Revised Draft Guide, Self-Assessment, Case Studies, and Roadmap

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1. Introduction

Transportation agencies increasingly rely on data to inform decision-making, communicate with stakeholders, and engage the public. However, the ability to transform raw data into compelling, actionable insights remains a challenge. This guide is designed to address that gap by offering a practical guide for creating and implementing effective data visualizations that resonate with audiences and support informed decision-making.

Data visualization serves as the bridge between technical analysis and clear communication, allowing agencies to illustrate performance metrics and foster better understanding among diverse stakeholders and across internal teams. Whether the goal is to gain insights into system performance, engage stakeholders and the public, or explore future case studies, effective visualizations play a critical role in advancing transportation objectives.

1.1. Who is this Guide for?

This guide is tailored to the needs of transportation professionals at all levels, including agency leaders, managers, and staff. It provides actionable insights for planners, engineers, IT specialists, and public engagement professionals who seek to improve their practices and build a culture of data-informed communication within their organizations.

Transportation agencies operate in complex environments, requiring coordination across departments and communication with diverse audiences. As such, this guide addresses the needs of both technical staff responsible for creating visualizations and decision-makers who rely on these tools to guide strategies and outcomes.

1.2. Overview of the Four-Part Framework

This guide is structured around a **four-part framework** that emphasizes not only the creation and evaluation of effective visualizations but also their successful implementation across the agency. Each part of the framework addresses a critical component of building and sustaining a culture of data visualization excellence:

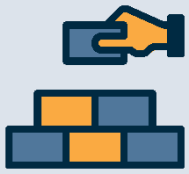
1. **Preparing for Success: Communication Objectives and Data Preparation**
   Laying the groundwork for effective visualizations starts with defining clear objectives grounded in quality data or information. Clear objectives ensure that visualizations align with organizational goals and effectively communicate key messages to the intended stakeholders. Specific focus in this section is also given to foundational data preparation techniques.

2. **Creating Your Visual: Graphic Solutions and Design Principles**
   The heart of effective visualization lies in the design. This section explores how to select appropriate visualization tools and elements, craft clear and engaging visuals, and incorporate accessibility and interactivity to meet the needs of diverse audiences.

3. **Assessing What Works: Evaluation and Continuous Improvement**
   Continuous evaluation is key to maintaining visualization effectiveness. This section focuses on building robust feedback channels, measuring impact, and refining practices to improve clarity, engagement, and alignment with audience needs.

4. **Implementing Across the Agency: Building Capacity and Sustaining Change**
   Ensuring the successful adoption of visualization practices requires organizational buy-in, training, and leadership support. This section provides guidance for integrating data visualization into agency workflows, establishing best practices, and fostering long-term cultural change.

Together, these topics create a comprehensive guide to transforming how transportation agencies communicate through visualizations. By addressing both the technical and cultural aspects of visualization, this guide equips agencies to create meaningful, impactful visuals that support their strategic goals and engage their stakeholders effectively.



2. Preparing for Success: Building the Foundation

Establishing a strong foundation for effective visualization begins with clearly defined objectives, technical readiness, and robust data preparation practices. This section focuses on aligning visualization efforts with strategic goals, ensuring the necessary tools and infrastructure are in place, and transforming raw data into a format suitable for meaningful analysis. By addressing these critical elements, agencies can create a solid starting point for producing accurate, impactful, and actionable visualizations.

2.1. Defining Clear Objectives

Clear objectives are the foundation of effective visualizations, ensuring that visuals are not only aesthetically pleasing but also purposeful and aligned with the agency's strategic goals. Effective visualizations serve as powerful tools for decision-making, communication, and engagement. This section explores how to establish clear objectives by aligning visualizations with agency priorities, understanding audience needs, using AI and software tools effectively, and translating complex data into actionable narratives.

2.1.1. Aligning with Agency Priorities

To create visualizations that drive impact, it is essential to start with a clear understanding of what the agency aims to achieve. Visualizations should address specific questions or decisions, ensuring they contribute meaningfully to the agency's objectives. Agencies must align their visualization goals with broader priorities, such as informing policy decisions, engaging the public, or improving interdepartmental communication. When visualizations are developed with these overarching goals in mind, they become tools that not only convey information but also advance the agency's mission.

2.1.2. Understanding Audience Needs

Visualizations must be designed with their intended audience in mind to ensure effectiveness. Policymakers, for instance, often require high-level summaries that highlight key trends and actionable takeaways, while technical staff may need detailed

analytics to inform specific operational decisions. Tailoring the content and presentation of visuals to the knowledge level and preferences of the target audience is critical.

Developing audience personas can be a helpful approach for guiding visualization efforts. By mapping out the roles, expectations, and preferences of different stakeholders, agencies can anticipate user needs and create visuals that resonate. For example, a public-facing infographic might focus on accessibility and simplicity, whereas an internal technical report might prioritize precision and detail. This audience-first approach ensures that visualizations are not only understood but also impactful.

2.1.3. Integrating AI into Visualization Workflows

AI capability is expected to continue improving each year—and often each week—for the foreseeable future. As of the writing of this guide, Anthropic's Claude Opus 4.6 was recently released. It represents a significant advancement: not merely a "copilot," but an autonomous agent capable of coordinating teams of agents to complete complex, multi-step tasks and generate software or applications 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. [Resource name] 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 1: Integrating AI into Visualizations Framework

Challenge Type	Problem Definition (Visualization Context)	Suitability for AI Use
Reasoning Challenges	Complex, multi-step analytical thinking required to design measures, structure prioritization criteria, evaluate tradeoffs, or interpret interacting variables within a visualization framework.	**Moderate–High (Analytical Support Role).** AI can assist with scenario testing, logic structuring, and exploratory analysis, but outputs require practitioner validation to ensure methodological rigor.
Effort Challenges	High-volume, repetitive tasks that are not conceptually complex but require scale—such as cleaning datasets, standardizing fields, generating draft charts, or reviewing project records.	**Very High (Primary Automation Role).** AI and automation significantly reduce manual burden and improve speed and consistency. Human oversight focuses on QA/QC.
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—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.

Together, these categories illustrate that AI is not uniformly applicable across visualization workflows; its value depends on whether the task is analytical, operational, collaborative, or strategic in nature. By identifying which challenge type dominates a visualization task, agencies can calibrate AI's role, deploying it as a primary analytical engine, an efficiency multiplier, a coordination aid, or a limited drafting assistant.

2.2. AI Fluency Map

2.2.1. Core Components of Effective AI Practice.

INPUTS

Prompt Design & Context Framing

What it is
Structuring inputs so AI can produce relevant, usable outputs.

In practice
Providing scope, background materials, constraints, and examples—not just a task request.

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

Advanced Prompting Techniques

What it is
Structured methods that improve reasoning quality and output control.

In practice
Using examples, staged reasoning, or multi-step instructions.

How to strengthen
Use few-shot examples. Ask AI to reason step-by-step. Pilot agent workflows.

OVERSIGHT

Technical Understanding

What it is
A working mental model of how AI systems generate responses, and where they fail.

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.

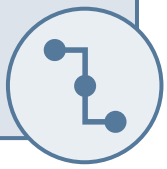
INTEGRATION

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. Provide glossaries. Require nuance, not just summaries.

2.2.2. Crafting Your Message

While AI fluency shapes workflows at all stages of visualization development, there is a general workflow discussed that all practitioners can follow. First and foremost is determining what the visualization is intended to accomplish. Clarity of message and audience remains the foundation of effective communication. Visualizations can have a variety of purposes, most commonly distilled down to four messaging types:

- to **inform**,
- to **persuade**,
- to **monitor** or **evaluate**,
- or to **explore** data.

Visualizations that aim to inform audiences typically have a goal of sharing facts, status updates, or trends. Persuasive visualizations aim to convince the audience of a point, need, or priority. The goal of visualizations which monitor or evaluate is to track progress toward goals or assess outcomes. Finally, the goal of visualizations that explore data is to enable analysis, discovery, and key insights.

With this knowledge, agency's can use the provided workflow to take their key message along with their identified audience to begin using this information to frame their message to have the most impact. For example, if an agency's goal is to increase transparency with the general public about an upcoming construction project and its impacts, a recommended approach would be to use infographics, dashboards, or summary visuals that highlight the most important information and key takeaways, without delving too far into the details. The agency should also try to avoid jargon or provide definitions of any terms the public may not be familiar with.

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 1: Defining Clear Objectives Decision Matrix

2.2.3. Data Storytelling: Framework for Actionable Narratives

One of the most effective ways to communicate complex data is by framing it as a story. Data storytelling techniques—such as illustrating cause-and-effect relationships or highlighting trends over time—can help make visualizations more engaging and easier to interpret. For instance, a visual that shows the relationship between investment in infrastructure and reductions in traffic congestion can provide context that resonates with both decision-makers and the public.

An actionable narrative guides the viewer toward a specific conclusion or decision, leaving little room for ambiguity. Titles, labels, and annotations can be used to reinforce the intended message, while visual elements like color and layout direct attention to the most important insights. An example can be seen in **Figure 2**. By providing context and clarity, a well-crafted narrative ensures that viewers understand not just the data but its significance.

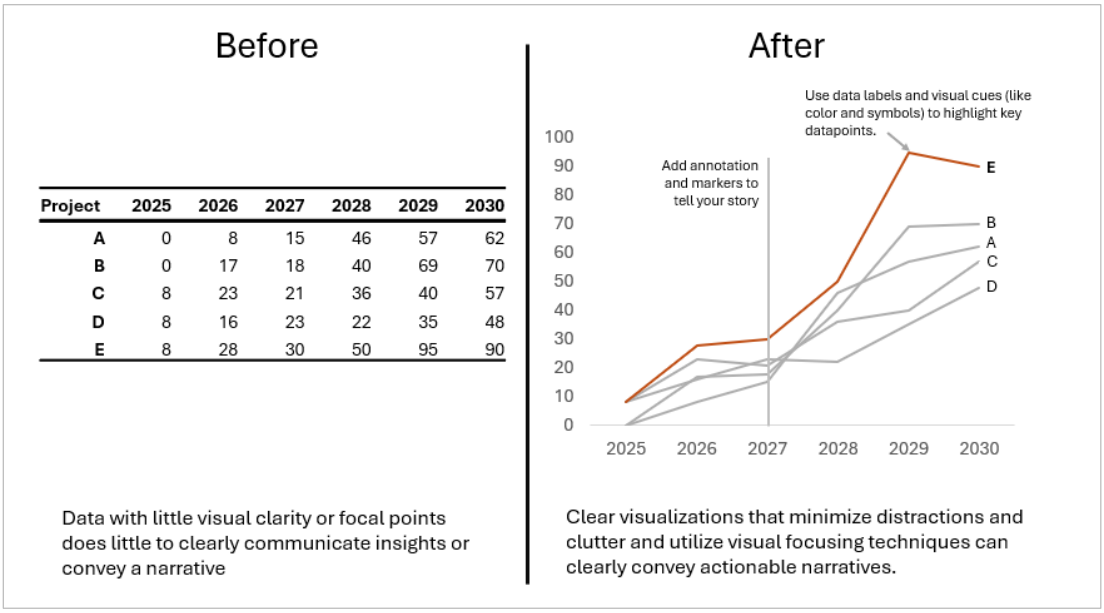


Figure 2: Visual Strategies for Creating Actionable Narratives.

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

The effectiveness of a visualization depends on both the tools used and the quality of the data behind it. This section introduces a structured approach for preparing data for visualization, **Figure 3**, starting with the selection of an appropriate visualization tool and followed by a deliberate process of understanding, cleaning, and transforming the data. Data preparation involves more than simply gathering information; it ensures that data is aligned with the objectives of the analysis and suited to the intended audience. Whether the goal is to inform, persuade, or inspire action, well-prepared data provides the foundation for clear, credible, and compelling visual storytelling.

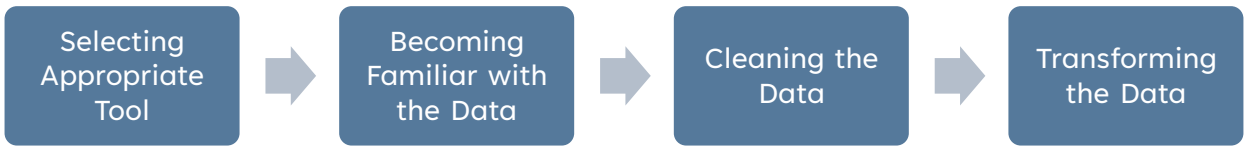


Figure 3: Data Preparation Steps

2.3.1. Selecting an Appropriate Tool for Visualization

Choosing an appropriate software platform for data visualization is a critical step in creating effective and sustainable visuals. Practitioners often have several visualization options at their disposal: PowerPoint, Excel, Power BI, Tableau, QGIS, ArcGIS applications, and perhaps other specialized software programs. The decision depends on understanding your specific needs, data environment, and audience requirements. To make an informed choice, it's important to consider factors such as the ability to connect to external data sources, handle various data formats, and support data cleaning and preparation. A well-chosen tool ensures that the visualization process is efficient and produces visuals that 1) work with available data 2) can be easily shared as intended and 3) are easy to maintain.

Additional considerations include the tool's ease of use, compatibility with existing organizational workflows, and ability to produce visuals that meet technical requirements such as accessibility and interactivity. For example, tools with automated refresh features are vital for dashboards that require frequent updates, while those with GIS capabilities are essential for spatial data visualization. The ability to publish visuals on internal intranet platforms or external websites should also align with the intended audience and level of data security. By balancing these factors, agencies can select tools that not only meet immediate visualization needs but also support long-term efficiency and maintenance.

Error! Not a valid bookmark self-reference. 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 2: 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

Once an appropriate visualization tool has been selected, it is crucial to explore your dataset to understand its structure, distribution, and overall quality. Effective data exploration relies on both numeric summaries and visual inspection, as each reveals different aspects of the data. Descriptive statistics can quickly summarize central tendency and variability, while visual techniques help expose patterns, relationships, and anomalies that may not be evident from numbers alone.

By employing tools like descriptive statistics, histograms, box plots, and scatter plots, you can gain a clearer picture of the dataset's behavior. **Table 3** highlights some of the most commonly used exploratory data analysis techniques.

Table 3: 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

This step also serves as a diagnostic check, helping to uncover potential issues such as errors, inconsistencies, outliers, and missing values that could impact downstream analyses and visualizations. An effective exploration process will lay the groundwork for more targeted cleaning and transformation.

Relying on only one type of exploration—numeric or visual—can obscure these issues. Classic examples such as Anscombe's Quartet (**Figure 4)** and Datasaurus Dozen (**Figure 5)**, demonstrate why numeric summaries should always be paired with visual exploration. In these examples, datasets share identical descriptive statistics (**Table 4** and **Table 5**), including means, variances, and correlations, but their visualizations reveal substantially different underlying patterns.

Table 4: Descriptive statistics of all four datasets visualized 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

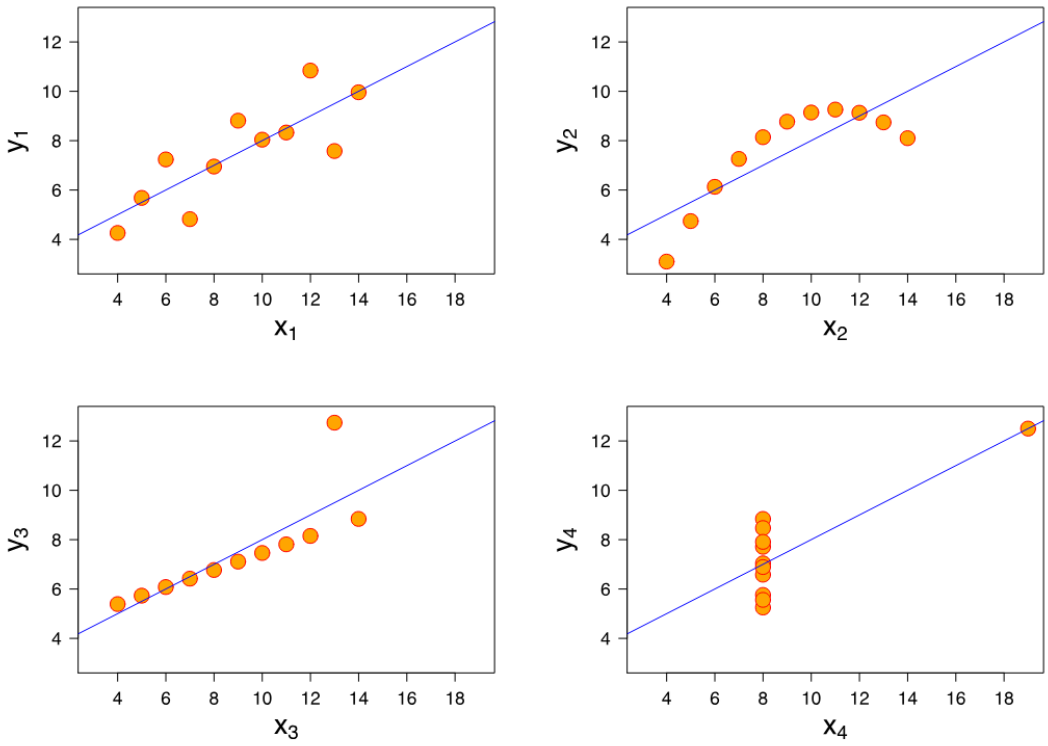


Figure 4: Visualization of Anscombe's Quartet

Table 5: 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

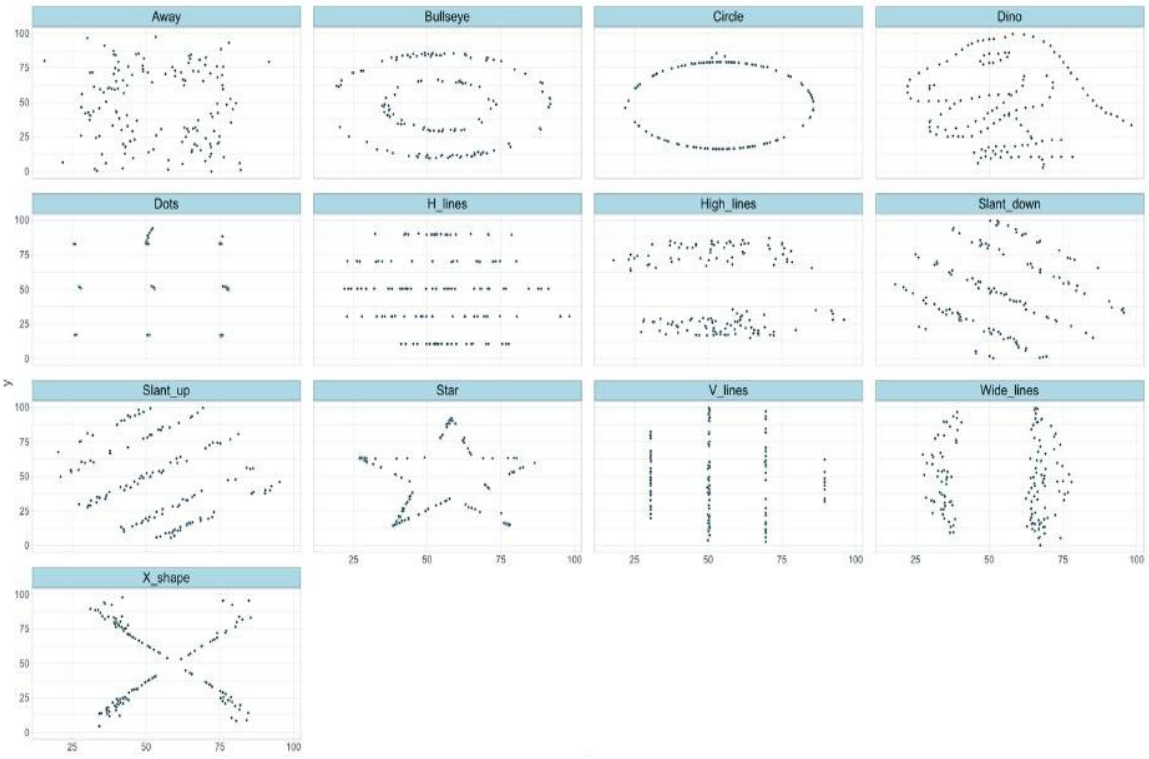


Figure 5: Visualization of Datasaurus Dozen

These cases highlight a key lesson: numeric summaries can suggest similarity where none exists, while visualizations reveal structure, outliers, clusters, and nonlinear relationships that change interpretation. Practitioners should treat numeric and visual exploration as complementary steps, not substitutes.

Beyond detecting problems, data exploration also enables you to uncover new insights, patterns, and relationships within your data. These discoveries can shape your visualization design, guiding you in crafting visual stories that effectively communicate the data's narrative.

2.3.3. Cleaning the Data

After exploring the data and identifying potential issues or patterns, the next step is cleaning it. Data cleaning focuses on resolving inaccuracies, inconsistencies, and missing information to ensure the dataset is accurate and reliable. This step is critical because unclean data can lead to distorted insights and unreliable visualizations.

For example, in a dataset analyzing traffic flow at intersections, duplicate vehicle counts may exaggerate congestion, missing timestamps can prevent meaningful time-series analysis, and inconsistent speed units, such as miles per hour versus kilometers per hour, can distort comparisons.

Effective data cleaning improves the integrity of the analysis and prevents errors from being carried forward into later stages of the workflow. By ensuring data validity, accuracy, completeness, consistency, uniqueness, and uniformity, practitioners establish a strong foundation for creating clear, trustworthy, and impactful visualizations. These key concepts 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. **Accuracy**
   Accuracy focuses on ensuring that the data reflects reality. For example, if you're recording the daily ridership of a bus line, the recorded value should match the actual count, not just any number that fits the format. While validity ensures the structure of data is correct, accuracy ensures that the content itself is reliable.

3. **Completeness**
   Complete data means no critical information is missing. Imagine analyzing a roadway performance measure dataset where the "roadway type" column is left blank for many entries. This lack of information makes it harder to understand the context of the data. Ensuring completeness is vital for creating datasets that provide comprehensive insights.

4. **Consistency**
   Consistency ensures that data across your dataset aligns logically. For instance, in a dataset tracking bike lane usage, if a day shows zero cyclists but records the lane as "highly congested," the data is inconsistent. Without consistency, your analysis might lead to contradictory or misleading conclusions.

5. **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.
6. **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 your analysis. For instance, if you are evaluating roadway conditions, a column tracking employee names might not be relevant. This step keeps your dataset focused and manageable.
- **Standardizing Data Formats:** Ensure consistent formatting across your dataset. For example, check that date fields use the same format throughout (e.g., "YYYY-MM-DD") and that units of measurement (like roadway lengths) are converted into a single standard (e.g., all distances in 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 your data for values significantly different from the norm. For example, if one bike lane shows a usage count ten times higher than others, investigate whether this is a valid exception or a data entry error. Based on your analysis goals, decide whether to exclude, adjust, or retain these values.

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

Best Practice: Define your method for handling outliers in advance to ensure consistency and objectivity (e.g., removing 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.

2.3.4. Transforming the Data

With the data now cleaned, the next step is to transform it into a format that supports analysis and visualization. Data transformation focuses on organizing and restructuring the dataset so that patterns, trends, and relationships can be clearly and consistently represented within visualization tools. While the specific transformations required will vary by use case, most visualization platforms rely on well-structured, tabular data as a foundation.

As shown in **Figure 6** 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 6: 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.
- **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 7**).

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 7: 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 8**).

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 8: Example table with long data format.

2. Transposing

Transposing swaps the rows and columns of a dataset, altering its orientation without changing its content. Typically used as an intermediary data transformation step, often in combination with other methods to achieve a desired structure.

- **Use Case:** Useful for reorganizing data to better match the requirements of certain analyses or tools.
- **Example:** A dataset where rows represent streets and columns represent dates can be transposed so that rows correspond to dates and columns to streets **(Figure 9)**.

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 9: 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 groups continuous data into intervals or “bins” to simplify analysis and visualization.

   - **Use Case:** Organizes data into manageable categories to reveal distribution patterns.
   - **Example:** Group daily bicycle counts into bins such as 'Low' (0–50), 'Medium' (51–100), and 'High' (101–150) to create a histogram showing the frequency of different traffic.

3. Creating Your Visual: Graphic Solutions Know-How

Crafting effective visuals is both an art and a science. A well-designed visual bridges the gap between complex data and actionable insights, ensuring the intended message resonates with the target audience. This section delves into the core components of creating visuals that communicate effectively.

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, 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 10**.

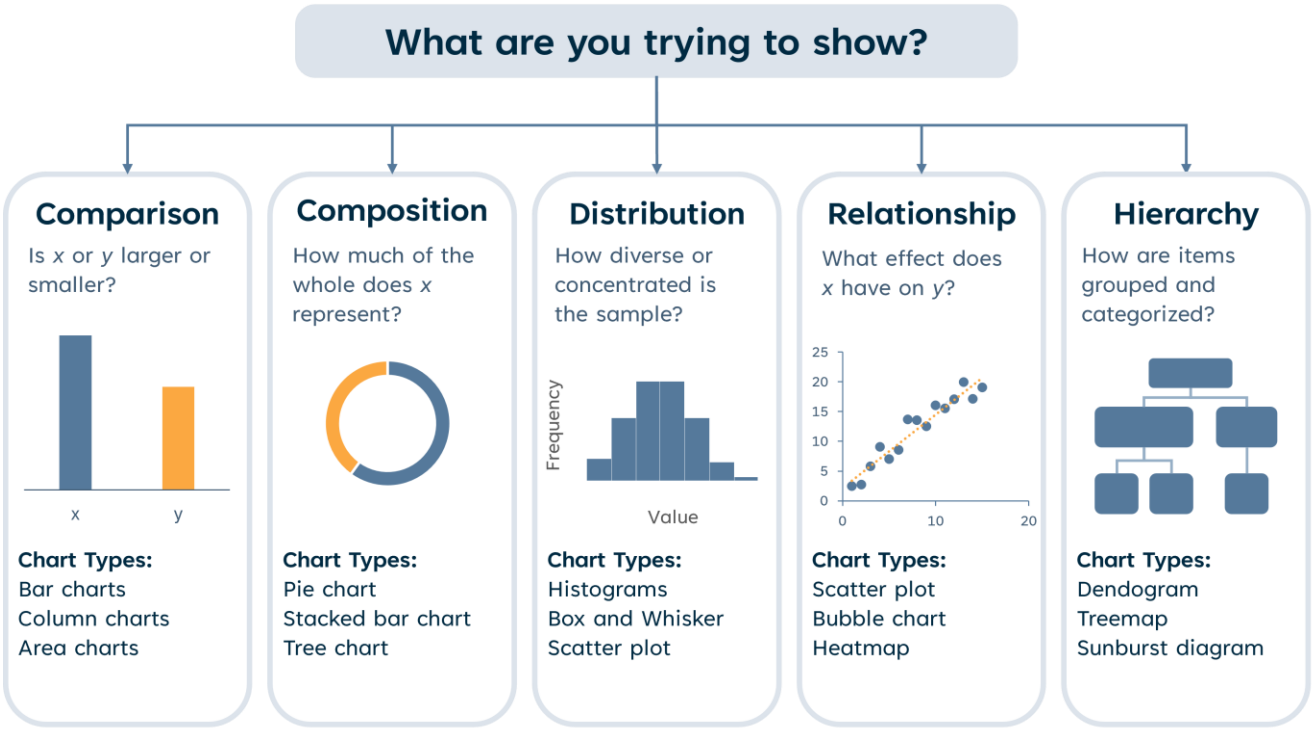


Figure 10: Visualization Type Selection.

3.1.1. Comparisons

For comparisons, bar or column charts are ideal, as they allow viewers to evaluate differences between categories with clarity and precision. For instance, when comparing traffic volumes across regions, a clustered bar chart can highlight discrepancies at a glance. These visuals emphasize contrasts and make it easy to identify the largest and smallest values within a dataset. For additional examples of comparison see **Figure 11**.

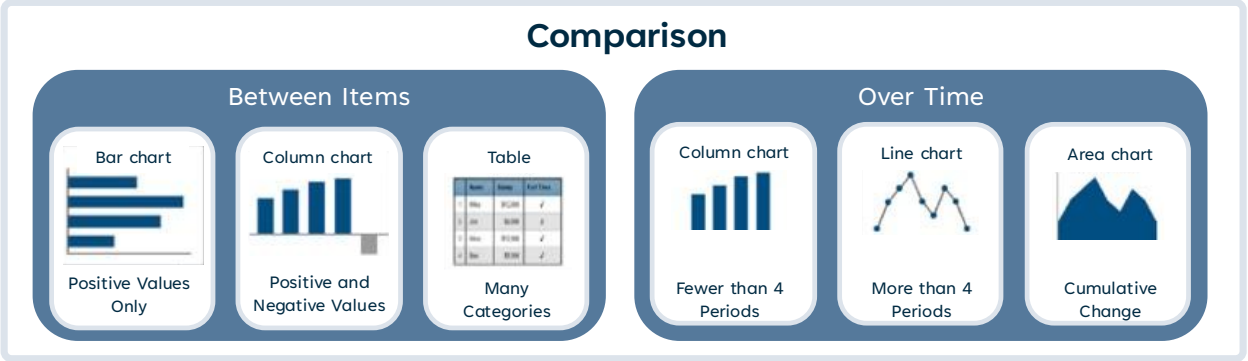


Figure 11: Comparison Chart Selections.

3.1.2. Composition

When representing proportions, pie charts, donut charts, or stacked bar graphs shine by illustrating how individual components contribute to a whole. They are particularly effective when focusing on one key metric, such as showing the percentage of funding allocated to different transportation projects. Careful design, such as limiting the number of segments, ensures that proportions are easily interpretable. Typically, pie charts are only recommended when comparing two items. **Figure 12** offers additional insights into the types of charts that can be used to showcase composition when showing many items or displaying time series data.

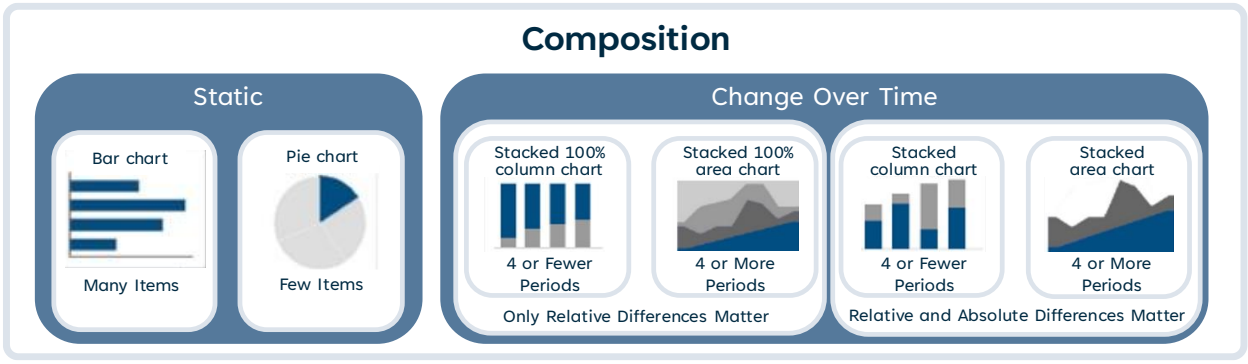


Figure 12: Composition Chart Selection.

3.1.3. Distributions

Distribution-focused visuals, such as histograms, box plots, or density plots reveal patterns within datasets, such as the frequency of road incidents by time of day or the spread of commute times across regions. These charts make it easy to identify trends, clusters, or outliers, which can inform policy changes or resource allocation. You can find examples and insights for charts to showcase distribution in **Figure 13**.

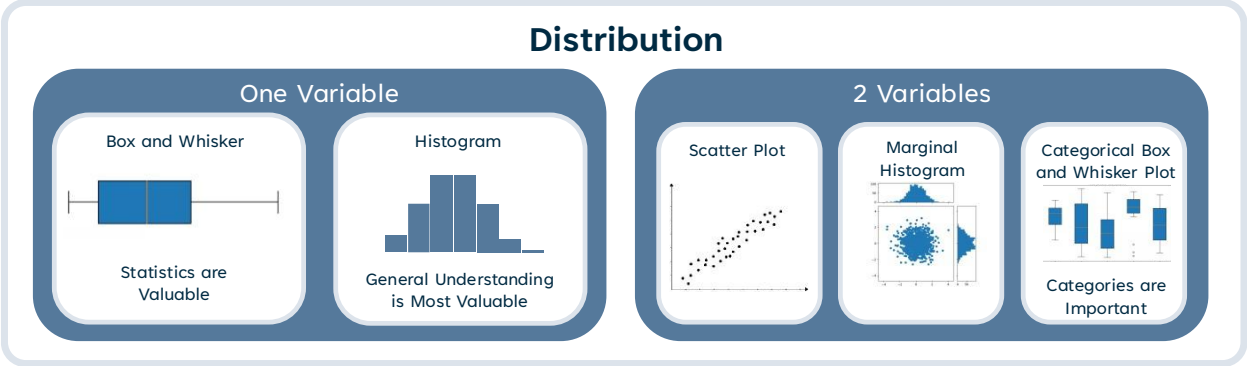


Figure 13: Distribution Chart Selections.

3.1.4. Relationships

To illustrate relationships between variables, agencies should consider scatter plots and bubble charts. They reveal correlations, clusters, and outliers, making them ideal for examining factors like the relationship between vehicle speed and fuel efficiency. Bubble charts can incorporate an additional dimension, such as population size, through varying bubble sizes, enhancing interpretative depth. Bubble charts also provide opportunities to showcase relationships between three variables as shown in **Figure 14**.

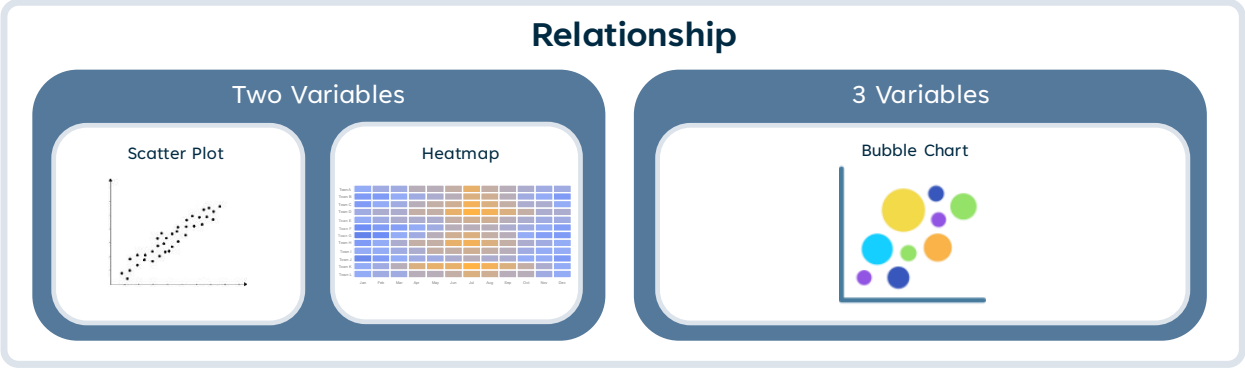


Figure 14: Relationship Chart Selections.

3.1.5. Hierarchy

Hierarchies are best conveyed through tree diagrams, sunburst charts, or organizational charts. These visuals highlight levels of importance or dependency, helping audiences understand complex structures, 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 15** provides insight into how to select charts based on if your data includes numeric/proportion information and the number of categories and layers you hope to visualize.

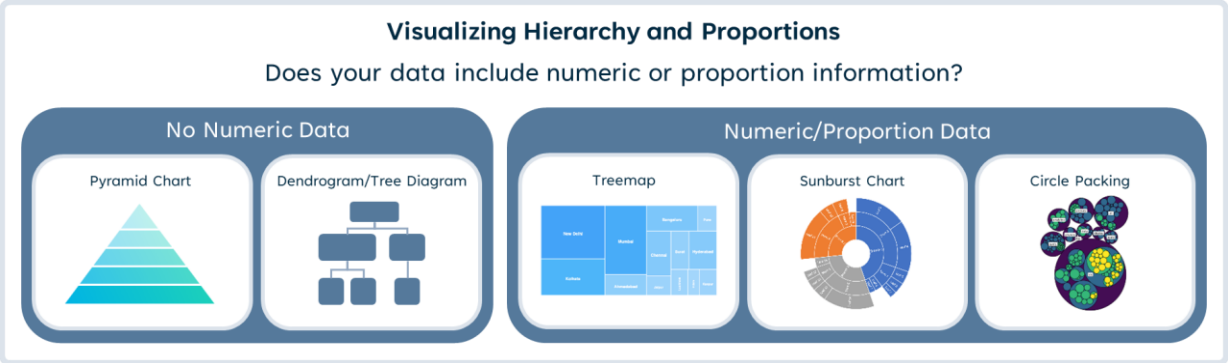


Figure 15: Hierarchy and Proportion Chart Selector.

3.2. Designing Effective Visualizations

3.2.1. Color Selection and Accessibility

Color is one of the most powerful tools in a designer's toolbox, but it is also one of the easiest ways to unintentionally create barriers for readers. Effective use of color can highlight trends, support comparisons, and emphasize key messages. Poor color choices, however, can obscure meaning, compete with labels, or prevent users—including those with visual impairments—from fully understanding the information. This section provides practical guidance for choosing color intentionally, applying it consistently, and ensuring that all users can interpret your visualizations.

3.2.2. Use Color Purposefully

Before choosing a palette, determine what role color will play in communicating your message. Ask: *What information needs emphasis? What comparisons need to be visible? Which elements should remain in the background?* Selecting colors with a clear purpose helps maintain visual hierarchy and prevents the chart from appearing noisy or cluttered.

Use color palettes that match the type of data you are displaying:

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

Figure 16: Sequential Color Palettes.

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

Figure 17: Diverging Color Palettes.

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

Figure 18: Categorical Color Palettes.

Avoid assigning colors arbitrarily or using highly saturated hues without reason. Neutrals and soft tones work well for contextual elements, allowing brighter colors to carry meaning where appropriate.

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

The **60/30/10 rule** provides a practical framework for distributing color harmoniously so the visual is balanced and easy to understand.

- **60% – Base Color**
  This should be your neutral or muted anchor—often a light gray, a desaturated tone, or even white. It forms the bulk of the visual environment (e.g., background, gridlines, axis labels, nonessential bars or lines).

- **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.

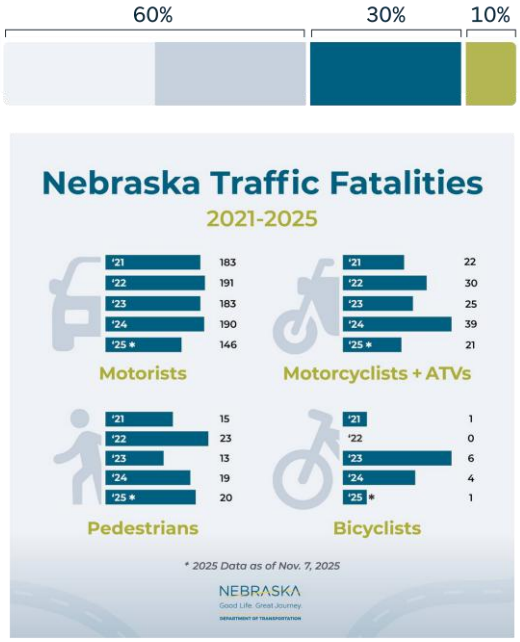


Figure 19: An example of the 60/30/10 rule for color balance, referencing a Nebraska DOT Instagram post.

- **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 and **Figure 19** and **Figure 20**.[23]

Figure 20: An example of the 60/30/10 rule for color balance, referencing a Federal Highway Administration Instagram post.

3.2.4. Reduce Visual Noise

Effective visualizations prioritize signal over decoration. Excess gridlines, background fills, heavy borders, and unnecessary shading compete with the data for attention. Remove or soften nonessential elements so the viewer's focus remains on the information itself.

- **Use consistent alignment.** Misaligned titles, uneven margins, or irregular spacing create subtle visual friction that makes charts feel cluttered even when content is minimal.
- **Simplify color use.** Avoid using a different color for every category if the message only requires highlighting one or two key elements.
- **Use whitespace intentionally.** Generous margins and spacing between elements improve comprehension and reduce cognitive load. Crowding elements together creates visual tension and fatigue.
- **Standardize spacing increments.** Use consistent spacing intervals (e.g., 8pt or 4pt systems in digital layouts) to avoid uneven gaps that subtly disrupt visual flow.
- **Avoid decorative imagery without purpose.** Photos, icons, and illustrations should support the message, not fill space.

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[2] Nebraska Department of Transportation. (2025, November). [*Infographic showing traffic incident data in Nebraska.*]. LinkedIn. https://www.linkedin.com/posts/nebraskadot_in-just-the-first-seven-days-of-november-activity-7392676741376299008-4bsU

[3] Federal Highway Administration. (2025, May). [*Infographic showing separate bike lanes information.*] LinkedIn. https://www.linkedin.com/posts/federal-highway-administration_nationalbikemonth-activity-7196162469201870848-Gl-w?utm_source=share&utm_medium=member_desktop&rcm=ACoAAAvtK1cBadmjckqqMVq0ra43jQM7OyOeS2w

Effective design favors clarity over decoration. By eliminating unnecessary elements and applying consistent structure, spacing, and color, visualizations become easier to read, easier to interpret, and more impactful.

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 about 10% of the population experiences some form of color blindness, like those shown in **Figure 21**, meaning that relying on color alone to convey meaning will exclude a portion of your audience.[4] In addition, many users may print your graphics in grayscale or view them on screens where color differences are less pronounced.

Figure 21: Simulated perception of a color palette across five vision types.

Understanding Common Types of Color Blindness

While color vision deficiencies vary, three common forms illustrate why some combinations are problematic:

- **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)** – Less common; challenges distinguishing blues from greens and yellows from violets.

Recommended Color Choices

Because color-blind users may perceive red, green, orange, and brown similarly, it is often safer to rely on combinations that maintain strong contrast across most types of color vision.

- Blue and yellow as one of the most consistently distinguishable pairs across major types of color blindness.
- Desaturated blues, violets, and deep yellows as generally strong performers for contrast.
- Avoiding reliance on hue alone—differences in brightness, saturation, or patterns help reinforce distinctions.

[4] Colour Blind Awareness. (n.d.). About Colour Blindness. Retrieved March 26, 2026, from https://www.colourblindawareness.org/colour-blindness/

Ensure sufficient contrast by aiming for WCAG-compliance – a minimum of 4.5:1 for body text and graphical elements conveying meaning.

Never Use Color Alone to Convey Meaning

Because color perception varies, pair your color choices with other cues:

- Patterns or textures (e.g., stripes, dots)
- Line styles (e.g., dashed vs. solid)
- Markers or shapes
- Direct labeling rather than relying on a color legend

Pattern overlays or direct labels significantly improve clarity and accessibility—especially when multiple series overlap or when printed in grayscale.

Test in Grayscale

Convert your chart temporarily to grayscale to verify whether categories remain distinguishable. If the relationships disappear, adjust brightness, line weight, or patterning before finalizing the visualization.

Alternative Text and Tagging for Accessible Visuals

Color-blind–safe palettes and grayscale testing help ensure visual clarity, but they do not, by themselves, make charts and graphics accessible to users who rely on assistive technologies. For non-visual users, accessibility depends on two closely related practices: alternative text and document tagging.

Alternative text (alt text) provides a concise, textual description of a visual element so that its purpose and key takeaway can be conveyed by screen readers. Effective alt text focuses on meaning rather than appearance. 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 22** illustrates a step-by-step guide to these decisions.

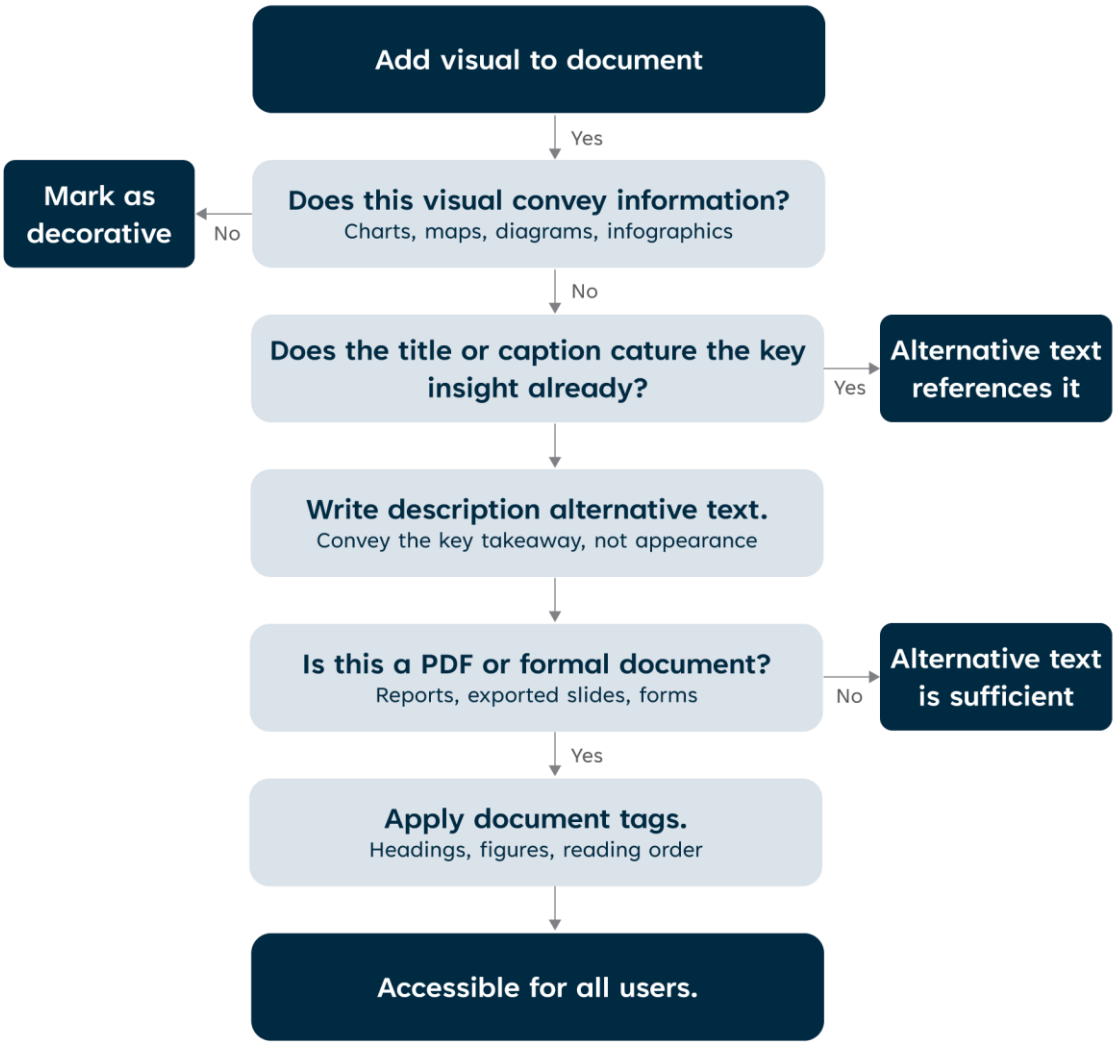


Figure 22: Alternative text decision flow chart.

Tagging ensures that digital documents, particularly PDFs and reports, have a logical structure that assistive technologies can interpret. Tags define reading order, headings, lists, tables, and figures so that content is presented coherently when read aloud or navigated non-visually. Without proper tagging, even well-designed visuals with alt text may be difficult or impossible to understand in context.

Accessibility Resources and Further Guidance

This guide introduces core accessibility concepts relevant to transportation data visualization, but many agencies and practitioners will require more detailed, tool-specific guidance to implement these practices consistently. A comprehensive set of federal accessibility resources is available through Section508.gov, which serves as a central hub for creating accessible digital content.

3.2.6. Font Selection and Typography

Typography plays a foundational role in the clarity, professionalism, and readability of any data visualization or communication product. Well-chosen typography supports the data story, establishes hierarchy, and ensures that all users—including those using assistive technology—can easily interpret the information. Poor font choices, overly decorative styles, or inconsistent typographic hierarchy can distract from the message and reduce overall accessibility.

Use Sans Serif Fonts for Digital Readability

For digital-first products including dashboards, infographics, presentations, webpage content, and PDF-based charts, sans serif fonts are preferred. Sans serif fonts lack the decorative strokes (serifs) at the ends of letterforms, which generally makes them easier to read on screens, especially at small sizes.

In contrast, serif fonts include decorative strokes that can become visually muddled when displayed at small sizes or low resolutions. Serif fonts typically perform better in long-form printed material, like books and reports, but even in print, sans serifs may still provide cleaner and more accessible readability for figure labels, data callouts, and diagram annotations.

Figure 23: Serif fonts versus sans serif fonts.

Maintain a Clear Typographic Hierarchy

A well-organized typographic hierarchy helps the viewer understand the order in which information should be read. Use variations in **font size, weight, and color** to guide the viewer's eye:

- **Title** — Largest size, boldest weight; clearly states what the visualization is about.
- **Subtitle or Supporting Line** — Slightly smaller, 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.

This hierarchy helps viewers quickly parse information—particularly in data-dense graphics or dashboards where multiple elements compete for attention.

Keep Font Choices Minimal

Limit your design to one or two font families to maintain consistency and cohesion across the product. Mixing many fonts introduces visual noise. If variation is needed, use:

- The bold or semibold version of your primary font for emphasis
- Italics sparingly for annotations or clarifications
- Color variations to distinguish focus areas (used in alignment with your color selection guidance)

Consistency across visualizations strengthens recognition, especially in multi-page products like guidebooks, reports, or online toolkits.

Prioritize Legibility and Accessibility

Ensure all text—especially labels on charts—is large enough to read without zooming and meets Section 508 contrast guidelines. Key considerations include:

- Minimum 12 pt for body text in print and at least 9–10 pt equivalent for digital graphics.
- Strong contrast between text and background (use WCAG contrast ratios).
- Avoiding ultra-light or thin font weights, which reduce legibility on screens.
- Ensuring text has sufficient spacing (e.g., line height ~1.2–1.4).

When exporting to PDF, check that fonts embed correctly so screen readers can interpret text accurately.

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 refers to the intentional integration of sensory modalities beyond sight to communicate information. Although visualization is typically approached as a visual activity, research in multisensory learning, auditory display, immersive analytics, and universal design shows that people understand and retain information more effectively when multiple senses are engaged.[5][6][7][8]

Why It Matters

Transportation systems are experienced physically and spatially. People perceive scale, navigate space, and respond to environmental conditions such as noise and proximity. When communication relies solely on charts or static renderings, important experiential aspects may remain abstract.

Strategic multisensory approaches can:

- Improve understanding of spatial tradeoffs and scale
- Support accessibility and inclusive engagement
- Clarify environmental or experiential impacts
- Reduce misunderstanding during public and regulatory coordination

Sensification does not replace visualization. It strengthens it by reinforcing visual information through additional sensory channels.

[5] Shams, L., & Seitz, A. R. (2008). Benefits of multisensory learning. Trends in Cognitive Sciences, 12(11), 411–417.
[6] Marriott, K., et al. (2018). Immersive Analytics. IEEE Computer Graphics and Applications, 38(3), 30–41.
[7] Kramer, G., et al. (1999). The Sonification Report: Status of the Field and Research Agenda. National Science Foundation; Hermann, T. (2008). Taxonomy and definitions for sonification and auditory display. Proceedings of ICAD.
[8] Mace, R. (1997). Principles of Universal Design. Center for Universal Design; World Wide Web Consortium (2018). Web Content Accessibility Guidelines (WCAG) 2.1.

Common Applications in Transportation Visualization

- **Tactile and Physical Models**
  3D printed corridor or interchange models 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.

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 24** 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.

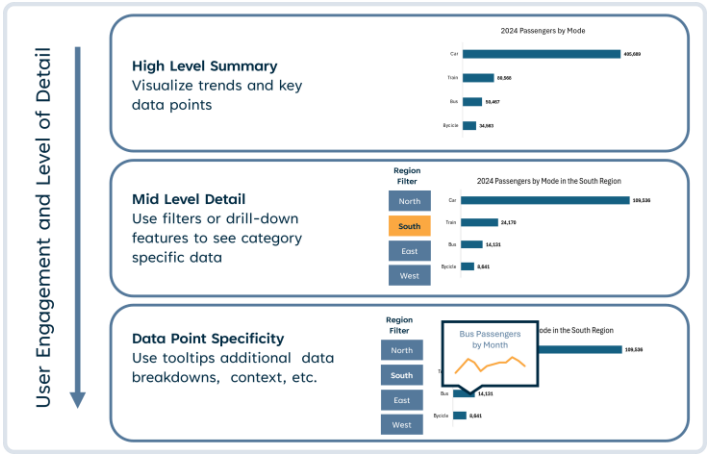


Figure 24: Encouraging User Engagement Through the Use of Interactivity.

3.3.1. Drill-Downs

Drill-down capabilities allow users to explore data hierarchies by transitioning from high-level summaries to more granular details. This functionality is particularly valuable for breaking down complex datasets, uncovering insights at different levels of aggregation, promoting exploration, and making intricate data more approachable and intuitive for users.

Best Practices for Drill-Downs:

1. **Prepare Data Fields:** Ensure the dataset supports drill-down by organizing fields hierarchically and linking them logically.
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 allow users to refine data views based on specific criteria, enabling customized exploration. They help narrow focus and uncover trends or patterns relevant to user needs.

Best Practices for Filters:

1. **Prioritize Key Dimensions**: Offer filters on the most meaningful dimensions, such as time, geography, or category.
2. **Provide Clear Labels**: Ensure filter labels are intuitive and descriptive, specifying if they support single or multiple selections.
3. **Single vs. Multiple Selection Filters**: Use single selection filters when users need to focus on a specific value or category. Use multiple-selection filters when users need to explore various combinations or compare multiple options.

4. **Use Default Views**: Set logical default filters to present data in a meaningful starting state.

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 enhance the user experience by providing on-demand information without cluttering the visualization. They can present additional data points, such as rankings or trends, clarify details about data sources, methodologies, or terminologies, and encourage further exploration through links or actionable insights. This feature allows users to access relevant information as needed, improving both the clarity and interactivity of the interface.

Best Practices for Tooltips:

1. **Be concise and relevant:** Keep tooltip content short and focused on key information to avoid overwhelming users.
2. **Provide Context:** Include helpful information that clarifies data sources, methodologies, or terms, especially if the audience is unfamiliar with the data.
3. **Ensure Responsiveness:** Design tooltips to load quickly and provide insight without delay.
4. **Emphasize Readability:** Use formatting elements like bold text, color, or font variations to highlight key information.

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.

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 map can be one of the most intuitive tools for understanding and communicating 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.

For transportation agencies, a simple map of crash locations, for example, immediately highlights problem areas that could warrant further analysis. Of course, maps aren't limited to simple visualizations. They can also allow transportation professionals to tackle more complex questions such as where gaps exist in current service, or how planned projects may impact various demographic groups differently. Creating effective maps or geospatial applications – whether simple or advanced – requires careful attention to design elements such as projection, scale, map type, and interactivity.

There are many different types of maps one can use depending on the data and type of relationship trying to be displayed. The graphic in **Figure 25** walks through a few simple questions to help choose the appropriate map type.

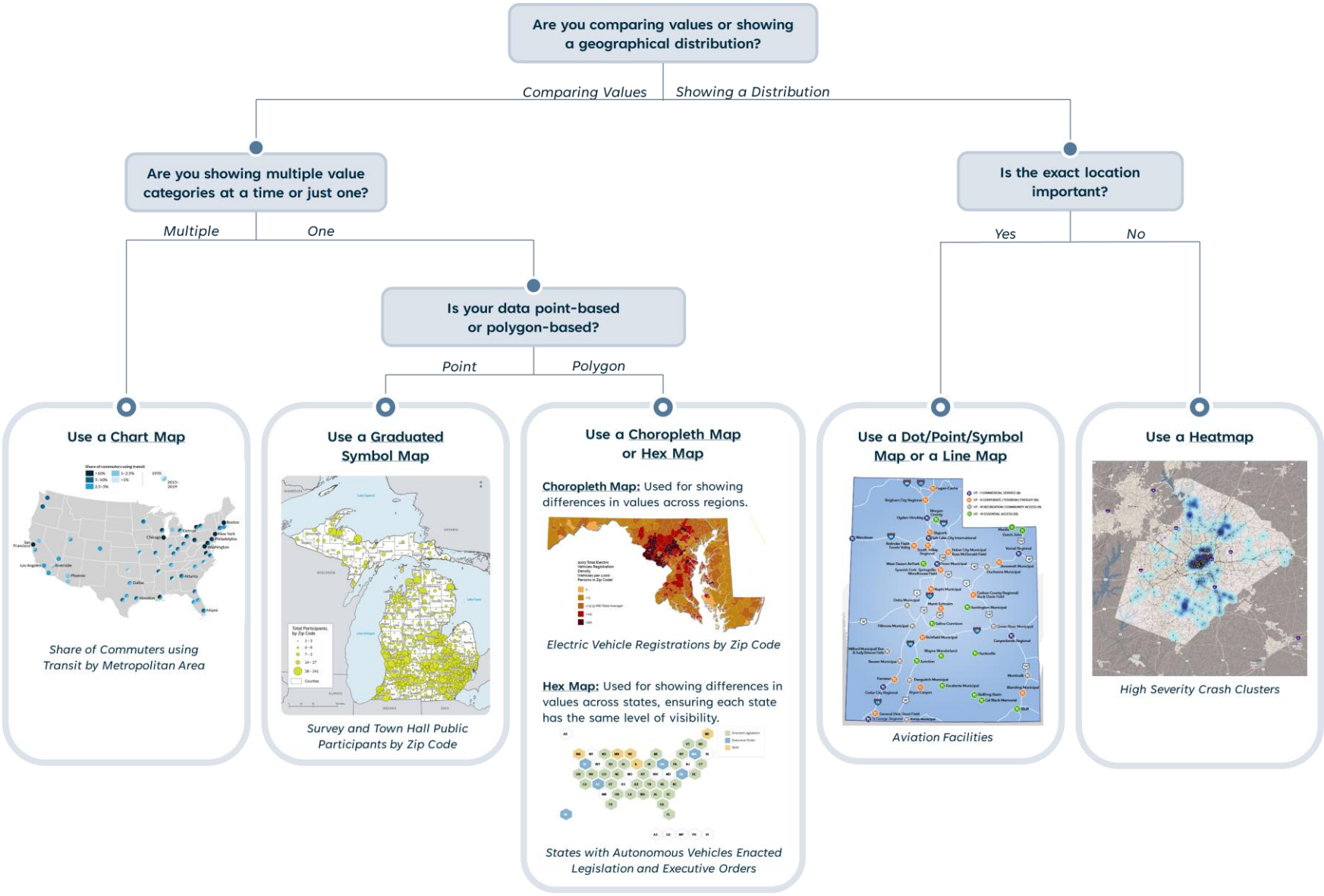


Figure 25: Choosing the Right Map Type.

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 the right map projection for a dataset. Choosing an inappropriate projection can largely distort geographies and misinterpret spatial relationships. For example, **Figure 26** shows the United States projected four different ways. Each one shows varying proportions of the states and the country as a whole.

Figure 26: The U.S. Projected Four Different Ways.

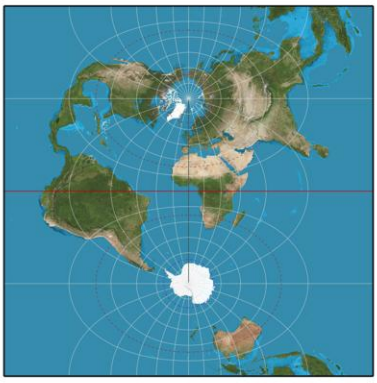
The following figure suggests projection types to use based on a map's extent – a local/regional map, a multistate or national map, or a specialized map such as one centered on a particular roadway corridor.

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 27: 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 statewide corridors.

- **High-Detailed Data:** Use large-scale maps (i.e., zoomed in to your areas of focus).
- **Broad Overview Data:** Use small-scale maps (i.e., zoomed out to your region or state).
- **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 allow users to explore data at multiple scales.

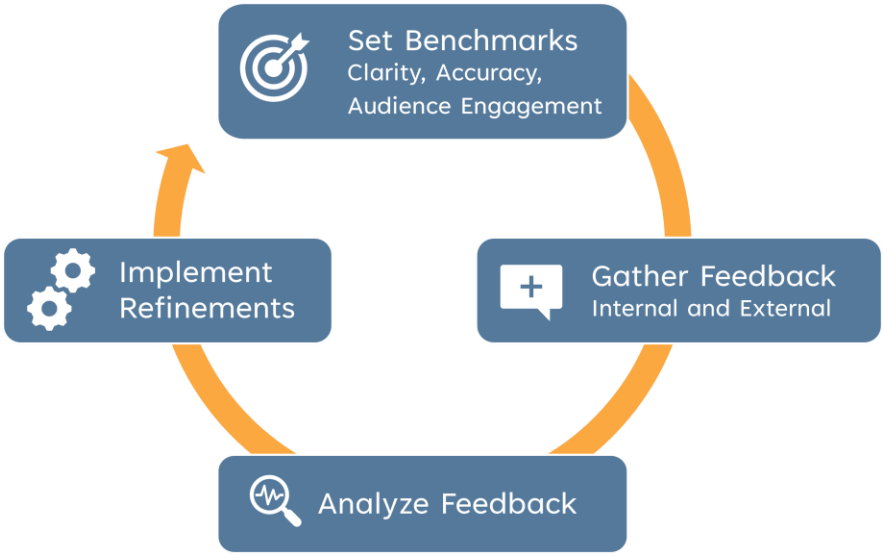
3.4.3. Real-Time Data

Adding real-time data to a map or geospatial application can further enhance decision-making, particularly in more dynamic contexts such as traffic management or emergency response. This could include real-time traffic maps showing congestion levels or accidents, or data such as current transit operations for public use.

4. Assessing What Works: Evaluation and Refinement

4.1. Developing an Evaluation Process

Effective data visualization is not a "set it and forget it" endeavor; it requires an ongoing commitment to evaluation and refinement, as illustrated through a Cycle of Continuous Improvement in **Figure 28**. This process begins by setting clear benchmarks for success, including clarity (is the visualization easy to understand?), accuracy (does it represent the data faithfully and without distortion?), and audience engagement (does it capture the audience's attention and meet their needs?). These benchmarks create a shared understanding of what constitutes a successful visualization and guide subsequent steps in the improvement cycle.



Cycle of Continuous Improvement

Figure 28: Cycle of Continuous Improvement.

The Insights Hub shown in **Figure 29** 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 29: The flow of feedback for data visualization design.

The Cycle of Continuous Improvement highlights the iterative nature of refining visualizations. After gathering feedback, agencies analyze this information to identify actionable improvements, implement refinements, and evaluate the results against established benchmarks. This structured approach ensures that visualizations remain relevant, impactful, and aligned with the evolving needs of stakeholders and audiences. By using an Insights Hub as a feedback engine, agencies can continuously refine their visualizations to drive better decision-making and engagement.

4.2. Identifying Strengths and Gaps

Once feedback has been gathered, the next step is to identify the strengths and weaknesses of the visualization by evaluating visuals on a framework that checks for clarity, accuracy, and audience engagement as highlighted in the Visualization Evaluation Matrix in **Table 6**. Strengths could include elements that effectively convey the intended message, such as a bar chart that makes trends instantly recognizable or an interactive map that enhances audience engagement by allowing users to explore data in-depth. Conversely, weaknesses might involve design choices that confuse or distract, such as overly complex graphics, unclear labels, or an overreliance on color that alienates colorblind viewers.

The Visualization Evaluation Matrix is designed to help users systematically assess their visuals across three critical dimensions: clarity, accuracy, and audience engagement. Each criterion is paired with guiding questions and a scoring system to highlight strengths and identify gaps.

To use the matrix effectively:

1. **Evaluate Each Criterion:** Start by answering the guiding questions for each criterion (e.g., "Does the visualization convey its message clearly?"). Score the visualization on a scale from 1 to 3, where 3 represents the strongest performance and 1 indicates significant issues that need attention.
2. **Analyze the Scores:** Review the scores across all dimensions. High scores indicate areas of strength, such as clear purpose or robust context, while low scores reveal specific weaknesses that require improvement.
3. **Take Action:** Use the guidance in the table to address gaps. For instance, if the visualization lacks context, consider adding benchmarks or comparisons to enhance decision-making. If interactivity is limited, explore accessible and intuitive features to better engage your audience.

For example, a visualization with unclear labels and an overcrowded design might score poorly in "Purpose Alignment" and "Design Simplicity." Referring to the suggested actions in the matrix, users can add annotations, simplify the layout, and reduce visual clutter to enhance clarity and focus. As agencies integrate this framework into their workflows, it can serve as a consistent benchmark for producing impactful and accessible visualizations tailored to diverse audiences.

Table 6: 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.*

Common Fixes and Recommendations:

- Begin with the end in mind: plan for the questions you expect stakeholders to ask of the data.
- Design from the ground up: begin with the simplest visuals with little flair and only add elements (icons, colors, labels, etc.) that serve a purpose.
- Use sorting and ordering in logical ways (by frequency, value, group, or alphabetically).
- Add annotations and data labels to increase clarity.

4.3. Building Continuous Improvement Cycles

Continuous improvement is essential to maintaining the effectiveness of visualizations over time. Audience needs and organizational priorities evolve, and visualizations must adapt accordingly. A feedback loop, such as that shown in **Figure 30**, that incorporates audience insights into future visualization practices is critical to staying relevant and impactful. This cycle might involve regular reviews of existing visuals, gathering fresh feedback, and implementing incremental updates based on user suggestions and lessons learned from past projects.

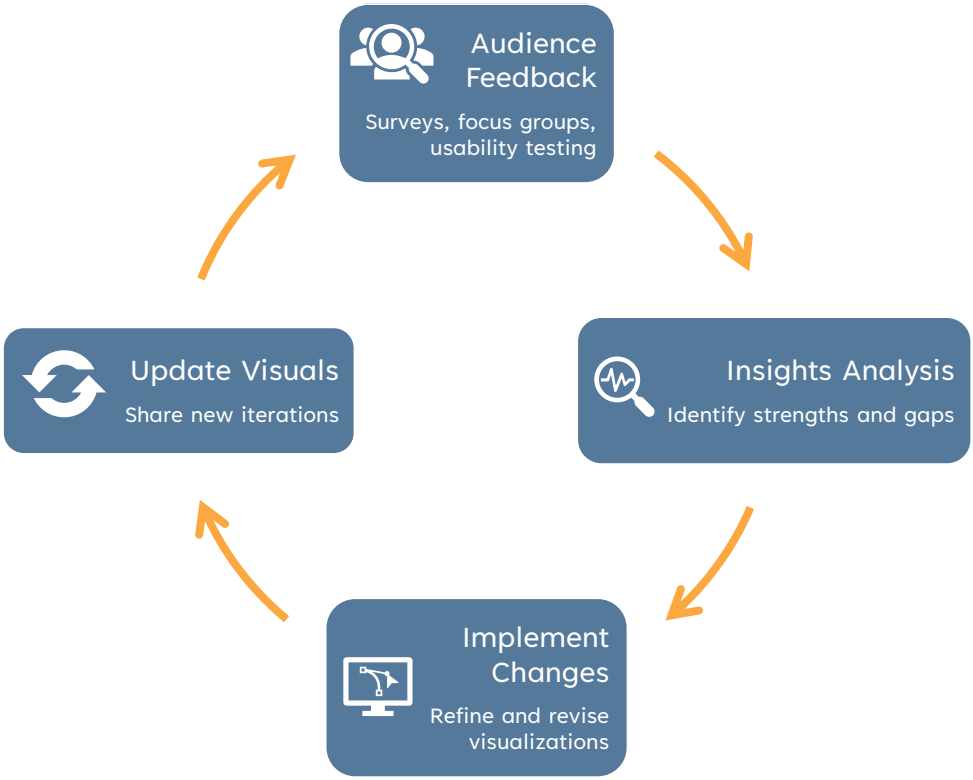


Figure 30: Continuous Improvement Through Feedback.

To support continuous improvement, agencies should establish a repository of successful examples and best practices. This repository can serve as a go-to resource for visualization development, offering templates, design tips, and case studies that illustrate what works well in different contexts. Over time, this knowledge base becomes a valuable organizational asset, fostering a culture of learning and innovation. By emphasizing iterative refinement and knowledge-sharing, agencies can ensure that their visualization practices continue to meet the needs of their stakeholders and advance their strategic goals.

User surveys are a common tool for gathering insights into the effectiveness of data visualization and broader digital interactions. A notable example is the Federal Highway Administration's (FHWA) use of pop-up surveys on its website, which prompts users to provide feedback after visiting the site multiple times. These surveys are designed to collect user opinions on their experience, including clarity of information, ease of navigation, and overall satisfaction. Such feedback loops are valuable for identifying areas of improvement, validating existing design choices, and ensuring that resources meet user needs.

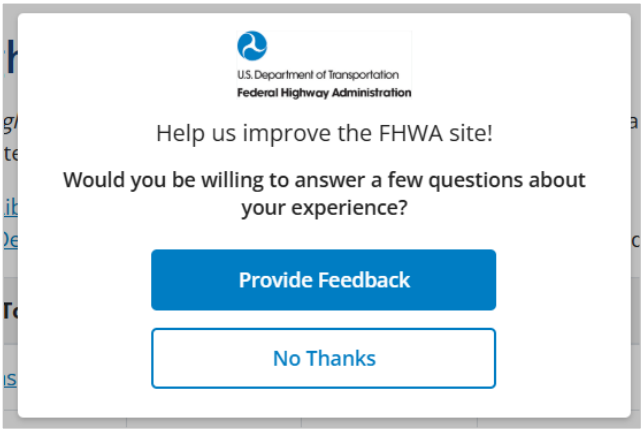


Figure 31: FHWA Website User Survey Request.

4.4. 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

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

5.1. Addressing Organizational Barriers

Organizational barriers can hinder the successful adoption of visualization practices, making it essential to identify and address these challenges proactively. **Figure 32** displays some of the most common organizational barriers organizations can face when adopting new practices, as well as their potential solutions.

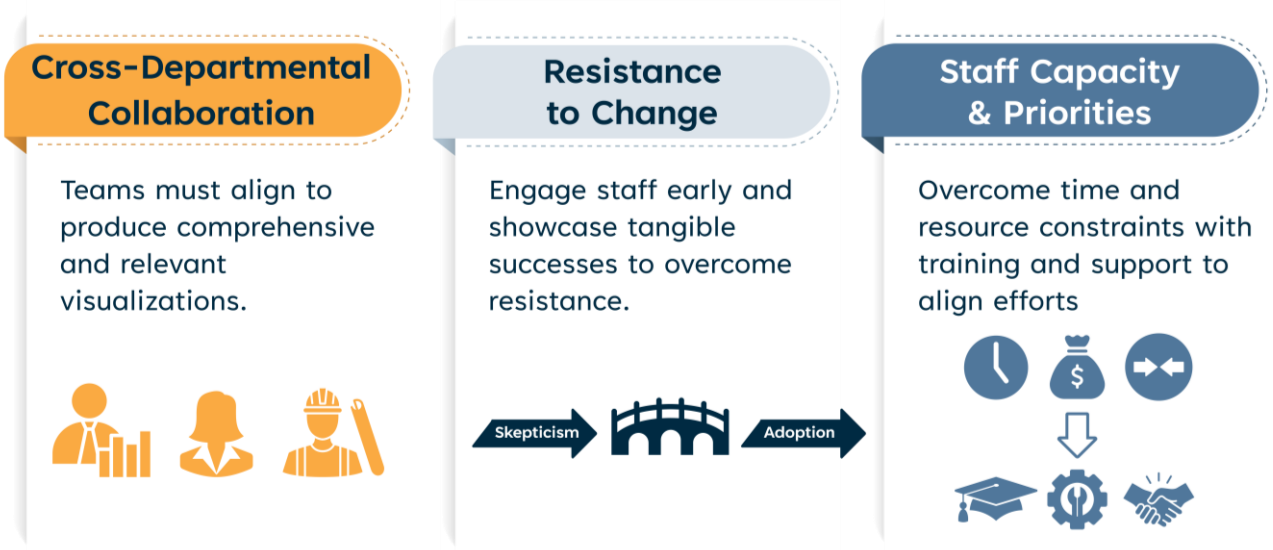


Figure 32: Common Organizational Barriers and Solutions.

Agencies often face issues such as siloed departments, where teams work in isolation, limiting opportunities for collaboration and the creation of comprehensive visualizations. Resistance to adopting new tools and technologies is another common hurdle, often stemming from unfamiliarity or skepticism about the value of visualizations. Additionally,

limited staff capacity and competing priorities can prevent agencies from dedicating the necessary time and resources to visualization efforts.

To overcome these challenges, agencies must engage staff early in the visualization process, fostering a sense of ownership and alignment with organizational goals. Showcasing tangible success stories, such as improved decision-making or public engagement, can help build momentum and support for these initiatives. Training programs can also play a critical role by demystifying visualization tools and equipping staff with the skills they need to succeed. Encouraging cross-departmental collaboration, such as forming teams that include representatives from planning, IT, and communications, ensures that visualizations are technically robust, aligned with organizational objectives, and tailored to diverse audiences.

5.2. Leadership and Buy-In

Leadership is a critical driver of cultural change within an organization, and fostering a culture of effective visualization is no exception. Leaders can set the tone by prioritizing visualization capability. Their active support, such as modeling the use of visualizations in meetings and reports, reinforces their importance and establishes them as a standard practice across the agency.

Securing leadership commitment involves demonstrating how visualizations align with the agency's strategic goals, such as enhancing transparency, improving public trust, or achieving performance benchmarks. Using data to show the impact of visualizations in other agencies can provide further justification for their adoption. When leaders are actively involved in shaping the visualization process and priorities, it sends a strong message to the organization about the value of these efforts and helps build the momentum needed for cultural transformation. **Figure 33** illustrates a four-step framework for how leaders can champion visualization practices and build organizational momentum.

1. **Set the Tone:** Leaders model the importance of data visualization by incorporating it into decision-making processes, presentations, and reports. This active use signals to staff that visualizations are an essential tool for communicating insights and driving decisions.
2. **Show Alignment:** Visualizations gain greater acceptance when they align with an agency's strategic objectives. Leaders can demonstrate how visualizations support goals like improving transparency, fostering public trust, and achieving

key performance metrics. Sharing examples of how similar initiatives have succeeded in other agencies can further strengthen the case for investment.

3. **Build Momentum:** Success stories within the organization serve as powerful tools for cultural transformation. By highlighting impactful visualizations and their outcomes, leaders can build momentum, encouraging teams to adopt and innovate visualization practices.
4. **Commit to Action:** Sustained change requires resource allocation and prioritization. Leaders play a key role in ensuring that visualizations are not only supported but also embedded into workflows by providing necessary tools, training, and staff capacity.

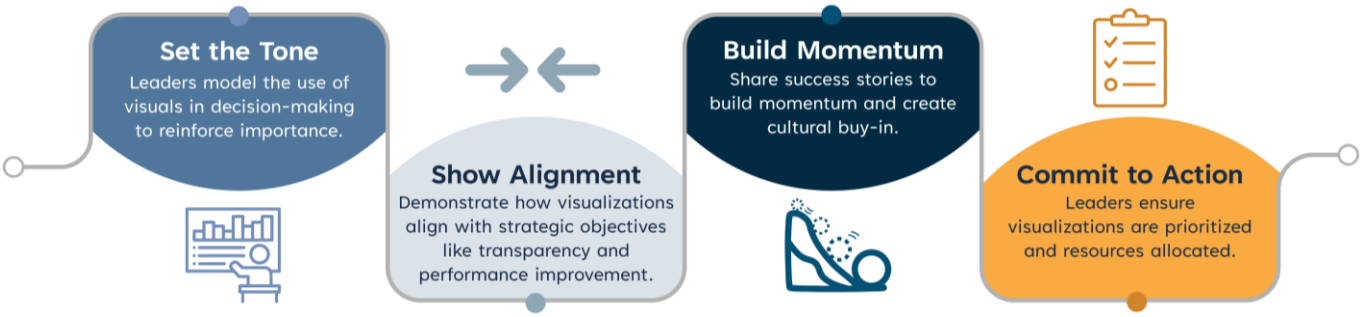


Figure 33: Leadership as a Catalyst for Cultural Transformation.

5.3. Valuing Data-Informed Communication

For visualizations to be fully embraced within an agency, visual, data-supported communication must be embedded into daily workflows and decision-making processes. Agencies can achieve this by making visualizations a standard component of their operations, whether in internal reporting, external communication, or public engagement. When visuals become an expected and integral part of shared information, they gain a foothold as a cultural norm.

Recognizing and celebrating successful visualization efforts within the agency can further reinforce their value. For example, highlighting achievements in newsletters, team meetings, or external communications demonstrates the organization's commitment to data-driven storytelling. Sharing these successes externally can also help build public trust and showcase the agency's dedication to transparency and innovation. **Figure 34** illustrates a four-step cycle for integrating visualizations into agency workflows, emphasizing the importance of consistency, recognition, and public engagement.

1. **Integrate:** Embed visuals into regular workflows such as internal reports or public communications to establish them as essential tools.
2. **Celebrate:** Recognize and reward successful visualization efforts to reinforce their importance and motivate continued innovation.
3. **Showcase:** Share visuals publicly to highlight the agency's commitment to transparency and innovation, building public trust.
4. **Success:** Use momentum from effective visuals to drive ongoing improvements and encourage the sustained use of data visualization.

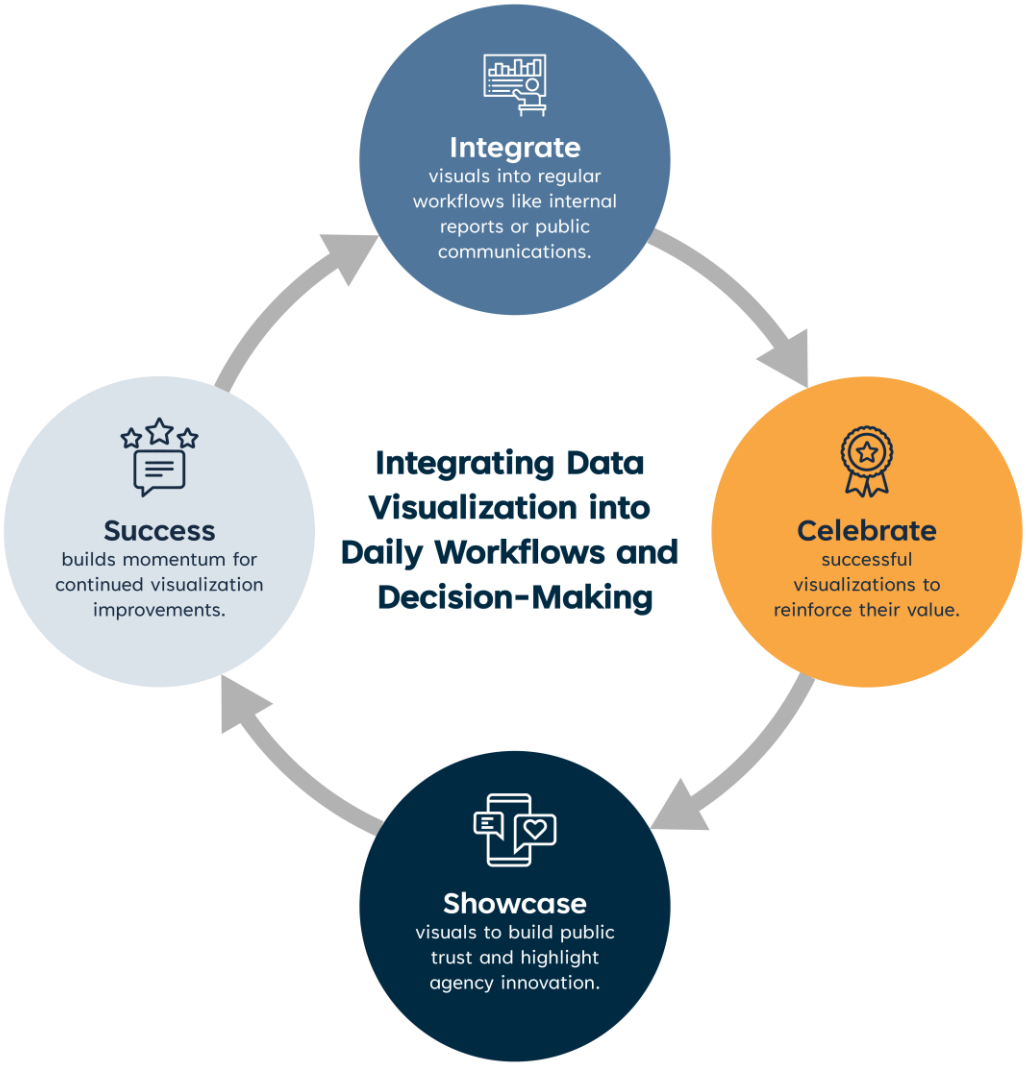


Figure 34: Integrating Data Visualization into Daily Workflows and Decision-Making.

5.4. Building Capacity Through Training and Professional Development

Developing a culture of effective data visualization begins with empowering staff through targeted training and professional development. Agencies should design and deliver training programs that address foundational and advanced visualization skills, tailored to the needs of different organizational roles. For instance, entry-level staff may benefit from workshops on selecting chart types and data preparation, while advanced practitioners could explore interactive visualization tools or interactive mapping techniques. Training should emphasize hands-on learning, allowing staff to apply their skills to real-world agency datasets. Incorporating case studies or examples of successful visualizations from similar organizations can inspire participants and reinforce the practical benefits of strong visualization practices.

To best help staff succeed in incorporating effective data visualization practices into their work, agencies can first identify existing skills and knowledge gaps in their organizations. This evaluation will help agencies inform their future training content.

With a preliminary lay of the land complete, agencies can then develop training content. These training tools should come in different forms, from in-person workshops to online videos, and they should also be developed with accessibility in mind. After a training activity, agencies can ask staff for feedback to ensure that the training provides meaningful benefits and enhances staff capabilities. The learning does not stop after the first activity though, so agencies should continue developing more training content and keeping their existing material up to date on the latest data visualization practices.

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 35: The first three steps to training employees on engagement practices.

5.4.1. Building a Holistic Approach to Data Visualization Expertise

Developing a culture of effective data visualization involves recognizing that different roles within an agency require distinct skill sets. A comprehensive training program should address a range of topics, from foundational skills like data wrangling to advanced practices such as designing dynamic dashboards. By fostering expertise in diverse areas, agencies can empower their staff to excel in visualizing complex datasets, maintaining data accuracy, and engaging various audiences effectively.

Figure 36 and **Figure 37** 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. Each area addresses unique aspects of the data visualization process, ranging from the technical preparation of datasets to the creation of polished and impactful visualizations. These categories are designed to align with the specific needs of staff members based on their roles and responsibilities.

By tailoring training opportunities and looking to hire across to these complementary domains of visualization skills, agencies can foster a well-rounded and capable workforce, better equipped to deliver clear, accurate, and impactful data visualizations that advance organizational goals.

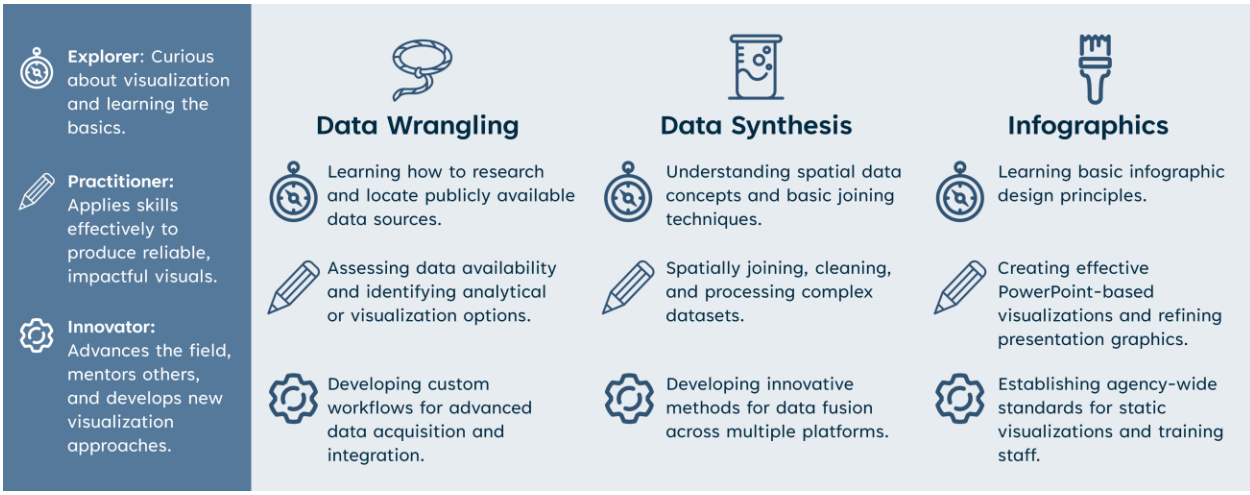


Figure 36: Aspects of data visualization and levels of expertise.

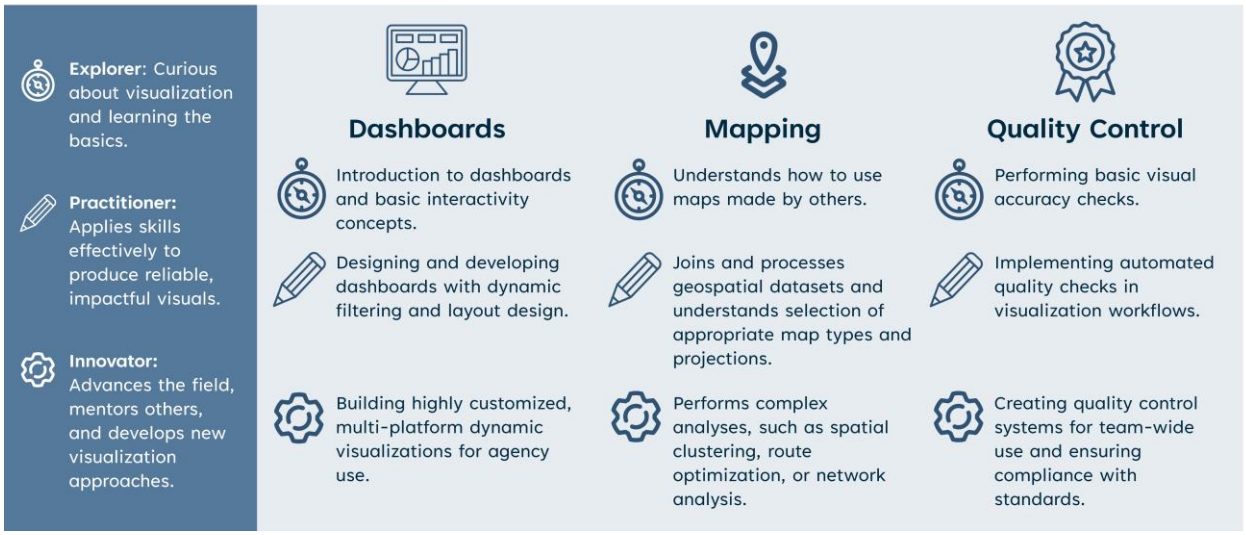


Figure 37: Aspects of data visualization and levels of expertise (continued).

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 38**) could house templates, guidelines, and best practices to streamline visualization efforts and reduce the learning curve for new staff. Readily available resources, such as Esri's Living Atlas or publicly accessible datasets, provide a strong starting point for geospatial visualizations and other data-driven projects. Plug-and-play apps and tools can further simplify workflows, enabling teams to focus on interpretation rather than technical setup. By establishing a culture of continuous learning and providing accessible resources, agencies can build a skilled workforce that is equipped to create impactful, data-driven visualizations, driving better decision-making and public engagement.

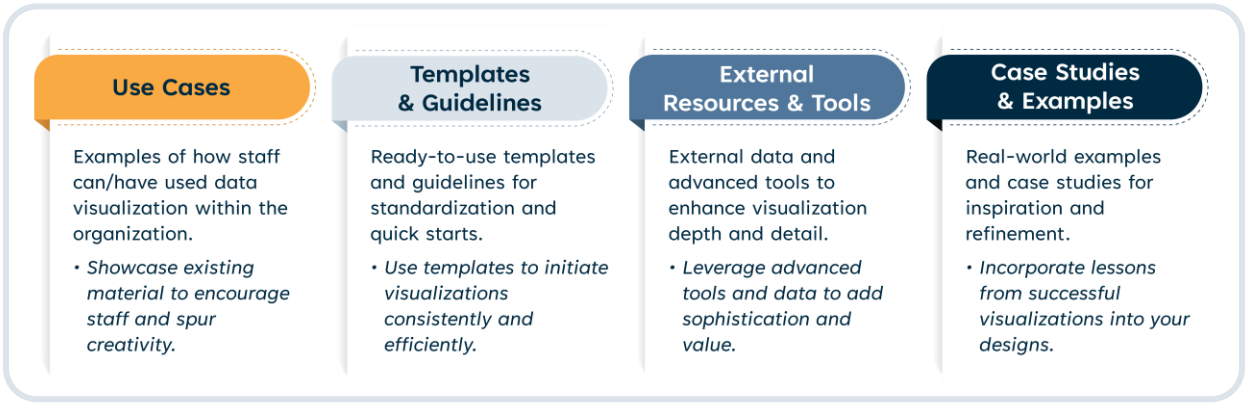


Figure 38: Key components of a data visualization knowledge hub.

5.4.2. 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/UCjhGlILWNloXJdR2NTCBMlA
- 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 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

6. 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.

6.1. 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

Access Link:
[is a current link available?]

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

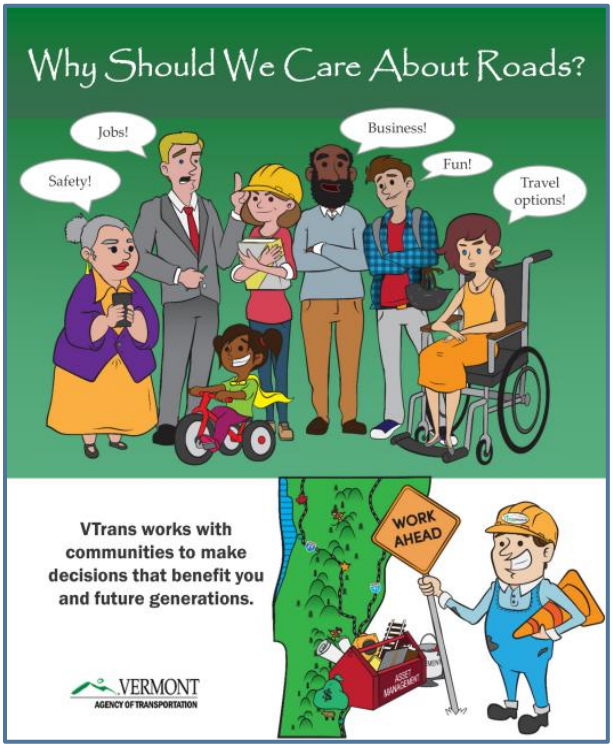
Audience-Led Framing
Content was shaped around how legislators and the public engage with information.

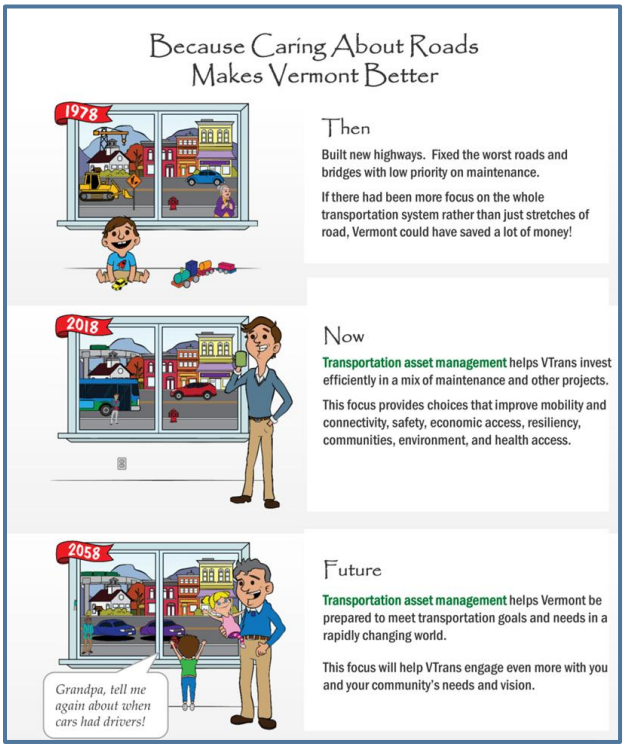
Simple Visuals
Icons and diagrams prioritize explanation and meaning over detailed performance measures.

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

ACS Data → Manual Processing → Datawrapper Charts → Embed on NVCOG Website

NVCOG starts with publicly available ACS datasets, then cleans and standardized 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.dot.ri.gov/projects/WashingtonBridgeRebuild/index.php#TravelDashboard

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:

Integration of live traffic, geospatial, and camera-based data sources → Automated refresh cycles to support near real-time updates → A streamlined interface designed for rapid interpretation under time pressure → Minimal user interaction to reduce friction during emergency use

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.

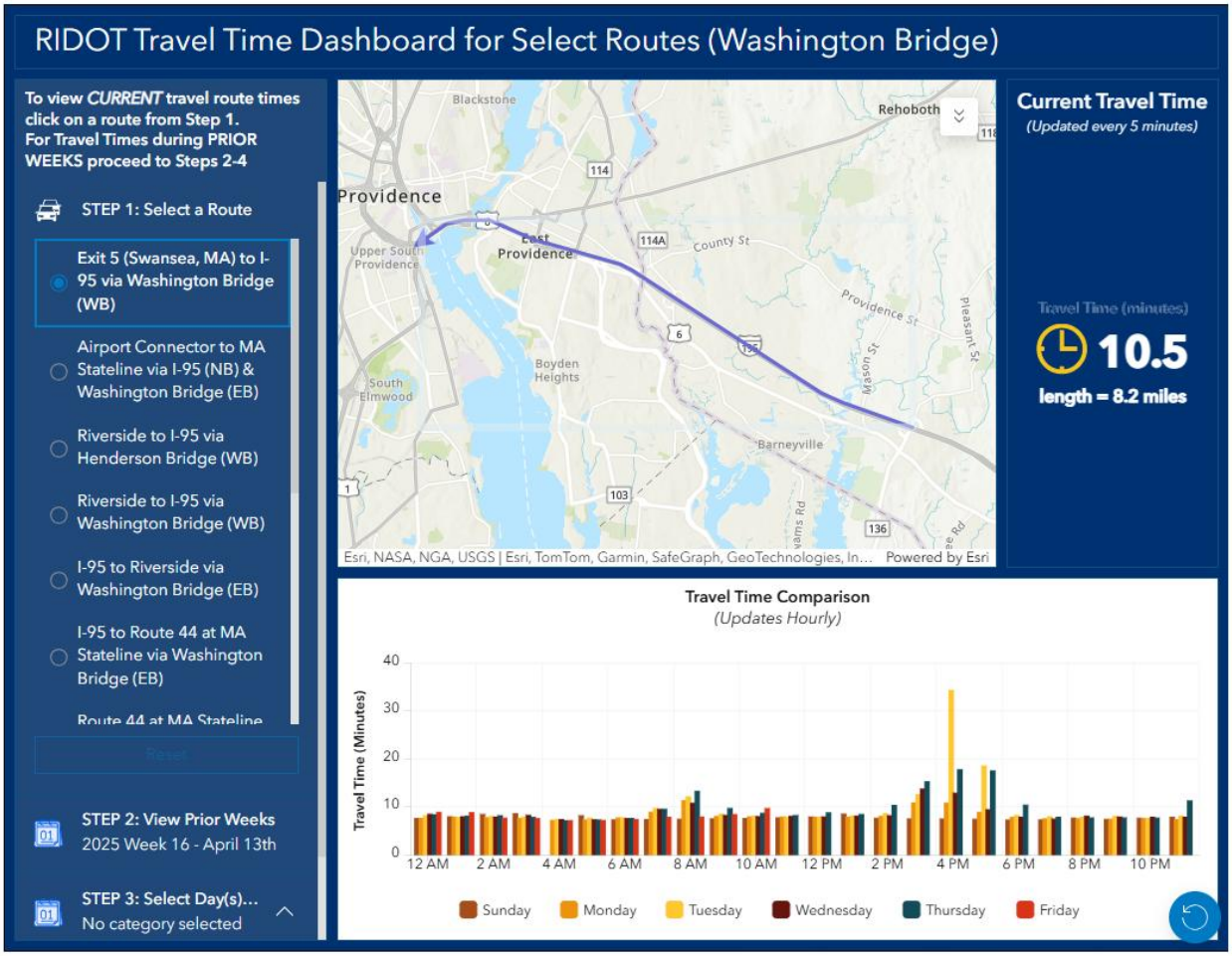
Designed for Speed, Not Exploration

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."

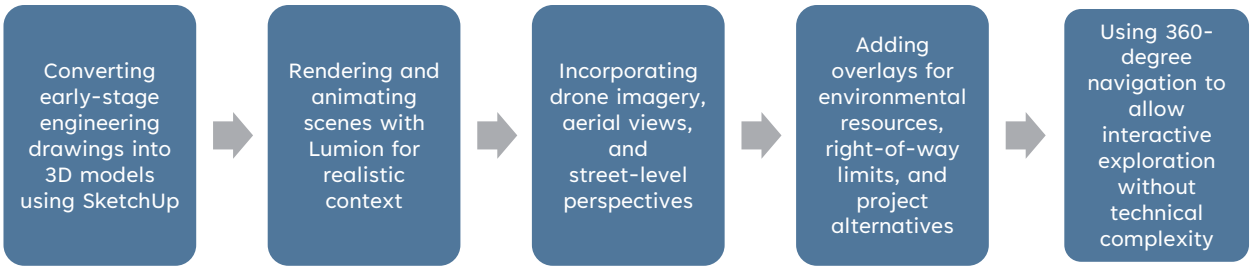
- Eileen M. White, P.E., Executive Officer
San Francisco Bay Regional Water Quality Control Board

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.

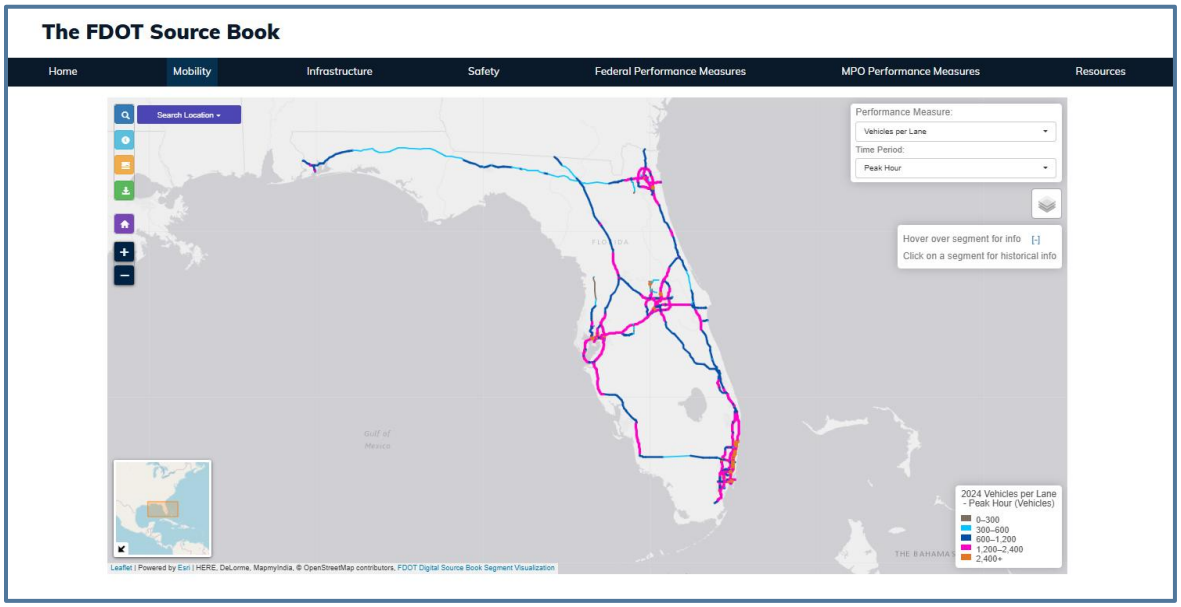
Governance Sustains Scale

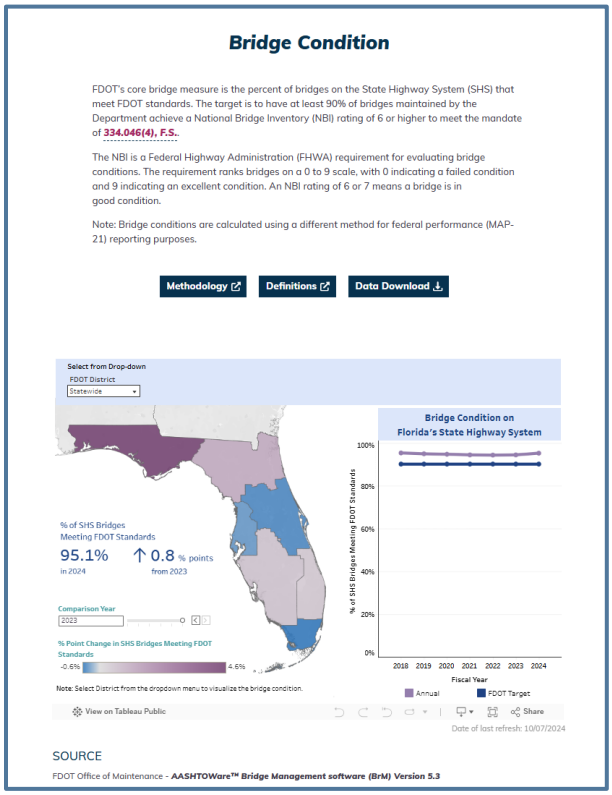
Strong coordination, documentation, and database infrastructure enable the platform to grow while remaining reliable and maintainable.

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.

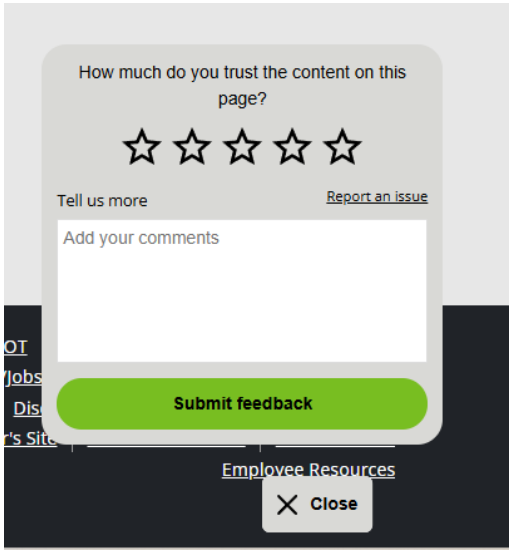
Disaggregation Adds Meaning
When beneficial for understanding, measures are broken into subcategories and supported by simple filters, allowing users to explore key dimensions of performance while preserving a clear, readable layout.

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.

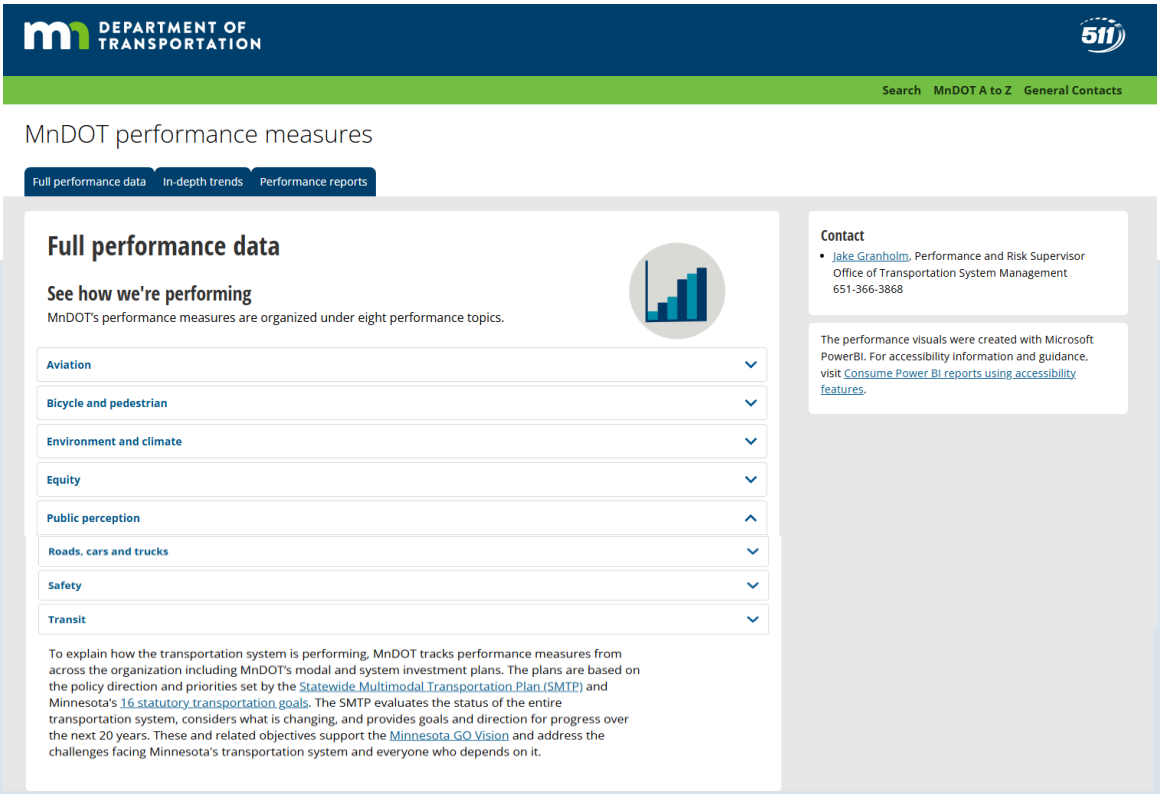
Feedback Loop

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.

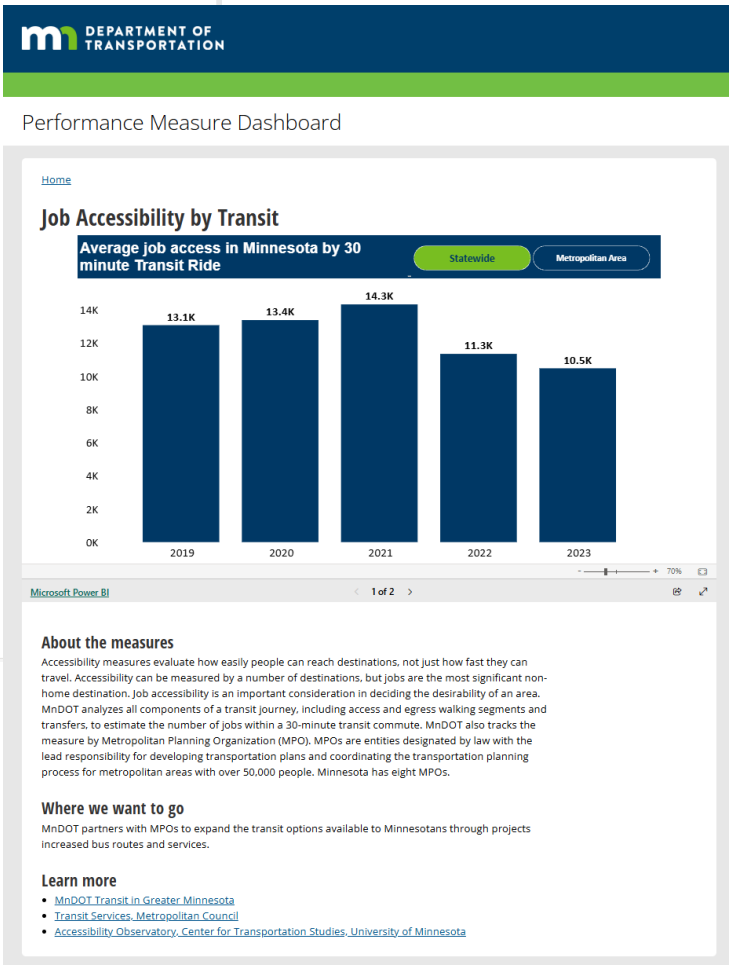


Samples



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.

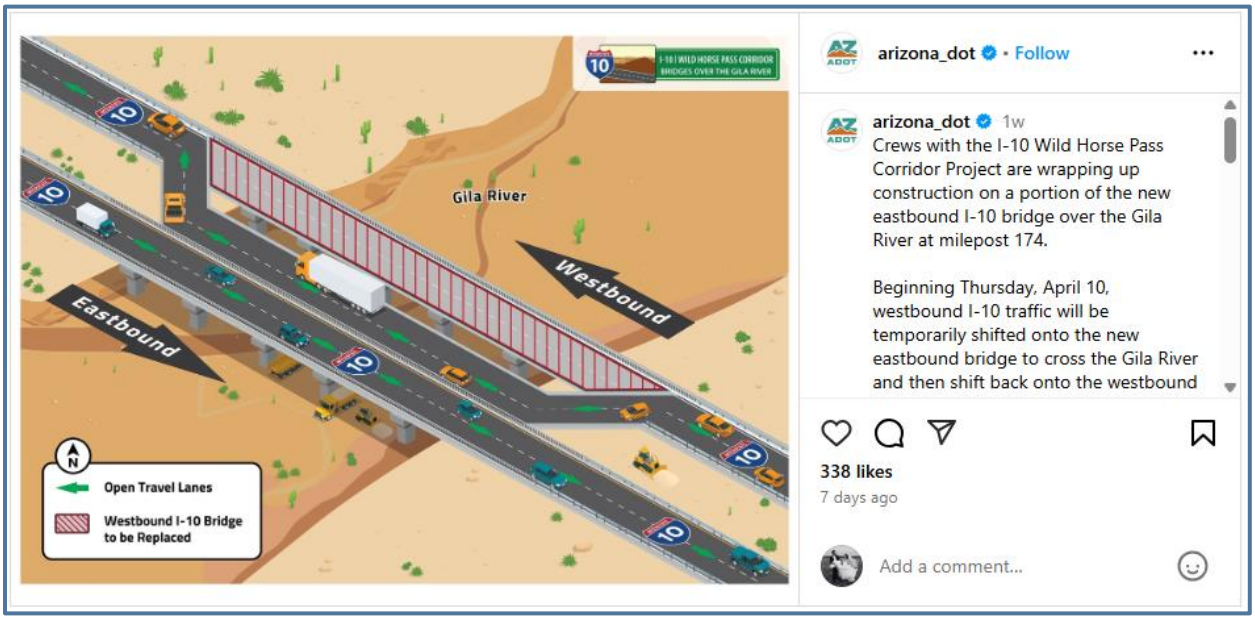
Single-Frame Visuals Reduce Cognitive Load

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 show 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 with Near Real-Time Data

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.

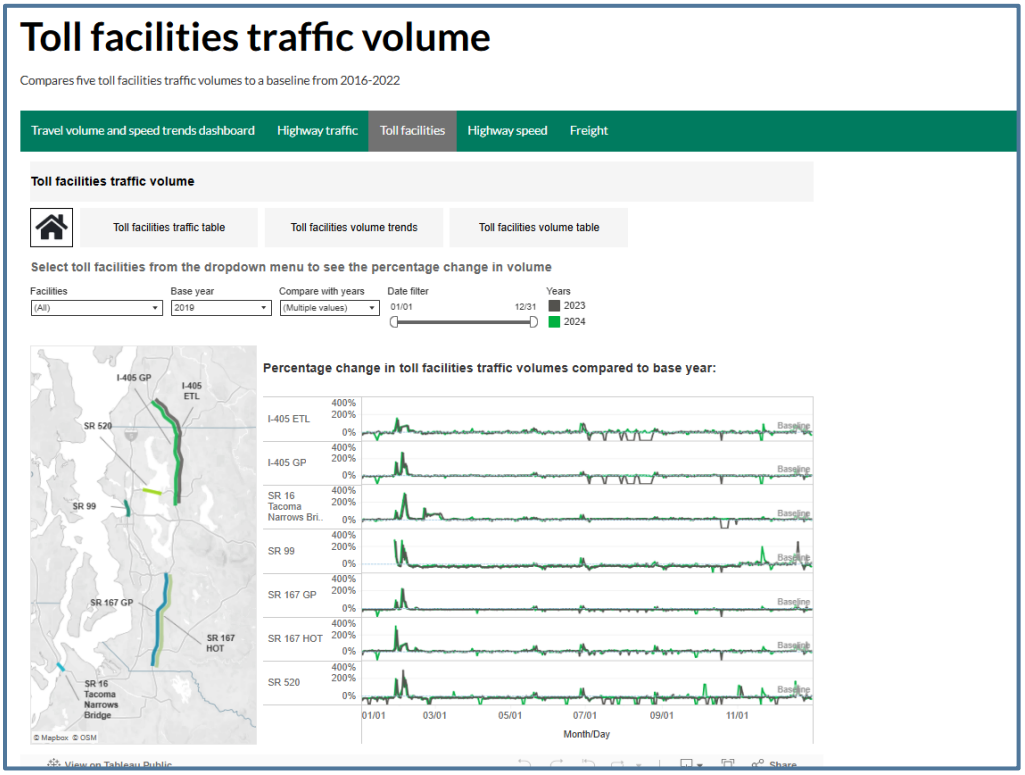
Multiple Time Scales Support Different Decisions

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

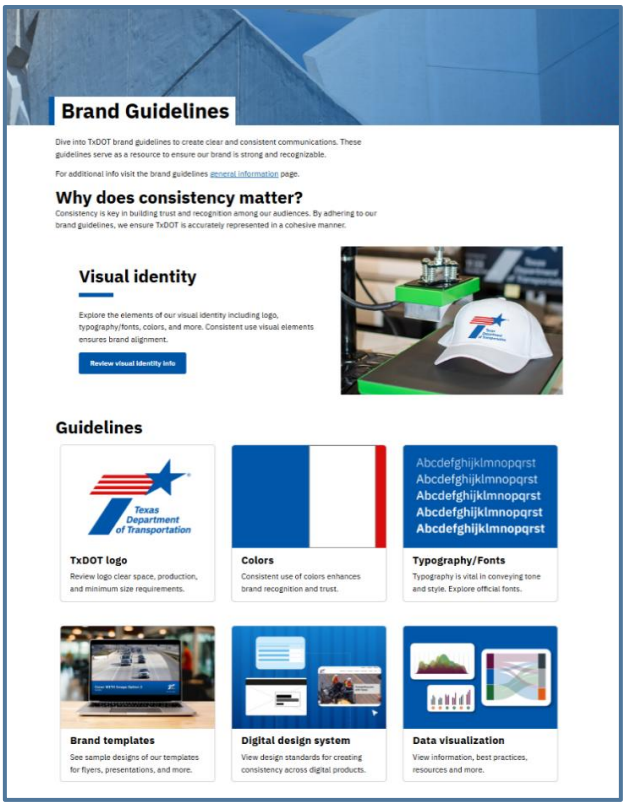
Standards as Shared Infrastructure
Clear, public guidelines function as foundational infrastructure, reducing rework and improving consistency across projects, districts, and teams.

Centralized Standards for Decentralized Creation
By centralizing standards and resources, TxDOT enables staff across the agency to produces 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.

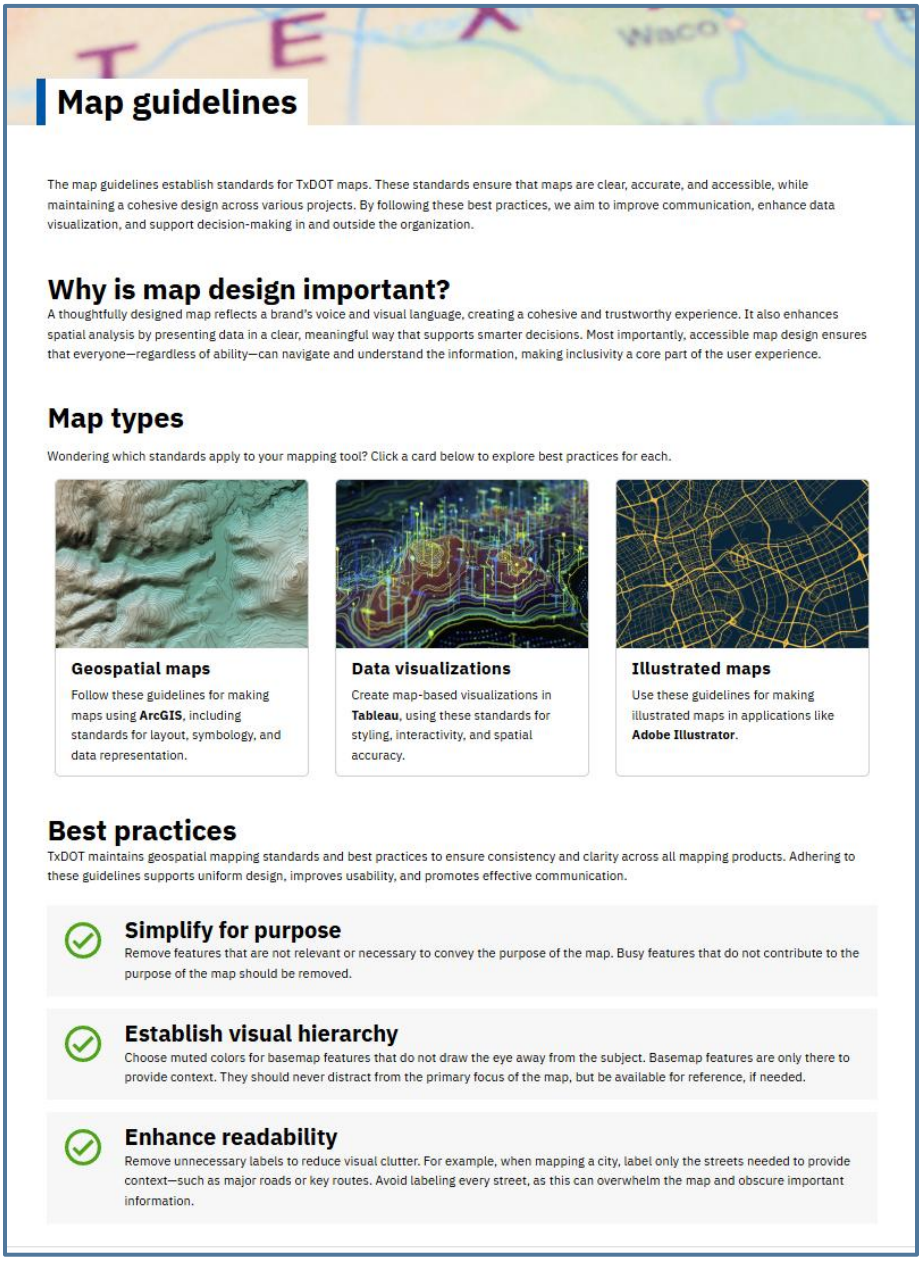
Standardized Spatial Rules Improve Analytical Consistency

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



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

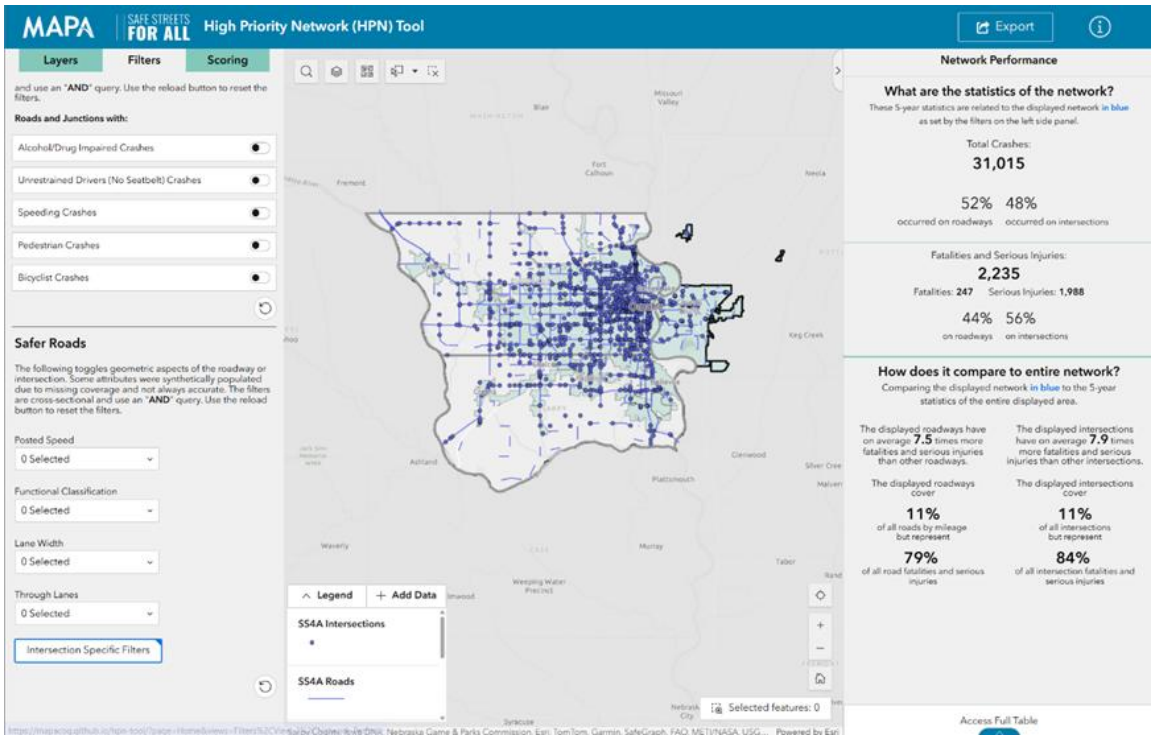
Crashes, Risk, and Lived Experience for a Complete Safety View
Combining historical crash data, modeled risk, and community-reported concerns creates a more complete picture of safety need than any single dataset

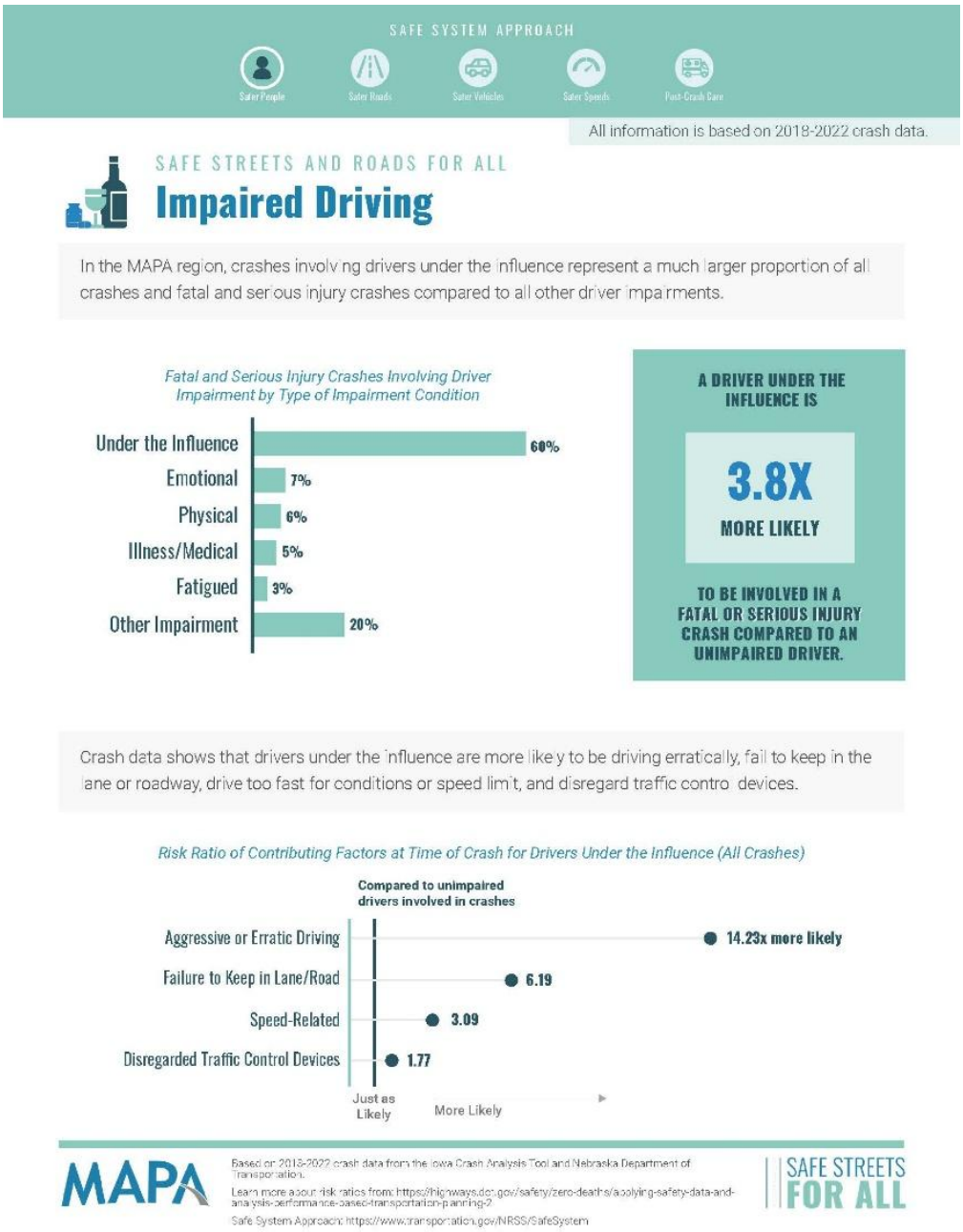
Different Outputs for Different Audiences
Pairing a flexible GIS-based tool with concise one-pagers helped translate complex analysis into accessible formats for leaders, stakeholders, and the public.

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.

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

7.1. 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.

7.2. 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.

7.2.1. 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: _____ (Max 12)

7.2.2. 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: _____

7.2.3. 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, LRTPs, budget presentations).	

Subtotal: _____

7.2.4. 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: _____

7.2.5. 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: _____

7.2.6. 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: _____

7.3. Total Score Summary

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

7.4. 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.

7.5. 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?

8. 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

8.1. Growing Your Tools & Technology

8.1.1. 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 have even set up quick "show-and-tell" sessions — 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.

8.1.2. 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 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.

8.1.3. Case Study

Texas DOT (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:

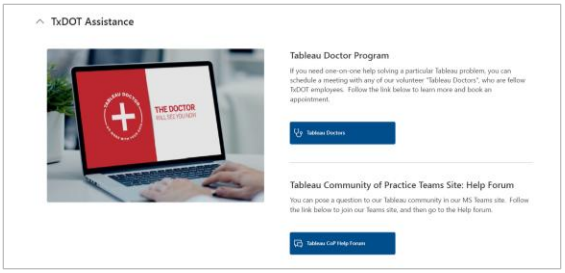


Figure 39: A screenshot of TxDOT's internal SharePoint site dedicated to the Tableau Community of Practice.

- 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)

8.2. Growing Your Skills and Staffing

8.2.1. 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 — 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 — for example, an analyst with a communications specialist — and have them co-develop a visual for a shared project. Both sides will learn from the experience.

8.2.2. 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 — even a simple checklist helps.

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.

8.2.3. 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 not only through training, but by fostering an internal culture where sharing and experimentation are encouraged.

8.3. Growing Your Leadership and Governance Capacity

8.3.1. 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.

8.3.2. 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 — 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.

8.4. Growing Your Communication Strategy

8.4.1. 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 do we want them to learn or do?* 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.

8.4.2. 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, not as decoration at the end. 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 40: Screenshot of Caltrans' animated drive-through video showcasing the new Yerba Buena Island Exit.

8.5. Data Infrastructure & Governance

8.5.1. 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.

8.5.2. 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

8.5.3. 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

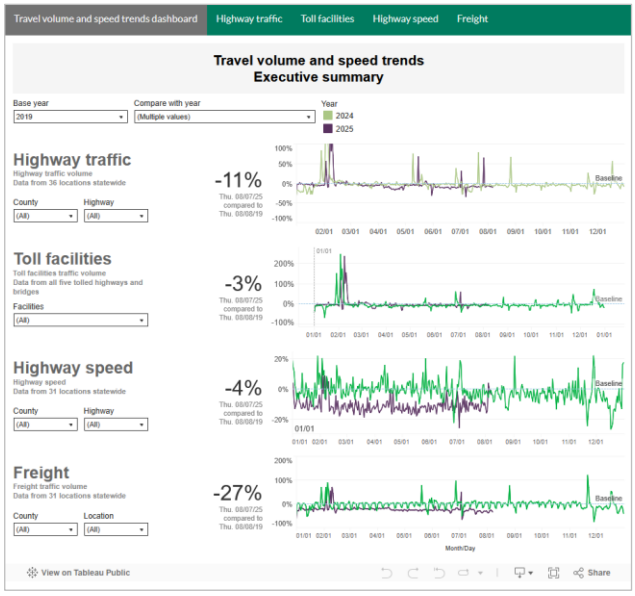


Figure 41: WSDOT's travel volume and speed trends dashboard.

pipeline, and ensuring alignment with planning and performance reporting goals. This robust infrastructure has helped WSDOT deliver consistent, trustworthy visualizations that support both internal decision-making and public transparency.

8.6. 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.

8.6.1. 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.

8.6.2. 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 DOT 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.

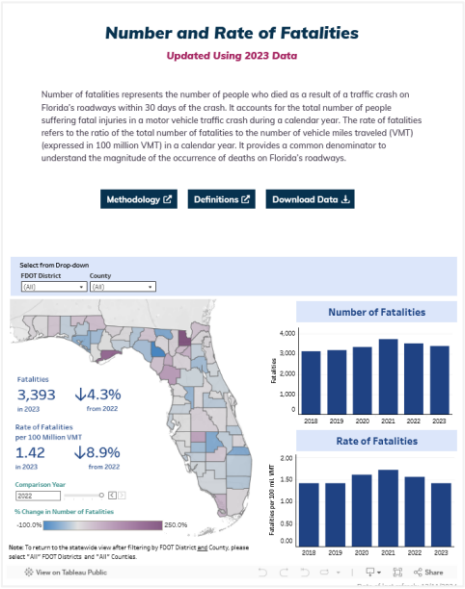


Figure 42: The FDOT Source Book’s number and rate of fatalities page with GIS

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.