished if no additional resources are made available.

1. Resource Requirements

Resources needed to accomplish the strategic goals are as follows.

- **Staffing:** As mentioned in Strategic Goal #1, hiring new federal FTEs should be a top priority. GIS cannot advance at DOT with the current staffing level. Modal GIOs should be appointed. The Modal GIO will usually be an existing GS 14 or higher who has an advanced understanding of GIS concepts and practices.

- **Budget:** Any budgetary requests from the GIO are currently charged to the working capital fund. Several deliverables needed to implement the strategic goals (such as creating an Intranet page, launching feature and map services, and resolving data gaps) require initiatives at the GIO level which will have an associated cost. To achieve the strategic goals and allow GIS to continue to aid in fulfilling DOT’s mission goals, a dedicated budget for the GIO is necessary.

- **Hardware and software needs:** Further discussion is needed regarding the option of setting up centralized system architecture. The CIO, GIO, and Associate CIO should discuss which GIS functions are more effective when controlled through the CIO’s office. An example could be map and feature services.

- **Awareness of and support for GIS:** One of the major issues that came to light during this plan’s writing was the low level of GIS awareness at DOT. Training and education which encourages DOT staff to “think spatially” and teaching them to use desktop or web-based GIS will contribute to DOT achieving the strategic goals.
2. Roles and Responsibilities
The following positions or groups will have key roles in the implementation of this strategic plan.

Chief Information Officer (CIO)
The CIO serves as the principal advisor to the Secretary of Transportation on matters involving information and technology. The DOT CIO has oversight responsibility for the entire DOT IT portfolio and operational responsibilities for the DOT Common Operating Environment. The CIO also promotes entrepreneurship, innovation, investment and alliances to address transportation issues by creating technology solutions.

Role in implementing the Strategic Plan: The CIO has the ability to allocate funds and resources (such as FTEs) to the geospatial endeavor. The CIO should read this Strategic Plan and be briefed if additional information on DOT’s geospatial program is desired. It is crucial that the CIO understand the depth of GIS analysis that is possible and specific ways that GIS can help DOT meet its mission goals. The CIO will lead the actions below during implementation of the strategic goals.

- Add federal FTEs as suggested in Section 3 to enable the modes to fully staff their GIS programs.
- Consider elevating the GIO position to an SES level, since all other cabinet level federal departments which have a GIO classify the position as SES.
- At the CIO level, clearly define OCIO’s role in geospatial endeavors and implement a geospatial budget at OCIO level to allocate resources to modes.
- Create and fund a budget for the GIO which includes separate allocations for geospatial data production and geospatial data visualization.
- Formally include GIS as part of the DOT IT Enterprise in order to provide more oversight of and communication with the modes.
- Develop content on the DOT Intranet including a GIS data directory (containing map and feature services where available), Modal GIO contact information, URLs for DOT’s GIS applications, and other related resources. Ideally, DOT will have a centralized repository of all GIS data created and maintained by DOT along with the offices designated as responsible for the accuracy, quality, and currency of the data. This will be similar to the NTAD maintained by OST-R, but it would contain all GIS data in DOT (including FAA).
- Designate the GIO as the principal-in-charge on the Enterprise License Agreement (ELA) with ESRI. The FAA will still have autonomy over its license use and will be involved with ELA decisions and negotiations. It is strongly recommended that FAA move the majority of its ESRI licenses to concurrent use in order to reduce license costs.
- Evaluate the benefits of building centralized systems architecture which would improve network performance for DOT’s geospatial applications and facilitate standardizing the applications’ platforms.
• Create map and feature services to share data internally and externally in real time. When map/feature services are not feasible or desirable, the GIO should create a policy on best practices for sharing GIS data internally at DOT through a dashboard or datamart.

**Geospatial Information Officer (GIO)**

The GIO provides strategic, programmatic, and technical leadership for geospatial activities across the Department. He facilitates DOT's role in the development and implementation of geospatial platforms. The GIO works collaboratively with DOT modes as well as other government and external stakeholders. The GIO serves as the principal advisor to the Chief Technology Officer, Deputy CIO, CIO and other top agency officials on cross-cutting program matters related to all aspects of geospatial policy, programs and technology. The GIO provides strategic planning, development and coordination of Department-wide geospatial standards, policy, programs and technology.

**Role in implementing the Strategic Plan:** The GIO has expert-level knowledge of GIS and is responsible for promoting DOT’s geospatial agenda. The GIO provided comments on drafts of this Strategic Plan. He should read the final Plan. The GIO will work closely with the CIO to obtain resources needed to meet the strategic goals. The GIO will lead the actions below during implementation of the strategic goals:

- Develop a communication plan to educate DOT management and non-supervisory employees about GIS.
- Resume quarterly meetings of the GIS Professionals Group (comprised of DOT’s GIS Managers, Analysts, and Specialists). Create a charter document for the group with its purpose, membership, and activities. The group’s mission is to provide a forum for GIS professionals to demonstrate how they are using GIS technology, allow them to discuss GIS-related issues, and troubleshoot for each other when needed.
- Designate a GIO in each mode. The modal GIO will generally be a FTE with knowledge of GIS and a grade level of GS 14 or higher. The modal GIO will act as a liaison between DOT’s GIO and current or potential GIS users in the mode.
- Resume an annual GIS Day open house to demonstrate the strategic and analytical possibilities of geospatial data to a wide range of DOT personnel.
- Meet with Volpe representatives and develop a strategy to improve usage of Volpe resources.
- Develop a policy at the GIO level which states that new data collection projects must be evaluated for GIS conversion possibilities before the data collection begins. Disseminate this policy to the modal GIOs.
- Create and implement plans to train
  - Senior management in GIS capabilities; emphasize level of resources needed
  - Technical users; beginners could start with free ESRI online courses, while advanced users may need training when new versions of GIS software are released, or to become familiar with newer technologies like open-source GIS.
  - Users of web/mobile GIS applications
• Document how modes are currently spending geospatial funds; allocate additional resources to modes based on their geospatial goals and current level of resources. Communicate to the CIO that use of GIS is dependent upon stable funding and staff resources as well as GIS software availability.
• Survey all GIS users to determine whether their hardware and software needs are being met; create a plan to rectify shortfalls.
• Formalize a list and description of “core GIS” staff to align with other specialty staff at DOT and a plan to continue to build DOT’s federal GIS workforce. Create standard position descriptions for GIS Managers, Specialists, and Analysts and work with HR to file them for each mode.
• Add a professional services component to the ESRI ELA which allows DOT staff to task ESRI with specific project responsibilities.
• Write a governance policy for the ESRI ELA.
• Work with modal GIOs to document or establish relationships and MOUs with other federal geospatial data providers, such as the Department of Homeland Security, the National Parks Service, and the U.S. Census. The goal is to identify relationship gaps and create a plan to open lines of communication.
• Per OMB Circular A-16 and Executive Order 12906, require that modes examine available geospatial data before embarking upon new geospatial data collection projects, and require modes to share metadata in FGDC format through NTAD.
• Post all publicly distributable geospatial data owned by DOT on geoplatform.gov, the government-wide geospatial datamart.
• Implement the standards described above to enable seamless sharing of multimodal data.
• Document and resolve data gaps.
• Eliminate DVD data distribution except where warranted (such as for sensitive datasets where distribution needs to be controlled); disseminate geospatial data through map and feature services.
• Evaluate feasibility of making existing GIS websites mobile-friendly or developing mobile apps.
• Discuss and resolve issues related to VPN connections, which can result in loss of productivity for offsite staff.
• Write and distribute an internal policy for use of ArcGIS Online.
• If resources are available, set up virtual servers that any mode can use to test new GIS software or tools.
Modal Geospatial Information Officers

Strategic Goal #1 notes the need to designate modal-level GIOs for each mode that uses or plans to use GIS. The modal GIOs are FTEs with knowledge of GIS and a grade level of GS 14 or higher. These will not be new positions. The Modal GIO will usually be a member of the GIS Professionals Group.

**Role in implementing the Strategic Plan:** Modal GIOs are necessary as a point of contact for the GIO. The GCC member in each mode is generally a senior manager who does not have technical GIS knowledge. The optimal communication path between the modal GIO, GIO, and GCC member is shown below.

The Modal GIOs will lead the actions below during implementation of the strategic goals:

- Review drafts of new regulations, mandates, and requirements for references to geospatial data; ensure they do not cite GIS data which does not exist or which is of poor quality.
- Review tabular datasets at the modal level for spatialization potential and spatialize those datasets if resources allow.
Geospatial Coordination Council (GCC)
The Geospatial Coordination Council facilitates and coordinates the sharing of information about a broad array of geospatial activities across the modes and ensures that DOT fulfills its responsibilities to the Office of Management and Budget (OMB) and the Federal Geographic Data Committee (FGDC). The GCC also advises senior leadership on the strategic application of geospatial data, technology, and tools in support of Department’s mission. The GCC provides coordination and vision related to the creation, sharing, and application of geospatial data and tools across the modes in support of DOT’s mission activities. It develops policies on the creation, purchase/lease, and use of geospatial information that ensures the Department fulfills its responsibilities to the OMB and the FGDC.

Role in implementing the Strategic Plan: The GCC brings together senior-level staff from each mode. As Strategic Goal #2 states, the GCC could function more effectively. The first step is to clarify the role of the GCC and maintain a stable membership base which is committed to regular meeting attendance. The GCC will have three major roles in implementing the Strategic Plan: to find resources at the modal level for the strategic goals, to build DOT-wide consensus and to take the lead regarding increasing awareness of GIS (Strategic Goal #1) within their mode.

The GCC will lead the actions below during implementation of the strategic goals:

- Improve the effectiveness of the GCC by:
  - Reviewing its membership and making changes as needed, with the goal of increased attendance and engagement.
  - Providing educational resources and/or training to members who would like more information about GIS.
  - Sharing decisions made at GCC meetings with technical GIS staff and receiving feedback.
  - Allowing the GCC to provide feedback to the modes on their geospatial programs.
- Formalize a policy on use of cloud environments for GIS applications and processing

GIS Professionals Group
The GIS Professionals group (which was relaunched in July 2016 after a hiatus) is comprised of federal DOT employees whose primary job duties are GIS analysis and/or managing geospatial projects. At the meetings, members have discussed geospatial products (such as the ESRI Enterprise License Agreement), opportunities or events (such as training courses and GIS Day) and have had the opportunity to showcase geospatial products they have created. This group has also been valuable for networking; attendees learn about what other modes are doing with GIS, exchange information about new technology, and can troubleshoot issues as a group. Strategic Goal #1 suggests quarterly meetings and writing a charter document.

Role in implementing the Strategic Plan: The GIS Professionals Group will be responsible for technical actions, such as identifying and resolving data gaps and creating standards. They will develop use cases
in order to provide guidance to less experienced GIS users. They will play a major role in evaluating and implementing emerging geospatial technology described in Strategic Goal #3, and in determining how to most effectively support mission goals with GIS (Strategic Goal #1). The group will also be responsible for outreach efforts which are targeted at GIS “laypeople,” such as the annual GIS Day.

The GIS Professionals Group will lead the actions below during implementation of the strategic goals:

- Plan and implement actions so that geospatial data, applications, and analysis can:
  - Meet mission goals of safety and promoting effective transportation
  - Support the Crisis Management Center and the National Response Plan
  - Improve data visualization, proving that “safety data makes a greater impact when it’s a picture.” For example, create a mobile GIS application that allows FAA field staff to view, collect, publish, and analyze airport infrastructure data.
  - Display DOT investments across the US and reveal under-served areas
  - Improve DOT’s use of GIS for risk analysis, with the goal of finding vulnerabilities and hazards before accidents or violations occur
  - Locate “hot spots” which may require additional staff or resources
  - Support the Secretary’s “ladders of opportunity” agenda
  - Facilitate connection of intermodal GIS data
  - At FAA, perform dynamic air traffic flow control which incorporates live weather and reallocates airspace boundaries for maximum efficiency

- Create an online space for all ArcGIS desktop users. Provide information regarding training, conferences, or networking events.

- Create use cases showing which tool to use for common tasks and distribute documentation to ArcGIS Desktop users

- Create a toolkit for common geospatial problems at DOT, such as how to optimize routes and how to pinpoint “hot spots.”

- Create best practices documentation related to
  - Sharing sensitive or protected geospatial data;
  - Resolving firewall issues which hinder effective data sharing;
  - Standardizing geospatial data production workflow, including a procedure to incorporate feedback when a dataset is modified or improved;
  - Improving requirements analysis and planning stages before beginning geospatial data collection or application development.

- Create best practices documentation related to
  - Network and governance procedures
  - Design of public-facing GIS applications and mobile apps
  - Geospatial data quality
  - Workarounds when web browsers are incompatible with GIS applications
  - GIS software deployment through 5-HELP, including providing Tier 1 technical support through 5-HELP
- Evaluate the suitability (including data security) of non-ESRI technologies such as OpenGIS components; add these technologies to the DOT ITSS software list
- Share knowledge of linear referencing and other “niche” GIS practices or technologies
- Discuss the concept of “story maps” and how DOT can use them to promote awareness of GIS capabilities. For example, FAA could create a story map depicting a typical passenger flight from departure to arrival. Along the way, each element of FAA safety oversight is portrayed: aircrew training, certification, and medical examination; mechanic certification and medical examination; maintenance facility oversight and certification; a rulemaking that institutes free flight.

**GIS users**

As mentioned above, over 700 DOT employees have access to ESRI GIS desktop software under the Enterprise License Agreement (ELA) with ESRI. The majority of these users share 166 concurrent use licenses, which indicates that most of these users are occasional or rare users of the software. DOT staff whose primary responsibility is GIS-related sometimes have standalone licenses.

**Role in implementing the Strategic Plan:** The large group of GIS users will mainly be consumers and beneficiaries of the changes brought about through implementation of the Strategic Plan. They will not have a direct role in implementing the plan, but they can give feedback about actions taken to either the GIS Professionals Group or the GCC.
3. Communication Plan

This Strategic Plan is not written only for the GIO and CIO. DOT employees at all levels should be encouraged to “think spatially” in their work. The logo on Page 3 was designed during the development of this plan. It is intended to be used to publicize the Strategic Plan and DOT’s commitment to growing its geospatial program. Posters with the logo should be placed throughout DOT, and the logo can be used at GIS Day and related events.

Management and decision makers should evaluate how GIS analysis and products can improve their ability to meet mission goals. When appropriate, non-supervisory employees can be trained to use desktop GIS or ArcGIS Online as well as existing mapping applications. As stated in Strategic Goal #2, existing tabular datasets should be reviewed to determine their potential to be spatialized. For example, PHMSA stores pipeline inspection reports in a tabular database. Although the inspection fields are not inherently spatial, the inspection areas are divided into “units.” Once the unit boundaries were mapped, PHMSA was able to link the inspection database to the pipeline GIS segments, enabling staff to query the inspection reports by choosing pipelines on a mapping application.

Opportunities for getting the word out about our GIS strategic goals include:

- A table and presentation at GIS Day in November
- Signs featuring the “Think Spatially” logo in DOT and FAA’s lobbies and hallways
- An image and link on the DOT Intranet’s rotating home page carousel
- Item in the modes’ daily newsletters
- A celebration at OCIO when the plan is released
- Presentations for the GCC, GIS Professionals Working Group, OCIO, and modal administrators
## 4. Deliverables

<table>
<thead>
<tr>
<th>Strategic Goal or Objective</th>
<th>Deliverables</th>
<th>Budgetary impact (minimal, $, $$, $$$)⁶</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improve communication and awareness related to GIS</td>
<td>Charter document for GIS Professionals Group, communication plan and promotional materials for GIS awareness (including GIS Day), policy for data collection projects</td>
<td>minimal</td>
</tr>
<tr>
<td>Centralize oversight of DOT’s GIS</td>
<td>DOT GIS intranet page, centralized system architecture if deemed feasible, updated GCC membership list</td>
<td>$ (intranet page) to $$ (with centralized architecture)</td>
</tr>
<tr>
<td>Share geospatial data and eliminate duplication</td>
<td>Centralized map and feature services, MOUs as needed, toolkit for common GIS problems, best practices documentation as described in Section 4</td>
<td>$</td>
</tr>
<tr>
<td>Standardize geospatial data and applications</td>
<td>Best practices documentation as described in Section 4, data standards implemented, data gaps investigated and resolved, tabular datasets spatialized where possible</td>
<td>$$ (highly dependent upon amount of new geospatial data)</td>
</tr>
<tr>
<td>Cultivate a 21st century geospatial workforce</td>
<td>Seminar for senior management, brown bags for GIS novices, specialized GIS training as needed, use cases describing to GIS novices which tool to use for common tasks</td>
<td>$</td>
</tr>
<tr>
<td>Leverage emerging geospatial technology</td>
<td>Policy on use of cloud for GIS, ESRI ELA governance, whitepapers on OpenGIS for DOT and mobile application standards, ArcGIS Online use policy, virtual servers for modes to test new technology</td>
<td>$$-$ $$ (depending on number of virtual servers needed)</td>
</tr>
<tr>
<td>Advance mission goals with geospatial analysis</td>
<td>Whitepaper written by GIS Professionals Group addressing technical points described in Section 4</td>
<td>minimal</td>
</tr>
<tr>
<td>Fund a mature GIS program</td>
<td>New FTE positions created, Modal GIOs assigned, budget figures on modes’ geospatial expenditures and additional budget resources allocated as desired, create a GIO budget with data production and visualization line items, list of core GIS staff, professional services contract rider for ESRI ELA</td>
<td>$$$</td>
</tr>
</tbody>
</table>

⁶ All figures are approximate, but $=$0-20K, $$=$20K-$100K, $$$=$100K+. 
5. Metrics and Return on Investment (ROI)

Progress towards implementing the strategic goals is better measured in tasks accomplished than in statistics. However, metrics could be used to show progress in the following ways.

- In early FY17, take a DOT-wide survey (or add a question to the Employee Viewpoint Survey) to gauge awareness of GIS. Repeat the survey after awareness efforts and training are completed.
- Gather statistics on the funds each mode is spending on GIS hardware, software, and contractor tasks. A centralized system architecture could provide savings if the modes are able to share data, tools, and environments.
- Geospatial data gaps can be inventoried and remediated as part of the “standardize geospatial data and applications” strategic objective.
- Spatialization can improve the quality of tabular datasets. For example, a tabular dataset describing the coverage of emergency response plans can be mapped, revealing gaps in coverage. DOT should track where spatialization resulted in better quality or more useful datasets.

Likewise, ROI from geospatial projects or data development can be hard to quantify. A more mature GIS program at DOT would mean:

- Improved transportation safety when risk assessment is spatially enabled, because GIS pinpoints where risk factors occur
- Improved ability to stop accidents before they happen by using GIS to forecast highly vulnerable areas or to pinpoint “hot spots”
- More effective transportation when GIS analysis discovers under-served areas and is used to optimize routes
- Better crisis/emergency response when GIS tools are fully leveraged, allowing for spatial analysis on the effects of an accident or emergency
- More impactful safety data through visualizations created with GIS
6. Milestones and Timetable

The authors suggest that this Strategic Plan be updated in three years. A proposed timetable for achieving this version’s strategic goals is below.

<table>
<thead>
<tr>
<th>Fiscal Year</th>
<th>Major Milestones</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY17</td>
<td>Relaunch GIS day, designate modal GIOs, begin development of the GIS intranet page, identify data gaps and tabular datasets that could be spatialized, develop best practices and use policy documents, request budget for GIO, advertise openings for additional FTEs.</td>
</tr>
<tr>
<td>FY18</td>
<td>Launch GIS intranet page, begin actions which require budget resources, including implementing a centralized system architecture, resolving data gaps, spatializing tabular data, standing up virtual servers, and creating map and feature services.</td>
</tr>
<tr>
<td>FY19</td>
<td>Renew ELA with ESRI, continue implementing and developing items from FY18, begin development of Strategic Plan 2.0.</td>
</tr>
</tbody>
</table>
Appendix A: About this Document

DOT’s first GIS Strategic Plan was written between March and September 2016. The primary author was Amy Nelson, PHMSA’s GIS Manager and a detaillee to OCIO while writing the plan. Dennis Nicholas, FAA Operations Research Analyst, researched and wrote the FAA portions. Steve Lewis, DOT’s Geospatial Information Officer, oversaw the plan’s development. Cindy Stark and Ron Chaney in OST designed the “think spatially” logo, and Jay Gregory at FAA assisted in designing the front cover.

Information used to create the Strategic Plan came from the following sources:

1) An anonymous online survey (see Appendix C) open between March and May 2016 and disseminated to DOT staff who were frequent GIS users or members of the GCC.
2) Interviews and input from with each of the modes mentioned in Section 3, as well as key staff such as the Chief Technology Officer, GIO, Chief Data Officer, and Associate CIO.
3) Interviews with non-DOT agencies and organizations who had written their own GIS Strategic Plans: Dan Widner at the Virginia Information Technologies Agency, Matthew Crossett and Julie Kanzler at the District of Columbia Office of the Chief Technology Officer, Steven Chozick at the City of Alexandria, Virginia Emerging Technologies and Advanced Analytics Division, and Tony Lavoi at the NOAA Office for Coastal Management.
4) Research by the authors.

The authors suggest that this Strategic Plan be updated every three years.
Appendix B: Guide to Acronyms

AGOL: ArcGIS Online
AIS: Aeronautical Information Services, a division of the FAA
ARNOLD: All Roads Network of Linear Referenced Data
AWS: Amazon Web Services, a cloud environment
BTS: Bureau of Transportation Statistics, a division of OST-R
CIO: Chief Information Officer
COE: Common Operating Environment
DOT: Department of Transportation
ELA: Enterprise License Agreement
ESRI: Enterprise Systems Research Institute, the leading provider of desktop GIS software
FAA: Federal Aviation Administration
FGDC: Federal Geospatial Data Committee
FHWA: Federal Highway Administration
FMCSA: Federal Motor Carrier Safety Administration
FRA: Federal Railroad Administration
FRAGIS: Federal Railroad Administration GIS application
FTA: Federal Transit Administration
FTE: Full-time Equivalent, or a full-time federal employee
GAO: General Accounting Office
GCC: Geospatial Coordination Council, a group comprised of senior management from each mode, the GIO, and OST representatives
GIo: Geospatial Information Officer
GIS: Geographic Information Systems
HPMS: Highway Performance Monitoring System
LRS: Linear Referencing Systems, a method of spatial referencing where features are described in terms of measurements along a linear element (e.g. mile markers)
MARAD: Maritime Administration
MOU: Memorandum of Understanding
NHTSA: National Highway Traffic Safety Administration
NIEM: National Information Exchange Model
NPMS: National Pipeline Mapping System
NSDI: National Spatial Data Infrastructure
NSGIC: National States Geographic Information Council
NTAD: National Transportation Atlas Database
OCIO: Office of the Chief Information Officer
OGC: Open Geospatial Consortium
OIG: Office of the Inspector General
OMB: Office of Management and Budget
OST: Office of the Secretary of Transportation
OST-R: Office of the Assistant Secretary of Research and Technology
PHMSA: Pipeline and Hazardous Materials Safety Administration
PIV: Personal Identity Verification, a technology used in DOT employee badges
SES: Senior Executive Service
SLSDC: Saint Lawrence Seaway Development Corporation
STB: Surface Transportation Board
VPN: Virtual Private Network
Appendix C: Results of the Online Survey

1. What kind of GIS user are you?
   1. Decision maker for your mode: 10.7%
   2. Primarily a technical, “hands-on” GIS user for your mode: 39.3%
   3. Both a decision maker and a hands-on user: 35.7%
   4. Other: 14.3%

2. Do you think that GIS should be part of the DOT IT Enterprise?
   - Yes: 78.6%
   - No: 0%
   - I don’t know: 21.4%

3. Does your mode have geospatial program needs that are not currently being met?
   - Yes: 85.7%
   - No: 0%
   - I don’t know: 14.3%

4. Please select all program needs not currently being met.
   - Data availability or development: 58.3%
   - Data visualization: 58.3%
   - Budgetary: 45.8%
   - Staffing: 41.7%
   - Hardware, software, and cloud environments: 66.7%
   - IT Support for geospatial applications/platforms: 70.8%
   - Technical training for GIS professionals: 54.2%
   - User training for customers: 41.7%
   - Standards and template development: 45.8%
   - Support from management: 37.5%
   - Partnerships within DOT: 70.8%
   - Partnerships external to DOT: 45.8%

5. In your opinion, how well is US DOT keeping pace with modern geospatial technology?
   - Not well at all: 7.7%
   - Below average: 26.9%
   - Average: 46.1%
   - Above average: 19.2%
   - Very well: 0%

6. What are the major challenges to increasing the use of GIS within your mode and for your customers? (Select all that apply)
   - Data availability and/or sharing issues: 70.4%
   - Cost of data collection: 29.6%
   - Non-GIS system or data integration: 66.7%
   - Lack of GIS staff: 48.1%
   - Lack of GIS training: 40.7%
7. If you are a member of the Geospatial Coordination Council, please rate its value to you.
   • Not valuable at all: 9.1%
   • Somewhat valuable: 54.6%
   • Very valuable: 27.3%

8. What kind of training do you need to help accomplish your mode’s goals with GIS?
   • Technical training such as OpenGIS or ESRI classes: 82.1%
   • Networking opportunities to understand what others are doing with GIS: 64.3%
   • End-user training such as learning to use existing GIS applications on the web: 67.9%
   • Other: 10.7%
   • None: 7.1%

9. What are the top three things you’d like to see US DOT GIS do in the next five years? (Write-in.)
   • A true enterprise deployment of GIS for all of DOT (including FAA).
   • 1) Full implementation of database driven charting. 2) Sharing Aeronautical Information data seamlessly through a single exchange mechanism. 3) Moving to an information product that spurs GIS query and survey by the user community.
   • Enterprise GIS system serving all sections and sub-sections.
   • 1) DOT Geospatial Master Plan. 2) HR initiative to incorporate GIS professional series at all levels of DOT. 3) Organizational sustainment for GIS initiatives.
   • 1) A streamlined geospatial data budget that can allocate resources to all modes. 2) Greater data integration and sharing both in and outside of DOT, to include geospatial data analysis in all programmatic aspects, including civil rights compliance. 3) Develop an online or desktop architecture that is accessible to casual users/non-GIS experts.
   • Encourage GIS data sharing among modes and provide GIS training.
   • Have a solidified community/working group, a mechanism to share/store/manipulate data to decrease duplicate efforts and break down silos, and have better communication within the GIS group in terms of following standards and what applications/projects are being developed and perhaps how other OAs can leverage that information.
   • Reduce security barriers to publishing data online or in the cloud, embrace open source geospatial applications, make GIS part of the base build for work stations.
   • 1) Ensure that OST Help Desk has the training and tools needed to provide adequate technical support (e.g., installation and setup, troubleshooting, etc.). 2) Development of department-wide metadata, data development and dissemination standards. 3) Development of standards and/or best practices for enterprise system development/implementation purposes.
• Move to OpenSource tools. Establish consistent access to enterprise GIS data (and develop those resources). Foster development and use of cloud- and web-based analysis and visualization tools.
• Establish clear goals and communicate to the different modes their role in helping to meet these goals. Address persistent security issues that prevent effective data sharing. Facilitate collaboration in GIS projects among the different modes.
• Integrated datasets. Comprehensive strategy. Increased coordination with OCIO and other OST Offices.
• Continue to consolidate our transportation spatial layers. Offer USDOT layers as services to users. Work with our IT Security to allow for more simple process at the modal level.
• Make NHTSA data more visual in terms of crash location data. Make our data easier to manipulate by location for outside users.
• Use GIS to integrate, visualize, and analyze data from across the DOT.
• 1) Establish a GIS Office within the Office of the Secretary (OST). A GIO is a good start but it’s not enough. 2) The office needs to manage and coordinate data collection, data development, application development, standards development, IT / infrastructure management, and more. 3) The GIS Office needs to set policy defining how data is collected and published, define policy for print and electronic mapping styles (USDOT should have a mapping brand that conveys professionalism and elicits confidence), and set policy that defines how applications are developed and how they can reuse components. The policies set by the office should establish mature and repeatable processes by which data, maps and applications are produced.
• Establish a cloud presence for external stakeholder sharing. Enhance the portfolio of available spatial tools to help with the collection of data. Provide the ability to effectively share resources for the product within the cloud that shares computing power.
• 1) Coordinate GIS efforts across all modes, reduce duplication of efforts and facilitate collaboration. 2) Develop a common look and feel to web applications, data download sites, etc. 3) Become recognizable by the public as much as some other government agencies are.
• 1) Internal and external geospatial data servers. 2) Update the DOT ITSS software list to include open source GIS software, specifically QGIS and OpenGeo suite as a free alternative to ESRI software. 3) Set up web-based sandbox server or internal virtual server instances to allow testing of different web-based open source geospatial tools, like Leaflet, GeoNode, and OpenLayers.
• Cloud-based ESRI architecture to host mapping applications.
• Set up an internal data sharing system (e.g. ArcGIS portal). Leadership at DOT should take GIS as seriously as many other federal agencies do (e.g. DOI, Dept. of Agriculture).
• 1) Revitalize the GIS user group. 2) Move to a cloud environment for most web-based mapping applications. 3) Conduct a campaign to promote awareness of GIS within DOT.
• GIS in the cloud, integration of geospatial data across modes, keep up with technology.

10. Please provide any additional relevant comments.
• Leave data decisions and to data people. Bring regular GIS work in house instead of heavily relying on contract support- gives the perception that the investment in a permanent program is not a priority and staff turnover hurts. Set an example that GIS support personnel are a great asset to any mode, just like writers, administrative personnel, data entry staff, customer support staff, IT support, etc. You don't just expect someone with another specialty to just do those things on the side and expect success. Simple GIS support should also not weigh down GIS staff that should be focused on bigger picture program design and implementation.

• FAA is an information provider to the GIS activity in the user community. We need to assure that the hooks in the data promote the use of GIS to combine, analyze, and create new, hidden information that was previously obscured with in the Aeronautical Information that we make available to the public.

• Performance is critical. When app licenses live in remote servers and local PC access to networks is poor, performance drops significantly to the point of losing interest.

• Need to get the word out. If I haven't heard of this, I know of about ten other people who are also involved in GIS-related production who also are unaware.

• While I like the ESRI product, the cost is prohibitive. I think we need to invest more time into implementing OpenGIS.

• Establish a standard delivery and deployment standard for desktop software.
Appendix D: List of GIS-related DOT Websites and Web Mapping Applications

**FAA**
- FAA Aviation Safety Field Offices Map: [http://arcg.is/1pgMc5y](http://arcg.is/1pgMc5y)
- FAA Flight Standards Field Offices Map: [http://arcg.is/25KA2VJ](http://arcg.is/25KA2VJ)

**FHWA**
- GIS at FHWA: [https://www.gis.fhwa.dot.gov/](https://www.gis.fhwa.dot.gov/)

**FRA**

**OST-R**

**PHMSA**