NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP Project 08-167

Guide for Creating Effective Transportation Visualizations

Final Deliverable

Research Report and Guide, with Self-Assessment, Visualization Adoption Roadmap, Case Studies, and Interactive Online Toolkit

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Prepared for

Transportation Research Board

of

The National Academies of Sciences, Engineering, and Medicine

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July 2026

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Final Report Summary

In an age of rising automation, keeping people and communities in the loop is more essential than ever. The human mind is hardwired to process information visually, and great communication can be done through images and visualizations. Data visualization gives transportation agencies an effective way to communicate their vision and needs. Done well, a visual can improve the safety and efficiency of transportation systems by informing policies, guiding decisions, and shaping public response. As agencies adopt Artificial Intelligence (AI) and automated analysis, visualization is one of the best ways to keep human judgment in the loop and turn data and models into something people can oversee, engage with, and act on.

Prior NCHRP work showed that there is inconsistent capability across agencies in developing effective visualizations. The 2017 data visualization methods guide (Higgins et al. 2017) and NCHRP Synthesis 584 (Broen 2022) each found growing agency interest and need in this topic alongside gaps in staff training, design standards, workflows, and evaluation.

NCHRP Project 08-167 set out to close those gaps. This effort treated visualization as an organizational capability rather than a narrow design task, addressing the full cycle of practice from defining objectives through evaluating results and sustaining a culture of improvement over time. The research team reviewed 43 sources spanning transportation, data science, and design. It fielded a national practitioner survey that drew 59 responses across the country from State Departments of Transportation (DOTs), Metropolitan Planning Organizations (MPOs), and other local and transit agencies. It ran two national workshops with practitioners, and it conducted interviews with eleven agencies that became the project's case studies. These activities pointed to one consistent conclusion. The biggest obstacles to effective visualization are organizational, and practitioners want practical, ready-to-use resources far more than additional theory.

This effort produced an integrated set of products: a comprehensive Guide for Creating Effective Transportation Visualizations (Part II of this volume), organized around a four-part framework covering Preparing for Success, Creating Your Visual, Assessing What Works, and Implementing Across the Agency. Supporting the guide are a self-assessment worksheet, a visualization adoption roadmap, a library of eleven case studies, and an interactive online toolkit. This report (Part I) documents the research approach and the findings that led to those products.

Chapter 1. Introduction

1.1. Purpose of the Research Report

This Research Report (Part I) documents the research conducted under NCHRP Project 08-167, "Guide for Creating Effective Transportation Visualizations," and explains how that research shaped the resources presented in the Guide (Part II of this volume) and its accompanying tools.

1.2. Problem Statement

Transportation agencies work in an environment defined by an extraordinary volume of data related to a wide range of connected topics such as safety, travel time, asset condition, land use, the natural environment, economic and demographic trends, and more. Their capacity to translate that data into visual communication for the benefit of themselves and their stakeholders has lagged behind the growth in data itself. Visualization is a competency that determines whether information reaches the audiences who need it. When done well, it makes complex information accessible, supports better decision-making, and reinforces public trust.

Prior NCHRP research established the groundwork that this effort builds upon. The 2017 NCHRP 08-36 (Task 128) data visualization methods guide (Higgins et al. 2017) and the 2022 NCHRP Synthesis 584 on visualizing highway performance measures (Broen 2022) both found data visualization to be an area with uneven maturity across agencies and rising interest for analysis and communication. Agencies were experimenting with tools such as Tableau, Adobe Creative Suite, a range of ESRI products, and Power BI. Today, agencies are also using Copilot, Claude, and other agentic AI. Recurring obstacles include limited staff training, the absence of design standards, siloed workflows between technical and communications teams, and a near-total absence of formal evaluation of visualization effectiveness. NCHRP Project 08-167 was initiated to address those obstacles through self-assessment tools, case studies, and guidance.

1.3. Research Objective

The objective of NCHRP Project 08-167 is to develop a guide and website for creating effective transportation visualizations. The guide is intended for professionals at every level, from agency leaders and managers to planners, engineers, analysts, IT specialists, and communications staff. It was meant to provide a practical roadmap for improving visualization practice and building a culture of data-informed communication. These resources can be used by professionals with widely varying levels of experience through self-assessments, action-oriented roadmaps, and case studies. A digital version of the guide and its supporting tools was to be developed as an interactive online toolkit, hosted for long-term accessibility at https://vizguide.tpm-portal.com/.

Chapter 2. Research Approach

2.1. Overview

The research combined four lines of inquiry:

- a literature review,
- a national practitioner survey,
- two practitioner workshops, and
- a series of agency interviews.

The agency interviews collectively built an understanding of current practice, identified gaps, and ensured the resources reflected practitioners' needs. Findings from these activities were synthesized into a four-part framework that structured the Guide, the self-assessment, the adoption roadmap, and the interactive online toolkit. **Figure 1** shows how the four research activities fed the framework and the final products.

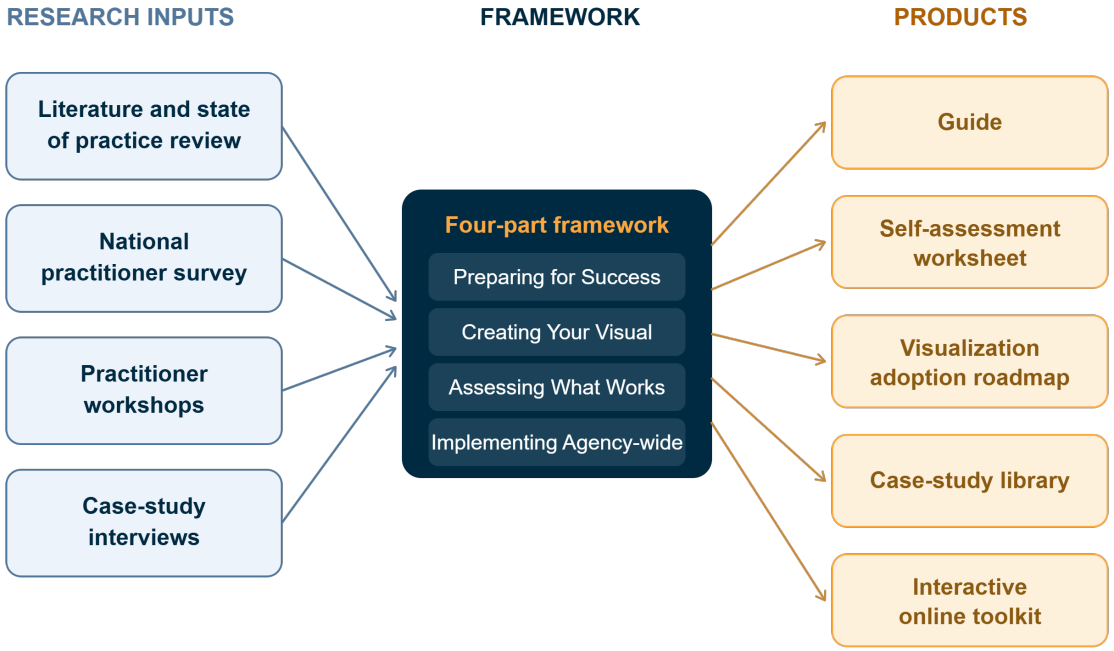


Figure 1: Research activities that informed the four-part framework and the five final products.

2.2. Literature and State-of-the-Practice Review

In total, the literature review included 43 sources, comprising 15 industry reports, 12 peer-reviewed journal articles, 8 public-agency guidance documents, and 8 digital tools and resources. The Research Team searched for sources through the TRID Database (Transportation Research International Documentation), Google Scholar, AASHTO

(American Association of State Highway Transportation Officials), and public-agency portals. Search terms included variations of content related to data visualization best practices, transportation data, visual design principles, maps, dashboards, accessibility, public engagement, and artificial intelligence in transportation. The review included sources beyond transportation, extending into fields related to design, data science, marketing, and geospatial analysis to surface transferable, user-centered design practices. Desk research covered basics of visualization theory from Edward Tufte (Tufte 2001) and William Cleveland (Cleveland 1985), Wickham's tidy data principles (Wickham 2014), and topics such as accessibility standards, visualizing geospatial data, color theory, user interactivity, and the use of AI tools in visualization workflows.

2.3. Practitioner Survey

The research team also ran a national survey through SoGoSurvey (Sogolytics software) to hear from practitioners. The survey went out to staff at state DOTs, MPOs, and other local transportation and transit agencies. The survey captured how agencies use visualization, the tools and skill levels available to them, the organizational barriers they face, their evaluation practices, and the resources they most need. The team sent personalized email invitations to members of TRB and AASHTO committees and shared a public link through promotional materials and at industry events, including the TRB Annual Meeting and the TRB Conference on Data and AI for Transportation Advancement. A promotional graphic was distributed through TRB committee channels to recruit participants. The survey received 59 responses, with the most participants being planners (30%), managers or executives (20%), data analysts (15%), or engineers (14%).

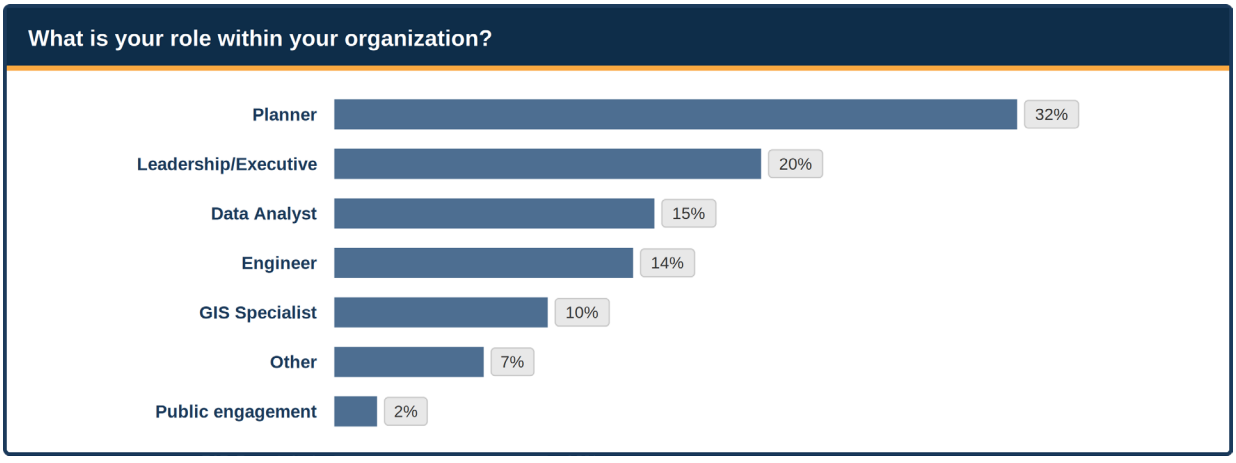


Figure 2: Survey respondents by role and agency type (n = 59).

2.4. Practitioner Workshops

The research team ran two national workshops to test draft guidance against practitioner experience. The first took place at the TRB Conference on Data and AI for Transportation Advancement. The workshop brought together planners, analysts, engineers, and communications professionals. Participants rotated through three stations on guiding principles, feedback and evaluation, and building a culture of visualization. In a hands-on challenge, teams received the same crash dataset and had to build visuals to support a decision-making scenario. The second workshop was conducted with the National Working Group on Visualization, a then-newly formed community of practice led by Department of Transportation (DOT) staff from Oregon, Washington, and California, where the research team presented the project's preliminary findings to a national peer network.

Figure 3: Image from one of four breakout groups during the effort's practitioner workshop during TRB's Conference on Data and AI for Transportation Advancement in Seattle, WA in May, 2025

2.5. Case-Study Interviews

The research team interviewed agency staff to build a library of case studies. Each interview asked why the agency created a visualization, the design decisions behind it, and what the agency learned from building and using it. The interviews captured the processes, trade-offs, and choices behind each visualization, information that often proves more useful to practitioners than the finished visuals alone. The completed library includes eleven case studies. Together they represent a range of agency types, visualization mediums, communication needs, audience types, data types, and levels of interactivity.

2.6. Framework and Toolkit Development

The research team pulled findings from all four lines of inquiry into a framework for effective visualization practice. The framework has three parts: preparation, creation, and evaluation. Organizational and cultural factors came up so often in the research that the team added a fourth part on implementation across the agency. The resulting four-part framework covers Preparing for Success, Creating Your Visual, Assessing What Works, and Implementing Across the Agency, and it became the organizing structure for the Guide and every supporting component. From the framework the research team developed two implementation-oriented tools. The Self-Assessment Worksheet lets agencies rate their current practices across six competency areas on a five-point scale. The Visualization Adoption Roadmap presents recommended actions along an emerging-to-developing-to-mature continuum and links directly to the relevant self-assessment results and case studies. An interactive online toolkit was developed to deliver these resources digitally, with a landing page, an interactive self-assessment, a digital roadmap, a searchable case-study library, and a curated resource library.

Chapter 3. Research Findings

3.1. Introduction

This chapter presents the substantive findings of the research and explains how each shaped the project's products. The findings are organized around the major lines of inquiry and the themes that ran across them.

3.2. State of the Practice

The literature review pointed to four things agencies need to get right. The first is knowing the purpose of the visual and handling the data well. Agencies that started with a clear purpose and put work into data practices like tidy data principles, standardized cleaning, and deliberate transformation produced better visuals.

The second is knowing how to develop effective visuals that are clear and memorable for the reader. Choosing an effective chart or map type, using color with purpose, adding

interactivity where it helps, and meeting accessibility standards are all steps that shape whether or not a visualization can be understood and acted on by different audiences.

The third is developing a feedback loop about the efficacy of visuals. User testing, stakeholder feedback, and web analytics can all measure effectiveness, but few agencies had done any structured evaluation. That left an obvious gap in practice.

The fourth came up more than any other. Building an organizational culture of visualization requires leadership support, staff training, standardized templates, and cross-department collaboration. The literature treated this theme as a precondition for the other three, and that framing drove the decision to expand the framework from three parts to four.

3.3. Practitioner Survey Findings

The survey drew 59 responses, mostly from state DOTs (58 percent) and MPOs (26 percent). Forty-two percent of respondents reported working for more than ten years in transportation. The results expanded upon the themes found in the literature. Silos between data owners ranked as the top organizational challenge, with 59 percent of respondents rating it high-impact. Only 8 of 59 respondents said their agency was fully equipped with the infrastructure needed for visualization work. Interest in AI tools was high, but experience was low: 31 of 59 respondents described themselves as "not familiar but interested," while only 6 said they were very familiar.

Survey respondents reported using visualizations for long-range planning, performance reporting, environmental reviews, safety analysis, and public engagement. Visuals served both internal audiences (like cross-team communication and executive briefings) and external ones (like the public, partner agencies, and elected officials). Agencies described visuals as central to communicating their work across many levels, from big-picture issues to technical details. Visualization development was often reported as split between internal staff and contractors. Some agencies reported wanting to bring more visualization work in-house but cited internal capacity-building as a challenge.

Organizational Challenges

There was a wide range of self-reported skill levels across respondents. Most identified as beginner or intermediate at visualization development. A few agencies employed dedicated visualization specialists. Most agencies relied on planning, performance, Geographic Information Systems (GIS), or public-affairs staff who were self-taught or learning on the job. Common tools included Tableau, ArcGIS, Adobe Creative Suite, Microsoft Excel, and Power BI. Access to supporting resources such as style guides, templates, icon libraries, and accessibility checklists varied considerably. Some

agencies had built in-house resources. Others used ad hoc approaches, and training was often informal.

Respondents identified several persistent organizational barriers. Limited staff time and technical capacity were the most-cited challenges for consistently developing effective visualizations at work. The absence of formal guidance or design standards was the second most-cited challenge. Software and IT constraints also arose as a top challenge, from licensing, procurement, and firewall restrictions. A disconnect between technical staff and communications teams, working in silos, rounded out the top four barriers to implementing effective visuals. These organizational obstacles, more than any technical limitation, were reported as the most challenging barriers for professionals who wanted to incorporate effective data visualization into their work.

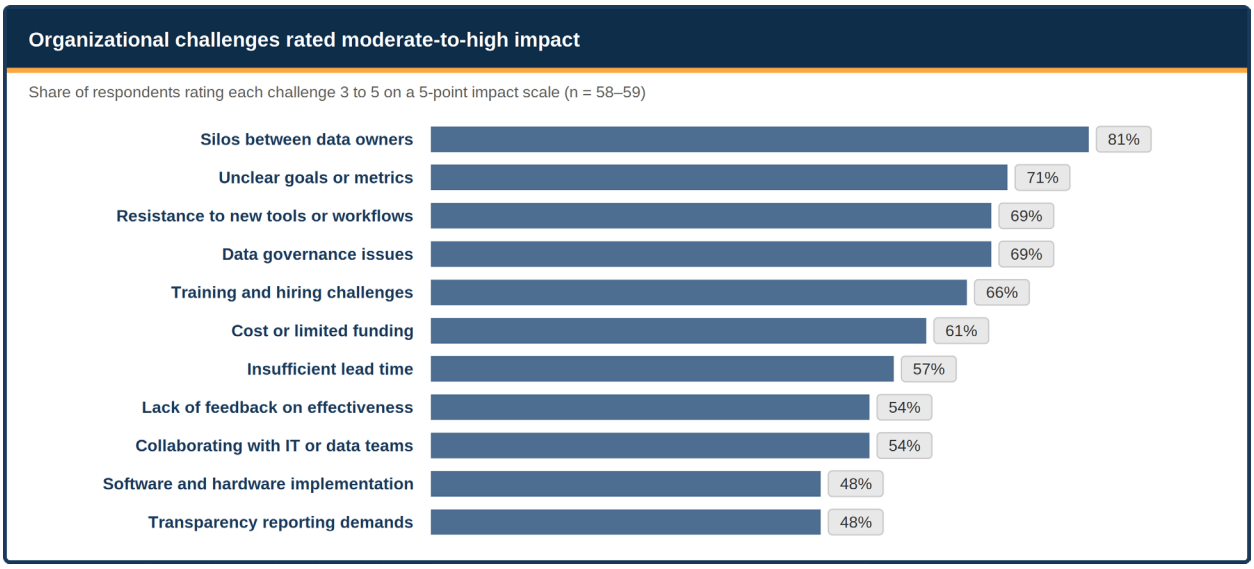


Figure 4: Extent to which organizational challenges affect visualization development, by share of respondents.

Technical Challenges and Infrastructure

The survey also asked about technical challenges, and while respondents did not cite them as extensively as organizational challenges, several common threads emerged. Limited access to quality data and limited staff capacity for advanced visualizations (AR, VR, 3D) were the most commonly reported challenges. Difficulty exporting information from agency systems and joining disparate datasets also came up frequently. When asked whether their agency had the infrastructure needed for visualization work, only 8 of 59 respondents said yes. Twenty-six said they were partially equipped but facing limitations, and 11 said they lacked the infrastructure entirely. Fourteen said they did not know.

Most respondents had limited experience with using AI to develop visualizations. Thirty-one of 59 described themselves as "not familiar but interested." Only 6 respondents said they were very familiar. Among those who had tried AI tools, the most cited challenge was a lack of training (36 respondents). Other barriers included ethical concerns or a lack of trust in the accuracy of AI outputs (30), and AI integration not being a priority for their organization (23).

Training Resources and Needs

Respondents were asked to select the types of training that would be most impactful to them. Data storytelling and communication was the most popular choice, with 45 respondents selecting it. Accessibility best practices came in at 39, and UX/UI design for online resources was close at 38. Geospatial visualization techniques and storytelling for infographics and presentations were also widely selected, at 36 and 34, respectively. Dashboard software training for tools like Power BI, Tableau, and ArcGIS Dashboards drew 31 responses, and interest in integrating AI into the visualization process was similar at 32.

The resources respondents said would help their organization were just as clear. Forty-seven of 59 selected "a guide or toolkit with best practices for creating visualizations." Thirty-five wanted principles or evaluation criteria to assess effectiveness. Thirty-one wanted training on data governance and managing performance data. When asked about the single most important area for improvement over the next three years, data integration and management led (24 respondents), followed by integrating AI and predictive analytics (12) and building internal data literacy and training programs (8).

3.4. Workshop Findings

Workshop participants echoed and expanded upon several issues raised in the survey responses. There was strong interest in agency-wide templates and adaptable examples. Most participants agreed that their agencies do little formal evaluation of visuals. The most commonly cited barriers were lack of time, skill and training gaps, and a lack of access to quality practitioner tools. Attendees were keen on developing agency-endorsed checklists and structured methods for building quality-control checks and user-feedback loops into habitual workflows. Leadership buy-in and culture change came up repeatedly as the things that make or break whether effective visualization practices stick at an agency. Simplicity and storytelling, more than technical sophistication, were what participants said help information be memorable and readily understood. For using generative AI, the consensus was that tools like ChatGPT, Gemini, Claude, and Copilot are useful for brainstorming and early prototyping, but participants did not trust them for final design decisions. Requests for AI workflow guidance came up enough that the research team included AI-specific guidance in the final Guide.

The second workshop surfaced a finding about terminology and scope that proved important to the project's positioning. The National Working Group on Visualization, composed largely of staff focused on project-level graphics such as 3D renderings, animations, and VR/AR, used the term "visualization" quite differently from the data-visualization focus of NCHRP 08-167. The group recommended that the project emphasize "data visualization" explicitly to set it apart from complementary efforts such as the NCHRP Synthesis on visualization for public involvement (Christians and Lebeaux 2024) and earlier work on visualization for project development from Synthesis 361, Visualization for Project Development (Hardy and Larsen, 2006). The exchange clarified a useful role for NCHRP 08-167 as a bridge between the planning and performance-visualization community and the design and project-development community, which often work in isolation from one another.

3.5. Case-Study Findings

The survey asked respondents to recommend exemplary visualizations, either from their agency or from another that they found useful. Workshop participants recommended additional agencies and visuals. From those leads, the research team set up roughly hour-long interviews with staff at each agency who had been involved in creating the visualization. The interviews covered why the agency built it, who it was for, what design decisions they made along the way, and what they learned from using it. The finished library holds eleven case studies. They cover everything from a printable Portable Document Format (PDF) brochure translating asset-management data for legislators to a live ArcGIS dashboard refreshing travel data every few minutes to agency-wide Tableau governance guidelines. Because these came from conversations with the people who built the visuals, the case studies capture the workflow and the tradeoffs behind each product, which turned out to be as useful to the Guide as the finished visuals themselves.

Table 1: Summary of the eleven case studies: agency, visualization type, primary audience, and the lesson each illustrates.

Agency	Visualization Type	Primary Audience	Lesson It Illustrates
Vermont Agency of Transportation (VTrans)	Printable brochure (PDF)	Public and legislators	Plain-language framing makes a technical asset-management topic approachable for non-technical readers.
Naugatuck Valley Council of Governments (NVCOG)	Interactive charts (Datawrapper)	Practitioners, municipal leadership	A scroll-based, one-chart-per-topic layout turns dense Census and ACS data into accessible visual stories.

Agency	Visualization Type	Primary Audience	Lesson It Illustrates
Rhode Island Department of Transportation (RIDOT)	ArcGIS dashboard	General public, travelers	Live data feeds refreshed every few minutes keep a public dashboard useful for real-time travel and emergency information.
California Department of Transportation (Caltrans)	360-degree virtual tour	Regulators, property owners, public	Immersive, navigable visuals support stakeholder engagement on a complex project better than static renderings.
Florida Department of Transportation (FDOT)	Web portal (Tableau + GIS)	Leadership, planners, MPOs, public	Transparent, consistent performance reporting builds trust across both internal and external audiences.
Minnesota Department of Transportation (MnDOT)	Web portal (Power BI)	Public, elected officials, staff	Deliberate simplicity in a performance dashboard creates shared ownership across very different audiences.
Arizona Department of Transportation (ADOT)	Social media image	General public	Mobile-first graphics deliver timely updates and foster accountability on the channels the public already uses.
Washington State Department of Transportation (WSDOT)	Embedded Tableau dashboard	Public and local partners	Near-real-time travel, freight, and toll data in one dashboard serves both public and industry users.
Metropolitan Area Planning Agency (MAPA)	GIS tool	Transportation staff, community stakeholders	Combining crash data with risk factors and community input strengthens proactive, system-level safety planning.
Texas Department of Transportation (TxDOT)	Visualization guidelines and Tableau community of practice	Internal staff, consultants, partners	A shared community of practice spreads visualization standards and skills across a large agency.
TxDOT	GIS governance and map guidelines	Internal staff, consultants, partners	Enterprise governance paired with a GIS community of practice institutionalizes mapping standards agency-wide.

3.6. How the Findings Shaped the Products

The findings drove a set of deliberate design decisions. The consistent prominence of organizational and cultural barriers led to a dedicated framework part on implementation and to the development of the Self-Assessment Worksheet and the Visualization Adoption Roadmap as practical instruments for institutional change. Practitioners were very interested in ready-to-use, peer-validated resources. In response to this, the Research Team developed the eleven-case-study library and placed an emphasis throughout the Guide on templates, checklists, and annotated examples rather than principles alone. The evaluation gap led to expanded guidance on building evaluation into routine workflows. The terminology finding led the team to scope the products explicitly around data visualization. The practitioner preference for digital, navigable resources led to the development of an interactive online toolkit, designed to provide users with multiple entry points into the same body of knowledge.

Chapter 4. Conclusions

The biggest obstacles to effective visualization at transportation agencies are organizational. Limited staff time, siloed roles, lack of leadership buy-in, and missing design standards and evaluation processes all came up more often and more forcefully than any gap in tools or software. That finding changed the shape of the project. The framework was originally three parts (preparation, creation, evaluation), but organizational and cultural factors showed up so consistently across the survey, workshops, and case studies that the research team added a fourth part dedicated to implementation across the agency.

The project benefited from going back to practitioners repeatedly. The survey, workshops, and case-study interviews brought in perspectives from planners, analysts, engineers, communications staff, and agency leadership, and that input changed what went into the Guide and how it was organized. Some topics the research team had not planned to cover, like the role of AI in visualization workflows, came up often enough in those conversations that they made it into the final Guide.

Forty-seven of 59 survey respondents said the resource they most wanted was a guide or toolkit with best practices for creating visualizations. But people described wanting to use that kind of resource in different ways. Some said they would start with a self-assessment to figure out where their agency stands. Others wanted to go straight to case studies and see what peer agencies have done. Others wanted an interactive online tool they could browse. The research team built all of these (a Guide, a self-assessment worksheet, an adoption roadmap, an eleven-case-study library, and an interactive online toolkit) so that agencies with different levels of experience could find their own way in.

1. Introduction to the Guide

Visualizations like maps, charts, and dashboards turn data into a human conversation. It is how an agency explains a safety trend to a community group, how a planner makes a case for funding needs, or how an engineer shows which performance metrics will improve as a result of a project. Transportation agencies at every level produce data that could inform better decisions, but only if it reaches practitioners and stakeholders in a form they can understand and respond to. This guide gives agencies practical methods for planning, building, and evaluating visualizations that do that work.

1.1. Who is this Guide for?

This guide is written for transportation professionals at every level: agency leaders, managers, and the staff who do the work. A wide range of professionals including planners, engineers, executives, IT specialists, and analysts will find methods they can apply directly.

Agencies work across departments and communicate with audiences that range from technical peers to legislators to the general public. The guide reflects that reality, addressing both the craft of making a visual and the judgment of knowing what a given audience needs.

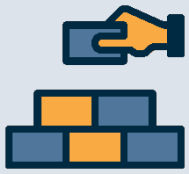
1.2. Overview of the Four-Part Framework

The guide is organized around four parts. Each addresses one stage of building and sustaining strong visualization practice.

1. *Preparing for Success: Communication Objectives and Data Preparation*. Effective visuals start before any chart is drawn. This part covers defining a clear objective and preparing sound data, the two things that set the ceiling on everything downstream.
2. *Creating Your Visual: Graphic Solutions and Design Principles.* This part covers the design work: choosing the right chart or map, using color and typography with purpose, and building in accessibility and interactivity for different audiences.

3. *Assessing What Works: Evaluation and Continuous Improvement.* How does an agency know if a visualization was effective? This part covers ways to gather feedback from audiences, test whether people understood what was communicated, and improve visuals based on the feedback.
4. *Implementing Across the Agency: Building Capacity and Sustaining Change.* Sustaining good practice takes more than individual skill. This part covers leadership support, training, and the workflows and standards that turn scattered good visuals into a lasting agency capability.

The four parts span both the technical and organizational sides of visualization, which is what agencies need to move from occasional strong visuals to a consistent, agency-wide practice.



2. Preparing for Success: Building the Foundation

Most of the work behind good visualization happens before anyone starts building it. The agencies in our case studies that produced the strongest visuals had three things in common: they knew what they were trying to say before they started designing, they had their tools and infrastructure sorted out, and they put time into preparing their data. This section covers those three foundations.

2.1. Defining Clear Objectives

One challenge in developing visualizations is when the author is highly familiar with the complex material and forgets that their audience is not. A practitioner who has spent six months on a corridor study looks at a chart of crash rates by segment and immediately sees the story. The legend is obvious because they picked the categories. The units and time periods are familiar because they have been working with the data every day. Then that same chart is presented to a group who is totally unfamiliar with the topic, and much to the analyst's dismay, nobody understands what they are looking at.

This happens often, and it is because the first and most essential step of visualization development can get skipped: sitting down before any design work and answering a handful of questions. Who is going to see this? How much do they already know about the topic? What should they understand after looking at it? What decision or conversation is this visual supposed to support? Transportation professionals are busy and these questions feel obvious, which is exactly why they get skipped. The answers feel obvious too, until someone tries to write them down and realizes the objective is fuzzier than expected.

2.1.1. Aligning with Agency Priorities

Most agencies have more data than they have time to visualize, so the question of what to build first is a practical one. A good starting point is to look at where the agency already has a communication need that is not being met well. That might be a federal reporting requirement where the current tables are hard for leadership to interpret. It

might be a public engagement process in which residents receive raw data rather than something they can react to. It might be an internal issue in which different divisions report on the same performance measures in different formats. Connecting a visualization project to one of those needs makes it easier to get buy-in, scope the work, and tell afterward whether it was worth the effort. A useful question to ask before starting any visualization project is: what should the person looking at this understand or do differently after seeing it?

2.1.2. Understanding Audience Needs

A visualization built for a state legislator looks different from one built for a traffic engineer. Legislators typically want high-level takeaways. Technical staff want the detail behind the numbers. Public audiences need plain language and accessible design. Thinking through who will see a visual, what they already know, and what they need to walk away with should happen before any design work begins.

Some agencies have found it helpful to write up short descriptions of their typical audiences (roles, what they care about, how much technical background they have) and keep those on hand when starting a new visualization project. A public-facing infographic, for example, will lean toward simplicity and accessibility. An internal performance report can afford more precision and detail.

2.1.3. Integrating AI into Visualization Workflows

AI tools are improving quickly, and that pace shows no sign of slowing. As of this writing, Anthropic's Claude Opus 4.8 had recently been released, capable of working as an autonomous agent that coordinates multi-step tasks and generates software with minimal prompting. Gemini, DeepSeek, OpenAI, and Copilot are likewise increasingly popular and continually evolving tools for addressing difficult work.

“Hard work,” however, is not all the same. AI’s suitability for assisting with or accomplishing a task depends largely on the nature of the work itself. AI Cred (Edwards, 2026) offers a helpful framework that enables practitioners to identify the type of challenge they are facing and use that understanding to determine (1) whether AI is an appropriate part of the solution and (2) which AI resource is best suited to the task. To use these tools effectively, however, practitioners must first understand the type of work they are asking AI to support. Different visualization tasks require different forms of reasoning, effort, coordination, and judgment, and AI’s role varies accordingly.

The following framework outlines six common challenge types that arise in visualization work and describes the relative suitability of AI in addressing each.

Table 2: Integrating AI into Visualizations Framework. Source: AI Cred (Edwards, 2026)

Challenge Type	Problem Definition (Visualization Context)	Suitability for AI Use
Reasoning Challenges	Multi-step analytical thinking: designing measures, setting prioritization criteria, weighing tradeoffs, or making sense of variables that interact within a visualization framework.	**Moderate to high**. AI is useful for scenario testing, structuring logic, and early exploratory analysis. A practitioner still has to validate the output, since the methodology has to hold up.
Effort Challenges	Repetitive work that takes scale rather than deep thought: cleaning datasets, standardizing fields, drafting charts, or combing through project records.	**Very High (Primary Automation Role).** AI and automation significantly reduce manual burden and improve speed and consistency. Human oversight focuses on quality assurance.
Coordination Challenges	Visualization development requiring alignment across departments, consultants, or partners, tracking inputs, reconciling feedback, and managing dependencies.	**Moderate (Support Role).** AI helps document and organize collaboration but cannot replace institutional alignment or decision authority.
Domain Expertise Challenges	Application of lived professional experience, understanding stakeholder interpretation, policy context, and how performance data should be framed visually.	**Low–Moderate (Reference Support Only).** AI can summarize practices or suggest formats but cannot replicate practitioner judgment or institutional knowledge.
Ambiguity Challenges	Situations where the visualization objective itself is unclear—e.g., agencies know they must "show performance" but have not defined the key question or message.	**Moderate (Exploratory Framing Role).** AI can generate framing options, prototype narratives, or draft visual structures, but humans define the final problem statement.
Judgment / Courage Challenges	Strategic or reputational decisions, such as how to present sensitive findings, frame safety or equity outcomes, or communicate politically charged results.	**Very Low (Advisory Only).** These require leadership accountability, ethical consideration, and institutional risk ownership. AI should not make or finalize these decisions.

The table demonstrates that AI is more useful for some visualization tasks than others. It can handle much of the repetitive work, such as cleaning data and generating draft charts. It is less helpful when the task involves professional judgment, political sensitivity, or coordinating across departments. Knowing which kind of problem is on the table helps an agency decide how much to lean on AI, and while a human is always in the loop, when the labor can be delegated with oversight.

2.2. AI Fluency Map

2.2.1. Core Components of Effective AI Practice

Adapted from AI Cred (Edwards, 2026.)

INPUTS

Prompt Design & Context Framing

What it is
Setting up inputs so the AI has enough to produce something usable.

In practice
Providing scope, background materials, constraints, and examples.

How to strengthen
Front-load context. Show examples. Define what success looks like.

Advanced Prompting Techniques

What it is
Methods that push the AI toward stronger reasoning and better output. It might include Worked examples, staged reasoning, and multi-step instructions.

How to strengthen
Give the AI a few examples to follow, ask it to reason a step at a time, and try agent-style workflows for bigger tasks.

OVERSIGHT

Technical Understanding

What it is
A working sense of how AI generates its answers, and where it tends to break down.

In practice
Recognizing pattern prediction vs. fact retrieval, training cutoffs, and hallucinations.

How to strengthen
Learn failure modes. Verify high-stakes facts. Match tools to tasks.

Critical Evaluation & Verification

What it is
Assessing outputs for accuracy, credibility, and fitness for purpose.

In practice
Checking claims, terminology, framing, and methodological soundness.

How to strengthen
Use QA/QC checklists. Cross-reference sources. Increase scrutiny outside core expertise.

INTEGRATION

Workflow Design & Integration

What it is
How intentionally AI is embedded into day-to-day work processes.

In practice
Providing documents, scope, practitioner interpretation, and defined asks, similar to onboarding staff.

How to strengthen
Document prompt templates. Build repeatable workflows. Decompose complex tasks.

Managing Expertise "Flattening"

What it is
Preventing AI from producing technically correct but generic outputs that lack practitioner nuance.

In practice
Ensuring outputs reflect real tradeoffs, stakeholder context, and institutional realities.

How to strengthen
Embed practitioner tensions and incorporate nuance.

2.2.2. Crafting Your Message

Once an agency knows its message and its audience, it can shape the visual for impact. **Figure 5** organizes this decision into three steps. First, define the objective by identifying the central message the visual needs to communicate. Second, identify the primary audience for the visual. Third, determine the messaging approach, choosing from the four goal types (inform, persuade, monitor/evaluate, or explore data). The matrix in **Figure 5** then maps that combination of audience and goal to recommended visual formats, with examples for each.

To use the matrix, start in the left column and find the audience that best matches the intended viewer. Then move across the row to the column that matches the communication goal. The cell at that intersection describes the types of visuals that tend to work for that pairing and gives a transportation-specific example. A few things to keep in mind when reading the matrix:

- The same dataset can support different visuals depending on who will see it and what they need to take away from it.
- Some audience-goal combinations work better than others. The matrix flags cases where a particular approach may be too complex for the audience, such as exploratory tools aimed at the general public.
- The examples in each cell are starting points. Agencies should adapt them to their own data, tools, and context.

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Defining Clear Objectives

1 Define Your Objective

What is your central message?
Considering agency priorities, establish the underlying key message of your visual.

2 Identify Your Audience

Who are you trying to reach?
Narrow your intended audience to one primary group.

3 Determine Your Messaging

What will your visualization do?
Decide what the intent of your visualization is.

	Inform	Persuade	Monitor / Evaluate	Explore Data
	Goal Share facts, status updates, or trends.	**Goal** Convince the audience of a point, need, or priority.	**Goal** Track progress toward goals or assess outcomes.	**Goal** Enable analysis, discovery, and insights.
Public Audience **Characteristics** Low familiarity with technical data; need simple, engaging visuals. **Key Focus** Clear, accessible communication that avoids jargon.	Use infographics, dashboards, or summary visuals that highlight key takeaways.	Use storytelling visuals (e.g., before-and-after comparisons) to show impact. **Example:** a side-by-side map comparing pre- and post-infrastructure improvements.	Show targets relative to recent performance. Avoid red/yellow/green indicators due to possible colorblindness.	**Avoid**—this level of detail is often too complex.
Policymakers / Executive Leaders **Characteristics** Require high-level takeaways and results; limited time to process information. **Key Focus** Focus on key trends, goals, and actionable insights that support decision-making.	Use simplified charts (e.g., bar charts, line graphs) to show progress or outcomes. **Example:** A dashboard displaying key performance metrics, such as congestion trends or crash reductions.	Use benefit-cost visuals or progress dashboards to justify investments. **Example:** A benefit-cost analysis infographic showing an 8-to-1 return on infrastructure spending.	Use high-level trend charts or scorecards summarizing progress. **Example:** A scorecard tracking statewide safety targets, such as crash reduction.	**Limited**—interactive visuals can enable exploration but should focus on summary takeaways.
Technical Staff / Analysts **Characteristics** High familiarity with data; need detailed and precise information. **Key Focus** Provide comprehensive, data-heavy visuals to support operational decisions and analysis.	Use detailed charts, tables, or maps for deeper analysis. **Example:** A scatter plot showing relationships between congestion and travel time reliability.	Use multi-dimensional visuals to support arguments for project prioritization. **Example:** A bubble chart showing project cost, benefits, and alignment with goals.	Use dashboards or detailed time-series analyses. **Example:** A heat map showing areas with recurring congestion or safety concerns.	Use interactive dashboards, scatter plots, and tools with filters/drill-downs. **Example:** An interactive map showing geospatial patterns of crashes, allowing exploration by year, location, or severity.
Internal Agency Teams **(Planning, Communications, IT, etc.)** **Characteristics** Balance between detail and clarity; visualizations must support collaboration and workflows. **Key Focus** Align goals across teams and ensure visual consistency for decision-making or reporting.	Use structured visuals that balance detail and clarity to align teams on goals and progress. **Example:** A status dashboard summarizing project milestones, deadlines, and resource allocation.	Use tailored visuals to support internal priorities, gain buy-in, and guide decision-making. **Example:** A comparative analysis showing different project scenarios and their resource impacts.	Use dashboards, reports, or structured visual summaries to track internal performance and workflow efficiency. **Example:** A KPI dashboard tracking team workload, project timelines, and budget adherence.	Use interactive dashboards and analytical tools to facilitate deeper insights and problem-solving. **Example:** A dynamic workflow visualization tool that identifies bottlenecks and tracks approval processes.

Figure 5: Defining Clear Objectives Decision Matrix

2.2.3. Data Storytelling: Framework for Actionable Narratives

Most people do not look at a chart and absorb numbers. They look for an overall pattern for a key takeaway. A chart that shows infrastructure investment rising and congestion falling in the same corridor is more persuasive than either number on its own, because the viewer can see the relationship without anyone having to explain it. That is what data storytelling comes down to: framing the data around a relationship (before and after, cause and effect, a trend over time) so that the point comes through in the visual itself.

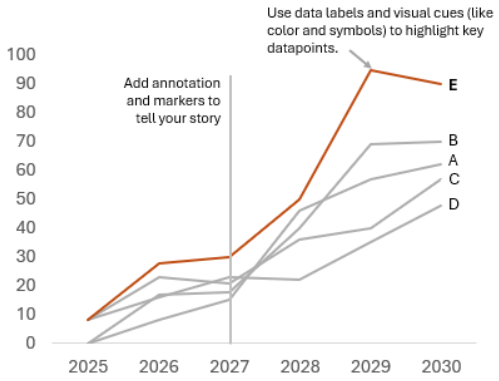
The goal is to guide the viewer toward a conclusion without making them work for it. Titles and labels should say what the viewer is looking at and what the takeaway is. Annotations can call out the most important data points. Color and layout should direct attention to the part of the visual that carries the message. **Figure 6** shows several of these techniques applied together.

Before

Project	2025	2026	2027	2028	2029	2030
A	0	8	15	46	57	62
B	0	17	18	40	69	70
C	8	23	21	36	40	57
D	8	16	23	22	35	48
E	8	28	30	50	95	90

Data with little visual clarity or focal points does little to clearly communicate insights or convey a narrative

After



Clear visualizations that minimize distractions and clutter and utilize visual focusing techniques can clearly convey actionable narratives.

Figure 6: Visual Strategies for Creating Actionable Narratives.

Key Takeaways:

- Align visualization goals with agency objectives, ensuring they address specific questions or priorities.
- Tailor visuals to meet the knowledge level and preferences of the target audience, using audience personas as a guiding tool.
- Use narrative techniques to translate complex data into clear, actionable stories that resonate with the intended audience.

2.3. Preparing Data for Visualization

A good visual is only as trustworthy as the data behind it. This section walks through the steps of preparing data for visualization, starting with tool selection and then moving on to understanding, cleaning, and transforming the data. **Figure 7** shows the full preparation sequence.

These steps take time and often benefit from cross-functional team coordination, which can be challenging given resource availability, expertise, and time constraints. The downside is that a visualization built on messy or misunderstood information can mislead. Or credibility can be lost the first time someone spots an error. The preparation is tedious, but it is the essential step in having a credible source for the visual.

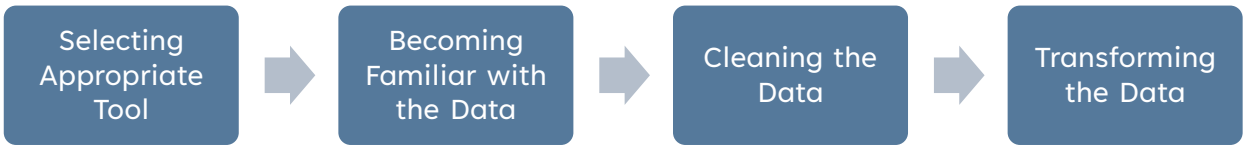


Figure 7: Data Preparation Steps

2.3.1. Selecting an Appropriate Tool for Visualization

Agencies typically have several visualization platforms available to them. PowerPoint, Excel, Power BI, Tableau, QGIS, and ArcGIS are among the most common. The right choice depends on what the data looks like, who the audience is, and how the finished visual will be shared and maintained.

A few practical questions help narrow the choice. The first is whether the tool can connect to the data source directly or whether someone will need to export and reformat data by hand each time the visual gets updated. File format compatibility is another one. Agencies should also think about where the finished product needs to live. A visual built for a public website has different publishing requirements than one shared on an internal intranet or dropped into a printed report. For dashboards that need regular updates, automated data refresh is important. For spatial data, built-in mapping capability is close to a requirement.

The tool also has to fit into how the agency works. A platform that requires specialized training may produce better visuals but sit unused if only one person on staff knows how to run it. A simpler tool that more people can use may be the better long-term choice even if it has fewer features. Agencies that have thought through these questions before committing to a platform tend to spend less time rebuilding visuals later when requirements change.

Table 3 provides a structured way to evaluate data visualization tools based on your agency's specific needs and use cases. Readers can use it as a checklist during the tool selection process, comparing options and identifying the best fit for their technical, organizational, and audience requirements.

Table 3: Key Considerations for Choosing a Data Visualization Tool.

Consideration	Questions to Ask	Example Implications
Data Connectivity	Can the tool connect to live external data sources (e.g., APIs, databases)?	Necessary for real-time dashboards or frequently updated visuals.
Data Cleaning Capabilities	Does the tool allow for cleaning and transforming data directly within the platform?	Helps streamline workflows for teams without dedicated data preparation tools.
Supported Data Type	Can the tool handle tabular, spatial (GIS), and other complex data formats?	Critical for visualizing diverse datasets, such as crash data or demographic overlays.
Data Refresh and Automation	How easily can the tool refresh or update data sources?	Essential for time-sensitive or recurring visuals, such as performance dashboards.
Publishing Options	Can the visuals be hosted on intranet platforms, external websites, or shared publicly?	Important for aligning with security, privacy, and audience accessibility needs.
Ease of Use	Does the tool have an intuitive interface or require specialized training?	Impacts adoption by non-technical users and the overall learning curve.
Interactivity and Engagement	Can the tool produce interactive visuals or dashboards for exploratory analysis?	Valuable for decision-makers or public engagement where audience interaction is key.
Accessibility	Does the tool support accessibility features, such as Section 508 or WCAG compliance?	Ensures inclusivity and compliance with federal or organizational standards.
Cost and Licensing	Does the tool fit within your budget, and does its licensing structure align with your agency’s needs?	Affects scalability and availability across teams or departments.
Support and Community	Is there a robust user community or technical support available for the tool?	Useful for troubleshooting, best practices, and keeping up with updates or new features.

2.3.2. Becoming Familiar with Your Data

Before building anything, it helps to spend time looking at the data to understand its structure, distribution, and overall quality. Running basic descriptive statistics (min, max, mean, median, count, missing values) gives a quick read on what the dataset contains and whether anything looks off. Sometimes just seeing the count of missing values in a column is enough to change an approach. Plotting the data helps too. Histograms show how values are distributed, box plots make outliers obvious, and scatterplots show whether two variables move together. Agencies that work with crash data or travel-time records will be familiar with how messy those datasets can be before anyone has cleaned them. The point of all of this is to catch problems like wrong values, gaps, duplicates, or unexpected patterns before they end up in a finished visual.

Table 4 lists effective methods for exploring data before developing a visualization.

Table 4: Common Exploratory Data Analysis Tools

Descriptive Statistics	Visually Explore the Data
• Data type (e.g., numerical, categorical, ordinal) • Minimum, Maximum, Mean, Median, Mode • Quantiles (25%, 50%, 75% percentiles) • Total count • Missing values count • Frequency table • Variance & Standard deviation	**One variable** • Histogram • Stem-and-Leaf Plot • Box & Whisker Plot **Multi-variable** • Line Graph • Scatterplot • Heatmap • Multi-set Bar Chart

Anscombe's Quartet (Anscombe 1973) is a set of four small datasets, each containing eleven x-y pairs. All four produce the summary statistics shown in **Table 5**. The means, variances, and correlation coefficients are identical across the four sets. A spreadsheet review of those numbers would give no indication that the datasets differ from one another. Plotting each one as a scatterplot (**Figure 8**) tells a different story. The first dataset follows a straightforward linear trend. The second traces a clean curve. The third is linear except for a single extreme outlier that pulls the regression. The fourth has all its x-values stacked at one point, with one far-flung observation driving the entire correlation. Anscombe created the quartet in 1973 specifically to demonstrate that summary statistics alone are an incomplete picture of a dataset, and the example has been a staple of introductory statistics courses since.

Table 5: Descriptive statistics of all four datasets visualized in Anscombe's Quartet

Descriptive Statistics	Value
Mean of x	9
Sample variance of x: s^2_x	11
Mean of y	7.5
Sample variance of y: s^2_y	4.125
Correlation between x and y	0.816
Linear regression line	y = 3.00 + 0.500x
Coefficient of determination of the linear regression: R^2	0.67

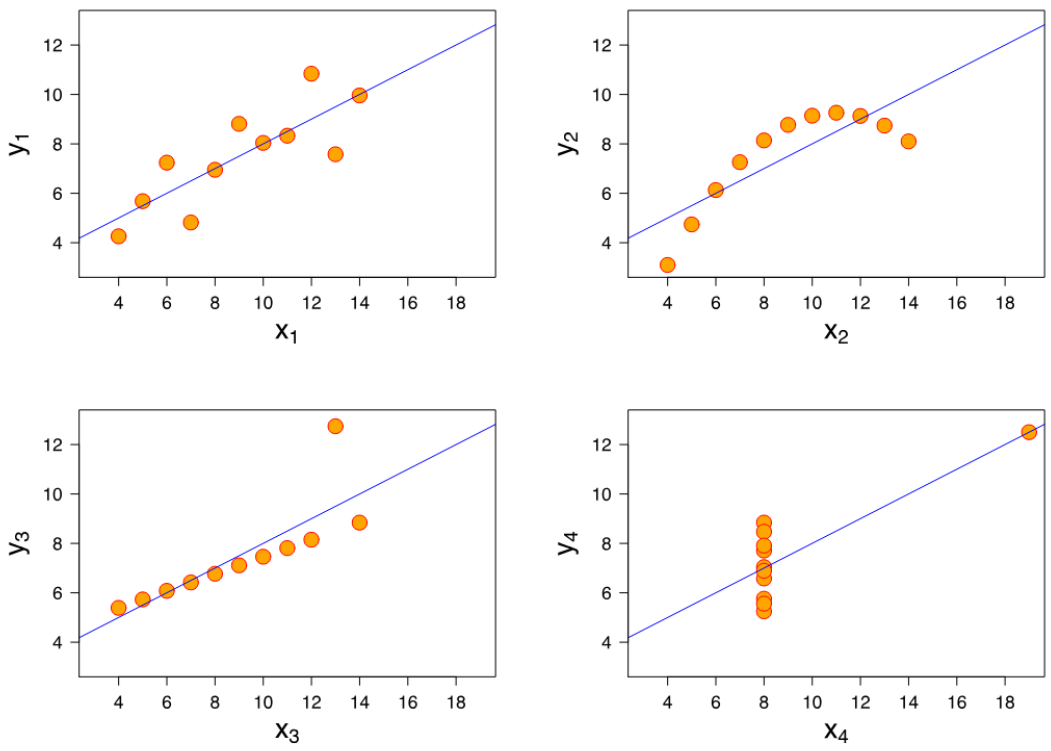


Figure 8: Visualization of Anscombe's Quartet. Source: Anscombe (1973)

The Datasaurus Dozen (Matejka and Fitzmaurice 2017) extends this idea to a larger and more dramatic set of examples. Thirteen datasets, each containing 142 x-y pairs, all share the summary statistics shown in **Table 6** The means, standard deviations, and correlations match across all thirteen sets. Plotting each dataset as a scatterplot (**Figure 9**) reveals shapes as varied as a five-pointed star, a set of parallel lines, a circle, an X, and a dinosaur. The original "dino" scatterplot was created by Alberto Cairo as a teaching tool. Matejka and Fitzmaurice then used a simulated-annealing algorithm to generate twelve additional datasets that preserved the same summary statistics while forming entirely different visual patterns. For transportation analysts working with performance measures or crash records, the exercise reinforces a practical point. Two

columns of data with the same average, the same spread, and the same correlation coefficient can describe fundamentally different conditions once they are graphed.

Table 6: Descriptive statistics of all datasets visualized in Datasaurus Dozen

Descriptive Statistics	Value
Mean of x	54.26
Sample variance of x: s^2_x	16.76
Mean of y	47.83
Sample variance of y: s^2_y	26.93
Correlation between x and y	-0.06
Linear regression line	y = 53 - 0.1x
Coefficient of determination of the linear regression: R^2	0.004

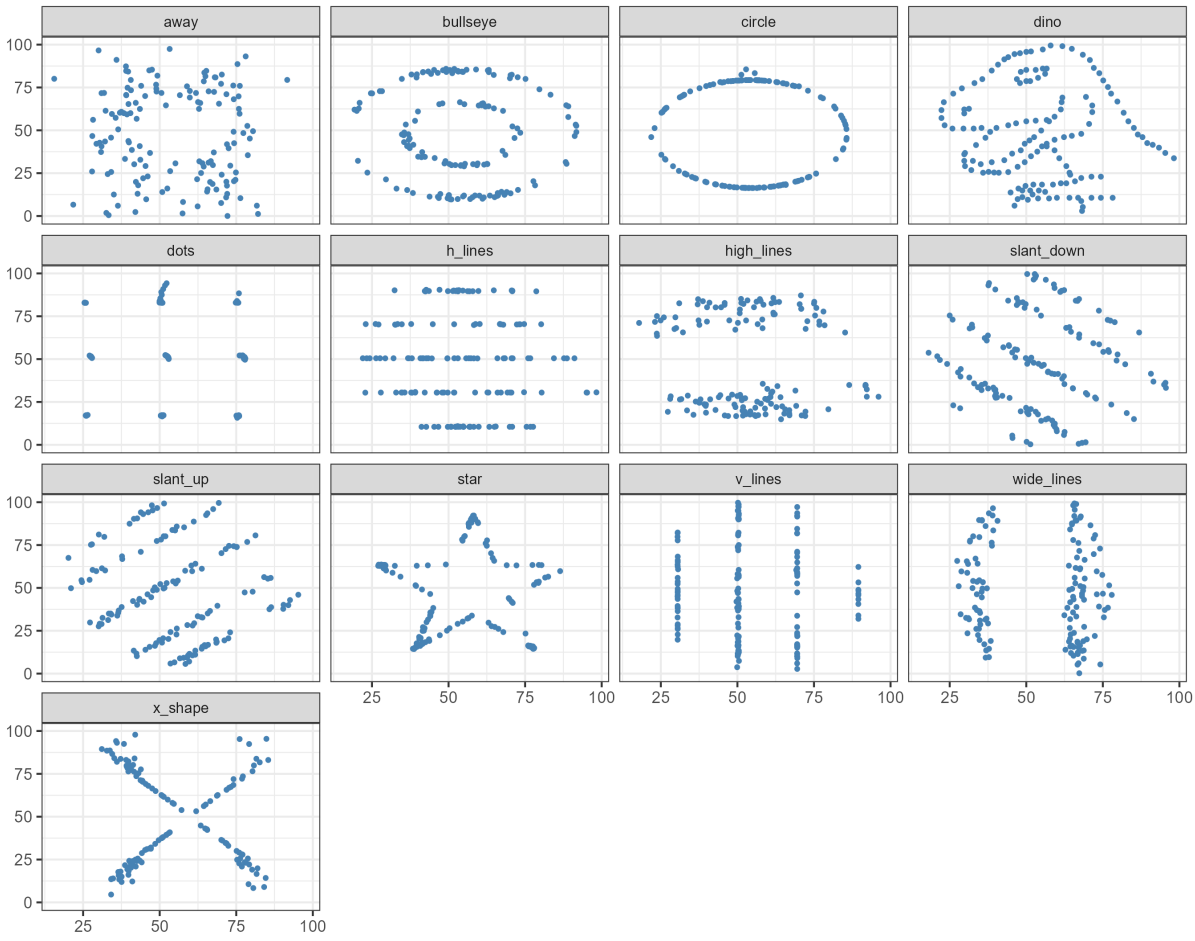


Figure 9: Visualization of Datasaurus Dozen. Source: Matejka and Fitzmaurice, 2017

The takeaway from both examples is simple: datasets that look the same statistically can look completely different when plotted, so doing both is worth the time.

2.3.3. Cleaning the Data

Once the data has been explored, the next step is cleaning it. Data cleaning means resolving inaccuracies, inconsistencies, and errors in the dataset (Bhandari 2021). This is where problems that showed up during exploration get fixed.

A traffic flow dataset is a good example of what can go wrong. Duplicate vehicle counts will exaggerate congestion at an intersection. Missing timestamps make time-series analysis impossible. If one sensor records speed in miles per hour and another in kilometers per hour, any comparison between them will be wrong. None of these problems are hard to fix individually, but if they go unnoticed they will carry through into the finished visual and undermine whatever conclusions it is trying to support.

The core principles of data cleaning are validity (does the data follow the expected rules and formats), accuracy (does it reflect what was measured), completeness (are there gaps), consistency (do related fields agree with each other), uniqueness (are there duplicates), and uniformity (are units and formats standardized). These are described below.

1. **Validity**
   Valid data meets predefined criteria for specific types of information. For instance, a roadway traffic count should only include positive whole numbers—negative counts or non-numeric entries like "abc" would be invalid. Ensuring validity eliminates basic errors that could compromise the reliability of your analysis.
2. **Completeness**
   Complete data means no critical information is missing. In a roadway performance dataset, if the "roadway type" column is blank for a large share of entries, any breakdown by roadway type becomes unreliable or impossible. Gaps like this are common in datasets assembled from multiple sources or entered by hand over long periods.
3. **Consistency**
   Consistent data means related fields agree with each other. If a bike lane usage dataset shows zero cyclists on a given day but records that same day as "highly congested," something is wrong. These kinds of contradictions tend to hide in large datasets and only show up when someone cross-checks the fields.
4. **Uniqueness**
   Identical entries (duplicates) can skew results. For example, if the same customer is counted twice in a sales report, it inflates the numbers inaccurately.
5. **Uniformity**
   Data must use the same units of measurement. If some temperatures are

recorded in Celsius and others in Fahrenheit, converting them to a single standard ensures meaningful analysis.[1]

In practice, this usually translates into finding and resolving data points that don't agree or fit with the rest of your dataset in more obvious ways. These data might be missing values, outliers, incorrectly formatted, or irrelevant.

- **Removing Duplicates**: Repeated entries in your dataset may arise from merging data sources or human error. Eliminate these duplicates, ensuring each observation is unique.
- **Removing Irrelevant Data:** Eliminate columns or rows that do not contribute to the analysis. For instance, if you are evaluating roadway conditions, a column tracking employee names might not be relevant.
- **Standardizing Data Formats:** Use consistent formatting. For example, check that date fields use the same format (e.g., "YYYY-MM-DD") and that units of measurement (like roadway lengths) are converted into a single standard (e.g., all distances in centerline miles).
- **Addressing Missing Values:** Scan your dataset for missing data points and decide how to handle them based on the context. For example:
    - Impute missing values: Fill in blanks with the mean, median, or a predicted value based on other data.
    - Remove incomplete records: If too much data is missing in a particular row or column, it may be better to exclude it entirely.
- **Handling Outliers:** Review data for values significantly different from the norm. For example, if one bike lane shows a usage count that is ten times higher than the others, investigate whether this is a valid exception or a data entry error. Based on the analysis goals, decide whether to exclude, adjust, or retain these values.

Best Practice: Define your method for handling outliers in advance to ensure consistency and objectivity (e.g., remove values that fall x standard deviations away from the mean).

What to Avoid: Avoid selectively removing outliers simply because they do not align with your expectations or hypotheses.

[1] Bhandari, P. (2021, November 23). *What is data cleansing?: Definition, guide & examples*. Scribbr. https://www.scribbr.com/methodology/data-cleansing/

After cleaning, the data usually needs to be reshaped before it will work well in a visualization tool. Most platforms (Tableau, Power BI, ArcGIS Dashboards) expect data in a structured tabular format, and the way a dataset is organized when it comes out of a source system is rarely the way it needs to be organized for charting or mapping. Transformation is the step where that restructuring happens. As shown in **Figure 10** this typically involves converting it into a tabular structure, where:

- Each record is represented as a single row.
- Column names are contained in one cell per column.
- Each column holds a single, consistent type of data.
- There are no blank rows or columns.
- Totals or subtotals are excluded.

Non-Tabular Data

	Jan		Feb	
Project Code - Task	Hours	Cost	Hours	Cost
Project 001- Task A	10	$ 647.67	25	$3,519.22
Project 001- Task B	20	$ 735.42	35	$2,045.18
Project 002- Task A	30	$1,628.98	45	$ 319.73
Project 002- Task C	40	$2,259.62	55	$ 98.01
Total	100	$5,271.68	160	$5,982.13

Tabular Data

Project Code	Task	Month	Hours	Cost
Project 001	A	Jan	10	$ 647.67
Project 001	A	Feb	25	$3,519.22
Project 001	B	Jan	20	$ 735.42
Project 001	B	Feb	35	$2,045.18
Project 002	A	Jan	30	$1,628.98
Project 002	A	Feb	45	$ 319.73
Project 002	C	Jan	40	$2,259.62
Project 002	C	Feb	55	$ 98.01

Figure 10: Non-Tabular vs Tabular Data

Structuring data in a tabular format helps ensure it is organized in a way that supports effective analysis and visualization. This structure makes it easier to identify trends, patterns, and relationships and prepares the data for use in visualization tools. In most cases, achieving this format may require applying multiple data transformation methods.

Presented below are the most common data transformation methods, explained with consistent examples using bicycle traffic counts recorded across multiple streets and days.

1. **Pivoting**
   Pivoting is the process of reshaping data between wide and long formats to make it more suitable for specific types of analysis or visualization. Each format has a distinct structure, and understanding these structures is essential for preparing data effectively.

a) **Wide Format**

- **Structure:** Each variable is represented by a separate column, while each row corresponds to a unique entity or observation, following the tidy-data principle (Wickham 2014).
- **Use Case:** This format groups all information about an entity into a single row, making it ideal for comparisons across variables or straightforward tabular presentations.
- **Example:** A dataset where daily counts of bicycle users are recorded with each day in its own column, and each row corresponds to a specific street (**Figure 11**).

Street	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Main Avenue	120	150	200	180	220	250	300
2nd Street	80	100	130	110	140	160	180

Figure 11: Example table with wide data format.

b) **Long Format:**

- **Structure:** Data is organized such that one column holds variable names, and another column contains their corresponding values. Each row represents a single observation of a variable-value pair.
- **Use Case:** For visualizations such as line charts, grouped bar plots, or scatterplots. This format is essential as most data visualization tools and libraries expect data to be structured in this way for optimal compatibility and functionality.
- **Example:** A dataset tracking daily bicycle counts on streets is organized so that streets and dates are repeated across rows, with each row containing a unique value in a separate column for bicycle counts (**Figure 12**).

Street	Day	Bike Counts
Main Avenue	Monday	120
Main Avenue	Tuesday	150
Main Avenue	Wednesday	200
Main Avenue	Thursday	180
Main Avenue	Friday	220
Main Avenue	Saturday	250
Main Avenue	Sunday	300
2nd Street	Monday	80
2nd Street	Tuesday	100
2nd Street	Wednesday	130
2nd Street	Thursday	110
2nd Street	Friday	140
2nd Street	Saturday	160
2nd Street	Sunday	180

Figure 12: Example table with long data format.

2. Transposing

Transposing swaps the rows and columns of a dataset. The content stays the same but the orientation changes.

- **Use Case:** This often comes up as an intermediate step when reshaping data for a specific tool or chart type.
- **Example:** A dataset where rows are streets and columns are dates can be transposed so that dates become the rows and streets become the columns (**Figure 13**). Whether or not to transpose depends on what the visualization platform expects and what comparison the visual is trying to show.

Original Data

Street	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Main Avenue	120	150	200	180	220	250	300
2nd Street	80	100	130	110	140	160	180

Transposed Data

Street	Main Avenue	2nd Street
Monday	120	80
Tuesday	150	100
Wednesday	200	130
Thursday	180	110
Friday	220	140
Saturday	250	160
Sunday	300	180

Figure 13: Example transpose data transformation

3. **Aggregation**
   Aggregation combines data values using functions like sum, mean, median, or count, summarizing data to highlight trends or patterns.
   - **Use Case:** Reduces data granularity to focus on broader insights.
   - **Example:** Instead of showing daily bicycle counts for every street, aggregate the data to calculate the average monthly or yearly bicycle traffic for each street.

4. **Calculating Derived Metrics**
   Creates new variables or columns created from existing data, such as ratios, percentages, or differences.
   - **Use Case:** Provides additional insights or context into the data.
   - **Example:** Calculate the percentage change in bicycle counts from one day to the next for each street or compute the total weekly traffic for each street.

5. **Binning**
   Binning takes continuous data and groups it into intervals, or "bins," to make it easier to visualize and interpret. Instead of plotting every individual value, binning collapses them into categories. This is especially helpful when the raw data has hundreds or thousands of unique values and plotting each one individually would produce a chart that is too dense to read. The tradeoff is that binning hides the detail within each bin, so choosing the right number of bins and the right breakpoints is an important decision. Too few bins and the visual oversimplifies the data. Too many and it is not much easier to read than the raw values. There is no single rule for where to draw the lines, but bins should reflect categories that make sense for the analysis and the audience.
   - **Use Case:** An agency has a column of raw daily bicycle counts with values ranging from 0 to 150 and wants to show the overall distribution without plotting every individual number.
   - **Example:** Daily bicycle counts at a trail counter could be grouped into "Low" (0–50), "Medium" (51–100), and "High" (101–150). Plotting those bins as a histogram makes it easy to see that most days fall in the low range, or that summer months cluster in the high range. The same approach works for speed data, crash counts, or any other continuous measure where the individual values are less important than the overall shape.

Key Takeaways:

- Choose a visualization tool based on how it connects to the data, who will maintain the visual over time, and where the finished product needs to be published.
- Explore the data before cleaning it. Running descriptive statistics and plotting distributions will surface problems that summary numbers alone can miss.
- Structure data in a clean tabular format before importing it into a visualization tool. Consistent column types, no blank rows, and no embedded totals will prevent most formatting errors downstream.

3. Creating Your Visual: Graphic Solutions Know-How

Crafting effective visuals is both an art and a science. This section covers how to build visuals for effective communication. The content includes effective chart selection, use of color, layout, accessibility, and interactivity for online tools, and the choices that determine whether a visualization gets the point across

Choosing the Right Visualization Elements

- Matching visualization types to communication goals (e.g., comparisons, trends, geospatial data).
- Decision-making tools like a “chart selector” to guide practitioners.

Designing for Clarity and Accessibility

- Principles of visual hierarchy and layout.
- Designing visuals for accessibility (e.g., Section 508, Web Content Accessibility Guidelines (WCAG) compliance).
- Use of color.

Incorporating Interactive and Dynamic Elements

- Adding drill-downs, filters, and other interactive features
- Designing visuals for cross-platform compatibility (desktop, mobile, GIS tools).

Mapping and Geospatial Visuals

- Selecting the right map projections and scales.
- Incorporating real-time data and overlays for transportation applications.

3.1. Choosing Strong Visualization Elements

Selecting the most effective visual representation is critical to achieving communication goals. Different goals call for distinct visual solutions. Agencies should first determine what their communication goal is and select a data visualization type that best displays that information. When selecting your communication goal consider if you are trying to show **Comparison**, **Composition**, **Distribution**, **Relationship**, or **Hierarchy** as shown in **Figure 14**.

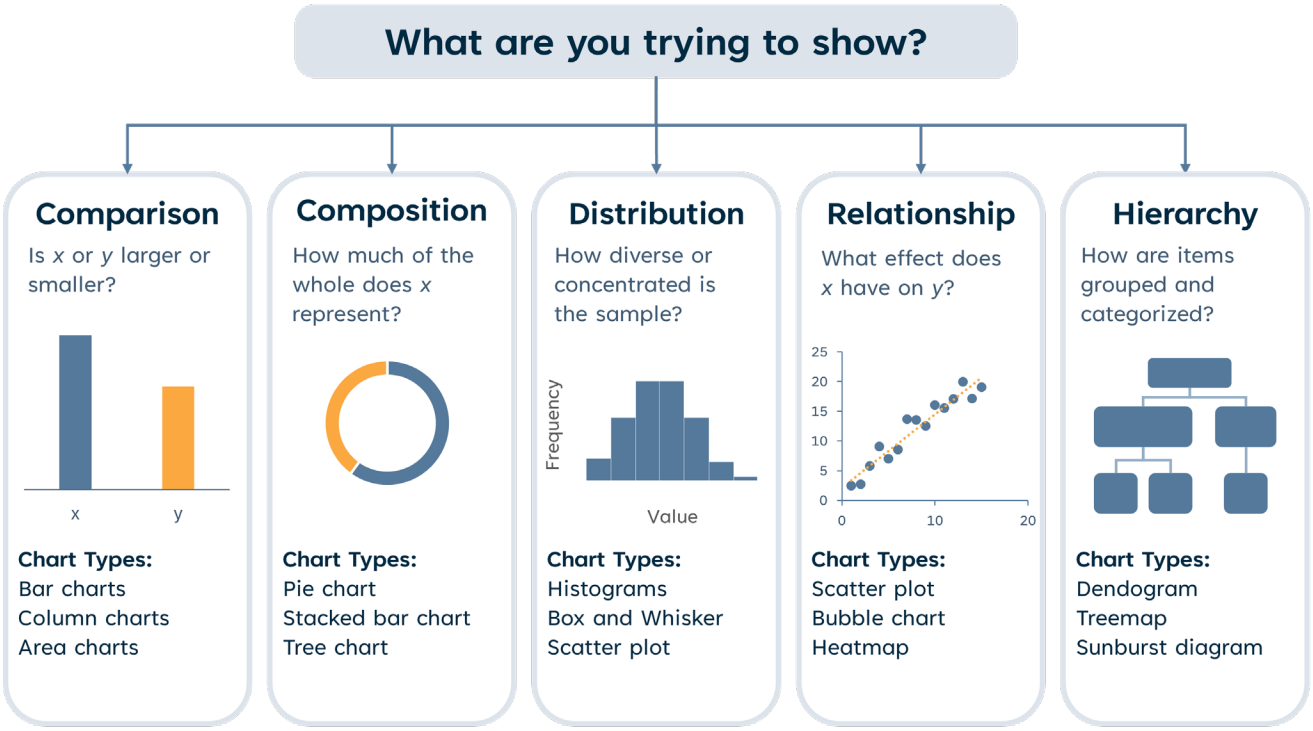


Figure 14: Visualization Type Selection.

3.1.1. Comparisons

Bar and column charts work well for comparisons. If an agency wants to show traffic volumes across regions, a clustered bar chart makes it obvious where the volumes are high and where they are low. Readers can scan the bar lengths and get the picture quickly without having to study the numbers. For additional examples of comparison, see **Figure 15**.

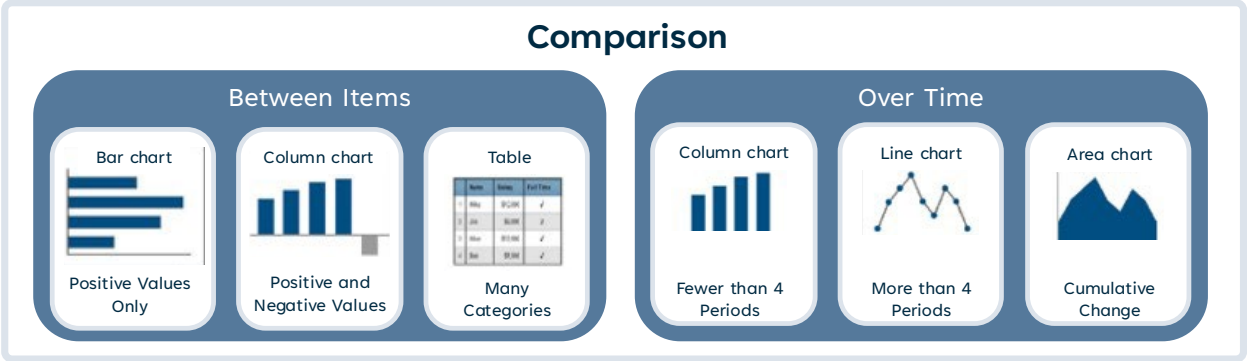


Figure 15: Comparison Chart Selections.

3.1.2. Composition

Pie charts, donut charts, and stacked bar graphs show how parts add up to a whole. A pie chart showing the percentage of funding going to different transportation projects, for example, gives a reader an immediate sense of where the money goes. Pie charts tend to get hard to read with more than two or three slices, though, so they work best for simple breakdowns. For comparisons with more categories, or for showing how composition changes over time, stacked bar charts are a better fit. **Figure 16** shows examples of both.

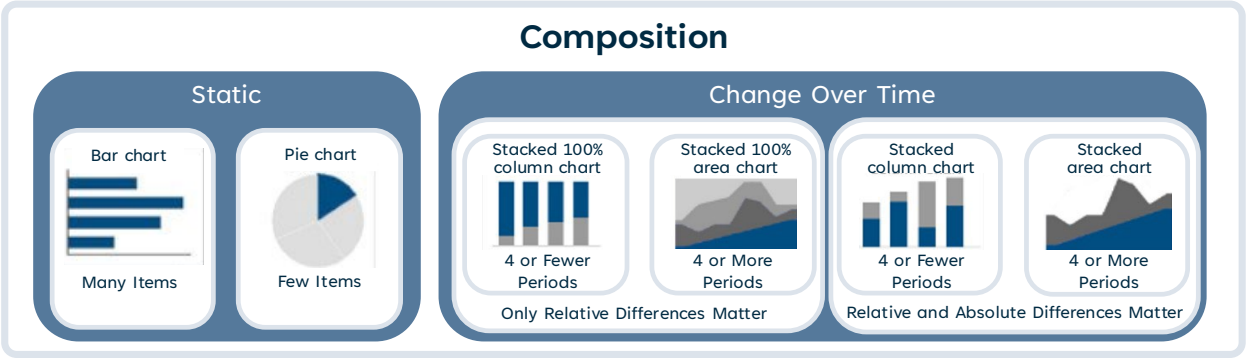


Figure 16: Composition Chart Selection.

3.1.3. Distributions

Histograms, box plots, and density plots show how values are spread across a dataset. A histogram of road incidents by time of day, for example, might show a clear spike during rush hour. A box plot of commute times across regions makes it easy to see which regions have the widest variation and where the outliers are. **Figure 17** shows examples of distribution charts.

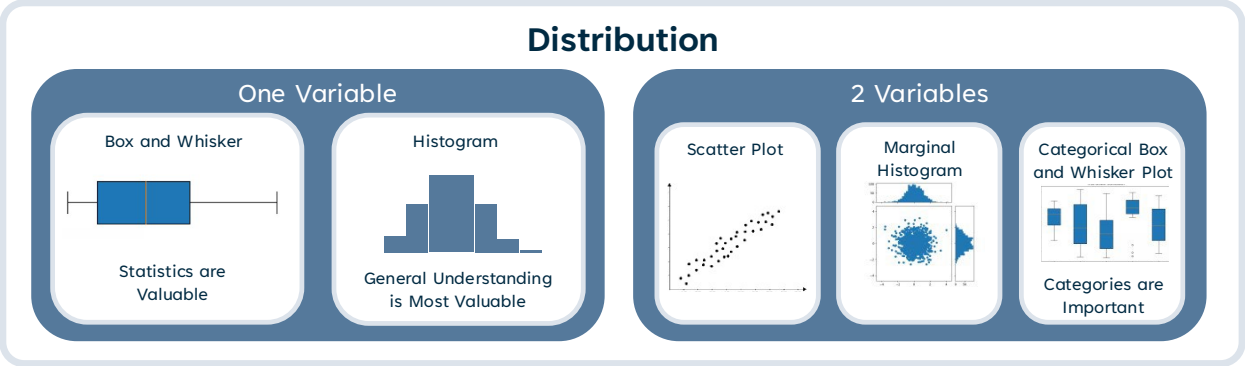


Figure 17: Distribution Chart Selections.

3.1.4. Relationships

Scatter plots and bubble charts show how two variables relate to each other. Plotting vehicle speed against fuel efficiency, for example, makes it easy to see whether the relationship is linear, curved, or scattered. Bubble charts add a third variable by changing the size of each dot. A bubble chart could plot speed against fuel efficiency and use bubble size to represent population, so the viewer can see all three variables at once. **Figure 18** shows examples.

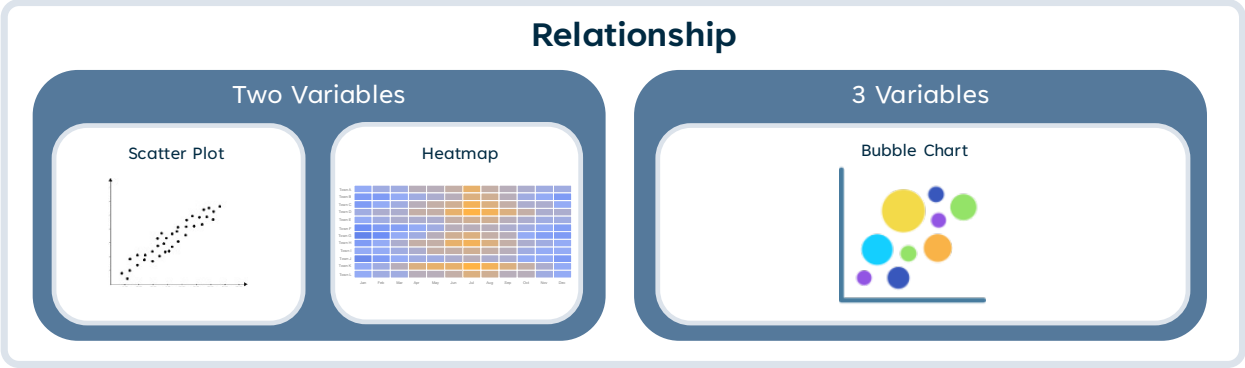


Figure 18: Relationship Chart Selections.

3.1.5. Hierarchy

Hierarchies are best conveyed through tree diagrams, sunburst charts, or corporate charts. These visuals highlight levels of importance or dependency, helping audiences understand complicated frameworks, such as the layers of decision-making in transportation agencies or project workflows. A clear hierarchy allows users to see the big picture while tracing details to their source. **Figure 19** provides guidance on selecting charts based on whether your data includes numeric/proportion information and the number of categories and layers you hope to visualize.

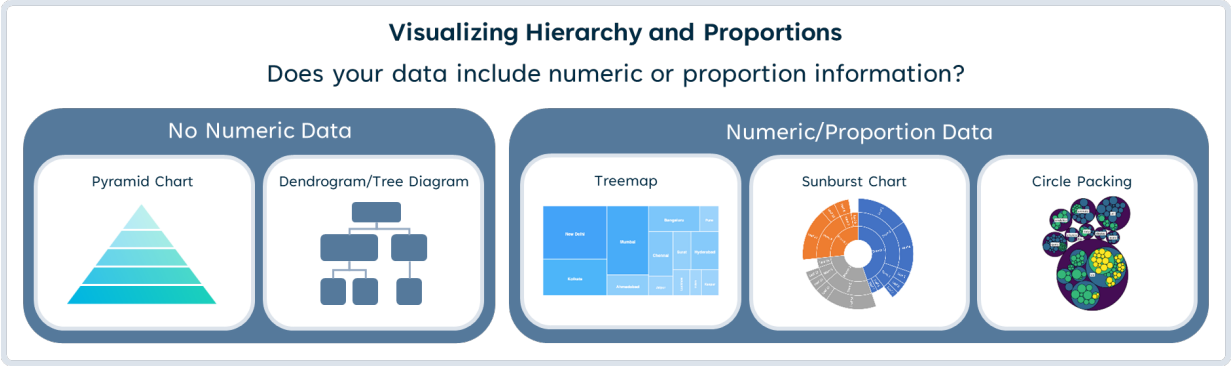


Figure 19: Hierarchy and Proportion Chart Selector.

3.2. Designing Effective Visualizations

3.2.1. Color Selection and Accessibility

Color is one of the best ways to communicate visually. Changes in color can create confusion when applied inconsistently. If a bar chart switches from blue to green with no explanation, the audience often assumes the color change means something, even if it does not. Accessibility is also an important topic discussed in this section. A palette that looks clear on screen may be hard to distinguish for colorblind users or in grayscale print. This section covers how to select colors with purpose and keep them accessible.

3.2.2. Use Color Purposefully

Before choosing a palette, decide what the color will communicate within the visual. For example, if you are comparing regions, each region could have a distinct color, with everything else in a neutral tone. Flagging values above or below a threshold? Color should mark that distinction and nothing else. The fewer colors doing work in a single visual, the easier it is for the reader to understand.

Here are sample color palettes that can be used in alignment with the type of information being displayed:

- **Sequential palettes** for values that increase or decrease in order.

Figure 20: Sequential Color Palettes.

- **Diverging palettes** when you need to show variation around a midpoint (e.g., above/below a target).

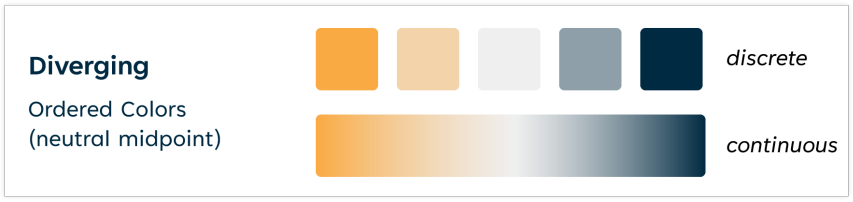


Figure 21: Diverging Color Palettes.

- **Categorical palettes** for comparisons across unrelated groups.

Figure 22: Categorical Color Palettes.

3.2.3. The 60/30/10 Rule for Color Balance

The **60/30/10 rule** is a simple way to think about how much of each color belongs in a visual.

- **60% – Base Color**
  About 60% of the color should be a neutral or muted color (light gray, desaturated background, white) that covers the background, gridlines, axis labels, and any elements that are not the focus.

- **30% – Secondary Color**
  This color helps distinguish secondary categories or data series. It should complement the base color and relate cohesively to your palette while remaining distinct enough to provide clear contrast. It's used about half as frequently as the base color.

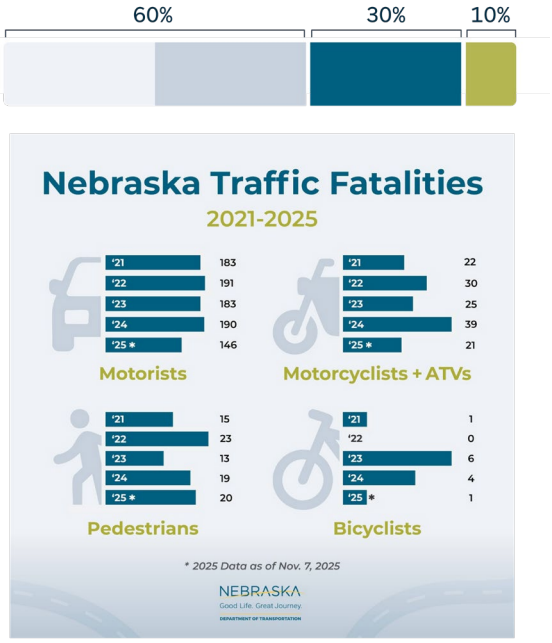


Figure 23: An example of the 60/30/10 rule for color balance. Source: Nebraska Department of Transportation.

- **10% – Accent Color**
  Use this color intentionally and sparingly to draw attention to the central message, such as the most important trend line, focal data point, or key comparison. Because it appears infrequently, the accent color immediately signals where the viewer's eye should go first.

Applying this ratio helps maintain restraint, reduces cognitive load, and directs viewer attention efficiently. Examples of good applications of the 60/30/10 rule are shown in **Figure 23** and **Figure 24**.

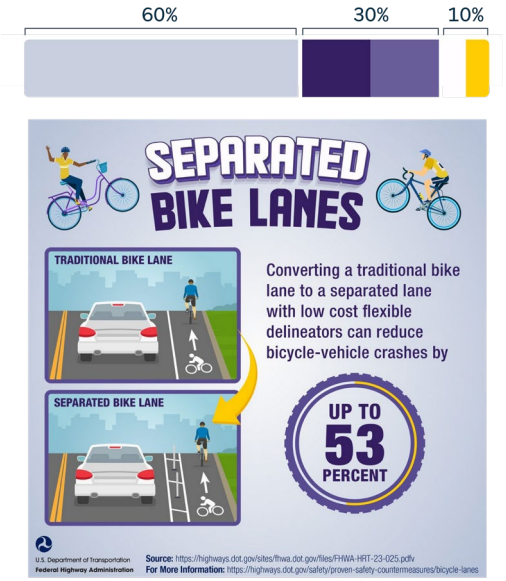


Figure 24: An example of the 60/30/10 rule for color balance. Source: Federal Highway Administration.

3.2.4. Reduce Visual Noise

The most common thing that makes a visualization hard to read is too much going on at once. Extra gridlines, background fills, heavy borders, and decorative shading all compete with the data for the viewer's attention. Stripping those back so the data stands out is usually more effective than adding more design.

- **Alignment and spacing.** A chart can feel cluttered even when there is not that much on it. Usually the problem is uneven spacing or misaligned elements. Using a consistent spacing system (8pt or 4pt increments in digital layouts) and leaving enough room between elements fixes most of it.
- **Color.** If the message only needs one or two elements highlighted, there is no reason to give every category its own color. Extra colors add visual noise without adding information.
- **Decorative elements.** Photos, icons, and illustrations are fine when they support the message. When they do not, they are clutter.

3.2.5. Selecting Accessible Colors

Designing with accessibility in mind helps to ensure that your visualizations can be accurately interpreted by all users. Research shows that approximately 1 in 12 men (8 percent) and 1 in 200 women experience some form of color blindness (Colour Blind Awareness n.d.), like those shown in **Figure 25**, meaning that relying on color alone to convey meaning will exclude a portion of your audience. In addition, many users may print your graphics in grayscale or view them on screens where color differences are less pronounced.

Figure 25: Simulated perception of a color palette across five vision types.

Understanding Common Types of Color Blindness

Color vision deficiencies take several forms, but three are most relevant to visualization design. Deuteranopia (green-blind) and protanopia (red-blind) are the most common and both make it difficult to tell reds from greens. Tritanopia (blue-yellow blind) is less common and makes it hard to distinguish blues from greens and yellows from violets.

- **Deuteranopia (green-blind)** – Difficulty distinguishing greens from reds; one of the most common types.
- **Protanopia (red-blind)** – Difficulty distinguishing reds from greens, often causing red tones to appear darker or muted.
- **Tritanopia (blue-yellow blind)** –Difficulty distinguishing blues from greens and yellows from violets.

Recommended Color Choices

The most common forms of color blindness see red, green, orange, and brown as nearly the same color. Blue and yellow tend to remain distinguishable across all three major types of colorblindness discussed above, which makes them a safe default pairing. Desaturated blues, violets, and deep yellows also hold up well. Adding differences in brightness, saturation, or pattern (such as dashes versus solid lines) gives viewers a second way to tell elements apart when the colors are hard to distinguish.

All graphical elements that convey meaning can meet WCAG contrast requirements by using a minimum ratio of 4.5:1 for body text and meaningful visual elements (W3C 2023). The best option is to not use color alone to convey meaning. This can be achieved by using patterns (stripes vs. dots), a different line style (dashed vs. solid), a

different marker shape, or a direct label on the visuals. Direct labeling is often the strongest option (when feasible) because it removes the need to cross-reference with a color legend.

Alternative Text and Tagging for Accessible Visuals

Using color-blind-friendly palettes, like those shown above and in the grayscale print preview, supports accessibility for colorblind users. But they do not, by themselves, make charts and graphics accessible to users who rely on assistive screen-reading technologies. The industry standard for accessibility accommodates colorblind readers and those who are blind. For blind users, accessibility depends on two closely related practices: alternative text and document tagging.

Alternative text (alt text) is a tag with a text description of a visual element. It's written to allow a screen reader to read the key from the visualization(s). Effective alt text focuses on the core message behind the visual. This ability to write effective alternative text tags is another reason to invest time upfront in key messages for the audience. Rather than describing every visual detail, alt text should focus on conveying the key insight the visualization is intended to communicate. In many cases, the chart title or caption already expresses the main point. Well-written alt text can reinforce or reference that takeaway rather than restating data values.

Not all images require descriptive alt text. Decorative graphics that do not convey information can and should be marked as decorative, so they are skipped by assistive technologies. Informational charts, maps, and diagrams, by contrast, require alt text that summarizes what the reader should learn from the visual. **Figure 26** illustrates a step-by-step guide to these decisions.

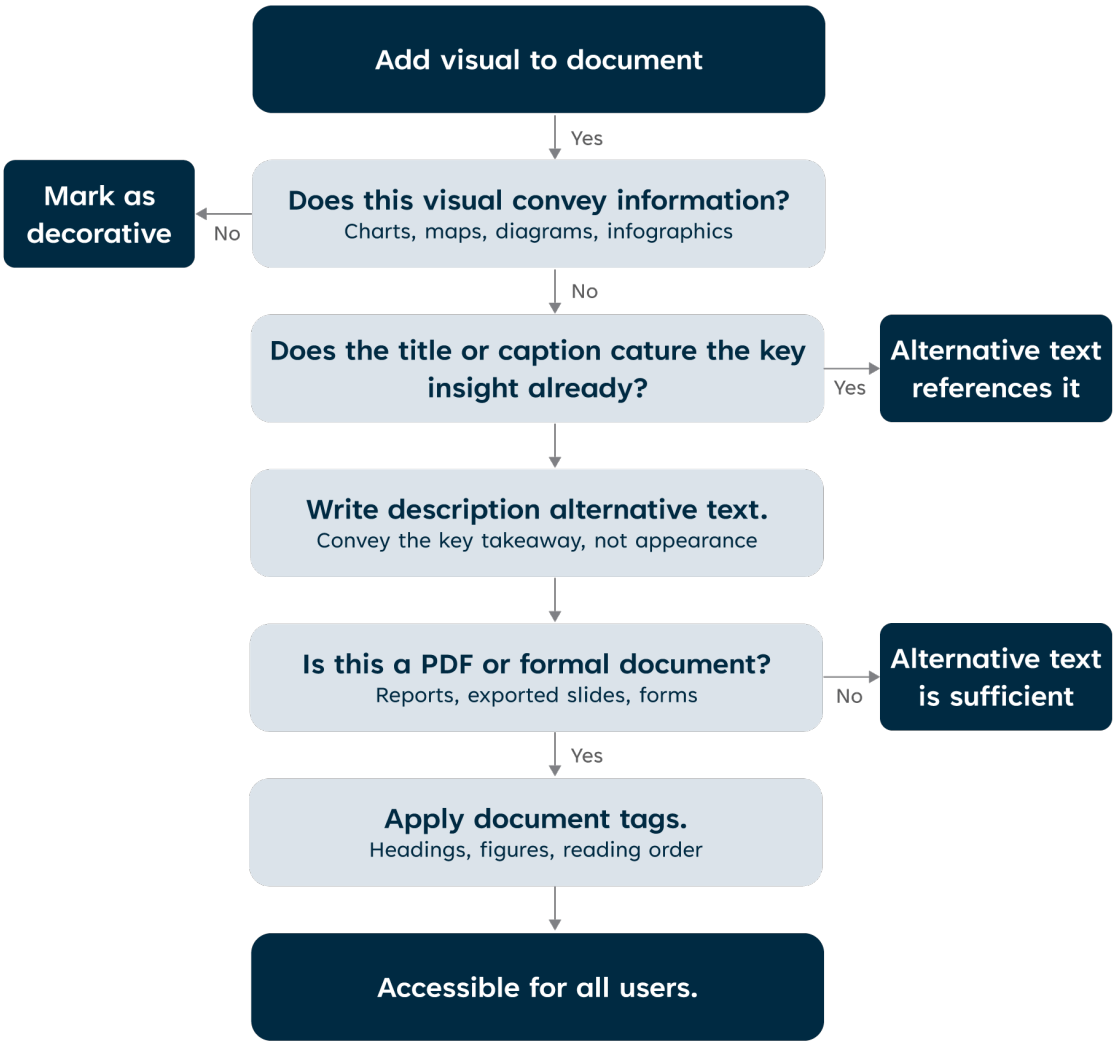


Figure 26: Alternative text decision flow chart.

Tagging gives a digital document (particularly PDFs and reports) a structure that screen readers can follow. Tags define the reading order, mark headings and lists, identify tables, and connect figures to their captions. Without proper tagging, a screen reader may read a page out of order or skip a chart entirely, even if that chart has good alt text attached to it.

Accessibility Resources and Further Guidance

This guide covers the accessibility basics that apply to transportation data visualization, but putting them into practice across different software platforms takes more detailed, tool-by-tool guidance than one guide can provide. Section508.gov is the best starting point for federal accessibility standards and has resources organized by document type, platform, and format.

3.2.6. Font Selection and Typography

Most of the typography decisions in data visualization come down to two things: picking a readable font and using size and weight to show the viewer where to look first.

Use Sans Serif Fonts for Digital Readability

For anything that will be viewed on a screen (dashboards, infographics, presentations, web content, PDF charts), sans serif fonts are the better choice. Sans serif fonts do not have the small decorative strokes at the ends of letters, which makes them easier to read on screens, especially at small sizes.

Figure 27: Serif fonts versus sans serif fonts.

Maintain a Clear Typographic Hierarchy

A consistent type hierarchy tells the viewer where to start reading and how the pieces of a visual relate to each other.

- **Title** — Largest size, boldest weight; clearly states what the visualization is about.
- **Subtitle or Supporting Line** — Smaller size and lighter color, providing context or the key takeaway.
- **Axis Labels and Category Labels** — Consistent medium size; descriptive but not overpowering.
- **Data Labels and Annotation Callouts** — Used sparingly and only where they reinforce the key message.
- **Footnotes, Sources, and Notes** — Smallest size, visually subtle.

When viewers can tell at a glance what level of information they are looking at, they spend less time figuring out the layout and more time absorbing the content. This is especially true in data-heavy dashboards, where many elements compete for attention on one screen.

Keep Font Choices Minimal

Limit designs to one or two font families. Mixing dissimilar fonts introduces visual noise and distraction, but the following tips can help emphasize key points within a single family.

- Bold or semibold for emphasis
- Italics for annotations or clarifications
- Color variations to distinguish focus areas (see the color selection guidance earlier in this section for more information)

Using the same typographic treatment across an entire report or dashboard builds familiarity. By the second or third page, viewers stop noticing the fonts and start focusing on the content.

Prioritize Legibility and Accessibility

Text needs to be large enough to read without zooming in order to align with accessibility guidance. This can be achieved by using:

- Minimum 12 pt for body text in print and at least 9 to 10 pt equivalent for digital graphics.
- Strong contrast between the text and the background (following WCAG contrast ratios).
- No light or thin font weights, which become hard to read on screens and projectors.
- Sufficient line spacing (1.2 to 1.4 times the font size) to keep dense text from feeling cramped.

Most tools embed fonts automatically when exporting to PDF. A problem tends to show up when an agency uses a custom or proprietary font, like a branded typeface the agency had designed or licensed for its publications. Some font licenses restrict embedding, which means the software cannot include the font data in the PDF even if the setting is turned on. When that happens, the PDF substitutes a generic font in its place, which can shift the layout, change the spacing, and break the look of the original design. Worse, if a screen reader cannot map the substituted characters back to readable text, it may read the content as nonsense or skip it altogether. If an agency is using a custom font, it is worth confirming that the license allows embedding before building an entire report or dashboard around it. A quick way to check whether it worked is to open the finished PDF and try selecting the text. If the text can be highlighted and copied, the fonts are embedded correctly.

Support Accessibility with More Than Font Choice

Accessible typography goes beyond font style. Support readability and comprehension by:

- Using direct labeling instead of relying on legends reduces the need for eye movement back and forth.
- Placing labels close to the data element they describe.
- Using mixed typographic signals (size, weight, spacing) alongside color, not color alone, to indicate emphasis.
- Avoiding text over busy backgrounds or images. If unavoidable, place text in a semi-transparent textbox.

These practices reduce the interpretation burden on the reader and help communicate the message more efficiently.

3.2.7. Sensification: Expanding Beyond the Visual

Sensification is an emerging topic associated with accessibility and with more immersive ways to communicate. Sensification means adding other senses (sound, touch, spatial immersion) to the way information gets communicated. Research in multisensory learning (Shams and Seitz 2008), auditory display (Kramer et al. 1999), immersive analytics (Marriott et al. 2018), and universal design (Mace 1997) all point to the same finding: people understand and remember information better when more than one sense is involved.

For transportation agencies, this has a few practical applications. For example, a public meeting about a proposed highway widening could include an audio simulation of what the noise level would sound like at the property line, alongside the visual rendering. A virtual reality (VR) walkthrough of a redesigned intersection lets community members experience the scale of the change in a way that a plan-view drawing cannot. These approaches also expand who can participate in the conversation, because they give people who cannot see or who struggle with abstract graphics another way to engage with the information. While visuals can still be the foundation, layering in other senses is one way to move beyond what a chart shows and what a project would feel like in the built environment.

Common Applications in Transportation Visualization

- **Tactile and Physical Models**
  3D printed models of proposed project locations can allow stakeholders to physically explore vertical changes, right of way impacts, and multimodal layouts. Tactile interaction can make spatial relationships clearer than plan sheets alone.
- **Immersive and 360-Degree Environments**
  Virtual or 360-degree project tours allow stakeholders to experience a project footprint at human scale. Research in immersive analytics shows that embodied interaction can enhance spatial reasoning and scenario evaluation.
- **Audio-Enhanced and Accessible Communication**
  Screen reader compatible dashboards, narrated summaries of key findings, and structured auditory cues support equitable access to information. Research in auditory display demonstrates that sound can effectively convey patterns and anomalies in data.

By expanding beyond sight alone, transportation agencies can create clearer, more inclusive visualization practices that reflect how infrastructure is actually experienced.

Key Takeaways:

- Build visual hierarchy into charts and graphics so that the most important information is what the viewer sees first. Size, color, and position all direct attention.
- Use online tools to test color palettes against common forms of color vision deficiency and provide alternative text for all non-decorative images to meet common accessibility standards.
- Keep typography within one or two font families, with consistent sizing and adequate contrast between text and background to improve readability across screen and print formats.

3.3. Incorporating Interactive and Dynamic Elements

Interactive and dynamic elements in data visualizations empower users to explore information at varying levels of detail, offering a personalized and discovery-driven experience. These features enhance user engagement, improve comprehension, and support progressive information disclosure, to go from high-level to detailed views. Described in the following sections are best practices for incorporating drill-downs, filters, and tooltips effectively. **Figure 28** provides examples of how interactive features can provide enhanced user engagement and detail by offering options for users to engage with the data in ways most relevant and interesting to them.

3.3.1. Drill-Downs

Drill-downs are interactive capabilities within online dashboards and applications. They allow users to start with a high-level summary and click “down” into more detail. For example, a statewide safety dashboard might open with total crash counts by district. Clicking on a district shows crashes by county. Clicking on a county shows individual crash locations. Each click moves one level deeper into the same data without leaving the page. This is a great feature to enable when some members of any audience just want a big picture and others want specifics. Both groups can get what they want from the same product.

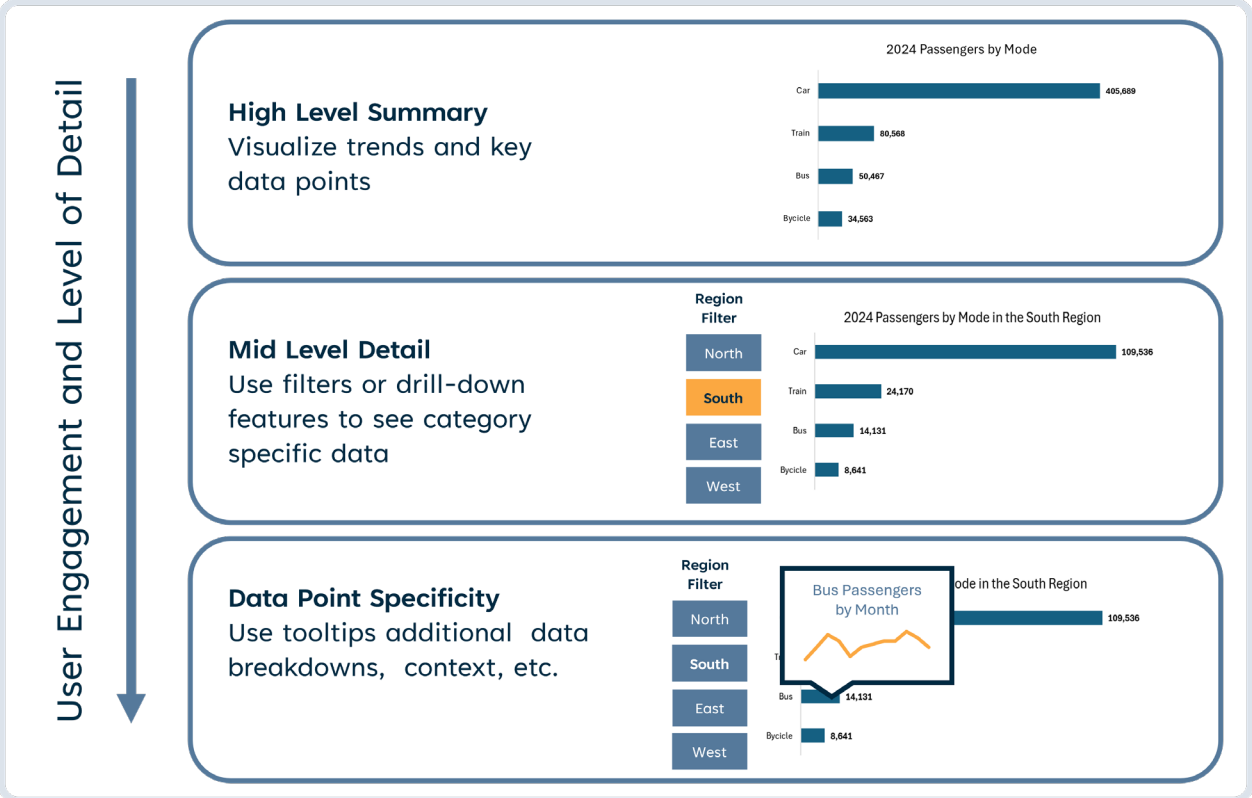


Figure 28: Encouraging User Engagement Through the Use of Interactivity.

Best Practices for Drill-Downs:

1. **Prepare Data Fields:** Organize the data fields hierarchically and link them logically so they can be used in a drill-down feature.
2. **Define Data Hierarchies:** Clearly outline the levels of data granularity. For example: Year → Quarter → Month or Country → State → City.
3. **Create Interactive Visualizations:** Design charts and graphs that dynamically update as users navigate through layers.

Tips for Effectiveness:

- **Dynamic Titles:** use dynamic chart titles and axis scales to reflect the current level of granularity.
- **Visual Cues:** Include visual cues like arrows or icons to guide users on where and how to interact with the tool.
- **Guidance through Tooltips:** Leverage tooltips for additional context and instructions.

3.3.2. Filters

Filters let a viewer pare down a visualization to focus on what they care about most. For example, a dashboard showing statewide crash data becomes more useful when someone can filter it to a single district, a specific year, or a particular crash type.

A few things make filters work better in practice. The filter options should cover the dimensions people are most likely to want to narrow by, which in transportation data usually means time period, geography, and category (project type, mode, funding source, etc.).

Tips for Effectiveness:

- **Highlight Active Filters:** Clearly indicate which filters are applied, so users can easily understand and modify their selections.
- **Visual Synchronization:** If you have multiple interactive visualizations, ensure filters are synchronized across all relevant visualizations to maintain consistent data context.
- **Show Results Counts:** Indicate how many results are displayed based on the current filter settings (e.g., "Showing 10 of 50 records"). This gives users an understanding of the data they're working with.
- **Reset and Clear Options:** Make it easy for users to reset all filters or clear individual selections with a "Clear All" or "Reset" button.

3.3.3. Tooltips

Tooltips are the small pop-ups that appear when a viewer hovers over or taps on an element in an interactive visual. They are a good place to put information that would clutter the chart if it were visible all the time but that viewers might want on demand. A tooltip can also define a term or explain a methodology for viewers who are unfamiliar with the data.

Tips for Effectiveness:

- **Position Thoughtfully:** Avoid covering important parts of the visualization, and ensure tooltips appear where the user expects them.
- **Use Appropriate Triggers:** Trigger tooltips on hover or click, depending on the complexity of the information, and ensure they don't appear too frequently or distract from the visualization.

Key Takeaways:

- Filters, tooltips, and drill-downs are useful when viewers need to explore the data at different levels of detail. Static visuals are often sufficient for a single message.
- Design tooltips to surface supporting context (a definition, a date range, an underlying count) without cluttering the default view.
- Test interactive visuals on the devices and platforms the audience will use. A dashboard that works well on a desktop monitor may be difficult to navigate on a phone or tablet.

3.4. Mapping and Geospatial Visuals

Geospatial data visualization is another powerful tool that transportation agencies can use to enable the analysis, presentation, and communication of spatial data. A good map can reveal spatial patterns and relationships that might otherwise go unnoticed when solely using non-spatial visualization methods such as charts.

There are many different types of maps one can use depending on the data and the type of relationship being displayed. The graphic in **Figure 29** walks through a few simple questions to help choose an appropriate map type.

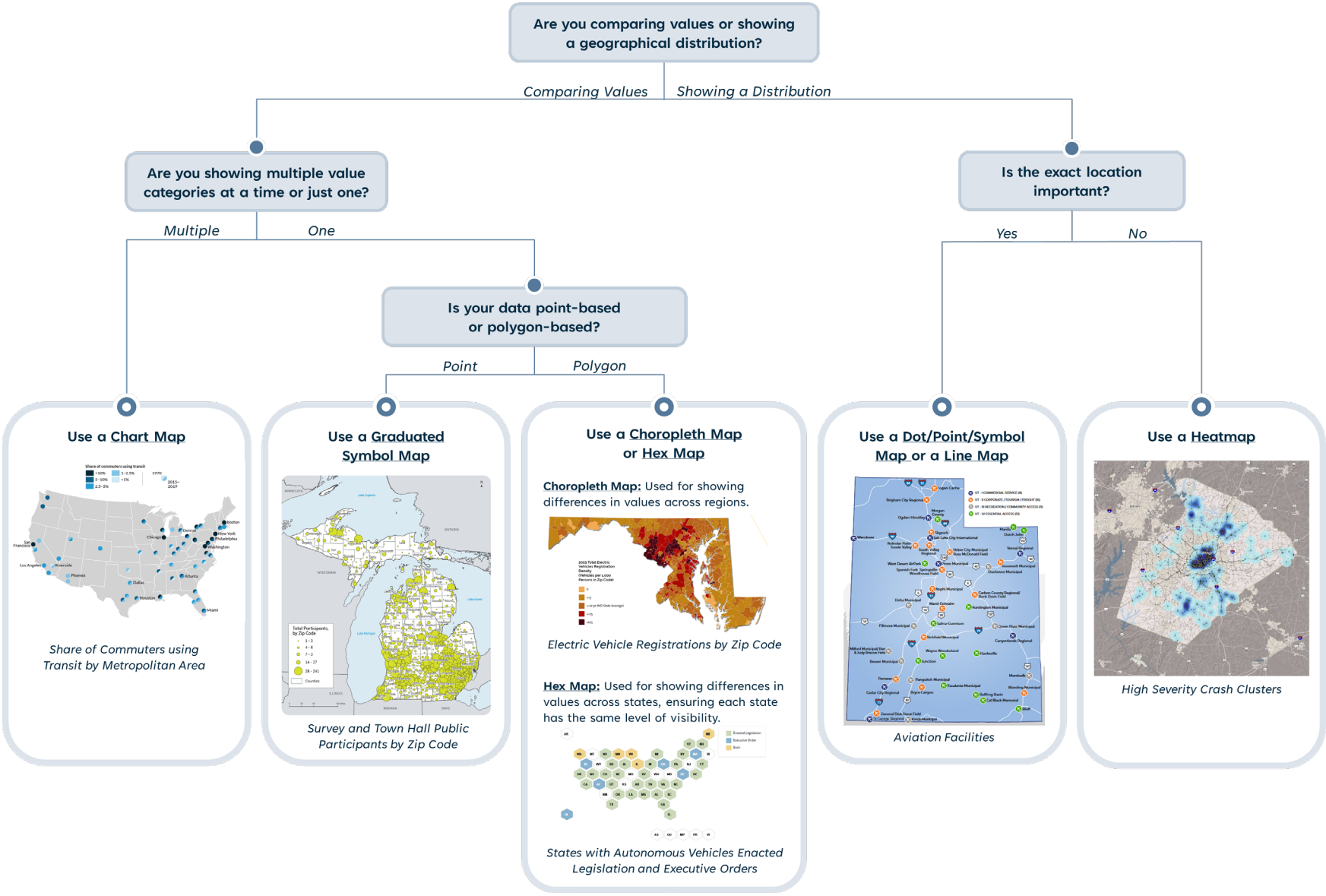


Figure 29: Choosing the Right Map Type.

3.4.1. Map Projections

A map projection translates the 3D Earth surface into a flat map. Since this transformation involves turning a 3D object into something 2D, there will always be distortions in the way things look. However, these distortions can be minimized by choosing a map projection well suited for a dataset. Choosing an inappropriate projection can distort geographies and misinterpret spatial relationships. For example, **Figure 30** shows the United States projected four different ways. Each one shows varying proportions of the states and the country as a whole.

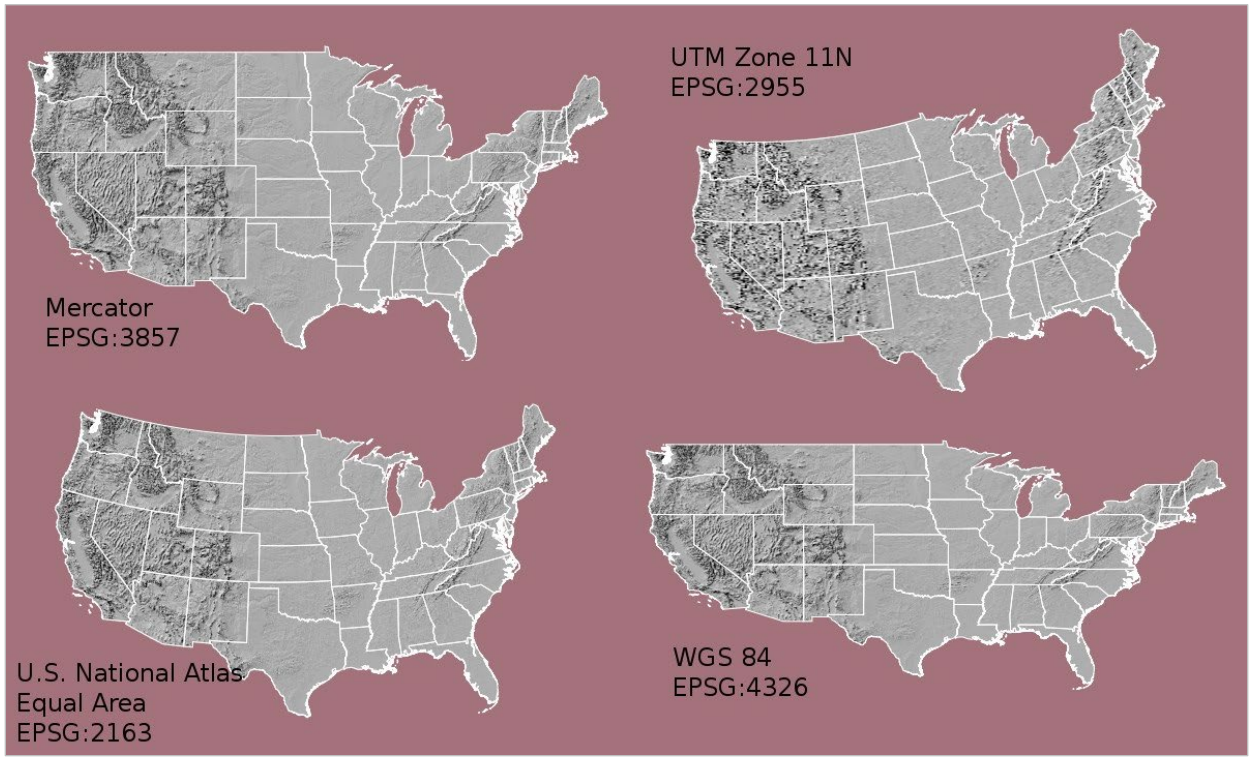


Figure 30: The U.S. Projected Four Different Ways.

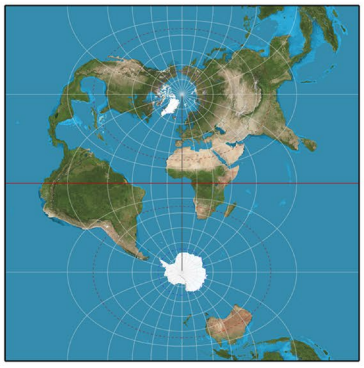
The following figure suggests projection types to use based on a map's extent: a local/regional map, a multistate or national map, or a specialized map such as one centered on a particular roadway corridor.

Local or Regional Maps

Recommended Projection: Transverse Mercator or other conformal projections

Pros: Minimizes distortion for smaller geographic areas

Example Use Cases: Show spatial data at a state or city level



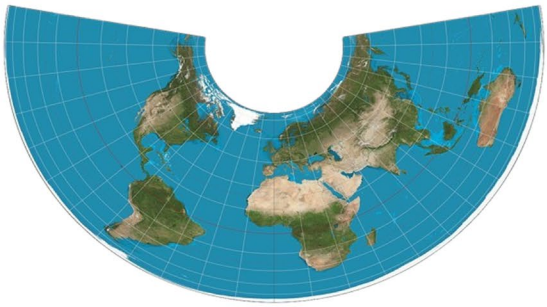
Globe transformed using Transverse Mercator projection

Multistate or National Maps

Projection: Albers Equal Area or other equal-area projections

Pros: Maintains proportions of larger areas

Example Use Cases: Show spatial data at national level or across a region that spans multiple states



Globe transformed using Albers Equal Area projection

Specialized Maps

Projection: Route-Centered Projection

Pros: Balances minimal shape and area distortion for a localized area

Example Use Cases: Show localized spatial data such as data focused on a specific roadway corridor or route

A localized projection centered on Eastern Illinois

Figure 31: Choosing the Right Map Projection.

Online resources such as epsg.io can help with finding specific map projections that best suit an area.

3.4.2. Map Scales

Scale determines the level of detail visible on a map and the extent of the information shown. Transportation data often covers varying levels of detail from street-level crash data to interstate corridors.

- **High-Detailed Data:** Use large-scale maps (i.e., zoomed in to areas of focus).
- **Broad Overview Data:** Use small-scale maps (i.e., zoomed out to a region).
- **Overview + Detailed Data:** Consider a small-scale map showing regional or state trends, with large-scale pop-out maps zoomed into specific areas of interest.
- **Interactive Data:** Provide zoom and filter options in online interactive maps to explore data at multiple scales.

3.4.3. Real-Time Data

Adding live data to a map or dashboard can be valuable for traffic management, emergency response, transit operations, and public traveler information. But real-time visualization brings a set of challenges that static visualizations do not have, and most of them are about what happens when things go wrong.

The first question is how the data gets from the source to the visual. Most real-time transportation data comes through an Application Programming Interface (API) or a data feed (like General Transit Feed Specification (GTFS)-realtime for transit or traffic sensor feeds). The connection between the data source and the dashboard needs to be reliable, because when it drops, the visual goes stale without warning. Every real-time visual should display a "last updated" timestamp so viewers can tell whether they are looking at current information or something from three hours ago. This sounds obvious, but a surprising number of public-facing dashboards do not include one.

Another best practice is to thoughtfully establish a refresh frequency based on users' needs. For example, a traffic operations center might want updates every 30 seconds because operators are making decisions in the moment. A public-facing congestion map could refresh every five minutes and still be useful. Faster refreshes put more load on the server, which might be fine to reduce if the use case allows it.

Real-time data can be more challenging to work with than static data because there is limited opportunity to clean it before it goes live. Sensors go offline and start reporting zeros. Automated checks can catch most hardware errors. Setting acceptable value ranges, flagging sensors that have stopped reporting, and suppressing obvious outliers before they reach the display all help keep erroneous data from reaching the display.

Key Takeaways:

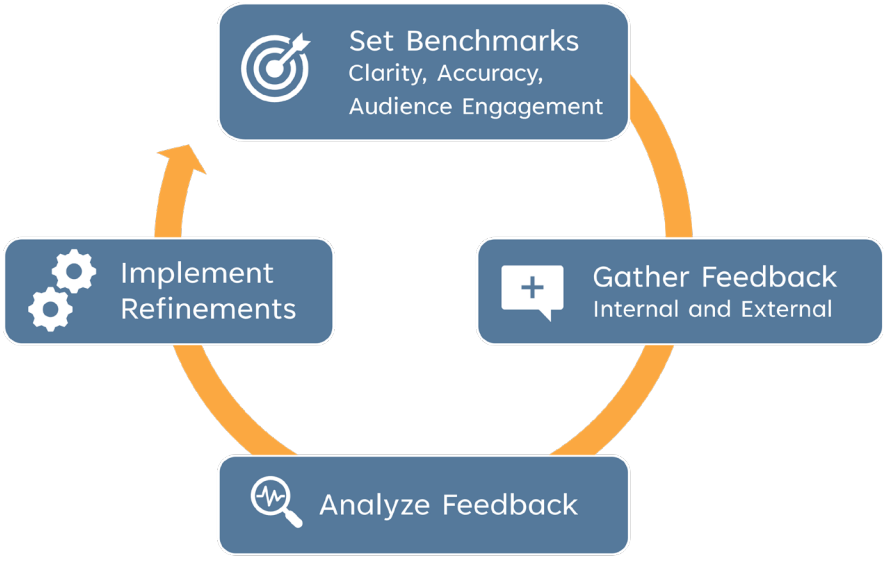
- Match the map projection to the geographic extent of the data.
- Set the map scale to the level of detail the audience needs. Street-level crash data calls for a large-scale (zoomed-in) map, while statewide performance trends call for a small-scale (zoomed-out) view.
- Layer contextual information (landmarks, jurisdictional boundaries, etc.) to help the viewer interpret the data. Layers that do not contribute to the message should be removed.

4. Assessing What Works: Evaluation and Refinement

4.1. Developing an Evaluation Process

Most visualizations get published and never revisited. The dashboard goes live, the report gets distributed, and the team moves on to the next project. The problem is that without going back to check whether the visual worked, agencies keep repeating the same mistakes and have no way to build on what went well. **Figure 32** shows a cycle for building evaluation into the normal workflow rather than treating it as an extra step.

The cycle starts with deciding what success means for a given visual before it is published. That might be as simple as seeing if the intended audience engaged with it. Success benchmarks do not need to be complicated, but they do need to exist. A team that publishes a dashboard without deciding in advance what success looks like will have a hard time evaluating it after the fact.



Cycle of Continuous Improvement

Figure 32: Cycle of Continuous Improvement.

The Insights Hub shown in **Figure 33** serves as the central mechanism for gathering and integrating feedback into this continuous improvement process. Feedback flows from both internal sources, such as team workshops, stakeholder reviews, and user testing, and external sources, like surveys, focus groups, and usability testing. By consolidating these insights in one place, agencies can analyze strengths and gaps in visualization practices, fostering alignment with organizational goals and audience needs.

Figure 33: The flow of feedback for data visualization design.

The Cycle of Continuous Improvement works when a team publishes a visualization, collects feedback on it (through any of the methods described in the previous section), looks at what the feedback says, makes changes, and then checks whether the changes helped. Then it starts again. The point is that evaluation is not something that happens once at the end of a project. It is something that happens each time the visual gets updated or reused.

An Insights Hub (a shared log where the team records feedback, tracks what changed, and notes what the results were) keeps this from becoming informal and forgettable. Without a central place to store feedback, lessons from one project rarely carry over to the next. With one, a team can look back at what worked and what did not across multiple products and start making better decisions about design, layout, and content over time.

4.2. Identifying Strengths and Gaps

After collecting feedback, it helps to have a structured way to sort through it. **Table 7** is an evaluation matrix built around three questions. Is the visualization clear? Is it accurate? Did the audience engage with it? Each question breaks down into specific items a reviewer can score, so the evaluation produces something concrete rather than a general impression that a visual "worked" or "did not work."

The matrix is meant to be used by the team that built the visualization, ideally with the feedback they collected in hand. Some items will be easy to answer (the labels are readable or they are not). Others require judgment (did the visual hold the audience's attention during a public meeting, or did people lose interest halfway through?). Scoring

each item separately makes it easier to see where a visual is strong and where it needs work, rather than making a single up-or-down call on the whole product.

The scoring process has three steps.

- **Score each item.** Go through the guiding questions in the matrix one at a time and score each on a 1-to-3 scale, where 3 means the visual performs well on that item and 1 means there is a clear problem. Answering the questions with specific feedback in hand (survey responses, meeting observations, analytics data) makes the scoring less subjective.
- **Look at the pattern.** Scoring by category will be more useful to practitioners than a single overall score because it shows where the problems are concentrated. A dashboard with accurate data but confusing labels is a different problem from one where the design is clean, but the numbers are out of date.
- **Use the matrix to decide what to fix.** Each row in the matrix includes suggested actions. If the visual scored low on design simplicity, the suggested actions might include removing unnecessary gridlines, cutting the number of colors, or simplifying the layout. If it scored low on context, it might need benchmarks, comparison values, or better annotations. The fixes should be specific enough to hand to whoever is doing the revision.

Patterns that emerge over time can be useful because they point to organizational issues (training, tools, standards) that go beyond any single visualization, and can connect directly to the implementation guidance in Part 4 of this guide.

Table 7: Visualization Evaluation Matrix.

Dimension	Criteria	Guiding Questions	Score		
			3	2	1
Clarity	Purpose Alignment	• Does the visualization convey its message clearly? • Is the takeaway immediately apparent? • Are annotations and labels clear?	Purpose is clear at first glance	Purpose requires effort to understand. *Add annotations, labels, or color to highlight key points.*	Purpose is unclear or misleading. *Explore other visual types or distil data to isolate meaning.*
	Design Simplicity	• Is the visualization free from clutter? • Are color choices, fonts, and chart types consistent and easy to interpret?	Clean design that enhances comprehension of desired message.	Design is acceptable but includes minor distractions. *Remove visual clutter or simplify design elements (use fewer colors/fonts/graphics).*	Overly complex or visually overwhelming. *Isolate the most simplified visual and add design elements as needed.*
Accuracy	Data Integrity	• Is the data accurately represented (no distortions or misleading visuals)? • Are data sources cited?	Data is precise and clearly sourced.	Some ambiguities or minor inaccuracies. *Cite data sources or provide clarifying text and address data accuracy*	Significant inaccuracies or lack of transparency. *Evaluate data processing and methodology to ensure clarity and accuracy*
	Context and Comparisons	• Does the visualization provide sufficient context (benchmarks, trends)? • Are comparisons fair and relevant?	Context is robust and supports decision-making.	Context is present but incomplete. *Offer additional context through annotations or other methods as needed.*	Lacks sufficient context for accurate interpretation. *Reevaluate visualization types or provide additional visuals and context to ensure effective messaging.*
Audience Engagement	Relevance to Audience	• Is the visualization tailored to the audience's knowledge and needs? • Does the visualization provide the appropriate data granularity for the audience? • Does it address relevant stakeholder questions?	Fully aligned with audience expectations	Partially aligned; some gaps. *Anticipate key questions from stakeholders and modify visuals to address them.*	Misaligned with audience needs. *Reassess audience needs and evaluate chart selection and data granularity as needed.*
	Interactivity and Accessibility	• Are interactive features intuitive? • Are insights accessible? • Is it accessible for diverse audiences (e.g., colorblind-friendly, in plain language)?	Highly engaging and accessible.	Moderate engagement with some accessibility issues. *Evaluate accessibility in detail and modify colors and design as necessary or provide alternate accessible formats as needed.*	Limited engagement and accessibility. *Reassess interactive features and chart selection to provide easy access to key information and intuitive interactive elements.*

4.3. Building Continuous Improvement Cycles

Visualizations can go stale over time. The data behind them changes, the audience shifts, leadership asks a new question, or the tool the agency used gets replaced. A dashboard that was useful two years ago may not be answering the right questions today. Building a habit of going back to evaluate and update published visuals keeps them useful over time. **Figure 34** shows what that cycle looks like.

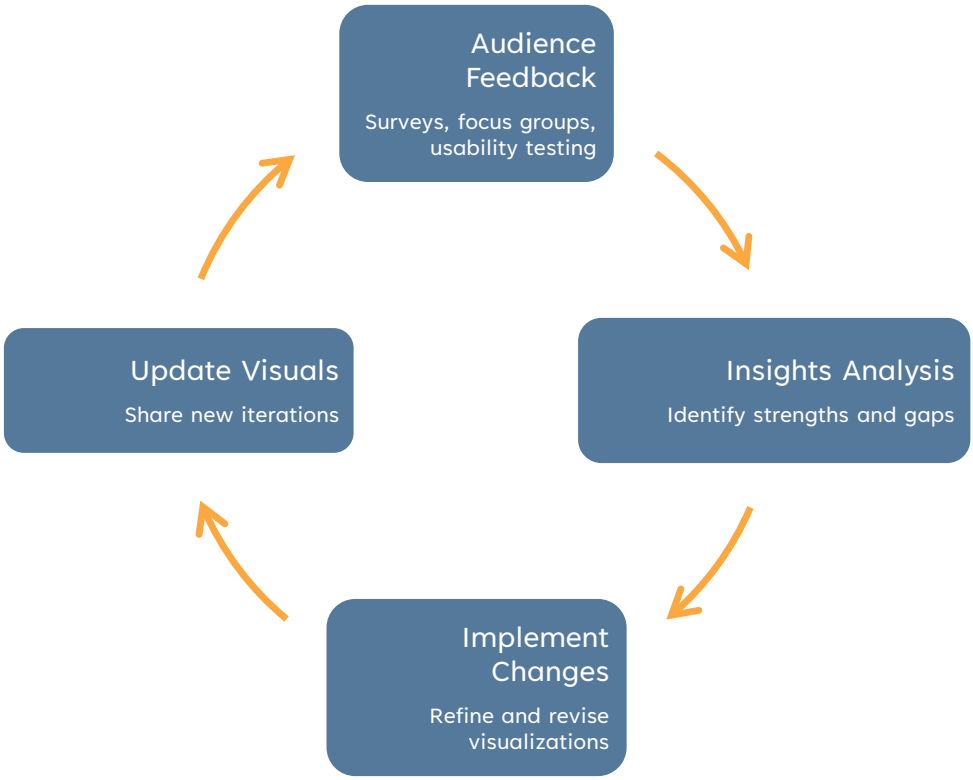


Figure 34: Continuous Improvement Through Feedback.

In practice, this can look like picking a regular interval (quarterly, twice a year) to review the agency's most-used visuals. The review can include checks to see whether the data is still current, the design still makes sense for the audience, and whether anyone has flagged problems or confusion.

It also helps to save examples of visuals that worked well. A collection of successful dashboards, reports, and graphics, with notes on what made them effective, gives the team something to reference the next time a similar project comes up. Several of the agencies interviewed for this project's case studies have started building this kind of internal library, and staff described it as one of the most useful resources available to them.

Ongoing user feedback is another great practice. The Federal Highway Administration (FHWA), for example, uses pop-up surveys on its website that ask visitors about their experience on the website after a few visits. The questions cover whether the information was clear, if the site was easy to navigate, and whether the visitor found what they were looking for. The survey provides lightweight, recurring feedback gives an agency a steady stream of information about how its products are landing, without requiring a formal evaluation project each time.

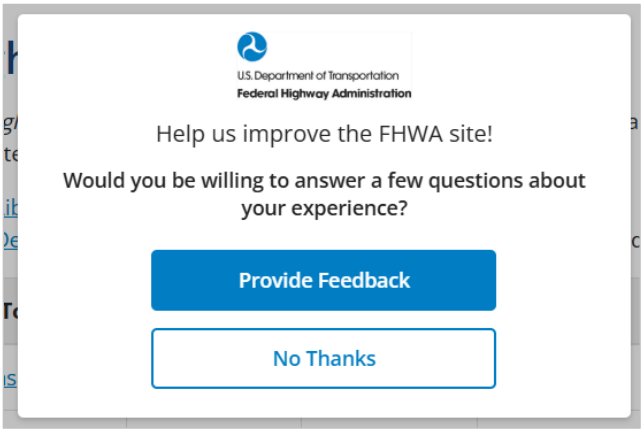


Figure 35: FHWA Website User Survey Request.

Key Takeaways:

- Build feedback into the visualization workflow from the start. Structured review points during development catch problems earlier than a single review at the end.
- Use the evaluation matrix to score visuals on clarity, accuracy, audience engagement, and actionability. Written scores make it easier to track improvement over time and to communicate specific revision needs.
- Treat evaluation as a recurring practice. Patterns that emerge across multiple reviews can point to organizational issues (training gaps, inconsistent standards) that go beyond any single visual.

5. Further Reading

The following publications provide additional insights into the academic research on effective data visualization and methods for evaluating visualization design and communication effectiveness. These resources are included for readers interested in exploring the research literature beyond the practical guidance provided in this guide.

Articles

Cairo, A. (2020). *Visualization: A guide to the state of the art.* Patterns, 1(6). Access link: https://www.cell.com/patterns/fulltext/S2666-3899(20)30189-6

Franconeri, S., Padilla, L., Shah, P., Zacks, J., & Hullman, J. (2021). *The Science of Visual Data Communication: What Works.* Access link: https://faculty.sites.iastate.edu/tesfatsi/archive/tesfatsi/ScienceOfVisualDataCommunication.FranconeriEtAl2021.pdf

Research and Technical Papers

Cleveland, W. & McGill, R. (1984). Graphical perception: *Theory, experimentation, and application to the development of graphical methods*. Journal of the American Statistical Association. Access Link: http://euclid.psych.yorku.ca/www/psy6135/papers/ClevelandMcGill1984.pdf

Few, S. (2007). *Data Visualization Effectiveness Profile.* Perceptual Edge. Access link: https://perceptualedge.com/articles/visual_business_intelligence/data_visualization_effectiveness_profile.pdf

Hullman, J., Gelman, A., & others. (2020). *Testing Statistical Graphs.* Annual Review of Statistics and Its Application. Access link: https://www.annualreviews.org/content/journals/10.1146/annurev-statistics-031219-041252

Statistical Society of Australia. (n.d.). *Tutorial: Effective Data Plots.* Access link: https://statsocaus.github.io/tutorial_effective_data_plots/

Wainer, H. (1984). *How to Display Data Badly.* The American Statistician. Access link: https://sites.stat.columbia.edu/gelman/communication/Wainer1984.pdf

Wainer, H., Hambleton, R., & Meara, K. (1999). *Alternative Graphical Displays for Item Response Theory Data.* Access link: https://sites.stat.columbia.edu/gelman/communication/WainerHambletonMeara1999.pdf

Books

Cairo, A. (2016). *The Truthful Art: Data, Charts, and Maps for Communication.* New Riders. Access link: https://books.google.com/books?hl=en&lr=&id=TKh6fdlKwfMC

Evergreen, S. (2017). *Effective Data Visualization: The Right Chart for the Right Data.* Sage Publications. Access link: https://books.google.com/books?id=XmmNDwAAQBAJ

Few, S. (2012). *Show Me the Numbers: Designing Tables and Graphs to Enlighten.* Analytics Press. Access link: https://books.google.com/books?hl=en&lr=&id=zxNglqU1FKgC

Knaflic, C. N. (2015). *Storytelling with Data: A Data Visualization Guide for Business Professionals.* Wiley. Access link: https://books.google.com/books?hl=en&lr=&id=7ZesAQAAQBAJ

Munzner, T. (2014). *Visualization Analysis and Design.* CRC Press. Access link: https://books.google.com/books?hl=en&lr=&id=A7jeDwAAQBAJ

6. Implementing Across the Agency: Building Capacity and Sustaining Change

6.1. Addressing Organizational Barriers

Every agency that tries to build up its visualization practice runs into organizational problems. The survey for this project confirmed it. Silos between departments was the top-rated barrier, with 59 percent of respondents scoring it a 4 or 5 out of 5. Data governance ranked second. Unclear goals, limited funding, and gaps in training and hiring all scored high as well. **Figure 36** shows the most common barriers alongside approaches agencies have used to work through them.

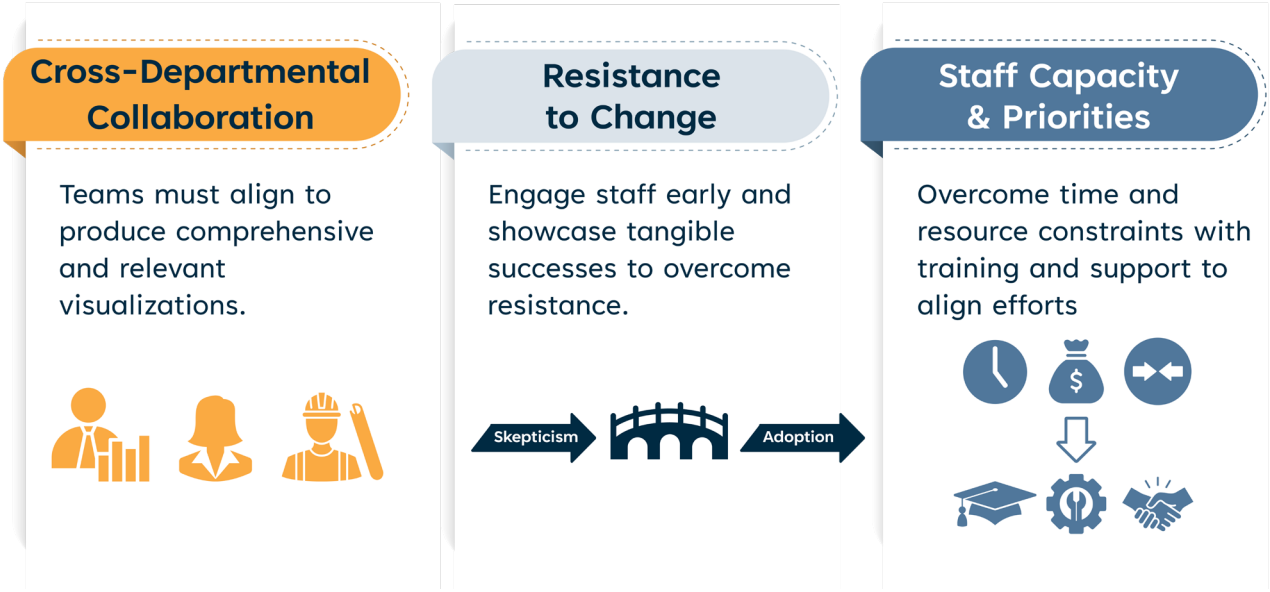


Figure 36: Common Organizational Barriers and Solutions.

The silo problem shows up in a few ways. The team that owns the data may not talk regularly to the team that communicates with the public, so visualizations get built without input from the people who know the audience best. IT controls the software licenses and server access, but may not be involved in conversations about what the agency is trying to communicate. Planning, communications, and IT each have a piece of what is needed, but if they are working separately, the visual that comes out the other end reflects only one perspective.

Resistance to new tools is another common issue, and it usually comes from somewhere reasonable. Staff are busy. Learning a new platform takes time they do not have. If previous attempts to introduce new tools did not stick, people are skeptical that this time will be different. The agencies in the case studies that had the most success getting staff on board did a few things. They started small, with a single project or a single team, and let the results speak for themselves. They brought staff into the process early so the new tools felt like something they chose rather than something imposed on them. And they made training available on an ongoing basis rather than as a one-time event that people forgot within a month.

Cross-departmental teams help with both problems. A visualization project that includes someone from planning, someone from IT, and someone from communications is more likely to produce something that is technically sound, answers the right question, and reaches the intended audience. Several survey respondents described this kind of collaboration as the single most effective thing their agency had done to improve visualization quality. Forty-two of 59 respondents selected cross-departmental collaboration as a strategy their agency had used to overcome barriers, the highest of any option in that question.

6.2. Leadership and Buy-In

Visualization practice does not take hold at an agency unless leadership is behind it. Staff can learn the tools and build good products, but if leadership does not use those products, ask for them, or make time for the work, it stays a side project that depends on one or two motivated individuals.

The most effective thing a leader can do is use visualizations in their own work. When a director walks into a budget meeting with a chart instead of a table, or when an executive presentation leads with a dashboard instead of a bulleted slide, it signals to the rest of the organization that this is how the agency communicates. The survey results reinforced this. Thirty-five of 59 respondents said strong leadership support was one of the ways their agency had worked through organizational barriers. **Figure 37** shows a four-step framework for how leaders can build and sustain support for visualization across an agency.

1. **Set the Tone:** Start using visualizations in meetings, presentations, and internal reports. Staff pay attention to what leadership puts in front of them. If the executive team relies on visualizations to make decisions, the rest of the agency will start producing them. If leadership never asks for a chart, staff have little reason to build one.

2. **Show Alignment.** Leadership is more likely to support visualization work when it serves something the agency is already responsible for.
3. **Build Momentum.** Agencies that have had a visualization go well will benefit from talking about it internally. Document and celebrate successes.
4. **Commit to Action.** None of this works without time, tools, and training. Staff who are told to build dashboards but not given the software, the data access, or the hours in their workload to do it will burn out or stop trying. Sustained commitment means budgeting for training, maintaining software licenses, and building visualization into job descriptions and workload planning rather than treating it as something people do on top of everything else.

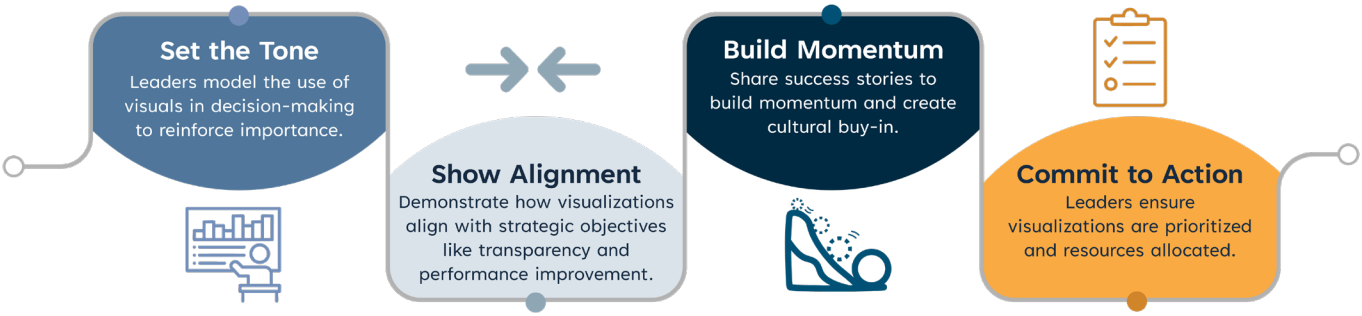


Figure 37: Leadership as a Catalyst for Cultural Transformation.

6.3. Valuing Data-Informed Communication

For visualizations to stick as a relevant resource, it helps when they show up in the places where people already do their work. That means building them into the reports, briefings, and public-facing materials the agency already produces, so they become part of how information moves through the organization.

When a visualization works well, say so. Feature it in a team meeting, include it in a newsletter, or point to it in a presentation to leadership. That kind of recognition signals to staff that the agency values this type of communication and makes it easier for the next person to justify the time spent building something similar. Sharing strong examples externally can also strengthen public confidence in the agency's work. **Figure 38** illustrates a four-step cycle for integrating visualizations into agency workflows.

1. **Integrate:** Build visuals into the reports, dashboards, and public communications the agency already produces so they become a routine part of how information is shared.
2. **Celebrate:** Recognize and reward successful visualization efforts to reinforce their importance and motivate a culture of effective visualization

3. **Showcase:** Put strong visuals in front of external audiences through public reports, social media, or presentations to elected officials and partner agencies.
4. **Success:** Let the momentum from visuals that perform well inform what comes next. Track which formats and approaches get traction and build on them.

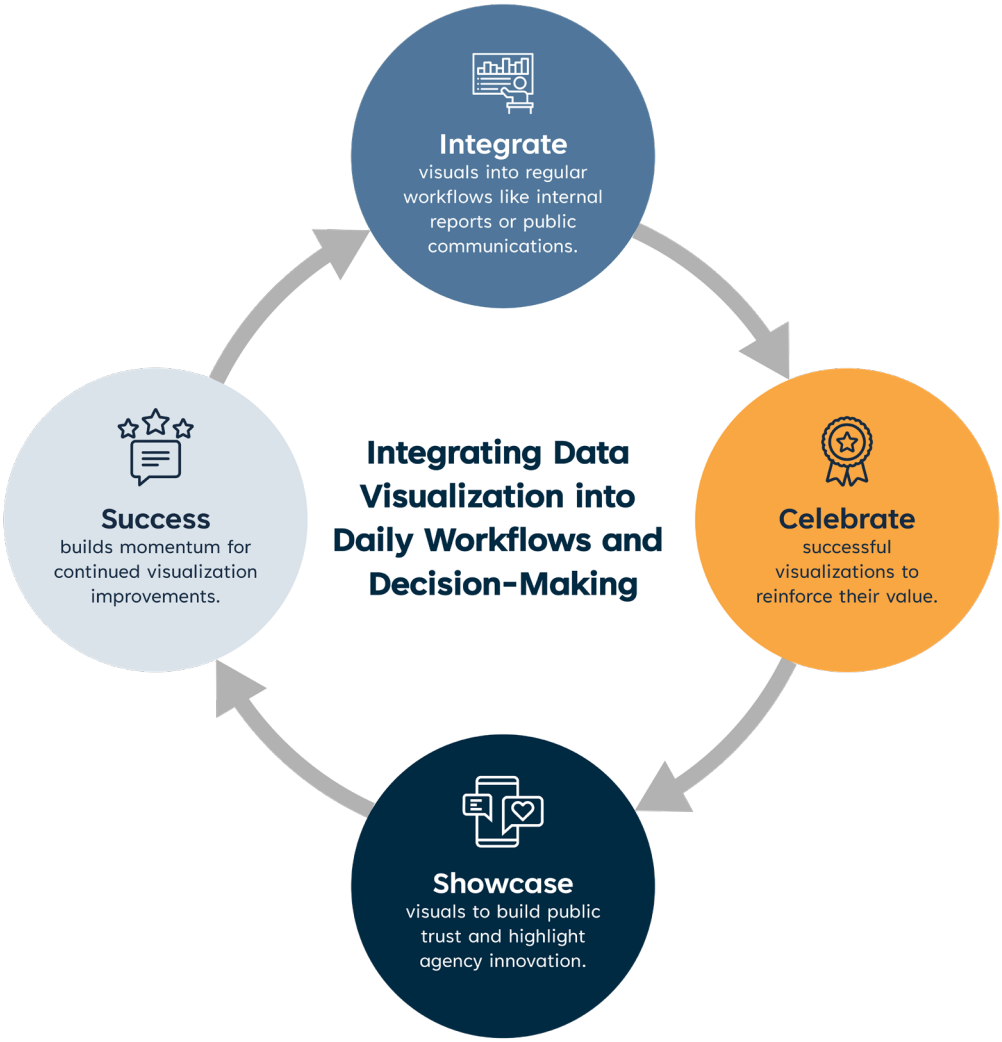


Figure 38: Integrating Data Visualization into Daily Workflows and Decision-Making.

6.4. Building Capacity Through Training and Professional Development

The agencies in this guide's subsequent case studies that had the most success with training did a few things consistently. They matched the training to what people do in their jobs, and treated training as an ongoing cycle rather than a one-time event. **Figure 39** outlines a five-step process for building and sustaining a visualization training program.

The cycle starts with identifying needs. A skills inventory or informal survey of staff (planners, analysts, GIS specialists, communications teams) can surface where the gaps are and which gaps are slowing down the work that the agency cares about most. With that picture in hand, the next step is developing content targeted to those gaps. Training for beginners might cover data cleaning basics or chart selection, while training for experienced staff might focus on advanced tools or case studies from peer agencies. Collaboration with subject matter experts helps keep the material grounded in the tasks people are doing day to day.

Delivery format is the third step. In-person workshops, webinars, and peer learning sessions each reach different staff in different settings. Offering flexible scheduling and online access helps accommodate field offices, remote workers, and staff whose availability shifts with project cycles.

The fourth step is evaluating whether the training worked. Short surveys, follow-up skill assessments, or simply tracking whether the visuals coming out of a team improve after a training session can all provide useful feedback. That feedback feeds directly into the fifth step, maintaining and updating the training resources over time. Templates, tool guides, and the internal knowledge hub should be refreshed as software changes, new case studies emerge, or staff flag topics they want covered. A standing feedback channel, even something as simple as a shared form, gives staff a way to request new content as needs evolve.

Identify Needs

Objective: Determine which skills and knowledge gaps exist across your team.

How to Achieve It:

- *Conduct a skills inventory or survey to assess the current abilities of staff members (e.g., planners, analysts, GIS specialists).*
- *Analyze agency priorities and workflows to determine which gaps most directly impact productivity and outcomes.*

Develop Content

Objective: Create targeted training materials that align with identified needs.

How to Achieve It:

- *Use foundational topics for beginners (e.g., data cleaning basics) and incorporate advanced tools and case studies for experienced staff.*
- *Collaborate with subject matter experts to ensure content is accurate, relevant, and tailored to specific job roles within the organization.*

Deliver Training

Objective: Share training through diverse and accessible formats to ensure engagement.

How to Achieve It:

- *Host workshops for hands-on learning, webinars for remote staff, and peer learning sessions to encourage collaborative skill-building.*
- *Offer flexible scheduling and online access to accommodate varying work hours and locations.*

Evaluate Impact

Objective: Assess whether the training met its goals and enhanced staff capabilities.

How to Achieve It:

- *Use surveys, quizzes, or practical skill assessments to gather feedback on the training's effectiveness.*
- *Monitor changes in performance and confidence levels to measure tangible improvements in skillsets.*

Maintain Resources

Objective: Ensure training materials and resources stay relevant and useful over time.

How to Achieve It:

- *Regularly update templates, tools, and the internal knowledge hub with new case studies, industry trends, or software updates.*
- *Create a feedback loop where staff can request or suggest additional resources to address emerging needs.*

Figure 39: The five steps to training employees on engagement practices.

6.4.1. Building a Holistic Approach to Data Visualization Expertise

Not everyone at an agency needs the same visualization skills. Training programs and hiring decisions work better when agencies think about visualization as a set of distinct skill areas rather than a single competency.

Figure 40 and **Figure 41** illustrate six key areas of expertise that agencies should focus on when developing training programs and hiring staff: Data Wrangling, Data Synthesis, Infographics, Dashboards, Mapping, and Quality Control. Some of these are technical (data wrangling, QC). Some are design-oriented (infographics, dashboards). Some sit in between (mapping, data synthesis). Most agencies will have staff who are strong in one or two areas and weaker in the rest. Mapping is often one of the stronger areas, since many state DOTs and metropolitan planning organizations (MPOs) already employ GIS professionals, and certifications such as the Geographic Information Systems Professional credential are common among that staff. Knowing where the gaps are helps target training to where it will do the most good and helps with hiring when positions open up.

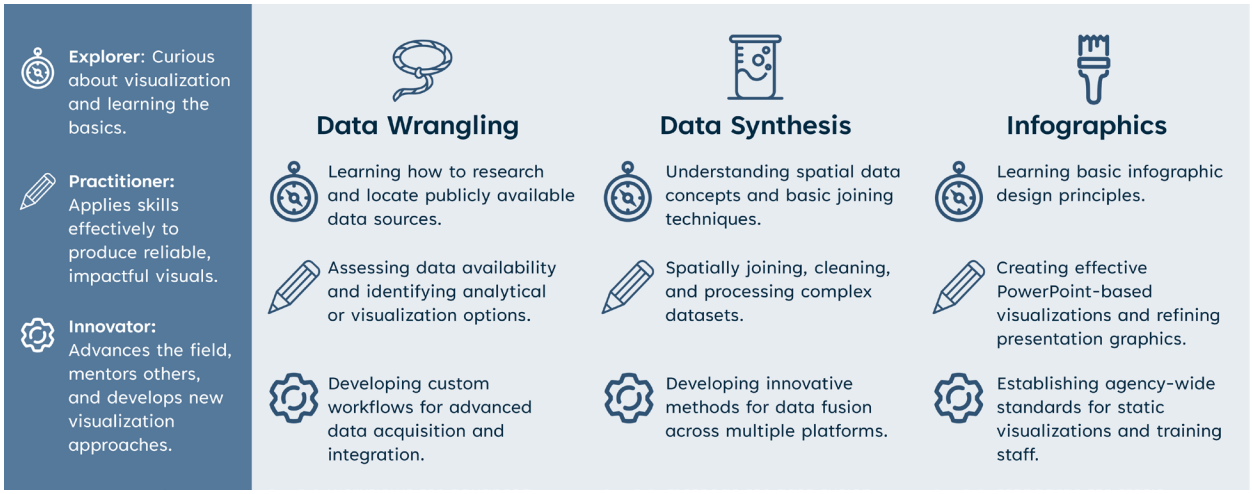


Figure 40: Aspects of data visualization and levels of expertise.

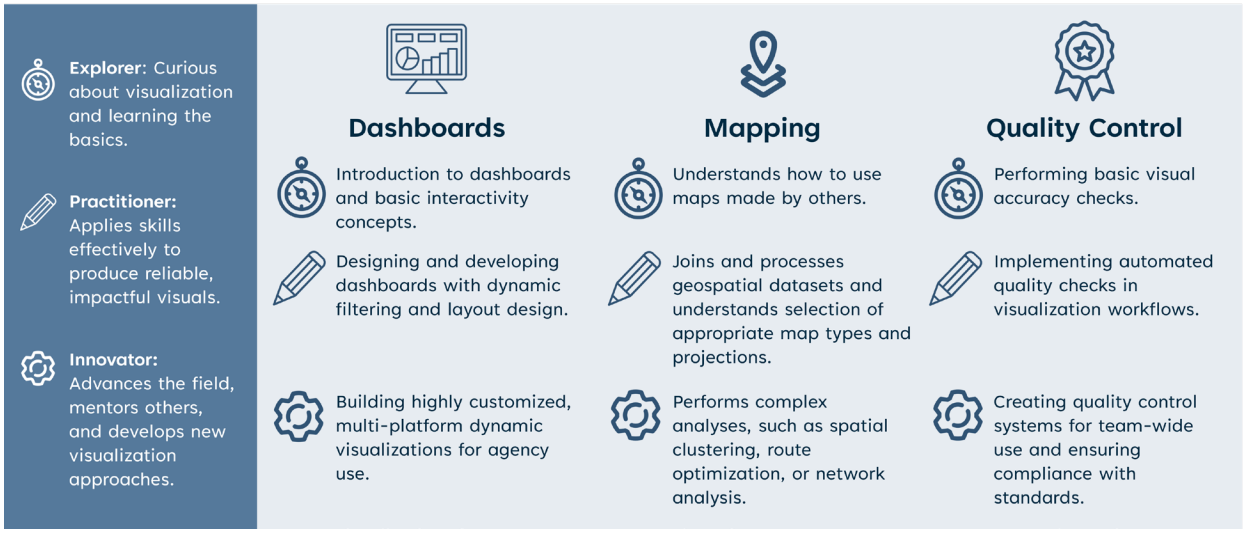


Figure 41: Aspects of data visualization and levels of expertise (continued).

To sustain these efforts, agencies can encourage ongoing knowledge-sharing and the creation of an internal knowledge hub. This hub and its components (see **Figure 42**) show what that hub might include. At its simplest, it is a shared folder or intranet page with templates, style guides, and examples of past work that turned out well. The point is to keep people from starting from scratch every time.

External resources can be part of the hub too. Esri's Living Atlas and publicly accessible datasets like Census and American Community Survey (ACS) data are useful starting points for geospatial work. Linking to those from the hub saves staff the time of tracking them down on their own. Some agencies have also had success collecting pre-built apps and tool configurations that staff can pick up and use without spending hours on setup, which frees up more time for the work that requires judgment.

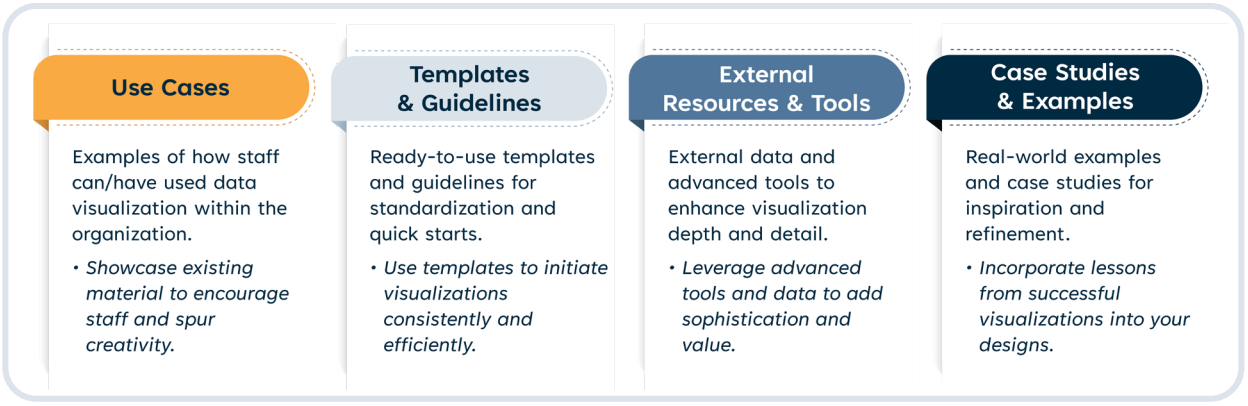


Figure 42: Key components of a data visualization knowledge hub.

6.4.2. Training Resources

Below are examples of external resources with training focus areas that agencies may find useful when building visualization capabilities. These resources are freely available online. Because web content changes frequently, links may change over time.

Agencies are encouraged to explore additional learning opportunities that best fit their needs. A wide range of tutorials, webinars, courses, and expert-led channels are available online. The resources below are organized by area of expertise.

Data Wrangling

Preparing, cleaning, transforming, and validating data for visualization

Training Focus Areas

- Structuring tabular data for visualization
- Automating data refresh workflows
- Managing missing or inconsistent data
- Documenting assumptions and data lineage
- Establishing reproducible workflows

Common Tools

Excel, Power Query, Python, R, Tableau Prep

Training Resources

- Microsoft Power BI Learning Paths: https://learn.microsoft.com/en-us/training/powerplatform/power-bi
- Tableau Training & eLearning: https://www.tableau.com/learn/training
- R Data Wrangling: https://cengel.github.io/R-data-wrangling/
- Python Data Manipulation with Pandas: https://www.kaggle.com/learn/pandas

Data Synthesis

Translating complex technical information into clear narratives

Training Focus Areas

- Defining the key message before selecting charts
- Designing executive-level summaries

- Applying progressive disclosure (overview first, detail later)
- Tailoring visuals to different audiences

Common Tools

PowerPoint, Adobe Creative Suite, ArcGIS StoryMaps, Tableau, Power BI

Training Resources

- Storytelling with Data: https://www.youtube.com/channel/UCjhGIILWNloXJdR2NTCBMlA
- Tableau - Five Best Practiced for Telling Great Stories with Data: https://www.tableau.com/sites/default/files/whitepapers/TS_MktgLtr_5best_final08_0_0.pdf
- ArcGIS StoryMaps: https://storymaps.arcgis.com/stories/cea22a609a1d4cccb8d54c650b595bc4
- The Pudding – Blog with Data Story Telling Examples: https://pudding.cool/

Infographics

Static visuals for reports, fact sheets, and public communication

Training Focus Areas

- Chart selection best practices
- Visual hierarchy and layout
- Branding and consistency standards

Common Tools

Adobe Illustrator, InDesign, Canva, PowerPoint

Training Resources

- Adobe Creative Cloud tutorials: https://www.adobe.com/learn/
- Canva Design School: https://www.canva.com/learn/design-school/
- Power Point Infographic Templates: https://powerpoint.cloud.microsoft/create/en/infographic-maker/

Dashboards

Interactive visualizations for performance monitoring and decision support

Training Focus Areas

- Dashboard layout and user experience
- Appropriate chart types by audience
- Interactivity (filters, drill-down, tooltips)
- Publishing standards and governance
- Usage analytics and adoption tracking

Common Tools

Power BI, Tableau, ArcGIS Dashboards and Experience Builder, Lookr, Qlik

Representative Training Resources

- Microsoft Power BI Guided Learning: https://learn.microsoft.com/en-us/power-bi/guided-learning/
- Tableau Training: https://www.tableau.com/learn/training
- ArcGIS Dashboards: https://www.esri.com/en-us/arcgis/products/arcgis-dashboards/resources
- ArcGIS Experience Builder: https://www.esri.com/en-us/arcgis/products/arcgis-experience-builder/resources
- Looker: https://www.skills.google/paths/28

Mapping

Spatial visualization and geospatial storytelling

Training Focus Areas

- Symbolization and classification best practices
- Geographic context and scale decisions
- Integrating GIS with dashboard platforms
- Publishing web maps and web apps
- Metadata and spatial documentation

Common Tools

Esri (ArcGIS Pro, ArcGIS Online, ArcGIS Experience Builder), QGIS

Training Resources

- Esri Massive Open Online Courses (MOOCs) – Free Online Courses: https://www.esri.com/training/mooc/
- QGIS Training Manual: https://docs.qgis.org/3.40/en/docs/training_manual/index.html

Quality Control and Governance

Ensuring consistency, transparency, accessibility, and sustainability

Training Focus Areas

- Peer review, testing, and quality assurance practices
- Data documentation and version control
- Naming conventions, file organization
- Accessibility compliance and inclusive design (e.g., 508/WCAG compliance, color contrast, alternative text, keyboard navigation, and readable layouts)
- Publishing and platform governance (e.g., server management, user permissions, publishing workflows, and archival practices)

Common Tools

SharePoint, Tableau Server, Power BI Service, ArcGIS Online

Training Resources

- Berkeley – Data Visualization Evaluation Checklist: https://bpm.berkeley.edu/sites/default/files/bpmo_data_viz_checklist_v4f.pdf
- WebAIM Accessibility Training Resources: https://webaim.org

7. Visualization Case Studies Library

This library presents 11 real-world visualization case studies selected to illustrate a range of communication goals, data types, and visualization techniques used by transportation agencies. Each case study includes an evaluation of design characteristics, interactivity, and governance to guide practitioners in adapting best practices to their own needs.

7.1. Summary Table of Case studies

Agency	Medium	Communication Need	Audience	Data Type	Interactivity
VTrans	Printable brochure (PDF)	Inform/Persuade	Public and legislative audience	Qualitative, summary asset data	None
NVCOG	Online interactive charts (Datawrapper)	Inform and persuade	Practitioners, municipal leadership	Quantitative, Census/ACS	Low: Highlighting, tooltips, data download
RIDOT	ArcGIS Dashboard	Instruct and inform	General public, travelers	Live-feed, geospatial, travel time	Low: Basic filtering, tooltips
Caltrans	360° virtual tour	Inform in real-time	Environmental regulators, property owners, public	Geospatial, photographic, qualitative	High: Rotation, selection, and immersive navigation through project area

FDOT	Interactive web portal (Tableau + GIS)	Persuade and inform	Leadership, planners, MPOs, public	Quantitative, performance, geospatial	High: Navigation, informational pop-ups, filtering, tooltips, data download
MnDOT	Interactive web portal (Power BI)	Inform and monitor progress	General public, elected officials, internal staff	Quantitative, trend data	Low: Navigation and measure selection
ADOT	Social media image	Inform and foster accountability	General public	Geospatial, project impacts	None
WSDOT	Embedded Tableau dashboard	Inform and monitor	General public and local partners	Live-feed, travel time, freight, toll data	High: Navigation, filtering, highlighting, tooltips, data download
MAPA	GIS Tool	Inform	Transportation staff and community stakeholders	Quantitative, qualitative, and geospatial	High: Filtering, zoom, tooltips, scoring, data export
TxDOT	Online mapping guidelines	Inform	Internal staff, consultants, partners, public	Geospatial	Low: Navigation and scrolling
TxDOT	Online branding, and data visualization guidelines	Inform	Internal staff, consultants, partners, public	Quantitative, qualitative	Low: Navigation and scrolling

VTrans TAMP Brochure: Making Technical Topics Approachable

Summary

Agency:
Vermont Agency of Transportation (VTrans)

Communication Need:
Inform and persuade

Audience:
Public and legislative audience

Type of Data:
Qualitative and summary asset management information

Type of Analysis:
Narrative with limited visual data analysis

Visualization Medium:
Printable brochure (PDF), structured like a scrolling report

Overview

To help non-technical audiences understand the value of asset management, VTrans developed a printable brochure that explains the purpose of the Transportation Asset Management Plan and its role in long-term stewardship and investment decisions. The brochure is designed to communicate core concepts without relying on technical performance tables or detailed condition metrics.

Rather than presenting detailed asset condition tables or performance measures, the brochure focuses on why asset management matters and how it supports better transportation decisions. Plain language, short sections, and approachable visuals guide readers through transportation challenges, investment tradeoffs, and long-term planning concepts. The format is intended to be easy to read and share.

"We needed to get beyond our normal graphs and charts and communicate with people on their terms."

- Asset Management Staff, VTrans

How it Works

The brochure was developed using a combination of in-house tools, staff expertise, and targeted contractor support for design and illustration within Microsoft Word. Content was organized around a clear narrative sequence, beginning with broad transportation needs and gradually introducing asset management concepts.

Key development elements included:

Translating technical TAMP content into plain-language summaries → Developing reusable illustrations and a consistent icon set → Iterating through multiple drafts with a cross-functional working group → Structuring the document to read smoothly in a vertical, scrolling format

By prioritizing narrative clarity and reusable visuals, VTrans delivered a polished communication product without advanced visualization software or a dedicated visualization unit.

Governance

Governance for the brochure was informal but intentional, with clear expectations for message consistency and review.

- Alignment with Vermont's statewide branding and communication priorities
- Led by communications-oriented staff, with technical review from planning and asset management teams
- Cross-functional coordination to confirm accuracy and maintain a consistent storyline
- No formal visualization style guide: consistency was achieved through shared templates and iterative review

Highlights

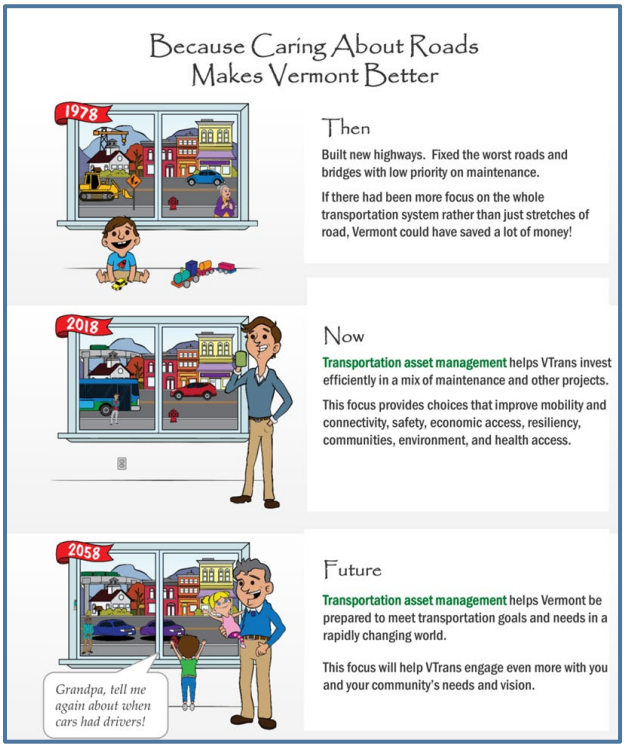
Audience-Led Framing
Content was shaped around how legislators and the public engage with information.

Simple Visuals
Icons and diagrams prioritize explanation and meaning over detailed performance measures.

Iteration Builds Buy-In
Multiple drafts balanced accessibility with technical credibility across divisions.

Cross-Disciplinary Collaboration
Planning, engineering, and communications staff worked together, with shared ownership of both the content and the message.

Samples



Key Takeaway

VTrans shows how agencies can make complex, technical planning topics accessible to public and legislative audiences by prioritizing narrative clarity, plain language, and simple visuals, without relying on advanced tools or large visualization teams.

NVCOG Data Download Page: Turning ACS Data into Accessible Visual Stories

Summary

Agency:
Naugatuck Valley Council of Governments (NVCOG)

Communication Need:
Instruct and inform

Audience:
Practitioners, planners, municipal leadership

Type of Data:
Quantitative, Census/American Community Survey (ACS) data

Type of Analysis:
Comparison, distribution, trends

Visualization Medium:
Online interactive charts

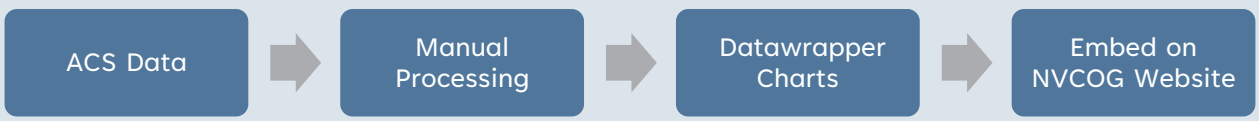
Access Link:
https://nvcogct.gov/maps-data/data-download/

Overview

NVCOG developed a collection of interactive charts to present commonly requested Census and American Community Survey data in a clear, accessible format. Topics such as population change, employment, and household income are organized in a scroll-based layout, with one chart per screen, allowing users to focus on individual trends without feeling overwhelmed.

Each visualization supports basic interaction, including hovering for values, tooltips, and direct data downloads. By housing these charts within its public Data Download page, NVCOG shifted from responding to repeated one-off data requests to offering a centralized, self-serve resource. This approach supports municipal staff, elected officials, and the public while reinforcing NVCOG's role as a regional data provider.

How it Works



NVCOG starts with publicly available ACS datasets, then cleans and standardizes the datasets for visualization. The processed data is then uploaded into Datawrapper, where the team designs interactive charts tailored for web display. These charts are embedded directly into NVCOG's website, creating a seamless experience where users can explore the data and access downloadable files within a single interface.

Governance

Lightweight but intentional governance characterized by:

- Encouraged experimentation and peer review
- Use of open, cloud-based tools
- Transparency through public-facing pages
- Limited formal policies for storage, security, or version control

Highlights

Designed for Progressive Reading

A scroll-based layout pairs focused visuals with interactivity, encouraging users to explore the data without cognitive overload.

Accessible Design

Consistent colors, clear titles, tooltips, keyboard navigation, and data download options ensure the visualizations are usable and accessible from the start.

Demand-Driven, Self-Serve Open Data

NVCOG translated recurring data requests into self-serve visualizations housed on a public data page, strengthening its role as a regional data hub and reducing staff burden.

Low-Lift, High-Impact Tools

Datawrapper enables interactive charts without the need for developers, coders, or GIS specialists.

Sample

Change in Employment Annual Averages, 2018-2023

Labor force measures are based on the civilian noninstitutional population 16 years old and over.

Geography	2018 Unemployment Rate	2023 Unemployment Rate	Percent Change in Unemployment Rate	Percent Change in Labor Force
Ansonia	5.7	5.1	-10.5%	-1.6%
Beacon Falls	3.8	3.6	-5.3%	-0.6%
Bethlehem	3.8	3.8	0.0%	-2.2%
Bristol	4.6	4.2	-8.7%	-1.5%
Cheshire	3.0	2.8	-6.7%	1.9%
Derby	5.2	4.6	-11.5%	-2.7%
Middlebury	3.4	3.4	0.0%	0.8%
Naugatuck	4.7	4.4	-6.4%	-2.6%
Oxford	3.4	3.2	-5.9%	2.0%
Plymouth	4.6	4.1	-10.9%	-2.0%
Prospect	3.6	3.3	-8.3%	-1.3%
Seymour	4.3	4.1	-4.7%	-1.2%
Shelton	4.1	4.0	-2.4%	-0.7%
Southbury	3.9	3.7	-5.1%	-0.1%
Thomaston	3.8	3.5	-7.9%	-1.8%
Waterbury	6.6	5.9	-10.6%	-2.9%
Watertown	3.6	3.6	-2.7%	-1.7%
Wolcott	3.7	3.7	0.0%	-1.2%
Woodbury	3.4	3.2	-5.9%	-1.9%

Key Takeaway

By building a public, self-serve pathway for common ACS requests, NVCOG reduced repetitive staff time spent responding to one-off inquiries while expanding access to consistent, interpretable regional data.

RIDOT Travel-Time Dashboard: Real-Time Travel Information for Emergency

Snapshot View

Agency:
Rhode Island Department of Transportation (RIDOT)

Communication Need:
Inform in real-time

Audience:
General public and travelers

Type of Data:
Live-feed, geospatial, and travel time data

Type of Analysis:
Live status monitoring with some trends

Visualization Medium:
Online dashboard

Access Link:
https://www.arcgis.com/apps/dashboards/d2753f41995145768958c6ee8ce1704f#

Overview

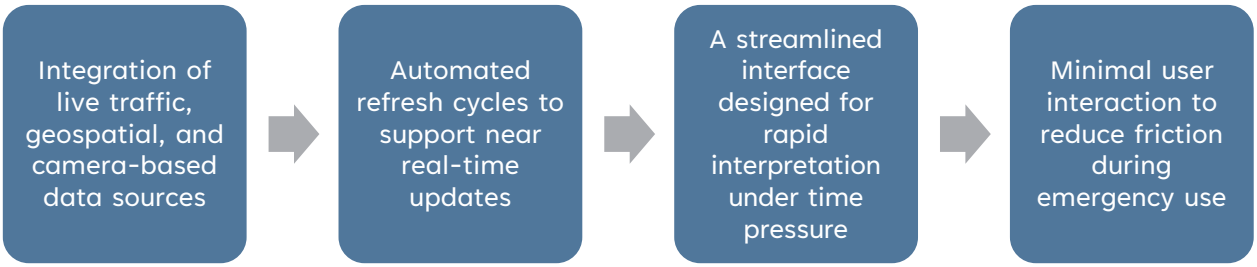
RIDOT developed an interactive travel-time dashboard to provide the public with clear, real-time information during an emergency bridge closure. The dashboard was designed to help travelers understand current delays and conditions on alternate routes, supporting quick and informed travel decisions during a rapidly evolving situation.

The visualization emphasizes immediacy and clarity. Rather than presenting historical performance or detailed analytics, the dashboard focuses on current travel conditions, using simple visual cues to communicate delay severity and route impacts at a glance. This approach allows users to quickly interpret conditions without navigating complex controls or filters.

How it Works

The dashboard is built using the ArcGIS Dashboard application and is powered by a custom backend connected to live traffic and operational data feeds. Information refreshes approximately every five minutes, ensuring that displayed conditions remain closely aligned with real-world conditions throughout the emergency response period.

Key development elements include:



This architecture allows the dashboard to function reliably as both a communication and situational awareness tool during high-impact events.

Governance

Governance for the dashboard emphasizes reliability, security, and operational continuity:

- Live data feeds supported by active monitoring and maintenance protocols
- Periodic quality checks to ensure accuracy and consistency
- Firewall protections and access controls to safeguard systems
- Clear operational ownership during the emergency response period

These practices help ensure that the dashboard remains stable and trustworthy when public reliance is highest.

Highlights

Visualization as Emergency Infrastructure

Visualization is treated as operational infrastructure that supports incident management and public communication simultaneously.

Fresh Data Is the Message

Near real-time updates align with immediate traveler needs.

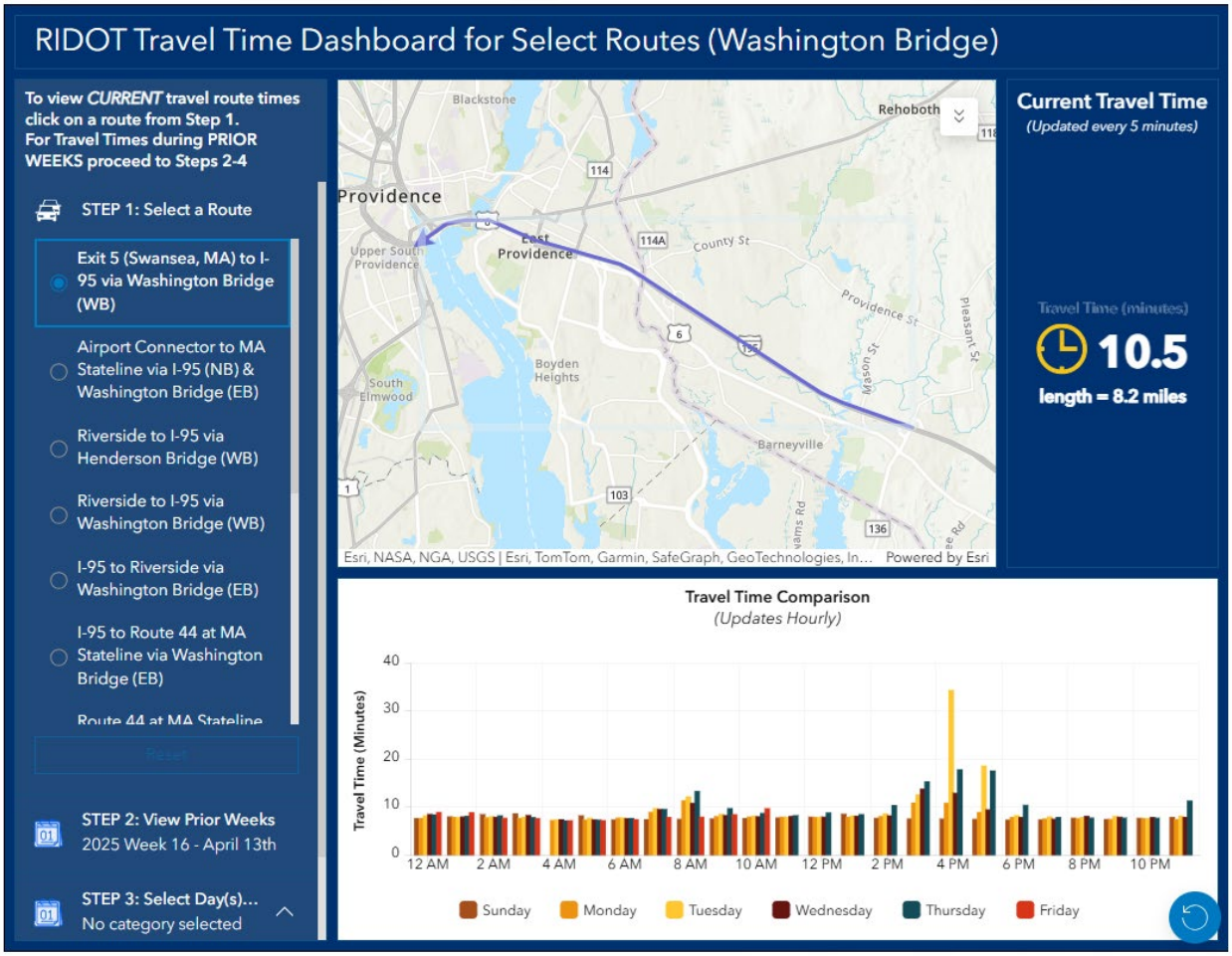
Designed for Speed, Not Exploration

The interface is intentionally constrained. Visual hierarchy, color-coding, directional indicators, and limited filtering prioritize fast comprehension.

Context Builds Confidence

Combining travel times with live camera feeds helps users interpret conditions more confidently.

Samples



Key Takeaway

RIDOT demonstrates how real-time dashboards can support public mobility and trust during emergencies by translating live operational data into clear, intuitive visuals that enable fast, informed decision-making for a general audience.

Caltrans 360 Tours: Immersive Stakeholder Engagement

Summary

Agency:
California Department of Transportation (Caltrans)

Communication Need:
Inform

Audience:
Public and stakeholders, contractors, engineers

Type of Data:
Geospatial, photographic, and qualitative

Type of Analysis:
Spatial relationship, project impact visualization

Visualization Medium:
Online 360-degree virtual tour

Access Link:
https://www.youtube.com/@CaltransD4Visualizations

Overview

Caltrans District 4 created 360-degree virtual tours to help stakeholders visualize project alternatives and understand tradeoffs earlier in the project development process. These immersive visuals provide context that is difficult to convey through traditional plans or static renderings alone.

Instead of treating visualization as a late-stage deliverable tied only to environmental documentation, the team uses these materials as a practical engagement tool for public meetings, agency coordination, and right-of-way conversations. The immersive format allows viewers to explore proposed changes from multiple perspectives and see how alternatives interact with existing conditions. This early, shared understanding has proven especially valuable for environmental engagement, where clearer context can reduce miscommunication and support more productive permitting conversations.

"... I was working the 360 viewer the entire meeting and was quite popular. I think folks really gravitate to the format and the interactive content. In my mind it has become essential to the public meeting format for my projects moving forward."

- Zachary Gifford, Senior Environmental Scientist
Caltrans District 4 Environmental Planning and Engineering

"The immersive environment of the 360 Tour really helped not only myself but all the stakeholders quickly understand the constraints and the opportunities of the project. It's a great way to accelerate the permitting process by quickly bringing everyone up to speed."

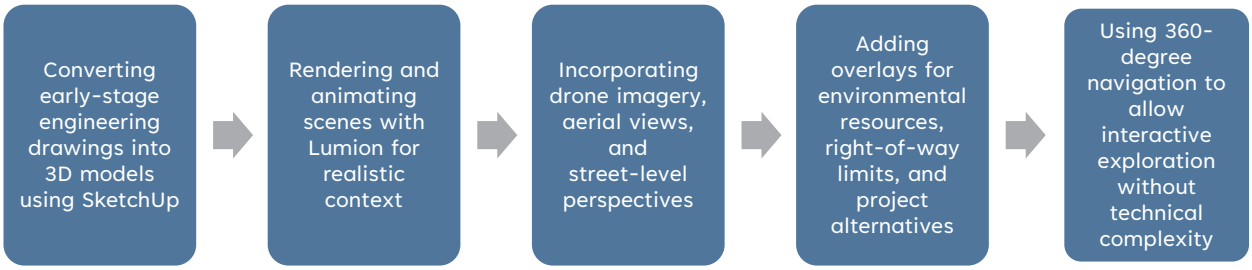
- Eileen M. White, P.E., Executive Officer
San Francisco Bay Regional Water Quality Control Board

How it Works

The 360-degree tours are produced in-house by a dedicated visualization team embedded within Caltrans District 4. The team works directly with project development teams during scoping and early planning to identify where immersive visualization will add value.

The visualization team joins Project Development Team (PDT) meetings, scopes visualization needs based on stakeholders and project phase, and then builds products ranging from quick sketches to immersive 360 tours. CAD information is translated into 3D models and rendered in tools selected for speed and scalability.

Key development elements include:



By engaging early and tailoring visuals to specific stakeholder concerns, the team ensures visualizations support discussion rather than react to conflict.

Governance

Caltrans embeds visualization staff directly within project development teams, ensuring early, consistent involvement in planning and engagement decisions. This structure is supported by district leadership and integrated into project initiation and scoping processes. Their governance emphasizes:

- Early inclusion of visualization in project budgets and work plans
- Close coordination with environmental planners, engineers, and public information staff
- Flexibility to adapt visuals based on audience and project context rather than rigid templates

This embedded model helps ensure visualizations remain relevant, timely, and aligned with project needs.

Highlights

Immersive Context for a Shared Understanding
The 360-degree conveys scale, proximity, and impact without requiring interpretation of engineering plans, supporting shared understanding among stakeholders.

Visualization Used Upstream
Visualization is introduced early to frame problems, compare alternatives, and guide discussion before decisions begin to solidify.

Visualization as a Team Function
Embedding visualization staff within project teams enables proactive use, reduces rework, and strengthens coordination and communication.

From Explanation to Exploration
Interactive navigation lets stakeholders move through the project environment themselves, shifting engagement from passive explanation to active understanding.

Samples

Key Takeaway

Caltrans shows how immersive visualization, when embedded early and supported by dedicated expertise, can replace abstract technical materials with shared, intuitive understanding and lead to more productive stakeholder engagement.

FDOT Source Book: Building Trust Through Transparent Performance Reporting

Snapshot View

Agency:
Florida Department of Transportation (FDOT)

Communication Need:
Inform and monitor progress

Audience:
Leadership, planners, MPOs, public

Type of Data:
Quantitative, performance, geospatial

Type of Analysis:
Trends, comparisons, performance targets

Visualization Medium:
Interactive web portal with embedded dashboard and maps

Access Link:
https://fdotsourcebook.com/

Overview

The FDOT Source Book is an interactive web portal that provides centralized access to multimodal transportation performance data across Florida. What began as a collection of spreadsheets and static reports has evolved into a comprehensive, publicly accessible platform that supports performance monitoring, planning coordination, and transparency.

Designed to serve a broad audience, including MPOs, internal staff, and the public, the portal allows users to explore historical trends, track key metrics, and visualize performance across Florida's transportation system in a transparent and consistent format. The Source Book integrates interactive charts, dashboards, and maps that enable comparison across districts, transportation modes, and time periods. Consistent layouts, explanatory text, and uniform color schemes support repeated use and help users navigate complex performance information with confidence. By making performance data easy to explore and download, the platform reinforces FDOT's role as a trusted source of statewide transportation information.

How it Works

The Source Book is supported by a robust technical and data infrastructure. A SQL Server database stores more than 70 multimodal performance measures spanning safety, mobility, reliability, transit, aviation, and other areas. Scripts process raw datasets and feed calculated

metrics directly into Tableau, which powers the interactive dashboards and charts. Geospatial components are integrated through ESRI tools, including interactive maps and downloadable shapefiles hosted via ArcGIS Hub and Open Data. The platform operates on a rolling update schedule, publishing data as soon as it becomes available following rigorous quality assurance and quality control processes, and clearly displaying the most recent update date on each page. This approach ensures that users are working with current, reliable information while maintaining consistency across measures and modules.

Governance

The Source Book reflects a mature and intentional data governance model:

- Data storage, transformation, and visualization are intentionally separated to support accuracy, scalability, and trust, with a centralized SQL database, version-controlled scripts, and Tableau-based dashboards
- Version-controlled scripts support consistent metric calculation and reliable updates
- Regular coordination with safety, modal, and analytics teams ensures alignment across programs
- Documented processes and data dictionaries support transparency and continuity
- Training resources and recorded webinars help onboard and support users

Over time, this governance approach has helped position the platform as FDOT's authoritative performance reporting tool.

Highlights

Consistency Enables Comparability

Standardized layouts, scales, and color schemes make it easier to compare performance across time, geography, and modes.

Transparency Builds Credibility

Pairing each visualization with definitions, calculation methodology, reporting frequency, update dates, and downloadable data supports informed and confident use of performance measures.

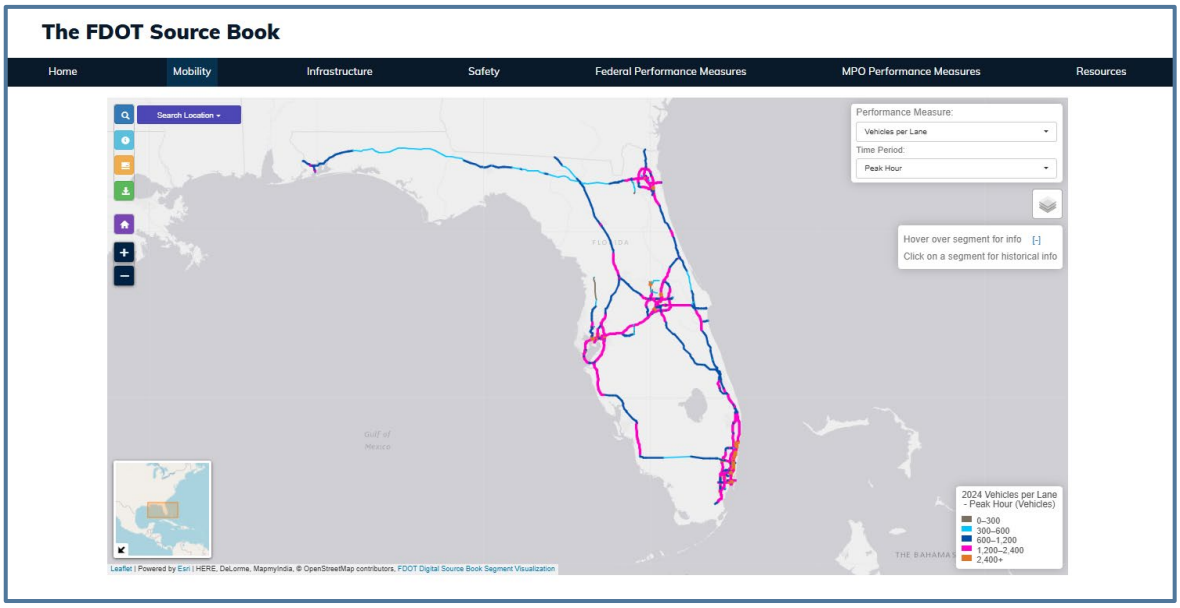
Governance Sustains Scale

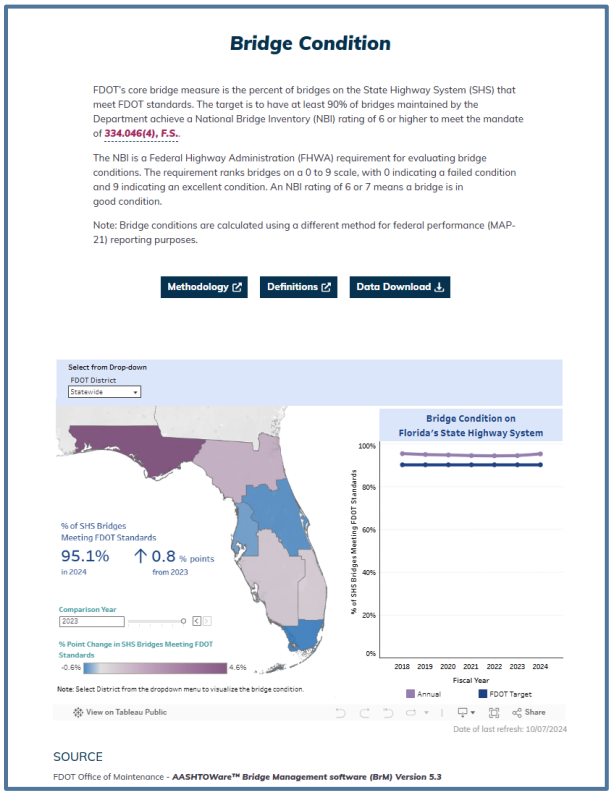
Strong coordination, documentation, and database infrastructure enable the platform to grow while remaining reliable and maintainable.

Support Turns Tools into Practice

Training resources and webinars help translate the platform from a reporting tool into a routinely used planning resource.

Samples





Key Takeaway

FDOT Source Book shows how strong governance, consistent design, and integrated data infrastructure can transform performance reporting into sustained internal coordination, external communication, and public accountability.

MnDOT Performance Dashboard: Simplicity for Shared Ownership

Summary

Agency:
Minnesota Department of Transportation (MnDOT)

Communication Need:
Inform

Audience:
General public, elected officials, internal staff

Type of Data:
Quantitative and narrative trend context

Type of Analysis:
Trends, benchmarks, target achievement, projections

Visualization Medium:
Interactive web portal with embedded Power BI dashboards across multiple pages

Access Link:
https://www.dot.state.mn.us/measures/index.html

Overview

MnDOT's Performance Dashboard is a public-facing website that presents transportation performance data in a clear, approachable, and consistent way. It consolidates key metrics from across the agency into a single platform that is easy to navigate and useful for both internal and external audiences, beginning with a "Snapshot" landing page that provides a high-level view of system performance.

The site is organized by performance area, allowing users to explore individual measures. Each page pairs interactive visuals with straightforward explanations about what is being measured, why it matters, and the strategies MnDOT and its partners are using to meet performance goals. This approach helps make data more understandable and policy-relevant. The dashboard supports leadership briefings, internal discussions, and public communication.

How It Works

MnDOT's performance dashboard is supported by a practical, human-centered production workflow that reflects both the structure of the agency's data systems and available staff capacity.

Data Export → Central Assembly & Standardization → Measure-Specific Preparation → Update & Publishing

Most measures originate from specific program areas such as pavement, safety, and traffic engineering are exported by subject matter experts on a regular schedule. These handoffs follow a structured and repeatable process that ensures consistency in definitions, timeframes, and reporting assumptions.

The performance team uses spreadsheets as a staging environment to standardize the datasets. This includes aligning definitions, confirming units and time periods, checking for outliers, and formatting tables for Power BI. For spatial or network-related measures, such as congestion, additional steps are taken to associate data with roadway segments or geographic areas.

Once visuals are prepared in Power BI, they are embedded into MnDOT's public dashboard site. Updates follow an annual or periodic schedule aligned with performance reporting cycles. This process allows MnDOT to maintain a stable, transparent platform without relying on automated data pipelines or complex integrations.

Governance

MnDOT's dashboard reflects a centralized but practical governance approach focused on consistency and sustainability:

- Performance reporting is centrally coordinated, with standardized dashboard templates and page layouts
- Visual design and organization align with agency planning documents and strategic objectives
- Coordination across divisions supports consistent definitions, messaging, and update timing
- Performance staff, with guidance from Communications staff, ensure metrics are framed in plain language and are accessible to non-technical audiences

Highlights

Measures Are Framed Around Agency Intent
Each page clearly states what the measure represents and how MnDOT uses it, anchoring the visualization to agency goals rather than leaving users to infer purpose from charts alone.

Long-Term Trends Are Prioritized Over Point-in-Time Results
Visuals emphasize multi-year trends and condition trajectories, helping users focus on system performance over time instead of reacting to short-term variation or single-year changes.

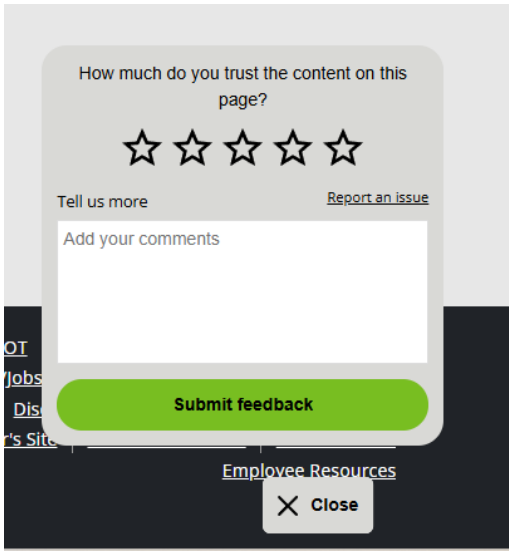
Disaggregation Adds Meaning
When beneficial for understanding, measures are broken into subcategories and supported by simple filters, allowing users to explore key dimensions of performance while preserving a clear, readable layout.

Persistent Navigation Supports Orientation and Discovery
A consistent right-hand navigation menu shows users where they are within the performance website while making it easy to move between related measures, encouraging exploration without losing context.

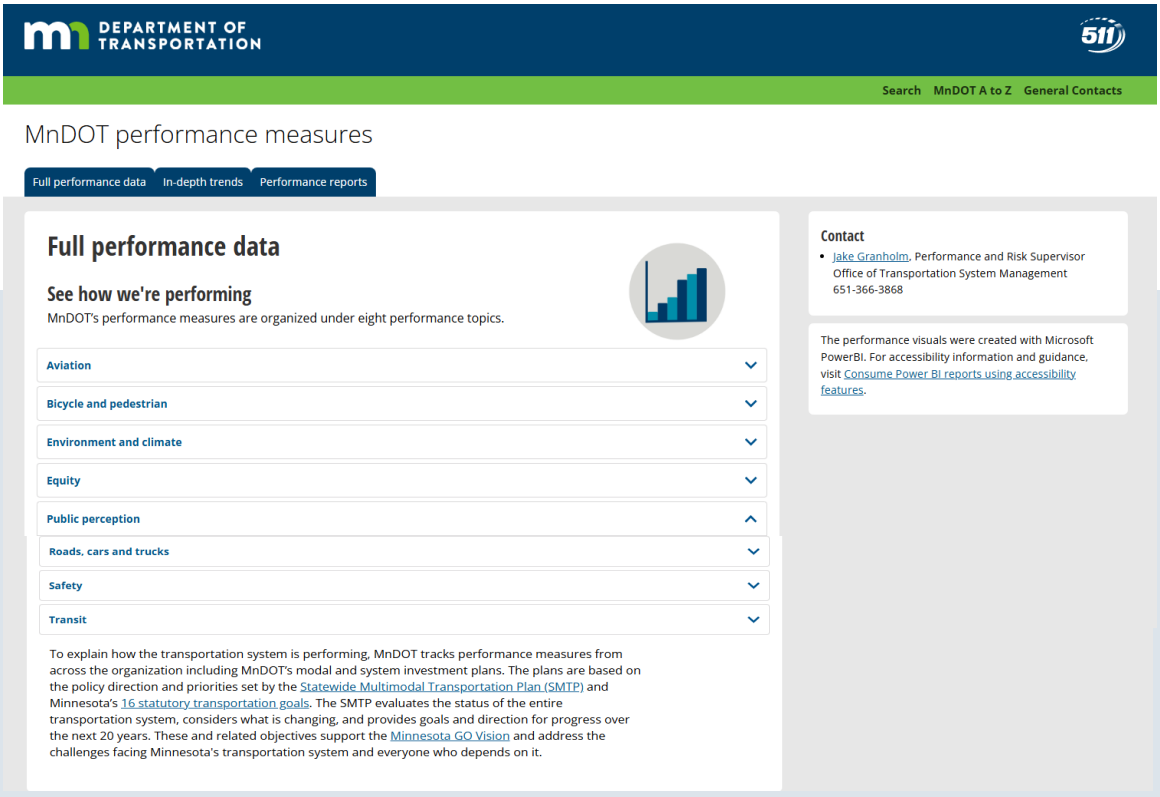
Feedback Loop

MnDOT's Performance Measures Dashboard includes two notable features that support user engagement and trust: (1) direct contact information for the staff member responsible for each dashboard, and (2) an embedded feedback tool. Each measure page lists the name, phone number, and hyperlinked email address of the supervising staff member, encouraging open lines of communication.

A pop-out interface allows users to rate their level of trust in the dashboard content on a scale of 1 to 5, provide written comments, and report issues. Feedback is routed to MnDOT's communications team. Together, these features support a two-way feedback loop and give users an easy way to ask questions, report concerns, or suggest improvements, while demonstrating how agencies can integrate feedback tools directly into digital platforms.

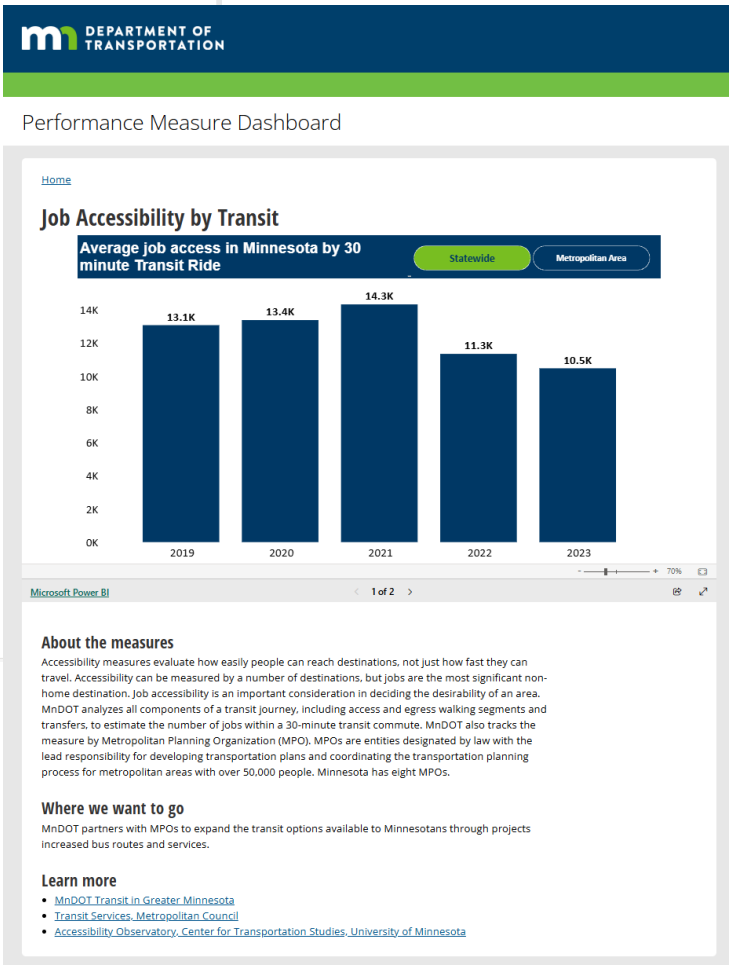


Samples



Samples

MnDOT performance measures



Key Takeaway

MnDOT Performance Dashboard demonstrates how intentional simplicity, strong narrative framing, and disciplined interactivity can make performance information usable for both internal decision-making and public transparency. By pairing clear explanations with consistent layouts, limited filters, and intuitive navigation, MnDOT enables users to understand agency performance without requiring advanced analytical skills or complex data infrastructure.

Arizona DOT: Social Media Graphics for Public Information

Summary

Agency:
Arizona Department of Transportation (ADOT)

Communication Need:
Inform

Audience:
General public

Type of Data:
Geospatial visualization and project impacts

Type of Analysis:
Basic location and impact illustration

Visualization Medium:
Social media image (Instagram)

Access Link:
https://www.instagram.com/p/DIRuoLJJAmb

Overview

ADOT creates graphics optimized for mobile screens that deliver timely transportation updates to the public via social media. The visuals focus on urgent roadway changes such as closures and detours and are designed to be understood quickly while scrolling on a phone.

A bird's-eye perspective, clear titles, and concise labels help users grasp key information at a glance. Rather than presenting detailed data or technical analysis, the graphics emphasize immediate situational awareness by showing affected areas, closures, and available alternate routes. By using a widely adopted social media platform, ADOT is able to distribute critical information efficiently, making the graphics especially effective during short-lived, time-sensitive events.

How It Works

ADOT uses its Instagram platform to communicate time-sensitive roadway information directly to the public. When closures or detours arise, operations or project staff quickly share location and impact details that are translated into clear, map-based graphics for public use.

That information is translated into a single, simplified visual that emphasizes spatial understanding. The image is published through ADOT's official Instagram account, enabling rapid distribution and resharing during active disruptions. The product is designed for immediacy and clarity, rather than long-term reference or analytical exploration.

Governance

Content is governed through ADOT's communications and public information functions:

- Decision-making emphasizes message clarity, accuracy, and timing, reflecting the graphic's role as a rapid public awareness tool
- Coordination with operations or project teams supports validation of closures and detours prior to publishing
- Visuals follow agency branding and readability standards appropriate for public-facing communications
- Products are not treated as long-term or archival data assets, aligning governance effort with the graphic's short lifecycle

Highlights

Spatial Orientation Supports Immediate Wayfinding
An overhead view allows users to quickly identify where an impact is occurring and how it relates to surrounding roadways, supporting rapid situational awareness without technical map reading skills.

Platform-Specific Design Improves Comprehension
The graphic is designed specifically for Instagram's mobile feed, using scale, orientation, and spacing that support quick understanding without requiring zooming or interaction.

Single-Frame Visuals Reduce Cognitive Load
By communicating the full message within one static image, the graphic avoids reliance on captions, links, or multi-slide carousels, ensuring essential information is conveyed even when users only glance at the post.

Short-Lived Media Supports Timely Updates
Instagram enables ADOT to share temporary but essential roadway updates with the public, prioritizing speed and accessibility over long-term archival value.

Samples

Key Takeaway

Arizona DOT's social media graphic shows how public agencies can use platform-aware visuals to communicate with the public. By focusing on spatial clarity, mobile accessibility, and a single-image format, ADOT helps viewers quickly understand road closures and detours.

WSDOT Travel Trends Dashboard: Communicating Traffic Conditions

Summary

Agency:
Washington State Department of Transportation (WSDOT)

Communication Need:
Inform and monitor evolving travel conditions

Audience:
Public and industry stakeholders

Type of Data:
Near real-time travel volumes, speeds, freight activity, toll data

Type of Analysis:
Trends, comparisons

Visualization Medium:
Tableau dashboard embedded in website

Access Link:
https://wsdot.wa.gov/about/data/travel-trends-dashboard/default.htm

Overview

The Travel Volume and Speed Trends Dashboard provides near real-time insight into highway, toll, and freight travel along Washington's most heavily traveled corridors. The dashboard builds on data pipelines and workflows originally developed for WSDOT's COVID-19 Travel Trends effort and is updated daily as new data become available.

Information is organized into four primary categories: highway traffic volumes, toll facility volumes, highway speeds, and freight traffic volumes. By pairing recent conditions with historical baselines, the dashboard helps users understand how travel patterns are evolving over time. On-page guidance supports consistent interpretation of charts and filters, making the dashboard a practical resource for public transparency, partner coordination, and ongoing monitoring of statewide travel trends.

"The goal was never to react to one day of data. It's about understanding patterns and context."

- Performance Management Staff, WSDOT

How It Works

The Travel Trends Dashboard is supported by an automated daily workflow developed and maintained internally by WSDOT staff, allowing the site to refresh quickly when new data become available.

Raw traffic data is managed through an internal web-based environment built with Python and Django. Each morning, Python scripts retrieve travel data, including volumes, speeds, freight indicators, and toll information, and process it through scheduled jobs. These scripts perform data quality checks, clean and aggregate records, and prepare standardized datasets for visualization. The workflow also identifies missing or faulty sensor data and uses historical information to fill gaps when necessary, helping ensure reliable daily updates.

Once processing is complete, the datasets are loaded into Tableau, where dashboards are refreshed and published through Tableau Public and embedded on WSDOT's website. This approach enables consistent daily updates while allowing staff to review the data before publication. Users can explore near real-time conditions alongside historical trends, supporting both immediate situational awareness and longer-term analysis of travel patterns.

Governance

WSDOT's Travel Trends Dashboard reflects a hybrid governance model that combines automation with deliberate oversight:

- Daily data processing and updates are handled through automated scripts to ensure timeliness
- Internal quality control checks are embedded in the data preparation process
- Dashboard maintenance and refinement are supported by a small, specialized internal team
- Strong executive sponsorship helped institutionalize the dashboard beyond its initial COVID-19 use case
- Ongoing use by leadership, partners, and the public reinforces accountability and continuity

Together, automation and oversight have helped the dashboard remain both responsive and trustworthy over time.

Highlights

Real-Time Data Is Framed for Interpretation, Not Reaction

Although the dashboard updates daily, visuals emphasize trends and context rather than momentary spikes, helping users interpret variability without overreacting to short-term changes.

Automation Is Paired with Human Oversight

Automated scripts handle daily processing, but quality checks and staff review remain integral, reinforcing trust in near real-time public reporting.

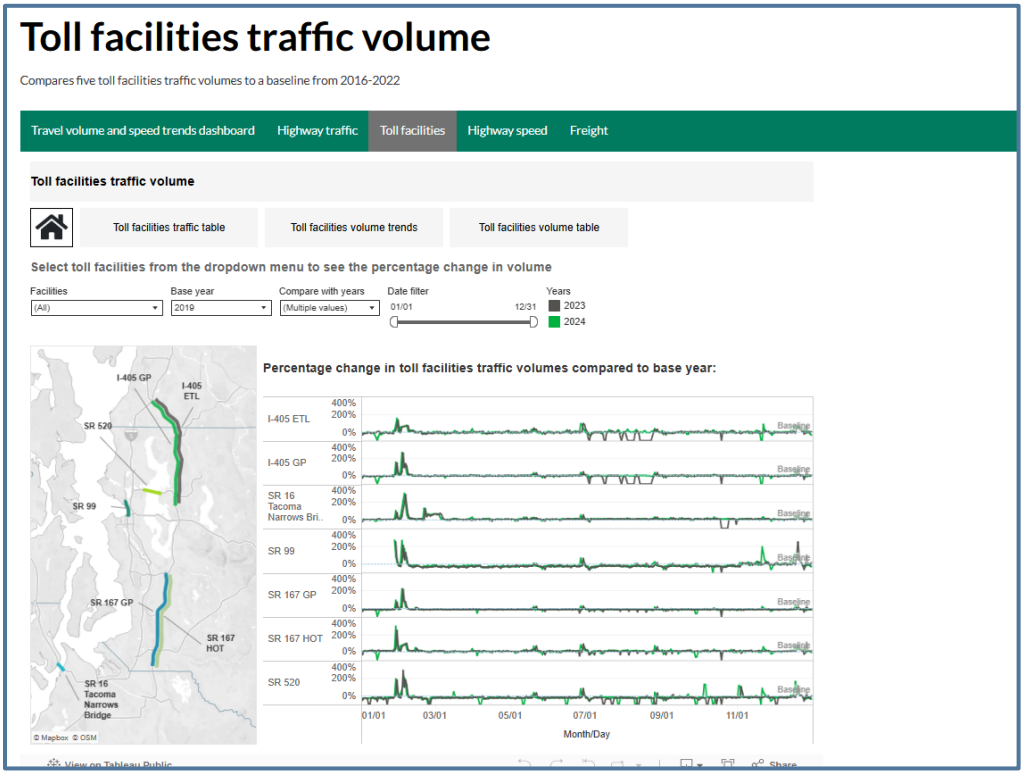
Multiple Time Scales Support Different Decisions

The dashboard allows users to view recent conditions alongside longer historical baselines, enabling the same tool to support executive briefings, partner coordination, and public understanding.

Operational Data Is Translated for Public Use

Complex operational inputs, such as toll transactions and system performance data, are aggregated and summarized into clear metrics that allow non-technical users to understand system use without exposing raw or sensitive data.

Samples



Key Takeaway

WSDOT's Travel Trends Dashboard shows how automation, internal quality control, and sustained leadership support can transform near real-time data into a trusted public resource. By combining daily updates with clear visual standards, WSDOT enables timely situational awareness while preserving analytical credibility.

TxDOT Visualization Guidelines and Tableau Community of Practice

Summary

Agency:
Texas Department of Transportation (TxDOT)

Communication Need:
Inform about visualization guidelines and resources

Audience:
TxDOT employees and contractors

Type of Data:
Quantitative, qualitative

Type of Analysis:
Not applicable (standards and guidance)

Visualization Medium:
Website

Access Link:
https://www.txdot.gov/about/brand-guidelines.html

Overview

TxDOT has agency-wide standards that govern how data are presented across platforms and audiences. Through its publicly accessible Brand Guidelines and Data Visualization Guidelines, the agency provides consistent direction on design elements like color, typography, symbology, chart selection, and accessibility.

These resources promote visual consistency and credibility across a large organization, while still allowing flexibility for different programs and use cases. Because the same online resource is used by both internal staff and external consultants, the guidelines help ensure that all visual materials, regardless of who creates them, adhere to a common set of expectations.

To reinforce these standards and encourage continuous learning, TxDOT also maintains a Tableau-focused Community of Practice, where staff from across the agency share knowledge, showcase their dashboards, and discuss evolving best practices.

How It Works

The Data Visualization Guidelines extend this consistency to charts and dashboards, offering guidance on chart selection, color use, hierarchy, accessibility, and common pitfalls in data presentation.

In addition to standardized guidance, TxDOT fosters internal consistency and peer learning by offering regular collaboration opportunities through a Tableau Community of Practice (CoP).

The CoP meets at least quarterly and draws an average of 75 Tableau developers and enthusiasts from across the agency. Sessions typically include project walkthroughs, peer feedback, open discussions, and tutorials on various Tableau features or design techniques.

By creating a space where staff can share works in progress, offer suggestions, and learn from each other, the CoP functions as an ongoing support structure that helps embed good visualization practices across the organization. TxDOT also hosts Tableau Office Hours within the CoP, providing their Data Analysts collaborative support, team-based solutions, and expert guidance from Tableau Doctors for development challenges. The CoP aspires to be a feedback loop, helping refine guidance over time while supporting staff adoption through peer learning rather than enforcement alone.

Governance

TxDOT's approach reflects a centralized but enabling governance model:

- Visualization and branding standards are centrally defined and publicly documented
- Guidelines apply to internal staff, consultants, and external partners
- A Community of Practice supports implementation through training, shared templates, and peer support
- Standards emphasize accessibility, clarity, and consistency rather than prescribing specific tools
- Feedback from users informs iterative updates to guidance and examples

This structure allows TxDOT to scale visualization efforts across a large organization while maintaining quality and coherence.

Highlights

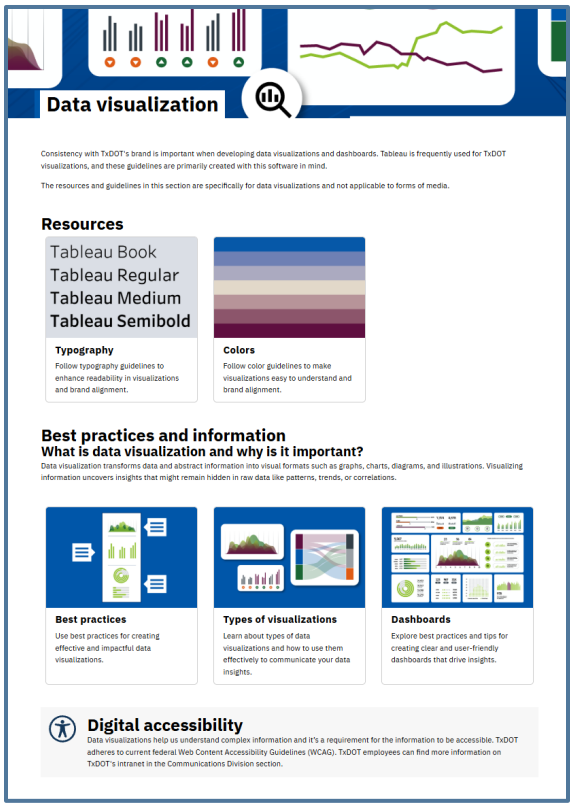
Standards as Shared Infrastructure
Clear, public guidelines function as foundational infrastructure, reducing rework and improving consistency across projects, districts, and teams.

Centralized Standards for Decentralized Creation
By centralizing standards and resources, TxDOT enables staff across the agency to produce visualizations confidently without relying on a single production team.

Communities of Practice Reinforce Adoption
The Tableau Community of Practice complements formal guidance by providing training, examples, and peer support, helping standards translate into everyday practice.

Operational Data Is Translated for Public Use
Clear guidance on charts, colors, and accessibility removes low-level design decisions, allowing staff and consultants to focus on analysis rather than visual debates while improving consistency and delivery speed.

Samples



Key Takeaway

TxDOT demonstrates how clear, centralized visualization standards can set a strong foundation for consistent, accessible design across tools and formats, from presentations and reports to Tableau dashboards. These standards help ensure visualizations meet internal quality expectations and align with agency branding and accessibility goals. That foundation is reinforced and sustained through an active Tableau Community of Practice that meets quarterly and provides a space for ongoing learning, collaboration, and knowledge sharing. Together, TxDOT's guidelines and CoP offer a dual approach that supports both technical consistency and professional growth, making it easier for staff at all levels to create impactful, user-friendly visuals.

TxDOT GIS Governance and Map Guidelines

Summary

Agency:
Texas Department of Transportation (TxDOT)

Communication Need:
Inform about visualization guidelines and resources

Audience:
TxDOT employees and contractors

Type of Data:
Geospatial

Type of Analysis:
Not applicable (standards and guidance)

Visualization Medium:
Website

Access Links:
https://www.txdot.gov/about/brand-guidelines/map-guidelines.html

Overview

TxDOT's Map Guidelines emerged from the formation of the TxDOT GIS Work Group (GISWG), which operated within a broader Enterprise Governance framework. This framework includes tactical and executive steering committees composed of senior leadership, along with work groups focused on specialized topics such as GIS.

In its early stages, the GISWG prioritized the development and publication of GIS standards, including metadata requirements and mapping guidelines. These standards were communicated agency-wide to create consistency in how maps were produced and shared. Over time, the work of the GISWG helped build the case for a permanent statewide GIS function.

Today, TxDOT's Statewide GIS section, also known as Geographic Information Management, provides dedicated staff to support GIS efforts across the agency. The Map Guidelines are part of a broader ecosystem that includes internal websites, Teams channels, annual conferences, GISP certification support, training sessions, office hours, and ongoing knowledge-sharing

How It Works

The Mapping Guidelines establish consistent approaches for basemaps, symbology, labeling, scale, and context, ensuring that maps produced across districts and divisions are interpretable and aligned with TxDOT's visual identity.

The GIS Community of Practice reinforces these standards through structured and informal engagement opportunities. Staff participate in trainings, conferences, and regular collaboration channels where mapping practices are discussed and refined. Rather than functioning as a static rulebook, the guidelines are supported by an active professional network that promotes shared understanding and continual improvement.

Governance

Governance for TxDOT's GIS program reflects an enterprise-level approach to spatial data and mapping standards.

- Developed within an Enterprise Governance framework that includes executive and tactical oversight
- Initially led by the GIS Work Group, which established early GIS standards and documentation
- Resulted in the creation of a permanent Statewide GIS section with dedicated staff
- Supported by an ongoing GIS Community of Practice offering training, conferences, and collaboration tools
- Designed to sustain long-term consistency in GIS practices across a large and decentralized agency

Highlights

Institutionalization Transforms Initiative into Program

The transition from a work group to a permanent Statewide GIS section demonstrates how mapping standards can evolve into sustained organizational capacity.

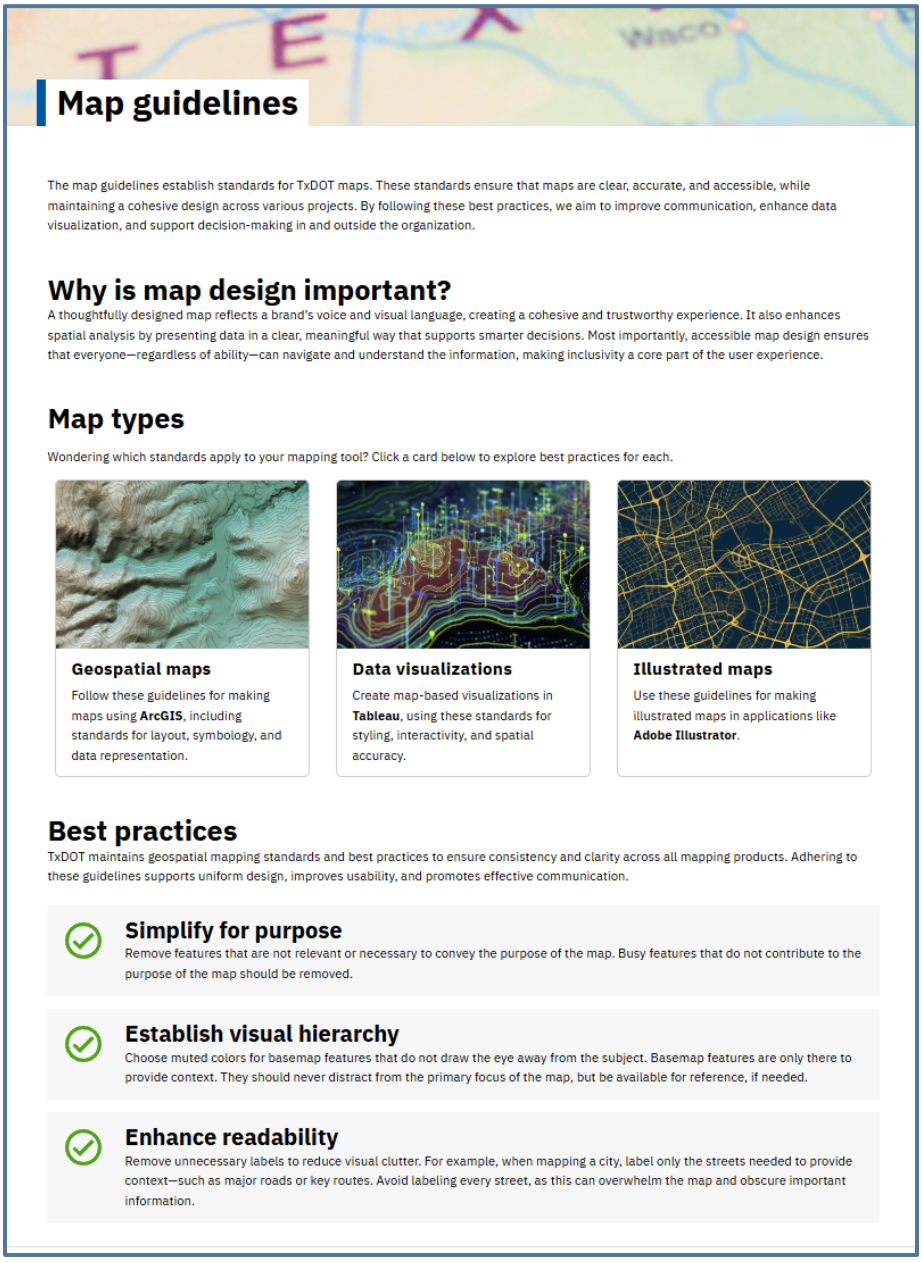
Standardized Spatial Rules Improve Analytical Consistency

Common guidance on metadata, projection, symbology, and network definitions ensures maps and spatial analyses are comparable across divisions and projects.

Internal Ecosystems Support Ongoing Practice

Dedicated internal sites, Teams channels, conferences, and certification support create a structured environment where GIS knowledge is continuously shared and maintained.

Samples



Map guidelines

The map guidelines establish standards for TxDOT maps. These standards ensure that maps are clear, accurate, and accessible, while maintaining a cohesive design across various projects. By following these best practices, we aim to improve communication, enhance data visualization, and support decision-making in and outside the organization.

Why is map design important?

A thoughtfully designed map reflects a brand's voice and visual language, creating a cohesive and trustworthy experience. It also enhances spatial analysis by presenting data in a clear, meaningful way that supports smarter decisions. Most importantly, accessible map design ensures that everyone—regardless of ability—can navigate and understand the information, making inclusivity a core part of the user experience.

Map types

Wondering which standards apply to your mapping tool? Click a card below to explore best practices for each.

Geospatial maps

Follow these guidelines for making maps using **ArcGIS**, including standards for layout, symbology, and data representation.

Data visualizations

Create map-based visualizations in **Tableau**, using these standards for styling, interactivity, and spatial accuracy.

Illustrated maps

Use these guidelines for making illustrated maps in applications like **Adobe Illustrator**.

Best practices

TxDOT maintains geospatial mapping standards and best practices to ensure consistency and clarity across all mapping products. Adhering to these guidelines supports uniform design, improves usability, and promotes effective communication.

Simplify for purpose

Remove features that are not relevant or necessary to convey the purpose of the map. Busy features that do not contribute to the purpose of the map should be removed.

Establish visual hierarchy

Choose muted colors for basemap features that do not draw the eye away from the subject. Basemap features are only there to provide context. They should never distract from the primary focus of the map, but be available for reference, if needed.

Enhance readability

Remove unnecessary labels to reduce visual clutter. For example, when mapping a city, label only the streets needed to provide context—such as major roads or key routes. Avoid labeling every street, as this can overwhelm the map and obscure important information.

Key Takeaway

TxDOT demonstrates how formal enterprise governance combined with a strong GIS Community of Practice can institutionalize mapping standards across a large organization. The Map Guidelines function not as isolated design rules, but as part of a broader ecosystem that supports consistency, training, and long-term GIS capacity.

MAPA High Priority Network Tool: Integrating Data, Risk, and Community Voice for Safety

Summary

Agency:
Metropolitan Area Planning Agency (MAPA)

Communication Need:
Inform

Audience:
Transportation and community stakeholders

Type of Data:
Quantitative, qualitative, and geospatial

Type of Analysis:
Network screening, comparison

Visualization Medium:
GIS Tool

Access Link:
https://mapacog.github.io/hpn-tool/

Overview

MAPA developed the High Priority Network (HPN) Tool as part of its Safe Streets and Roads for All Action Plan to support proactive, system-level safety planning across the Omaha–Council Bluffs region. Rather than relying solely on historical crash data, the tool integrates three complementary signals: where serious crashes have occurred, where future risk is likely, and where community members report feeling unsafe.

This approach reframes safety analysis from a purely reactive exercise to one that balances historical need, predicted risk, and lived experience. By combining these perspectives into a single decision space, MAPA created a tool that helps agencies identify both known problem locations and emerging safety risks, including areas where crashes may be underreported but community concern is high.

To complement the technical tool, MAPA also developed Safety Snapshots: concise, one-page visuals that translate complex safety analysis into clear, audience-specific narratives for leaders, stakeholders, and the public.

How It Works

The High Priority Network (HPN) Tool is a GIS-based analysis and visualization tool developed using an ArcGIS environment. It evaluates every roadway segment and intersection in the Omaha–Council Bluffs region using a single, regionwide dataset that integrates information from both Iowa and Nebraska.

To support consistent analysis across state lines, MAPA first standardized crash and roadway data from both states. Crash records were aligned across formats and coding schemes, consolidated into one record per crash, and spatially assigned to a unified roadway network. This created a common foundation for network-level safety screening.

The tool integrates three complementary data inputs. Historical fatal and serious injury crashes represent safety need. Roadway characteristics, such as lane count and speed limits, are used to estimate systemic risk at locations where severe crashes may occur. Community-reported safety concerns are incorporated through a spatial survey, with responses geocoded and linked to the same roadway network.

Within the GIS tool, users can explore these inputs individually or in combination and apply filters based on crash types and roadway characteristics. To support non-technical audiences, MAPA also developed Safety Snapshots, which translate the underlying GIS analysis into concise, one-page visuals for briefings, public communication, and early coordination.

Governance

Governance for the High Priority Network Tool emphasized transparency, shared understanding, and long-term usability in a multi-jurisdictional region.

- Developed by a consultant in close coordination with MAPA, with iterative review to confirm data assumptions, methods, and usability
- MAPA maintains ownership of the underlying datasets, analytical framework, and outputs as a regional planning resource
- Scoring logic, network rules, and data inputs are documented and visible to support partner understanding and trust
- The GIS-based framework is structured to support future updates as new crash data, roadway information, or community input become available

Highlights

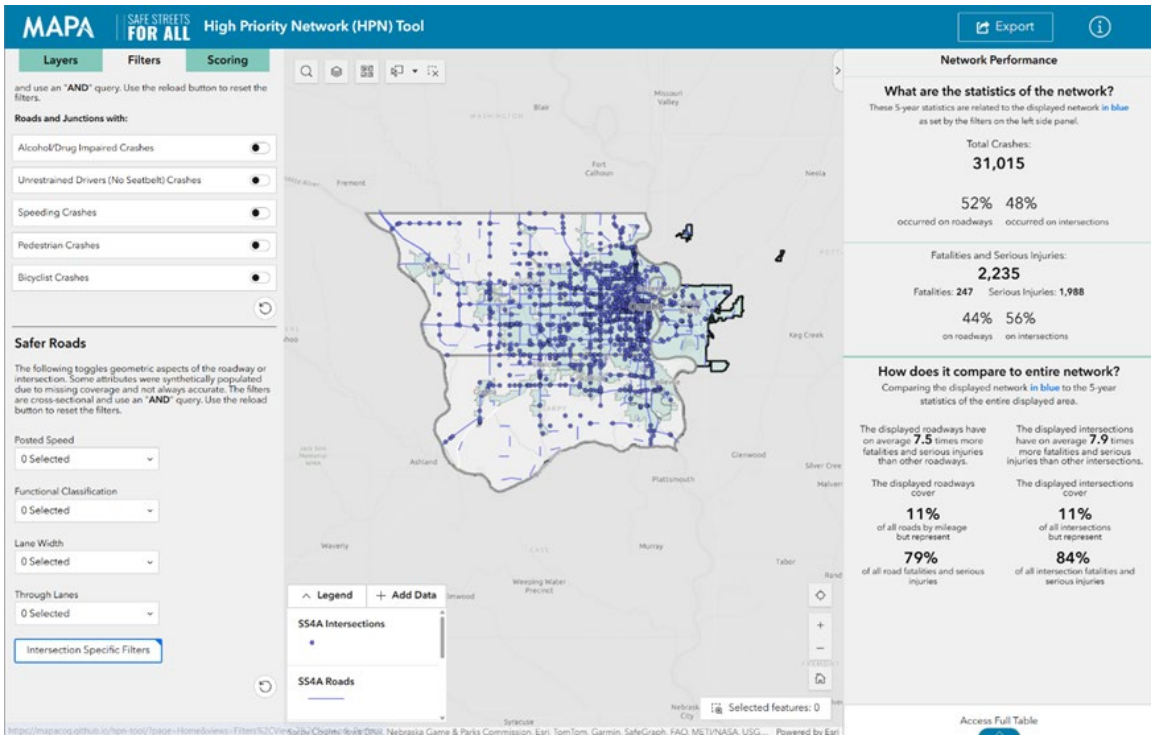
Crashes, Risk, and Lived Experience for a Complete Safety View
Combining historical crash data, modeled risk, and community-reported concerns creates a more complete picture of safety need than any single dataset

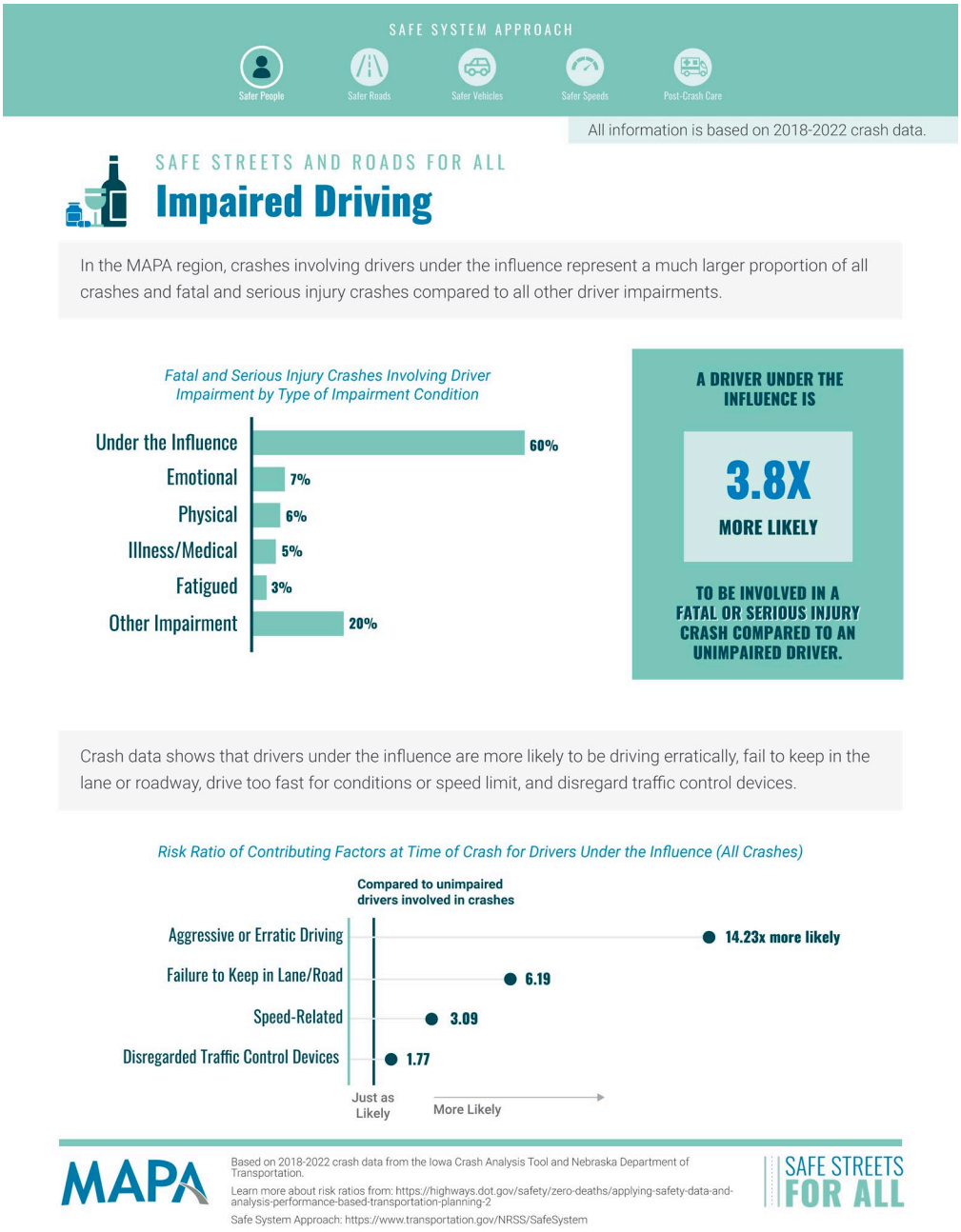
Different Outputs for Different Audiences
Pairing a flexible GIS-based tool with concise one-pagers helped translate complex analysis into accessible formats for leaders, stakeholders, and the public.

GIS-Based Visualization Preserves Location Context
Mapping safety outcomes directly to roadway segments and intersections allows users to see where safety issues occur within the network, rather than relying on aggregated summaries that can obscure local conditions.

Using Comparison to Understand Safety Outcomes
The Network Performance panel compares the filtered network to the rest of the roadway system, providing immediate context for interpreting safety outcomes. This built-in comparison is unique and helps users quickly assess whether outcomes are typical or disproportionately severe.

Samples





Key Takeaway

MAPA's High Priority Network Tool illustrates how regional planning agencies can integrate multiple sources of safety data, like historical crash records, modeled roadway risk, and community-reported concerns, into a single, actionable framework. This approach moves beyond traditional, reactive safety planning and helps agencies identify both known and emerging risk areas.

8. Self-Assessment Worksheet: Advancing Data Visualization at Your Agency

8.1. Purpose:

This self-assessment is designed to help agencies reflect on their current practices in data visualization across six key areas of competency. It is a first step in identifying areas of strength, recognizing opportunities for growth, and using the Visualization Adoption Roadmap to plan targeted improvements.

You can complete this worksheet on your own, but working through it as a team often leads to richer insights and a more complete assessment.

8.2. Instructions:

- Rate each statement from 1 to 5 based on how true it is for your agency, where:
  - **1 — Not Yet**
    This is not in place or rarely happens.
  - **2 — Beginning**
    Some early steps are happening, but inconsistently.
  - **3 — Sometimes**
    This occurs regularly but is not fully established.
  - **4 — Mostly True**
    This is well established, though occasional gaps remain.
  - **5 — Consistently True**
    This is fully implemented and consistently practiced.
- Total your scores per competency and review the scoring guidance at the end to determine your agency's overall profile.
- Then, use the Visualization Adoption Roadmap sections of this report to explore how to advance to the next level.

8.2.1. Tools & Technology

Statement	Rating (1–5)
I have access / our staff have access to basic data visualization tools (e.g., Excel, PowerPoint).	
Relevant staff use specialized software (e.g., Power BI, Tableau, ArcGIS, Adobe Creative Products, Blender, etc.) for creating interactive visuals or dashboards.	
There are licenses and platforms across the agency for people who want to develop data visualization.	
Visualization tools are integrated with our existing data systems.	

Subtotal: _____

8.2.2. Skills & Staffing

Statement	Rating (1–5)
We have a go-to person or team recognized as internal expert(s) for data visualization.	
Staff across various roles, such as planning, data, and communications, receive visualization training or support.	
Data visualization is often included in job descriptions or performance expectations.	
Staff collaborate across teams to improve visuals.	

Subtotal: _____

8.2.3. Leadership & Governance

Statement	Rating (1–5)
Leaders in our agency request visuals to inform their decisions.	
At least one senior leader champions improved communication through visuals and speaks publicly about its value.	
We have internal guidelines or standards for what good visualization looks like.	
Visualizations are built into key deliverables (e.g., performance plans, long-range transportation plans, budget presentations).	

Subtotal: _____

8.2.4. Communication Strategy

Statement	Rating (1–5)
Staff tailor visualizations for specific audiences (e.g., simplifying for public use, highlighting key takeaways for executives, or preserving technical detail for engineers).	
Staff include narrative elements or callouts (e.g., key findings, headlines, or recommended actions) to help audiences interpret the visual.	
Designated staff and/or other resources are available to align messaging with leadership objectives for public and agency-wide visualizations.	
Templates and/or guidelines are available for staff to follow agency branding and logo use in their visuals.	

Subtotal: _____

8.2.5. Data Infrastructure & Governance

Statement	Rating (1–5)
Our data is stored in a way that supports connections and updates to visualization software.	
We have consistent field definitions, metadata, and formatting standards.	
Data updates and maintenance are automated.	
Staff know where to access approved data for visualization.	

Subtotal: _____

8.2.6. Evaluation & Feedback

Statement	Rating (1–5)
Staff review visualizations to assess whether they achieved their intended purpose (e.g., clarity, engagement, decision impact)	
Stakeholders and end users are asked to provide feedback on visualizations, either informally or through structured input.	
Staff have improved or adapted visual formats or tools based on lessons learned from past projects or feedback.	
Metrics are used to evaluate visualization effectiveness, such as click rates, comprehension scores, or stakeholder satisfaction.	

Subtotal: _____

8.3. Total Score Summary

Competency	Score
Tools & Technology	
Skills & Staffing	
Leadership & Governance	
Communication Strategy	
Data Infrastructure & Governance	
Evaluation & Feedback	

8.4. Scoring Guidance

Look closely at your scores within each of the six competency areas.

Score Range (per section)	Visualization Maturity Level	Suggested Next Step
4-10	**Emerging**	Begin building foundational capacity. Use the Visualization Adoption Roadmap to identify 1–2 "quick win" areas to strengthen. Focus on tools access, skills development, and small pilot efforts.
11-15	**Developing**	You have established practices and are ready to formalize and scale. Prioritize governance, cross-team collaboration, and performance evaluation. Use the Visualization Adoption Roadmap to move toward institutionalization.
16-20	**Mature**	You are a strong candidate for peer exchange, piloting advanced methods, or mentoring others. Focus on innovation, sustainability, and alignment with strategic goals. Consider contributing a case study to this guide.

Start by identifying your lowest-scoring areas, these are likely your biggest opportunities for improvement. Then, go directly to the corresponding section of the Visualization Adoption Roadmap to explore strategies and ideas tailored to that topic. Use the Visualization Adoption Roadmap to pinpoint practical first steps, explore ways to build sustainable practices, and see peer examples and case studies relevant to your agency context.

8.5. Reflections Before Reviewing the Visualization Adoption Roadmap

You can use the space below to guide internal discussion or personal reflection before you dive into the Visualization Adoption Roadmap:

- Which of these areas, if improved, would have the biggest impact on your agency's ability to communicate with visuals?
- What is one concrete step you could take this quarter to begin improving in that area?
- Who could you involve or learn from to build momentum in this area?

9. Visualization Adoption Roadmap

This guide is meant to be practical. Agencies are at very different points when it comes to data visualization, some are just getting started with spreadsheets and maps, others already have dashboards running, but want to raise the bar. Wherever you are, the goal here is to help you take the next step.

If you've already filled out the Self-Assessment Worksheet, start by looking at the areas where your scores came in lowest. That's usually where you'll see the biggest opportunities for growth.

We've organized the guide around six areas that together make up a strong visualization practice:

1. **Tools & Technology:** Getting the right tools in place, piloting them, and eventually scaling them across teams.
2. **Skills & Staffing:** Making sure people have the time, training, and support to use visuals well.
3. **Leadership & Governance:** Building buy-in and setting expectations so visuals become part of everyday decision-making.
4. **Communication Strategy:** Making sure visuals are tied to clear messages and the needs of your audience.
5. **Data Infrastructure & Governance:** Ensuring the data behind visuals is reliable, consistent, and accessible.
6. **Evaluation & Feedback Loops:** Learning what works, fixing what doesn't, and improving over time.

In each section, you'll find practical steps for moving from "emerging" practices to more developed and mature ones, plus examples from agencies that have already tried these approaches. Use the summary roadmap as a quick reference for what progress can look like across the six areas, and then dig into the sections that match your agency's needs.

Competency Area	Emerging (Getting Started)	Developing (Building Systems)	Mature (Sustaining & Innovating)
1. Tools & Technology	Staff use basic tools (Excel, PPT, GIS exports); ad hoc visuals	Teams pilot advanced tools (Power BI, Tableau, ArcGIS), begin consistent workflows	Tools are integrated with systems; agency uses templates and automation across teams
2. Skills & Staffing	A few individuals create visuals; little training or support	Visualization roles, trainings, and peer learning networks emerge	Visualization is a shared skill across departments; job descriptions and mentorships in place
3. Leadership & Governance	Occasional leadership support; no formal expectations	Some leaders champion visuals; basic standards or expectations set	Leaders model best practices; visualization policies and governance structures guide practice
4. Communication Strategy	Visuals created without audience in mind; limited messaging	Staff begin tailoring visuals by audience and using narrative callouts	Strategic communications staff co-develop visuals; visuals are part of campaigns and planning
5. Data Infrastructure	Key datasets exist but are siloed or unstandardized	Shared data folders, documentation, and informal data stewards	Automated pipelines, centralized access, and clear governance of data for visualization
6. Evaluation & Feedback	Visuals rarely reviewed after release	Staff gather informal feedback; some visuals adapted over time	Structured feedback loops, embedded metrics, and continuous improvement inform visual design

9.1. Growing Your Tools & Technology

9.1.1. From Emerging to Developing

Most agencies start out with whatever's at hand: Excel charts, PowerPoint maps, maybe a few static GIS exports. That's fine for a while, but as soon as people want to tell bigger stories with data, those tools hit their limits.

A practical first step is simply taking stock. What licenses does your agency already own? Who's actually using them? You may already have a few early adopters tinkering with Tableau, Power BI, or ArcGIS StoryMaps. It helps to find them and make their work more visible.

Next, pick one problem worth solving. Don't overcomplicate it. Perhaps it's visualizing safety trends for leadership or creating a clearer chart for a public survey. Pilot one tool or workflow in that context, and support a small team in trying it out.

Some agencies set up quick "show-and-tell" sessions, such as 15 minutes at a staff meeting where someone shares a dashboard or map they've been experimenting with. These small steps matter. They signal that experimentation is encouraged, and they create a record of what worked (and what didn't). Over time, this shifts visualization from being an ad hoc effort to something more intentional and repeatable.

Sample 90-Day Plan:

Quick Wins (first 90 days):

- ✓ Take stock of what you already have. Make a simple list of your licenses and tools. You might be surprised at what's hiding in different divisions.
- ✓ Pick one high-value project (like safety trends or a public survey) and test a tool or workflow there. Keep the scope small but visible.
- ✓ Capture a "before and after" example. Even one upgraded chart can help show leadership why this work matters.

Medium-Term Goal (3–6 months):

- ✓ Try out a new visualization platform (like Tableau or Power BI) on a public-facing product. A dashboard or report that gets outside eyes will surface both the potential and the gaps.

Collaboration Idea:

- ✓ Host a short session with planning, IT, and communications to map out shared needs. Sometimes you'll find three teams building the same chart in three different ways.

9.1.2. From Developing to Mature

Agencies that have moved beyond initial pilots often face a new challenge: how to scale effective visualization practices across teams, programs, and leadership levels. At this stage, the goal is no longer just access to tools, it's creating the infrastructure and support that make high-quality visuals routine and reliable.

This means making access equitable across relevant teams, standardizing how tools are used, and creating reusable templates and workflows that reduce duplication and improve consistency. Coordination with Information Technology (IT) becomes essential, both to expand access to licensed tools and to ensure that data connections are secure, up to date, and automated where possible. Teams should also consider interoperability, specifically how visuals integrate with broader platforms like performance dashboards, planning reports, or legislative briefings.

Sample 90-Day Plan:

Quick Wins (first 90 days):

- ✓ Draft 1–2 branded templates or visual styles that anyone can grab.
- ✓ Document a couple of common "data-to-visualization" workflows so new staff can follow them.
- ✓ Review existing dashboards or reports to find spots where automation could save staff time.

Medium-Term Goal (3–6 months):

- ✓ Set up a clear internal request process (for example, an intranet form) so staff know where to go for visualization help and templates.

Collaboration Idea:

- ✓ Start a working group or community of practice around visualization. Agencies that do this often find it's the best way to spread lessons learned and build momentum.

9.1.3. Case Study

Texas Department of Transportation (TxDOT) - Tableau Community of Practice

The Texas Department of Transportation (TxDOT) illustrates how agencies can evolve from early-stage visualization efforts to a more mature, strategic approach. Rather than focusing solely on tools, TxDOT prioritized internal capacity-building and peer learning through a Tableau Community of Practice (CoP).

The CoP brought together staff from across disciplines for regular office hours and meetings to share dashboards, troubleshooting challenges, and tailor visuals to audience

needs. This structure helped lower barriers for new users and fostered a culture of experimentation.

Organizationally, TxDOT addressed common hurdles like licensing and IT coordination, while developing shared templates and tip sheets to promote consistency. By aligning tool use with real agency needs, such as performance tracking and public engagement, they created a sustainable model for scaling visualization practices agency-wide. They use some of the following free and low-cost resources:

- LinkedIn Learning (Free and low-cost data visualization courses are available for a wide range of software)
- Esri Massive Open Online Courses (MOOCs)
- Coursera (Free and low-cost data visualization courses are available for a wide range of software)

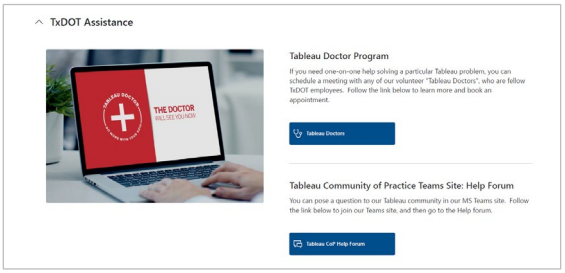


Figure 43: A screenshot of TxDOT's internal SharePoint site dedicated to the Tableau Community of Practice.

9.2. Growing Your Skills and Staffing

9.2.1. From Emerging to Developing

Tools alone don't move the needle, people do. Agencies often hit a wall when staff simply don't have the time, training, or confidence to use new visualization tools effectively. The first step is to look inside your own organization. Who already shows an interest in visuals? It might be a planner who always sneaks charts into their memos, or an engineer who enjoys experimenting with GIS exports. These early enthusiasts can become the spark for broader momentum.

90-Day Plan for Getting Started:

- ✓ Spot the people already creating visuals (or eager to learn) and invite them into the conversation.
- ✓ Share simple skill-building aids, such as quick feedback checklists, one-page "when to use which chart" guides, or resources included in this Visualization Adoption Roadmap.
- ✓ Add a small but telling prompt to project planning forms: "Will this task include visuals? If so, who's creating them?" Even that gentle nudge can raise awareness.

Medium-Term Goal (3–6 months):

- ✓ Test a lightweight training effort. This could be a short tutorial series, a lunch-and-learn on chart design, or a quick GIS mapping walkthrough led by a staff member.

Collaboration Idea:

- ✓ Pair up staff across functions, such as an analyst and a communications specialist, and have them co-develop a visual for a shared project. Intentional team roles with complementary perspectives can learn from each other and strengthen visual products.

9.2.2. From Developing to Mature

As your agency builds experience with data visualization, the next step is to scale that capacity across teams and make it sustainable and consistent. Moving from a few capable individuals to a well-supported, cross-functional talent pool requires some intentional planning. This includes creating structures for collaboration, formalizing responsibilities, and embedding visualization expectations into roles and workflows.

90-Day Plan for Scaling Up:

- ✓ Refresh one or two job descriptions to include visualization skills as part of the role.
- ✓ Add visualization targets to annual training goals or staff development plans.
- ✓ Launch a peer review process for visuals in internal reports or dashboards. A simple checklist can serve as a starting point that can be built upon over time.

Medium-Term Goal (3–6 months):

- ✓ Create an internal training track or mentoring program so advanced staff can coach newer learners.

Collaboration Idea:

- ✓ Convene a cross-functional task group (planning, communications, data) to co-create a “starter guide” with agency-specific tips and examples of effective visuals.

9.2.3. Case Study

MnDOT District Visualization Support

MnDOT's approach to supporting its districts in developing visualization skills illustrates how to nurture internal talent and build shared capacity. While each district had different needs and levels of technical expertise, the central office promoted cross-district learning by offering branded templates, peer-developed tools, and informal mentoring. This decentralized but connected approach helped elevate visualization quality across the agency, supporting planners, designers, and public engagement staff. MnDOT's strategy emphasizes the importance of growing staff skills by fostering an internal culture where sharing and experimentation are encouraged.

9.3. Growing Your Leadership and Governance Capacity

9.3.1. From Emerging to Developing

Leadership plays a critical role in shaping a culture where visual communication is valued and expected. Without leadership buy-in, even talented staff and strong tools can struggle to gain traction. Start by identifying a champion, someone in a leadership role who supports visual communication and is willing to model it in meetings, briefings, or public presentations. Encourage staff to use visuals when preparing materials for leadership and prompt leaders to request visual summaries.

Equally important is recognizing and celebrating when staff produce compelling visuals. Small signals matter. Even informal praise in emails or meetings can validate effort and encourage others. Establishing light-touch expectations (e.g., "Include a summary graphic in every board briefing") can set a consistent tone without requiring major policy changes.

Sample 90-Day Plan:

- ✓ Identify one or two leaders willing to champion visualization and use visuals in their own communications.
- ✓ Encourage visuals in executive briefings and reports. Start by adding one key chart or map.
- ✓ Showcase a strong internal example in a leadership meeting or email to spotlight good work.

Medium-Term Goal (3–6 months):

- ✓ Ask leadership to adopt a standing expectation: each major report or plan should include at least one visual summary.

Collaboration Idea:

- ✓ Host a short working session with staff and leadership to look at visuals from recent projects. Discuss which ones landed well, which didn't, and why.

9.3.2. From Developing to Mature

As agencies progress, the focus shifts to embedding visualization into leadership routines, decision-making processes, and governance frameworks. The goal is to move beyond isolated champions toward a culture where expectations, resources, and accountability for visualization are clearly established.

This means setting formal expectations for visual quality and inclusion, through strategic plans, performance frameworks, or project management guidance. Leaders should be involved in visual reviews, providing feedback and helping staff refine their communication. Strong leadership support also means making investments: allocating resources for staffing, training, or platform access, and using governance tools like branding standards or reporting requirements to reinforce consistency and quality.

Sample 90-Day Plan:

- ✓ Develop templates for executive dashboards or briefing visuals that leaders can use and request consistently.
- ✓ Launch a "visual of the month" spotlight led by leadership to recognize strong examples.
- ✓ Collect and document where visuals are already shaping strategic decisions. You can use those stories to reinforce the value.

Medium-Term Goal (3–6 months):

- ✓ Establish or formalize a governance structure (e.g., visualization standards, internal review steps, or visual storytelling goals).

Collaboration Idea:

- ✓ Form a cross-departmental task force (planning, public affairs, performance, etc.) to co-develop agency-wide visual guidelines and review protocols.

9.4. Growing Your Communication Strategy

9.4.1. From Emerging to Developing

A visual that's technically correct isn't always effective. At the early stage, agencies often crank out charts or maps that look fine but don't land with their audience. The goal here is to move from just "producing visuals" to actually *communicating messages*.

Start with your audiences. Who do you serve most often: the public, executives, engineers, legislators? Each one needs different framing. Pair every chart or map with a short takeaway statement that explains *what the data shows* and *why it matters*.

When in doubt, ask: *Who is this for? What will they learn?* Even a checklist or a consistent way of writing titles can make visuals sharper and easier to understand.

Sample 90-Day Plan:

- ✓ Add takeaway statements or more descriptive titles to visuals in reports and presentations.
- ✓ Encourage staff to try a simple "Know Your Audience" worksheet before creating visuals (similar to the "Defining Clear Objectives" exercise in this guide).
- ✓ Take one recent report and revise a few visuals for clarity or alignment with strategic messages. Use it as a learning example.

Medium-Term Goal (3–6 months):

- ✓ Build a short messaging checklist or slide template that has space for both the graphic and the "so what" statement. Prompts like "This chart shows..." or "This matters because..." are good starting points.

Collaboration Idea:

- ✓ Pair up analysts and communications staff to revise an existing visual together for a public audience. Both sides will see how much clearer the end product can be.

9.4.2. From Developing to Mature

Once basic audience-tailoring is in place, the next step is weaving visualization into the agency's broader communication strategy. That means thinking about visuals at the start of a project. It also means using visual storytelling, building a sequence of graphics that guides viewers through trends, comparisons, or trade-offs.

At this level, cross-team collaboration is essential. Planning, data, and communications staff should routinely co-develop visuals so that technical accuracy and message clarity go hand in hand. Agencies should also track impact: are visuals reused? Do they influence decisions? Do they boost public engagement?

Sample 90-Day Plan:

- ✓ Collect a few "before and after" examples where messaging improved the clarity of visuals. Share them as learning tools.
- ✓ Add storytelling tips and sample visuals to internal communication guidelines.
- ✓ Audit existing visuals for tone, voice, and alignment with agency priorities.

Medium-Term Goal (3–6 months):

- ✓ Create a reusable template that includes both the graphic and narrative framing elements (e.g., "What you should know..." or "This means...") for public-facing products.

Collaboration Idea:

- ✓ Convene a cross-functional working group (communications, planning, public affairs) to develop shared messaging tools and pick out visuals for upcoming outreach campaigns.

Case Study: Caltrans 360 Visualization for Public Engagement

Caltrans' use of immersive 360-degree tours exemplifies audience-centered design and visual storytelling. These tools allow the public to virtually navigate proposed projects and understand design trade-offs in real-world environments. By overlaying spatial annotations and using interactive navigation, Caltrans has made complex engineering proposals more accessible and engaging. The agency uses these visuals in public outreach meetings, reflecting an intentional strategy to align visualization formats with communication goals. This case shows how effective visuals can support public understanding, trust, and meaningful participation.

Figure 44: Screenshot of Caltrans' animated drive-through video showcasing the new Yerba Buena Island Exit.

9.5. Data Infrastructure & Governance

9.5.1. From Emerging to Developing

Good visuals depend on good data, and for many agencies, that's where the cracks show first. Early on, it's common to see siloed spreadsheets, outdated files, or staff hunting through old folders for the "latest" version. The starting point is simple: figure out what you have, who owns it, and where it lives.

Take inventory of the datasets most often used for visuals, especially in performance reporting, planning, safety, or asset management. Identify both formal and informal data stewards. Sometimes it's an IT manager, other times it's just the one analyst who knows where the files are. Then, create shared access points (like common drives or folders) so everyone is working from the same source.

Even small steps like building a basic data dictionary with definitions, units, and update frequency can reduce confusion and create consistency. These foundational practices shift the agency from reactive data wrangling toward a more strategic, shared approach.

Sample 90-Day Plan:

- ✓ List 10 or so datasets most commonly used in visuals.
- ✓ Identify who maintains them and where they're stored.
- ✓ Draft a simple data dictionary to capture definitions, units, and update frequency.

Medium-Term Goal (3–6 months):

- ✓ Set up a shared "data shelf," a central location where approved visualization datasets are stored and kept up to date.

Collaboration Idea:

- ✓ Bring planning, safety, and IT staff together to review the dataset list. Use the session to spot overlaps, gaps, and opportunities for shared stewardship.

9.5.2. From Developing to Mature

Once the basics are in place, the next challenge is scale. At this stage, the goal is to replace manual updates and inconsistent sources with automated pipelines and clear governance. That way, staff can trust the data that feeds their dashboards, maps, and reports.

Start by connecting visualization tools directly to source systems wherever possible, reducing the need for manual updates. Formalize governance roles such as data stewards and create internal policies for update schedules, review protocols, and access control.

Develop an authoritative "source of truth" platform or catalog where staff can easily find approved datasets for visual reporting. Work with IT to manage permissions and security protocols, especially if visuals include sensitive or public-facing information. These steps reduce friction, improve trust in the data, and allow visualization efforts to scale efficiently across the agency.

Sample 90-Day Plan:

- ✓ Document current governance roles and identify any gaps.
- ✓ Draft a checklist with IT for dashboard/data platform deployment, covering refresh schedules, permissions, and security.

Medium-Term Goal (3–6 months):

- ✓ Develop a full roles-and-responsibilities chart for data governance, filling the gaps identified earlier.

Collaboration Idea:

- ✓ Meet jointly with IT and public affairs staff to set permissions for both internal and public-facing datasets, ensuring access is clear and appropriate

9.5.3. Case Study

WSDOT Travel Trends Dashboard

WSDOT's Travel Trends Dashboard was developed to support ongoing performance reporting through a structured, reliable data infrastructure. The system uses Python and Django for backend data processing and publishing, enabling automated updates and integration with internal databases. Tableau is used for the visual front-end, allowing users to explore multimodal travel patterns through interactive dashboards. The data pipeline incorporates scheduled refreshes, version control, and quality checks to flag anomalies before publishing. Governance roles are clearly defined, with a dedicated team responsible for maintaining source datasets, managing the end-to-end data pipeline, and ensuring alignment with planning and performance reporting goals. This robust infrastructure has helped WSDOT deliver

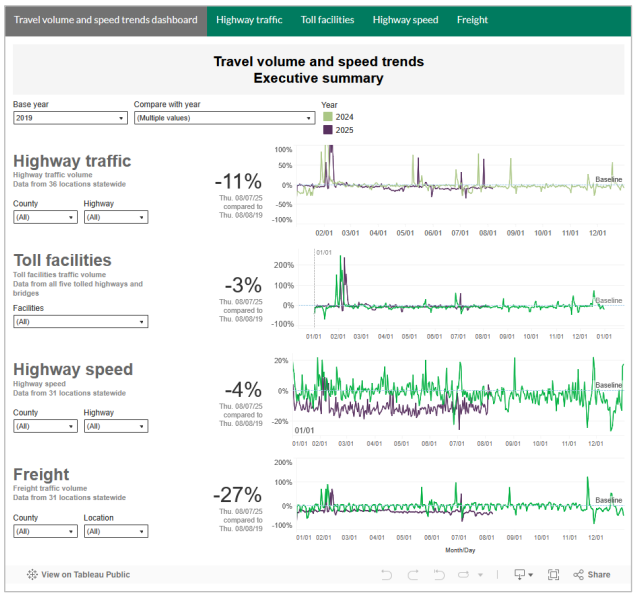


Figure 45: WSDOT's travel volume and speed trends dashboard.

consistent, trustworthy visualizations that support both internal decision-making and public transparency.

9.6. Growing Your Evaluation & Feedback Loops

Strong visual communication evolves over time. Agencies that build evaluation into their routine learn faster, adapt more easily, and earn more trust from their audiences. Feedback loops help you spot what's working, fix what isn't, and keep improving clarity, accessibility, and impact over time.

9.6.1. From Emerging to Developing

Start small. The first step is to create a lightweight way to capture feedback. That could mean a quick debrief after releasing a report, or simply asking a colleague or end user: *"Was this clear?"* or *"What stood out to you?"* Even informal input can reveal how visuals are actually being read and whether they're helping decision-making.

Usage data is another easy entry point. Tracking dashboard views, downloads, or email open rates won't tell the whole story, but it gives you a baseline for audience engagement.

Sample 90-Day Plan:

- ✓ Add a single feedback prompt to a dashboard or visualization (e.g., "Was this useful?").
- ✓ Start tracking basic usage stats like page views, downloads, or meeting mentions.
- ✓ Keep a running "lessons learned" deck where staff capture quick notes on what worked well or fell flat.

Medium-Term Goal (3–6 months):

- ✓ Add a reflection step into at least one project close-out: a slide or short discussion on whether the visuals were effective.

Collaboration Idea:

- ✓ Ask a communications or external affairs staff member to review a new visual and give audience-centered feedback.

9.6.2. From Developing to Mature

Once agencies are comfortable gathering input, the next step is to make it part of everyday workflow. This means moving from ad hoc feedback to structured processes that collect, analyze, and respond to input. Formal feedback channels, such as surveys or interactive comment boxes, can help gather structured input. Use this feedback to identify recurring issues and address them through training or updates to style guides.

Make sure to close the loop: when feedback is received, let users know how it influenced future updates.

Sample 90-Day Plan:

Case Study

- ✓ Add a short feedback form to one high-visibility report or dashboard.
- ✓ Create or update a feedback checklist for internal reviews.
- ✓ Collect 3–5 examples where user feedback led to improvements and share them across teams.

Medium-Term Goal (3–6 months):

- ✓ Launch a quarterly review of feedback trends and use it to guide agency-wide updates to visuals, messaging, or templates.

Collaboration Idea:

- ✓ Convene a “visual feedback roundtable” with staff from different departments to review recent visuals and share takeaways for future work.

Florida Department of Transportation (FDOT) Source Book

FDOT’s Source Book dashboard was created as both a reporting tool and an evolving resource shaped by stakeholder feedback. After the initial publication, the team realized the dashboard was being underutilized. In response, they hosted a rollout webinar during a quarterly Florida Metropolitan Planning Partnership meeting and followed up with an email blast to increase visibility and engagement. These sessions also served as an opportunity to gather feedback directly from users.

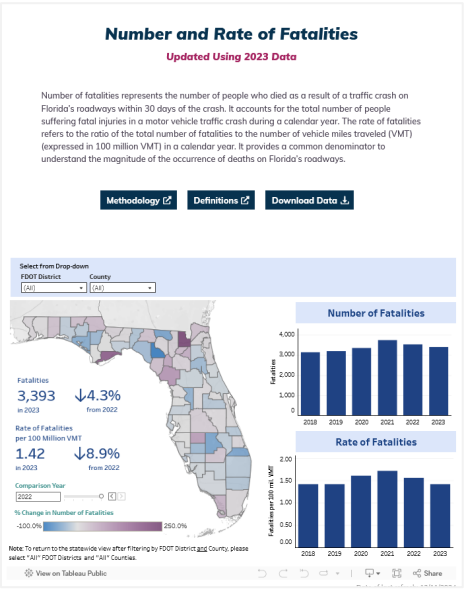


Figure 46: The FDOT Source Book’s number and rate of fatalities page with GIS integration.

FDOT has since made enhancements, including the addition of GIS-based segment-level visualizations that allow users to explore performance metrics on an interactive map. FDOT has also compiled documented use cases from FDOT offices and partners, showcased in the recorded webinar "Exploring Capabilities of FDOT Source Book." This case highlights the importance of ongoing engagement, documentation, and continuous iteration to strengthen the value and utility of a performance dashboard.

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