NEBRASKA
DEPARTMENT OF TRANSPORTATION

Data Dashboard Design Guide

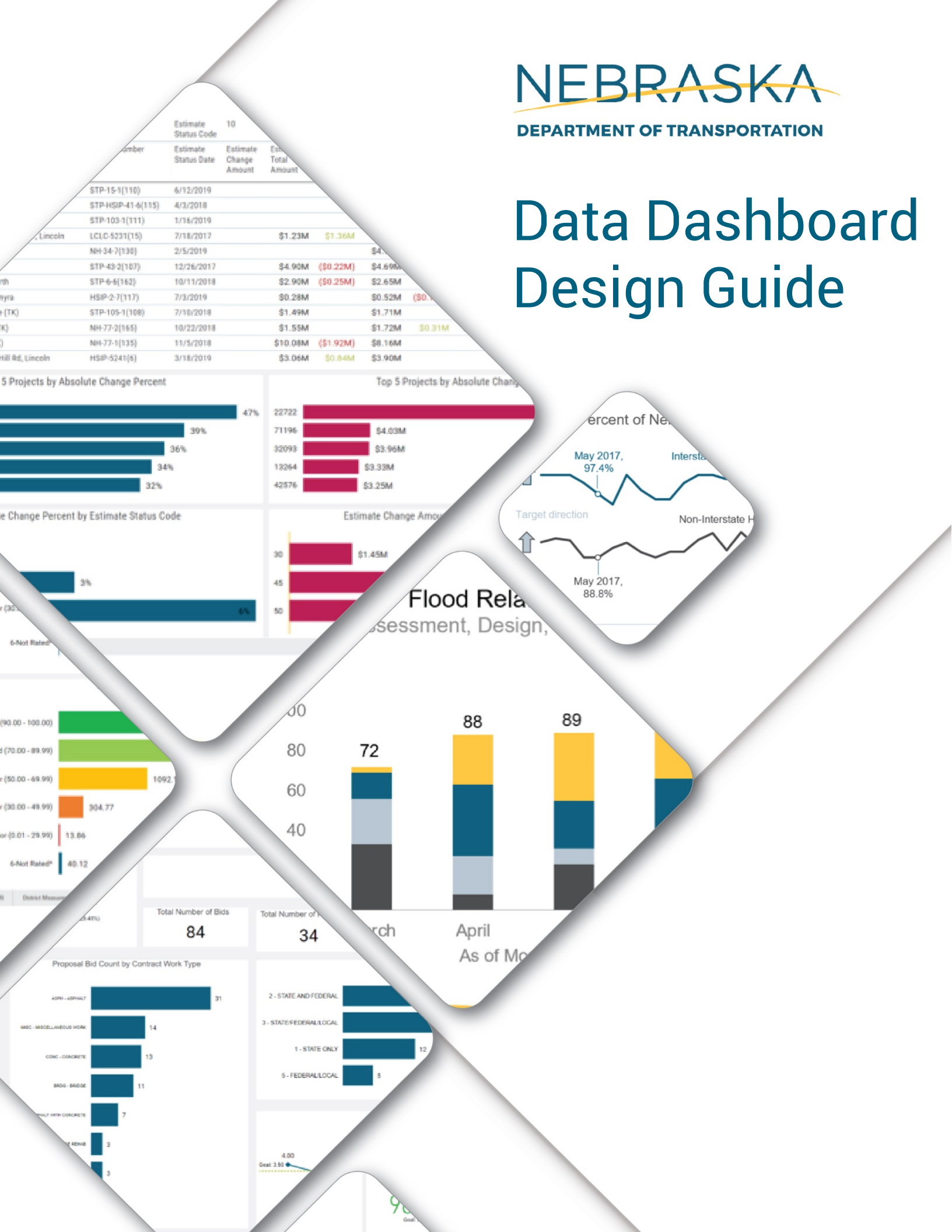


Table of Contents

Introduction *2*

Dashboard Design *3*

1. Identify your audience and purpose **3**

Audience 3

Purpose 3

2. Get your data in shape **4**

Verify & Clean 4

Transform and Shape 5

3. Placement, repetition, and attention: leverage the brain's natural tendencies **6**

Placement 6

Repetition 6

Contrast keeps attention 6

4. Distinguish the signal from the noise **7**

Simplify 7

Simplify 8

Simplify 8

5. Enable interactions conscientiously **9**

Filters 9

Highlighting 10

Drill down 10

6. Iterate, iterate, iterate **10**

Introduction

Nebraska Department of Transportation (the Department) increasingly uses data dashboards to internally communicate progress and processes. A data dashboard is an information management tool that visually tracks, analyzes and displays key performance indicators, metrics and data points. Many divisions within the Department developed data dashboards over that last few years with support from contractor CATCH Intelligence. These dashboards are read by leadership within the Department to better understand internal performance.

An opportunity was identified to improve several dashboards to further effective performance communication within the Department. To these ends, High Street Consulting and CATCH Intelligence were contracted to review the design and functionality of select dashboards during in-person conversations that took place with several dashboard owners at NDOT Headquarters. Suggested improvements for ten different dashboards were provided during the meetings.

In addition, the following report provides general best practices for data dashboard design and functionality that the Department can apply to future dashboard development. Some of the content from NDOT dashboards are referenced below as best practice examples. The charts and dashboards shown in this report are intended for the purpose of illustrating data visualization best practices. Some of the numbers used in the charts may be placeholder information developed for illustration only. The material in this report should not be used or re-printed as a source for any information beyond its intended use to illustrate chart selection.

Dashboard Design

A dashboard is an at-a-glance display of complex information that often changes over time and informs decision making. Dashboards typically include multiple graphics along with callouts for important information. Some dashboards provide a static high-level overview of results, such as a scorecard, but in most cases dashboards provide for some level of interactivity. Dashboards can be created in familiar software programs like Excel, but dedicated dashboarding software such as Tableau or Power BI is becoming increasingly common. No matter which tool is being used to create them, there are a number of best practices to ensure any dashboard serves its purpose as well as possible.

1. Identify your Audience and Purpose

A great dashboard answers one or two questions very well- it doesn't answer everything at once. Similarly, not every dashboard will work for every audience. Before even moving your mouse, ask and answer some fundamental questions:

- What data do you have?
- Who uses this data?
- How are they going to use it?
- What decisions do users need to make based on this dashboard?

Audience

Dashboard design may shift depending on one's intended audience. Will this be a busy executive with 30 seconds to glance at the message? Or a team of strategists using the dashboard during a two-hour meeting? Some important elements when considering your audience are:

1) How much time they have;
2) What is their level of familiarity with and interest in the topic and data; and
3) How much detail they are likely to want to see.

In general, the busier or less familiar your audience is, the clearer the message should be and the less detail is needed. Internal or technical staff well acquainted with a topic, on the other hand, will require detailed information to answer complex questions.

Purpose

The data, visuals, and capabilities in a dashboard should be in direct service to the dashboard's purpose. The dashboard should answer one or two very clear questions. It's easy to want to cover as many bases as possible with a dashboard- it's efficient, right?! However, you're not doing your viewers any favors unless you keep the scope of your dashboard tight. For questions and uses beyond that scope, you can always create new dashboards.

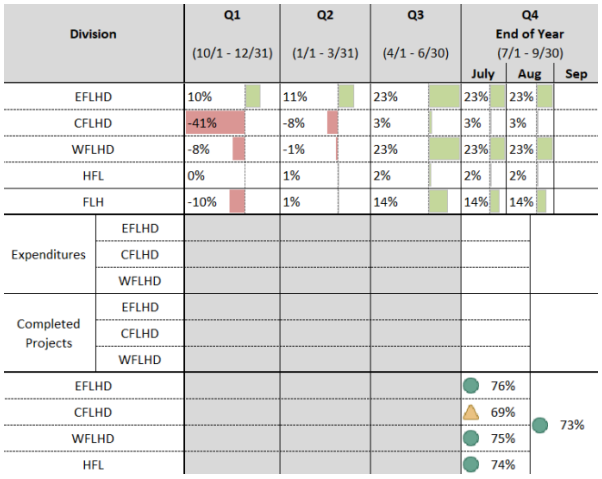
2. Get your data in shape

Preparing data is one of the most important and yet overlooked steps in the visualization process. There are two primary steps in preparing data for dashboards:

1. Verify & Clean - make sure the data is in good shape; and
2. Transform & Shape - structure the data to meet your needs.

Verify & Clean

Figure 1: Spreadsheet with inconsistent rows and columns



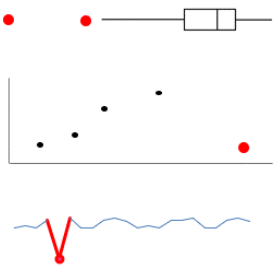
Making sure the data is in good shape refers to good old-fashioned quality control. Is the data complete and accurate? Are there outliers that seem like errors? Was the data set up in a spreadsheet with irregular merging and splitting of rows and columns? If so, spend some time cleaning the data. Check with data owners on any values that seem questionable. You can use preliminary visualizations to help determine if the data "looks right" or if there are any notable anomalies in the values. When all is said and done, every measure of interest should be represented by a clearly named column (or "field"), and every row (or "record") should represent a unique instance of the combination of fields.

Figure 2 Comparing summary results to expected values indicates missing values.

State	Count	Total	Diff
Texas	254	254	0
Kentucky	120	120	0
Kansas	**103**	**105**	**2**
Illinois	102	102	0
Nebraska	93	93	0
Missouri	**89**	**92**	**3**

When verifying your data, you are primarily checking for **completeness** and **quality**. When checking for completeness, you can generate different summaries of the data and compare the results with the number you would expect to see. If data appear to be missing, explore the records more closely to determine what is missing and how to address it.

When assessing the quality of the data, you can begin to use initial visualizations to discover anomalies. Approaches may include:



1. Look for anomalous values **within** one variable at a time.

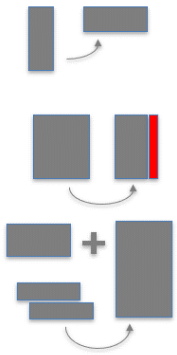
2. Look for anomalous values in combination with another variable (**across** columns).

3. For geographic or temporal data, look for anomalous changes **between** neighboring items (adjacency).

Transform and Shape

The shape of data refers to whether it is “short and wide” with lots of columns, or fields, and a handful of rows (common in Excel, particularly time series data) or “long and skinny” with only a few key columns and many rows, or records (preferred by data scientists). How you decide what makes a row or column influences your options to display it, which can have a profound impact on your dashboard design. So before you build your dashboard, put some time into structuring or “shaping” the data in a way that makes sense for what you want to show.

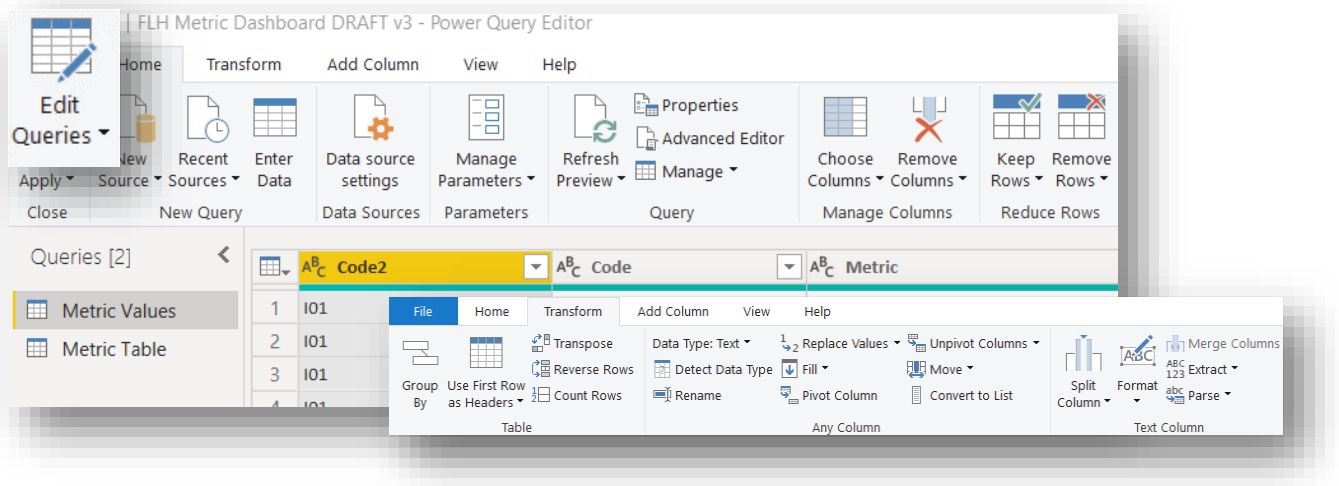
In this process of structuring your data, you may notice that you need to rename columns, combine columns, break them apart, calculate new fields, merge data sets, append newer data to an older data set, or some other adjustment. Additionally, if you have a large data set and will only need a subset for your dashboard, you can filter the data to what you need in order to improve the performance of your dashboard.



1. Get the right structure in place (data shape)
2. Relabel, split, combine variables or create new calculated fields
3. Merge, append, or filter data

It is possible you will not realize whether the current data structure works or not until you try to build a dashboard and run into a barrier. Dashboarding software has built-in tools that can help users adjust the structure of their data on-the-fly, without going back to the original data source. For example, Power BI has Power Query Editor where you can clean data, replace values, or transform by “pivoting” or “unpivoting” columns and rows.

Figure 3 Power BI’s Power Query Editor



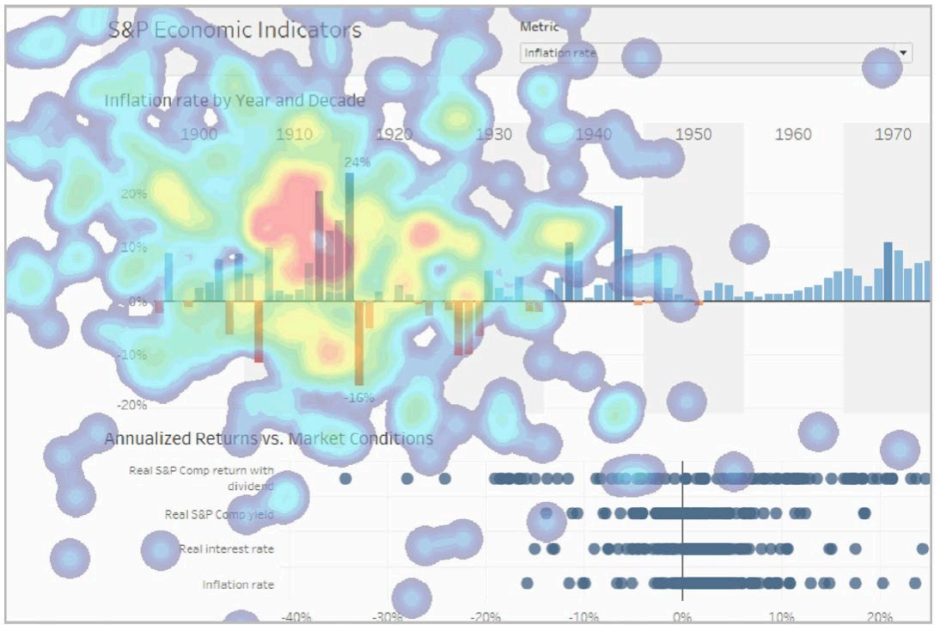
3. Placement, repetition, and attention: leverage the brain's natural tendencies

Placement

Order matters when it comes to which dashboard elements get the most attention. According to a 2017 study by Tableau, the human eye tends to spend the longest in the upper left-hand corner of a screen, and the least amount of time in the lower right-hand corner. This behavior is called the F-pattern. An exception to this finding is including a large number. These elements attract the eye regardless of where they are placed.

Depending on the amount of time a viewer is expected to allot looking at all the information, the order of information or design style may change. Designing one's dashboard to complement humans' instinct to read from left to right and top to bottom will also help highlight the most important information. The graphic below shows a heat map with typical scanning patterns.

Figure 4: Eye Tracking Heat Map



Source: Tableau Eye-Tracking Study https://www.tableau.com/about/blog/2017/6/eye-tracking-study-5-key-learnings-data-designers-everywhere-72395 Accessed 9/1/2019

Repetition

The study also found that avoiding repetitive visuals keeps attention for longer throughout more of the dashboard. For example, if a line graph is repeated throughout the dashboard, the one on the far right or on the bottom got the least views.

Contrast keeps attention

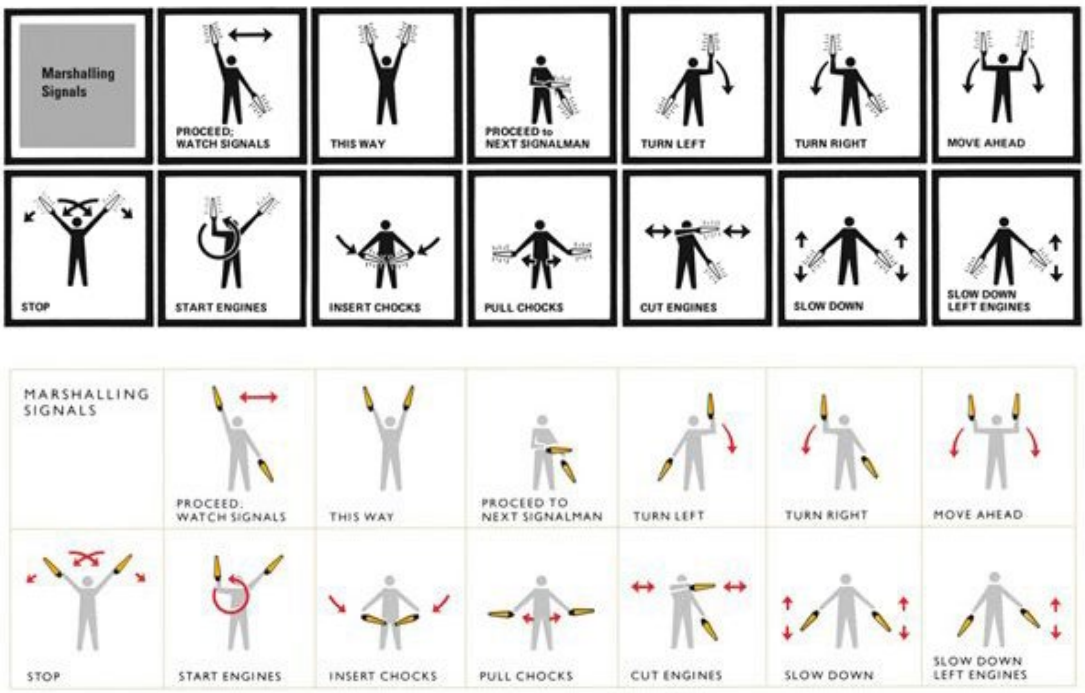
In addition to sequencing, the study found that eyes jumped from one area of color contrast to the next. Thus, color contrast can be used to help guide the viewer along important information.

4. Distinguish the signal from the noise…

… And simplify, simplify, simplify! Noise distracts from your message in any context. With so many different elements in close proximity on a single page, the potential to be overwhelmed by noise is particularly great for dashboards. Avoid a noisy dashboard by distinguishing your message elements from supporting elements and highlighting the message while eliminating or downplaying everything else.

Visualization guru Edward Tufte illustrates this principle with this series of graphics showing how to perform various marshalling signals. At first glance, the black-and-white version seems clear and tidy, with each graphic labeled and in its own evenly spaced, well defined box. But it is possible to look deeper and ask if it really highlights the message elements the best it can. What are the message elements in this case? When it comes down to it, the main message comes from the position of the flags and the required movement, indicated by arrows. If only these elements are highlighted and everything else—box borders, human figure, and text—is minimized, the result is an even clearer visualization.

Figure 5 Redesign of Marshalling Signals to reduce "noise", from Envisioning Information (1990) by Edward Tufte



Simplify

How do you know what is message and what is noise? Visual noise is any line, label, color, or other page marking that does not actively tell the viewer necessary information. When you are looking at a chart or visual that you created, ask yourself what you would keep if you could only have one or two elements remain on the page to get your point across. These are the signal you want to highlight. Everything else is additional context that may or may not be needed.

Whether these contextual elements are needed will depend in part on the space you have for each visual, the purpose of the visual, and the intended audience. If you have a small amount

of space, be ruthless and reduce the context to as little as possible. Is the purpose of the visual to inform precise amounts to the hundredth decimal place, or merely to give a "gist" of what the data look like? If the former, you will need to keep more information available to users, while in the latter case you can do without elements like labels and axes. Finally, return to thinking about your intended audience. Will users be internal engineers wanting exact answers, or is the audience going to spend very little time with the data—such as executive leadership or the public—and you need to get one message across quickly? In the latter case, it becomes more important to make sure only the message is highlighted.

Simplify

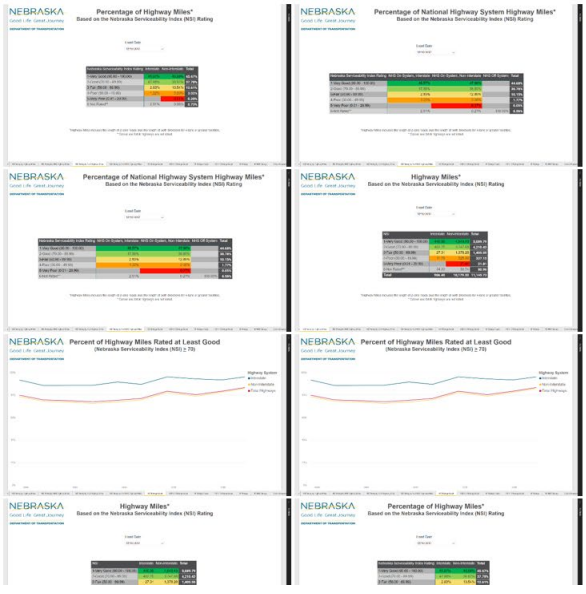
In the process of simplifying and eliminating noise, it may become necessary to "kill your darling." A concept used by writers, this refers to taking out a favorite scene or character because they no longer serve the narrative. The same should go for designers. Keep the big picture goal in mind and be honest about what is working and what is not. If you're on the fence, ask a colleague. It can be particularly helpful if the person you ask is not familiar with the data for the dashboard, so they can honestly react as an outside user might.

Simplify

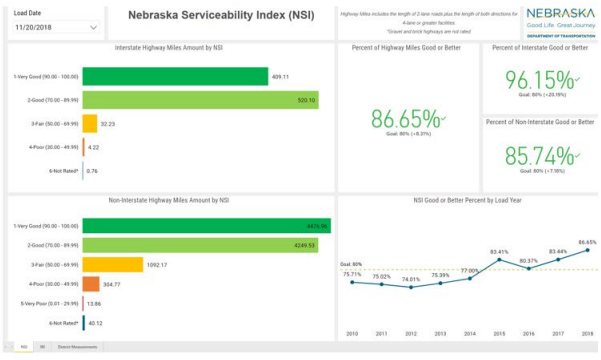
In any data design you do, use general data visualization best practices on chart selection, use of color, labeling, graphic elements, and text formatting. The redesigned dashboard below converts tables with only color to distinguish magnitude—a problem for color blindness— to a bar chart that leverages the brain's ability to quickly compare sizes. Trend lines are made clearer with labels, and the most important values are increased to an easy-to-read, pops-off-the-page size.

Figure 6 The eight visuals on the left can combine into a streamlined dashboard using data visualization best practices

Original



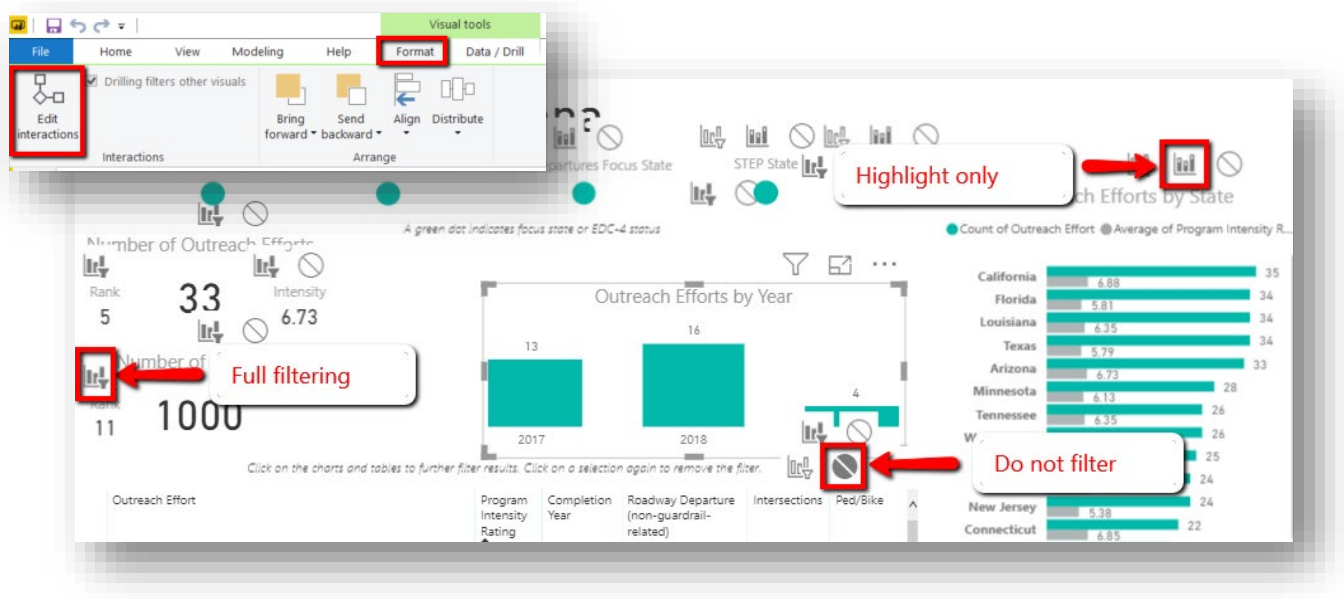
Revised



5. Enable interactions conscientiously

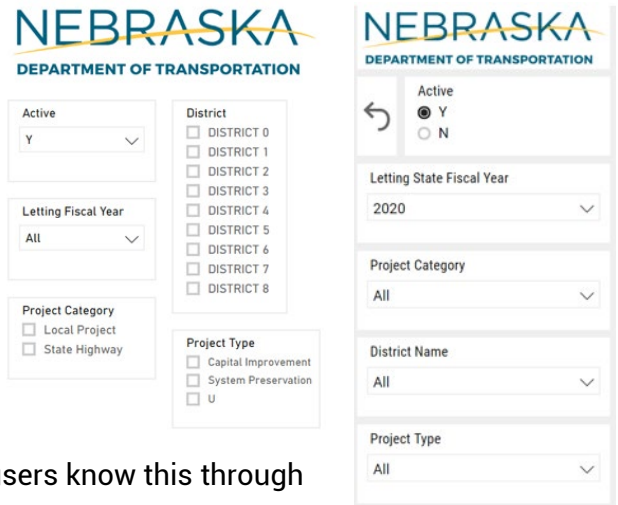
If you have a lot of data you want users to have access to, an interactive dashboard—one that lets users filter, highlight, and drill down—is a must. With these useful interactions, however, designers must take care to understand how they are applied to avoid misinterpretations and incorrect data being displayed. Each dashboard software has its own method of managing the interactions between elements, and within each software there are often multiple ways to create an interaction. Be conscientious and triple check that displays match what you expect to see.

Figure 7 Power BI users can change which visuals a filter affects using the gray icons available in 'See Interactions' mode. Other dashboarding tools have similar capabilities.



Filters

Figure 8: The filter on the left takes up space and adds visual clutter. Dropdown filters like those on the right are a better default.



Adding filters or slicers to a dashboard keeps the main view uncluttered, while allowing users to access the precise information they are interested in. Filters can be applied to a single visual, a whole page, or an entire series of dashboard pages. As a best practice, default to using a drop-down style filter for more than a small handful of categories. Compared to a long list, dropdowns reduce visual clutter and save space on your page.

In many dashboard software, a visual can also serve as a filter on the other views in the dashboard. It is sometimes helpful to let users know this through brief explanatory captions.

Highlighting

Highlighting is similar to filtering except that it does not remove the unselected data from view completely. Using a highlight instead of a filter has the advantage that users can still compare the selected data to the rest, which often provides useful context, but the data of most interest is clearly discernable. This can be particularly helpful if data points are clumped together or otherwise indistinguishable, as shown in the example below. Highlighting exposes the category of data that was hidden when all data points are shown together, but the user can still compare the relative values and spread of the selected category to the other data points.

Figure 9 The left panel shows all data displayed equally, while the right shows the same data set with a single category highlighted, revealing data points previously indistinguishable.

Drill down

Drill-down charts help maximize information by presenting data in digestible chunks, and allowing the user to explore the level of detail of most interest to them within a defined amount of dashboard real estate. Drill-downs should be used with related data at different levels of granularity, such as time levels (year, quarter, month, day) or category levels (state, county, city). Hierarchies can be established in many dashboarding software that set data up for drill-down visuals. When using drill-down capabilities, keep the following best practices in mind:

- Understand the data thoroughly – Know how the data are related and what impacts the different levels of detail will have on the visual space.
- Clearly indicate the chart has drill-down – A user cannot access the detailed data if they do not know it is available.
- Use breadcrumb-style captions – Similar to navigation panes on web pages, make sure users can see what level they are looking at and how to get back to the main view.

6. Iterate, iterate, iterate

The first iteration of a dashboard likely won't encompass all the nuances of data complexities or varying user needs. Expect to edit the dashboard based on user feedback or new ideas that surface along the way. Edits could even warrant rethinking your underlying data structure or whether new data fields are needed to fully express the story you want to tell. The more versions you create and the more feedback you solicit along the way, the better the final product will be. A dashboard should be an organic tool that updates with new data and changes to reflect the current business or decision-making need.