Bringing Clarity to Transparency

A Study of Dashboard Implementation in the Public Sector

Thesis presented by Stephen Costa to the Department of Art & Design

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This paper explores the possibilities and potential of data dashboards created by public organizations such as government agencies or non-profits. The current state of the governmental dashboard is uneven, some communicate data clearly while others raise more questions than they are able to answer. Two case studies were conducted to identify a number of trending issues in the aesthetic choices and data organization of existing dashboards.

Through the study of existing dashboards and their development over time particular issues have become evident. Through the study of public policies impacting the ability to publish public-facing dashboards, new issues of workflow and resources become evident. By analyzing public policy alongside widely accepted design principles a consolidated set of rules and guidelines for the creation of standardized dashboard in the public sector were compiled.

While taking into consideration the blockers and issues that these experts have encountered in their experience, a set recommendations have been generated in order to better their experience and improve their end products to increase transparency and communication between the public and government agencies.
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Introduction

“A data dashboard is an information management tool that visually tracks, analyzes and displays key performance indicators (KPI), metrics and key data points to monitor the health of a business, department or specific process.”

(“What Is a Data Dashboard?” n.d.)

Data dashboards have rapidly become more prevalent in recent years due to an increased desire for quickly digestible information. Due to the speed of popularity growth there has been very little time spent on the refinement of this form. As with any developing design trend, there is a period of exploration that pushes boundaries and attempts to define the design space in which the trend will rest. This exploration has gone on for quite some time, with the first data dashboards beginning to be developed around the 1980’s (“Executive Information System - Computer Business Research” n.d.) in the form of Executive Information Systems (EIS).

These early iterations of what we call a Data Dashboard today were not stored on the internet but were rather used by businesses internally as a way to make data driven decisions quickly and effectively. This practice is what laid the groundwork for the Dashboards we see today, and are rooted in the ability to access complex data quickly and efficiently. Although the concept of tiled data visualizations in the form of a dashboard...
has been in use for decades, there has yet to be a set of best practices developed for the design and implementation of dashboards in specific work environments or sectors. There have however been several books written about the general concept of creating an informational dashboard but the resources available for those creating these visualizations have remained vague and non-specific.

The creation of EIS dashboards was intended for use by decision making officials in a given company or organization. Due to the consideration of the audience at the time, the use of advanced visualizations and specific KPI values were common. When considering the audience that is involved in the daily use of government data dashboards, the selection of visualizations and metric becomes more complicated. Due to the diverse knowledge base and variance of cultural background, the dashboards of today must be created with more consideration. In order to ensure that the general public has equitable access to information simplicity is called for. The use of visual metaphors, for example, might be helpful to some that are familiar with the real-world counterpart but would be visual noise to those who cannot personally relate to it. In the creation of government dashboards specifically, the selection of KPIs and the application of visuals should be simplistic and obvious to account for the diversity of viewership.

The needs of agencies in different sectors and fields of study or service vary so greatly that the application of generalized guidelines can become difficult as particular needs are not met. To further explain the need for discourse specific design guidelines, the concept of accessibility in design offers a unique embodiment of the differing needs of a field of practice. Accessibility in this context can be defined by the considerations made in order to provide public data and materials in a manner which can be understood and accessed by any member of the public regardless of any disability that they may face.

The guidelines of accessibility in design for such instances are spelled out in detail in the (ADA) Americans with Disabilities Act (“2010 ADA Standards for Accessible Design” 2010). This set of requirements compose a complex set of design restrictions and requirements that are unique to the public sector. The ADA is
just one of many examples of complicating factors when it comes to designing for government or public agencies and illuminates the need for discourse specific design guidelines in general but more specifically guidelines for the Data Dashboards being published every day. Government agencies are held to a strict standard in regard to requirements of accessibility, for disabled persons as well as the reading level at which the content included is written. These requirements are comprehensive, encompassing all aspects of information the government makes available on the internet (“2010 ADA Standards for Accessible Design” 2010).

Openness and transparency are key ingredients to build accountability and trust, which are necessary for the functioning of democracies and market economies (Gurría 2019). It is said that free governments are founded on these principles, and that they play an intrinsic role in the success of a democracy (Gurría 2019). The ability of the public to evaluate their leadership’s performance is essential to their satisfactory participation in government. In recent years, there have been a number of laws passed meant to aid in the public’s ability to access “public data.” These efforts include things like the Freedom of Information Act, and “open data” repositories. Although these efforts are huge leaps in the right direction, it seems that much is being lost in translation. Large amounts of data sets are being made available to the public, but the form and format in which they are displayed and delivered are not consistent and often require a certain amount of statistical literacy in order to be understood. To combat this knowledge gap, many government agencies have begun to develop data dashboards to visualize relevant data sets in an attempt to increase the public’s understanding as well as telling the story of what an agency is doing to accomplish their mission. Due to many factors, such as lack of staff, funding, or experience, these dashboards can be similarly if not more confusing for users to understand. The lack of experienced designers can most obviously be seen in dashboards that attempt to use metaphors to increase understanding. Although this method of visualization is quite common, there are instances where the visualizations seem to be misleading the public at first glance.
The main issue with the data visualizations and information designs produced by the government at all levels seems to be the lack of subject matter experts. It becomes clear as one begins to evaluate the existing dashboards that there are several problem points. The government agencies lack the design and visualization expertise needed in order to simplify complex data for the public, and the public generally lacks the statistical knowledge to decipher what had been made available thus far. Educating millions of people on the basics of statistics is a hefty task, a more logical solution seems to be educating the public workers in how to successfully visualize common types of data.

In addition to design and visualization education, another issue that government agencies commonly face is a lack of funding. This fiscal deterrent may be a contributing factor in the choices made in regard to digital visualizations. The lack of financial support pushes many agencies to scour the internet in search of free and pre-coded visualizations or software such as Tableau Public. These free-to-use solutions are great for simple visualization, but offer limited options for more complex data sets and therefore lead to the selection of inappropriate visuals.

Although the exploration of existing work offers insight into what is being done at the present time in the aesthetics of data dashboards, but the act of correcting missteps being made may prove more difficult than simply applying aesthetic solutions. Often times in public sector agencies and organizations there are unnecessarily complex processes involved in decision making that hinder the creative process. This bureaucracy can be comprised of public officials on many levels that have their own professional or political leanings. This complex and diverse network of decision makers can derail a project at any point in the process as it involves many conflicting opinions about a project.

In addition to the recommendations about how to visually represent public data, the effect of political motivations on the creative process must be considered as well. The guidelines that will be generated in this exercise will also aim to make changes to the implementation process in dashboard development. For example, one goal would be to limit the number of officials involved in the development of government dashboards in the
earlier stages of the project. The earlier stages of a project may benefit from a smaller team of subject matter experts that are given the appropriate time to build the tool that is needed. Later in the development process, the committee of reviewers may be able to grow to a large number.

Government agencies face a set of unique restrictions when publishing data, while simultaneously being expected to be one of the most transparent and open types of agencies. This dichotomy has led to many half measures being taken in order to fulfill requirements of the public, their peers, and the policy makers that drive them. Through the exploration outlined in this paper, critique of existing work and recommendations on how to better that work moving forward will be generated. The hope is that what is discussed here will take into consideration all of the complicating factors a public sector information designer may encounter, allowing them to focus on the production of a successful final product. To further aid these designers in doing so, a set of recommendations, based on the third-party review that will be conducted, will allow designers throughout this sector to create a more unified and in some ways pre-approved visual language that will increase the public's visual literacy as it pertains to Data Dashboards. Once the public understands a Dashboard in one instance, the standardization we are striving for may escalate the rate of comprehension across the board thus increasing transparency, accessibility, and the public’s ability to engage with their public entities.

The importance of narrative or storytelling in a dashboard is an aspect that is often overlooked. Typically there are javascript codes that create a masonry grid that fits each piece together perfectly into a shape. This method of arranging the visualizations is meant to organize the dashboard as a whole in an orderly manner but ignores the content and story. The story of the dashboard is about the communication the agency is having with the public, not a story in the traditional sense. They agency makes the dashboard in order to communicate something specific to the public, and the dashboard should be a tool used to further a message or to bring context to a mission the agency has. The story the Parks and Recreation department for example might be trying to tell the public so that they are working hard on improving the greenspaces through the city. Now the agency
could chose a statistic that is easy for them to be tracking like dollars spent, etc. But is this the best way to tell your story? Would it not be more effective to illustrate this narrative in a more digestible way such as a series of tiles that show facts like how many trees have been planted – maybe this year or a total up to this point in time. This could be paired with a financial stat and then followed by something about mileage shown in an understandable way like “four football fields” of green space have been renovated or created. These things do a much better job of showing the public (no matter their reading level) what is being done by the agency and provides an understandable context. Just by glancing at the dashboard quickly could be a good way of understand what the department’s mission might be and what they are doing to achieve this goal.

The creation of EIS dashboards was intended for use by decision making officials in a given company or organization. Due to the consideration of the audience at the time, the use of advanced visualizations and specific KPI values were common. When considering the audience that is involved in the daily use of government data dashboards, the selection of visualizations and metric becomes more complicated. Due to the diverse knowledge base and variance of cultural background, the dashboards of today must be created with more consideration. In order to ensure that the general public has equitable access to information simplicity is called for. The use of visual metaphors, for example, might be helpful to some that are familiar with the real-world counterpart but would be visual noise to those who cannot personally relate to it. In the creation of government dashboards specifically, the selection of KPIs and the application of visuals should be simplistic and obvious to account for the diversity of viewership.
Analysis of Government Dashboards

A key aspect in understanding the problems that dashboard developers and designers face is looking into what is being done today. The following section applies a critical eye to overall design of dashboards and discusses the current state of the field. Without defining what constitutes a data dashboard, we cannot hope to refine the craft of producing a successful one.

As part of the exploration of the design space a lot of cataloging and critique will take place. By examining the approaches taken in the creation of existing dashboard and how they came to be in this state, a set of best practices may become apparent. There are a great many approaches to hierarchy, aesthetics, and visualization shown in even the smaller sample that has been collected at this point. Although this causes difficulty in the definition of trends and common thought processes, it also makes the lack of standardization evident. Furthermore, there are enormous variances in the adherence to accessibility standards require by federal law (“2010 ADA Standards for Accessible Design” 2010). An initial exploration and evaluation of the dashboards found can be seen in the following pages.
The foreign assistance dashboard shown here is a prime example of the diversity we see in Dashboards as it does not follow anything resembling a tiled array of visualizations. If we look back to the earliest examples of tiled dashboards such as the EIS, there are distinct differences that are worth pointing out and discussing. First and foremost, the general layout of this dashboard leads us to ponder what defines as dashboard as such. This visualization instead uses layered data panels and filtering options to integrate what would have been many tiled visualizations and a very long webpage to scroll through. Although this format has its benefits, it may prove extremely difficult to replicate across the board for other public agencies.

Figure 1: Foreign Assistance (FA)
Screen captures of the FA dashboard.
https://www.foreignassistance.gov/explore
and therefore may not be ideal. If a dashboards format cannot be reproduced easily, that means that there is a unique visual language being communicated. The implementation of a new visual language that fits a particular agency’s goals may benefit that agency but would ultimately make more work for the public users by means of decoding new languages while collecting information across the board.

There is much to be said about the unique approach Foreign Assistance has taken in that it requires an entirely different kind of literacy than what is usually under consideration when creating a dashboard for public agencies. The type of literacy required here is that of user interfaces, and a working knowledge of Geographic Information System (GIS) map interactions. There is an expectation that the public will have the instinct to click on the map in the background and know that it is something to interact with. Although this may seem obvious to many, there are those who may see the map as a background image or supplemental to the dashboard itself. In order to make this interaction run smoothly, a need for pop-up directional windows is needed and adds yet another layer of complication to interacting with dashboard. Moving past this map function, there are several floating panels above it that display certain subsets of the data being referenced. While the ability to read these panels in the way they are written and displayed should come naturally enough, this interaction involves several pieces. In order to get the data, the user would like to view, they must scroll down the webpage to find the drop menu filtering options which control the data panels. Again, this added step to obtain information, while making for a more customized experience for the viewers, may over complicate the consumption of data. There is a technical literacy required to effectively use this interface that is above what is generally expected from digital tools created for the public sector. After consulting the U.S. Department of Health & Human Services Usability Guidelines, these observations are verified. “Studies have shown that users can find what they are looking for more quickly in a sparse and uncluttered display than in a dense display” (“HHS.Gov” n.d.). The heavily visual display created in this example uses layering an opacity shifts to show all the information on one screen (with no scrolling intended), but the cluttering may make it difficult for some users to access the information they need.
As discussed earlier, there has yet to be any kind of definition of what a user should expect when visiting an online Dashboard. The application of a more standardized and straightforward visual language seems to be the best way to aid the public in the understanding of public information. Although statistical literacy and reading comprehension levels are always going to be an issue, and perhaps why those at foreignassistance.gov chose this visual method, a standard approach and treatment will allow the public to learn.

The Metropolitan Transportation Commission Vital Signs Dashboard is a, for sake of discussion traditional example of Data Dashboards layout. It used many simple visualizations in a tiled format for organization. This Dashboard simplified charts and organized groupings to guide the user’s eye throughout the dashboard and easily access chunks of comparable data. Another important aspect of Dashboards that is often overlooked is context. Often times dashboards exist in a vacuum.
where the data is displayed without any means of comparison for evaluation of the visualization. The dashboard shown here though, is a prime example of how giving context to data can provide an added level of understanding to even the layman. All of the visualizations in this example are created using similar data from cities in the surrounding area in California. This provides a quick understanding of trends and outliers which aids in the speed of comprehension for users. For any given section of this comprehensive dashboard shows data in context of other data. This practice is the key to standardizing the dashboard in its entirety. Although this dashboard shows many city’s data in an agglomeration, it is easy to imagine how it could be split apart into five city-specific dashboards. If a visual language such as this could be developed for all cities, then these clear comparisons could be made between any two dashboards in the country. This would allow for quick analysis for regular users and even researchers.

Another issue that comes up in the development of dashboard is the peer buy-in, or the convincing of other departments to collaborate on a huge undertaking like the Vital Signs dashboard. In it’s consolidation of data sources, this dashboard created a funnel for data from surrounding areas to be dropped into a sort of template. This templated experience reduces the amount of approvals and effort require on the behalf of collaborators. Not only does the similar treatment of the data help with understanding but it is also solving the problem of buy-in in that would have involved over 5 creative processes and teams by consolidating the work into one larger project. This dashboard accomplishes much of what others should be aiming for in the way of communicating the context of their accomplishments and problem points through data visualization as an agency.
USPTO recently updated its dashboard, due to public comments asking for them to do so. The screen captures to the right depict the updated look of the dashboard on uspto.gov. There are stylistic issues that come about when navigating through this dashboard such as the change in aesthetic between charts. The car dashboard motif, while eye catching, is not a relevant or appropriate way to be displaying this data.

An in-depth evaluation of this dashboard can be seen in the Case Study section of this document. See figures 11-27.
Massachusetts Bay Transportation Authority’s data blog allows for the viewing of relatively small datasets that reflect the results of performance reports. This is a great start for the tool, but leaves something to be desired in regard to the depth of the data. Although this is a good start to a dashboard, it almost seems as though this could have been part of a larger and elaborate group of datasets shown in a dashboard. The context of more data would tell a better story about the accomplishments of the MBTA.

Aesthetically this is one of the more successful government dashboard I have come by and it is fully responsive.
This dashboard operates on two levels. The landing page is tiled with categories that have visualization sliders on them. Clicking into these categories provides you with even more visualizations. There is also a toggle to the level of data you are looking for, be it national or regional.

The idea of filtering down to region is something that is missing from a lot of the dashboards I have seen. This is something I would plan to implement for a Boston dashboard — city and neighborhood levels.
This dashboard requires more analysis on the part of the viewer due to the advanced visualizations being used. There is a large amount of data displayed here, but it needs to be deciphered.

The best part about this is that there is in fact a lot of information being shared here, which enhances transparency but does not lend itself to a narrative for the organization. The information needs to be simplified and organized in a way that is easily digestible by the audience.

An interesting approach of dashboarding without any graphics or visualizations to support it. This dashboard had a project status feature as well as numeric indicators of progress and change.
This is a public-facing dashboard that offers employee data that is meant to illustrate diversity in the city’s workforce. While there are many ways to filter this data, the visualizations are not always the easiest to understand due to crowding. Although the amount of information that is packed into this display makes things a bit confusing for the average user, there is a small detail that can not be ignored. The fact that this complex dashboard is screen reader accessible is in accordance with the ADA and ensures that data is accessibly both in its publishing but also in the sense that those with disabilities can obtain it easily as well. This is a design requirement that seldom met by public agencies regardless of the fact that it is a legal requirement.

This small sample of dashboards exhibits the breadth of design techniques and choices that have been made in an attempt to achieve the same goal—transparency and accessibility. Although there are aspects of each and every one of these examples that could be deemed successful, they also have their own downsfalls. Given the observations gained from this study,
part of the goal becomes the standardization of all dashboard. Once a larger sample can be analyzed, a visual language for this specific type of dashboard can be created. Standardizing the aesthetic and organizational aspects of data dashboard will not only increase understanding in the present day, but exponentially as more agencies begin to adhere to them.

A prime example of poorly selected visualizations is the United States Patent Office (UPSTO) dashboard. This dashboard was so confusing that the public requested that the agency revisit the design work to increase legibility. The redesign resulted in the use, or overuse, or a speedometer metaphor. This speedometer visualization is used to represent data types ranging from months spent in an evaluation status, to the amount of money spend on an initiative. The decision to use a physical dashboard style is a common one that tends to lead to easy legibility due to its familiarity, but not always the most honest representation of the actual data (Ganapati 2011).

Although there are a lot of free-to-use options available, there is something to be said for the value gained in actually investing in a quality dashboard. The benefits of dashboard for the public are obvious, but there are also organizational benefits as well. The Office of Management and Budget (OBM) uses a simple dashboard Figure 10-11 as a means of reducing investment risks by comparing similar values across a large scope of municipalities. The investment or time and money made in order to create this dashboard has enabled the federal government to reduce financial risks elsewhere (http://www.gao.gov 2012). Investments made in the development of dashboard resources does not necessarily need to be repeated by every agency. There are those who think a dashboard’s true value lies in its ability consolidate different sources and types of like data (Matheus 2018). This consolidation may be able to take place in more than one form as the financial burden may be shared by the participating agencies in clusters. For example, all transit agencies and organizations may be able to consolidate their dollars and time to making one comprehensive dashboard that offers context through comparison by laying out their like data side-by-side.
**Browse by Agency**

From the list below, select the name of the agency whose data you wish to view. If you are interested in seeing the information technology investments for the entire government, then select the Government Wide View to see all.

- **Department of Agriculture**
  - Total FY2019 Spending: **$2.4B**

- **Department of Commerce**
  - Total FY2019 Spending: **$3.3B**

- **Department of Defense**
  - Total FY2019 Spending: **$38B**

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**Figure 9: OBM Dashboard Navigation**

The OBM dashboard uses imagery of seals and broad information (total spending) to help the users navigate. [https://itdashboard.gov/#learn-basic-stats](https://itdashboard.gov/#learn-basic-stats)

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**CIO Risk Ratings for Investments**

This graph displays the latest Chief Information Officer (CIO) Risk ratings for IT investments government-wide. CIOs rate each investment using a set of pre-established criteria and issue a CIO Evaluation Number that reflects the investment’s ability to accomplish its goals within the current fiscal year (FY) 2019. This number ranges from 1 - 5, and the higher it is, the better the investment has been rated to meet its goals. Please refer to [FAQ #7](https://itdashboard.gov/) for the CIO Evaluation criteria.

- **High Risk (in red)**
  - % of the total number of major IT investments that scored a CIO evaluation number of 1 or 2

- **Medium Risk (in yellow)**
  - % of the total number of major IT investments that scored a CIO evaluation number of 3

- **Low Risk (in green)**
  - % of the total number of major IT investments that scored a CIO evaluation number of 4 or 5

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**Figure 10: OBM Dashboard Navigation**

The use of conventional visualizations help make complex data simple, even the color coding is spelled out. [https://itdashboard.gov/#learn-basic-stats](https://itdashboard.gov/#learn-basic-stats)
Although the collaboration of a large number of agencies may be difficult to coordinate, there are also smaller scale groupings that may be more feasible. The grouping of data on a smaller (local) scale organized in a task oriented nature. Dashboards can be used to enable the public, or even city officials, to make more informed decisions (Nemani 2016). To this end, a single municipality can rally its organizations to consolidate relevant data to aid specific decision making scenarios.

United States Patent & Trademark Office (UPSTO) “In response to public comment we have redesigned the Patents Data Visualization Center. We hope you find the dashboard useful. If you have any questions, comments, or feedback, please click here to send and e-mail to the Dashboard Administrator” (“Data Visualization Center: Your Window to the USPTO. Patents Dashboard” n.d.). The United States Patent and Trademark Office has made great efforts to bring public data to life and engage the public in its visualization. Although their initial attempt was met with quite a lot of criticism, there is a working relationship between their dashboarding team and the public. This collaboration is a great step toward the co-production that should be taking place across the board in government agencies – listening to feedback, and improving their work accordingly. In the end, the public is a client of the agency, and the aim should ultimately be to give their clients what they need.

Although the relationship with the public is a definite strength for UPSTO, their attempt to simplify their data may have been an overstep. The visualization shown in a vast majority of their data points is a speedometer. This visualization is not only inappropriate for some of the data points it is being used for, but at times it is largely misleading. For example, when the goal is expediency and a speedometer visual is used to convey time spent in processing phases, the position of the dial needle miscommunicated the information as seen in Figure 1.
The decision to redesign the dashboard was made in the best of intentions and for the best possible reason — public need. With that being said the final product seems to be lacking not only in variety of visualization forms, but also in the types of data being shown. In examining the previous version of the dashboard, a clear choice was made to select data the UPSTO deemed appropriate for use in an angular gauge. This choice begs the question if the visualization was chosen for some other reason such as the availability of pre-coded visuals, cost saving measures, or expediency of the final product.
Theory & Principles

There are many moving parts to consider in the creation of a data dashboard in the public sector as the requirements for publishing come from many different sources. There are graphic and information design principles to take into account, but also government policies, public perception, and federally mandated accessibility standards. When all of these limitations culminate, it becomes difficult to see a clear path to a design solution.

Government data dashboards are used to create a digestible way for the public to take in complex information that pertains to them in some way shape or form. This practice is something that comes from the Freedom of Information Act that was implemented during the Obama administration. This Act goes a long way to mandate that public agencies make data publicly available in a remotely usable format. Although the data is mandated to be made available, there is a fair amount to technical know-how and statistical literacy required for the public to be able to understand the data. There are a lot of agencies that still make it as hard as possible to obtain data requested. A major reason for pushing back on information requests is an issue of political optics. At times there are datasets that are guarded because of the fear of
Misinterpretation and poor outlook in a political realm. Due to this, not only is the data not visualized, but the files are withheld on purpose. To avoid any misinterpretation, and stand visual language is needed for the public to be able to reliably be trusted to interpret the materials. This standardization is a way to improve the relationship between public agencies and their respective publics. Due to this complication, there is a huge push from inside of government agencies to not only drop data into repositories for download but also to visualize the data for the public. Although this push comes from a place of transparent intent, it seems that the lack of standardization in the visual language is creating yet another boundary for the public to get the information they need.

When considering the amount of work that goes into visualizing data in a clear and succinct way, it seems obvious that there may be a bit of resistance from any participating agencies. The standardization of this practice would enable agencies to quickly and efficiently produce dashboards. The original implementation of dashboards was actually a push from inside public agencies in order to lessen the workload of the agency overall when it comes to public records requests. By simply making a streamlined process for the dashboard visualization, this process can become simpler and more effective for the agencies and their respective publics.

**Government Policy**

Open Data (“Open Data Policy — Managing Information as an Asset” 2019) | There are many public policies that mandate what types of data should be made available publicly. These policies however focus mainly on the data itself and not necessarily on how it is displayed. In reviewing the guidelines listed in the Project Open Data (“Open Data Policy — Managing Information as an Asset” 2019) website the guidelines are focused essentially on the format and subject matter of what is provided. The guidelines do not go so far as to dictate any form of direction for the visualization of the data being generated. An example of the guidelines are below:
• **Public.** Consistent with OMB’s Open Government Directive, agencies must adopt a presumption in favor of openness to the extent permitted by law and subject to privacy, confidentiality, security, or other valid restrictions.

• **Accessible.** Open data are made available in convenient, modifiable, and open formats that can be retrieved, downloaded, indexed, and searched. Formats should be machine-readable (i.e., data are reasonably structured to allow automated processing). Open data structures do not discriminate against any person or group of persons and should be made available to the widest range of users for the widest range of purposes, often by providing the data in multiple formats for consumption. To the extent permitted by law, these formats should be non-proprietary, publicly available, and no restrictions should be placed upon their use.

• **Described.** Open data are described fully so that consumers of the data have sufficient information to understand their strengths, weaknesses, analytical limitations, security requirements, as well as how to process them. This involves the use of robust, granular metadata (i.e., fields or elements that describe data), thorough documentation of data elements, data dictionaries, and, if applicable, additional descriptions of the purpose of the collection, the population of interest, the characteristics of the sample, and the method of data collection.

• **Reusable.** Open data are made available under an open license that places no restrictions on their use.

• **Complete.** Open data are published in primary forms (i.e., as collected at the source), with the finest possible level of granularity that is practicable and permitted by law and other requirements. Derived or aggregate open data should also be published but must reference the primary data.

• **Timely.** Open data are made available as quickly as necessary to preserve the value of the data. Frequency of release should account for key audiences and downstream needs.
• **Managed Post-Release.** A point of contact must be designated to assist with data use and to respond to complaints about adherence to these open data requirements.

As is evident in this small sample of guidelines, the considerations being made are for the collection, maintenance and delivery of datasets. There is little to no mention of visualization principles to be found on this set of recommendations. These guidelines are useful for government researchers and organizations that collect large amounts of data, but do not consider the public facing visualization that will eventually be created. One interesting point taken from this source is the introductory paragraph where it discusses the role of open data in our government today. (see left) It describes information and data as an asset to be managed and in doing so creates a sense of importance and value on the management of data. If this data is as important as it is made out to be, why not also the visualization of it?

HHS Usability Guidelines (“HHS.Gov” n.d.) | “These guidelines are research based and are intended to provide best practices over a broad range of web design and digital communications issues.” (“HHS.Gov” n.d.).

The HHS guidelines were created to aid public agencies in the creation of digital assets. These instructions go as far as to offer guidance on things from color selection, to clickable button appearance. Some aspects of the set of guidelines can and should be applied to the created of data dashboards but many of the rules and restrictions listed here refer to the design of a website as a whole, not necessarily the unique dashboard experience. Some of the items specified are concerned with a micro level of website design such as when to use radial buttons versus when to use check boxes. Although these design decisions are important in the overall design of a website, they do not necessarily apply to the creation of a dashboard. For this reason only aspects from this set of recommendations as well as from other sources, will be used to create a set of dashboard specific guides throughout the course of this project. The recommendations that have been selected for application to this project are as follows:
• **2:3 Standardize Task Sequences**
  Allow users to perform tasks in the same sequence and manner across similar conditions.

• **2:15 Provide Printing Options**
  Provide a link to printable and downloadable document versions.

• **6:4 Structure for Easy Comparison**
  Structure information so that it can be easily scanned and compared.

• **6:8 Use Fluid Layouts**
  Use a fluid layout that automatically adjusts the page size...

• **11:1 Use Black Text on Plain, High-Contrast Backgrounds**
  When users are expected to rapidly read and understand prose text, use black text on a plain, high-contrast, non-patterned background.

• **11:4 Ensure Visual Consistency**
  Ensure visual consistency of website elements within and between webpages.

• **11:9 Color-Coding and Instructions**
  When using color-coding on your Web site, be sure that the coding scheme can be quickly and easily understood.

• **11:11 Highlighting Information**
  Do not use two (or more) different ways to highlight the same information on one page.

• **12:1 Order Elements to Maximize User Performance**
  Arrange lists and tasks in an order that best facilitates efficient and successful user performance.

• **14:1 Use Simple Backgrounds**
  Use background images sparingly and make sure they are simple, especially if they are used behind text.

• **14:10 Include Actual Data with Data Graphics**
  Include actual data values with graphical displays of data when precise reading of the data is required.
14:11 Display Monitoring Information Graphically

Use a graphic format to display data when users must monitor changing data.

Freedom of Information Act (Act (FOIA) n.d.): “The basic function of the Freedom of Information Act is to ensure informed citizens, vital to the functioning of a democratic society.” (Act (FOIA) n.d.)

“The FOIA provides that when processing requests, agencies should withhold information only if they reasonably foresee that disclosure would harm an interest protected by an exemption, or if disclosure is prohibited by law. Agencies should also consider whether partial disclosure of information is possible whenever they determine that full disclosure is not possible and they should take reasonable steps to segregate and release nonexempt information. The Office of Information Policy at the Department of Justice is responsible for issuing government-wide guidance on the FOIA as part of its responsibilities to encourage all agencies to fully comply with both the letter and the spirit of the FOIA” (Act (FOIA) n.d.).

The FOIA policy is meant to make information readily available to the public so that they can stay informed and make decisions. Although this policy only states that government organizations merely have to comply in sharing data with the public, it does not dictate in what format this sharing must occur in. This means that the data provided to the public, often as a personnel restriction, is not always digitized or in a usable format. The processing of requests involves a lot of work on behalf of government agencies in order to deliver. As a way of minimizing the amount of requests coming in, the data dashboard began to rise in popularity. The use of dashboards as a live-updated public source of information could provide the public with the means to understand the complexity of the public data without having to directly request information in a person-by-person basis. Once the data is visualized and published in an updatable way, any member of the public should be able to access it rather than repeating parts of the data process.
While taking into consideration the existing policies and requirements for the publishing of data in the public sector discussed previously, there are also considerations to made in a strictly graphic/information design send. Though some requirements for consideration seem to be common sense and without need for explanation, they should be explicitly spelled out in ensure that they are followed correctly. In order to ensure that there are clear guidelines being delivered to designers, the help of outside resources is required. Namely, the Universal Principles of Design book by Lidwell will be referenced as an authoritative piece on design principles and theories. This book has a wide breadth of principles for designers to follow but apply every single principle to any one design may be overwhelming if not impossible. For this reason a few particularly relevant principles discussed in Lidwell’s work will be implemented and integrated into the running list of considerations for the development of data dashboards.

Skeuomorphic & Flat Design

“Skeuomorphism was used in UI design long before flat design and it is built upon the notion of metaphors and affordances. Flat design is the main design trend used in most UIs today and, unlike skeuomorphic design, it is considered as a way to explore the digital medium without trying to reproduce the appearance of the physical world.” (Spiliotopoulos, Rigou, and Sirmakessis 2018)

Skeuomorphism is a design principle that focuses on the use of life-like and often 3 dimensional design elements to allow for greater ease of use on behalf of a user. The quintessential example of this style is its use in the design of Apple’s original iPhone iOS. See Figure 11. This operating system was created using an entirely skeuomorphic approach that leaned heavily into the concept of affordances. An affordance is a design choices that offer clues as to the use or function of a particular element. In the case of Apple’s iOS, the most prominent affordance is the appearance of the application icons. The icons use heavy shading and gloss effects to give the impression of
dimensionality. This dimensionality is meant to connote a button-like feel. The thought here is that the real-life button appearance should trigger an action in the user. What does one do with a button? They press it. Once Apple successfully convinces a user to press one button, the familiar appearance makes all other function in iOS that much simpler to understand. The uniformity of their approach played into the familiarity for users, and the consistency of the application made it so that all tasks were similarly accomplished. This is a successful example of skeuomorphism as it was based around dimensionality and its ability to trigger an action. As can be seen in Figure 11, this style has been phased out over time in favor of a flat design approach, but elements of skeuomorphism can still be seen particularly in the use of drop shadows behind the application icons that still hint at dimensionality and there for an action.

Figure 11: Apple iOS over time
http://i.imgur.com/Z9dCA7D.jpg
“flat design for interface design and their findings suggest that flat design must tackle the problem of missing information due to simplification and should put careful focus on the semantics of the used elements” (Spiliotopoulos, Rigou, and Sirmakessis 2018)

The carrying forward of more refined and discreet elements of skeuomorphism by Apple in the design of iOS 7 seen in Figure 11, brings to question usability features of the principle. Flat design is defined as a “style in which the elements lose their stylistic characters such as shadows, textures, gradients and anything which would create the sense of depth on the interface” (Spiliotopoulos, Rigou, and Sirmakessis 2018). When considering this definition in the context of the iOS example the grey area between these design styles become evident. It seems as though there are elements from skeuomorphism that can be adapted to a flat design mentality in the interest of increasing usability.

Hierarchy of Needs (Lidwell 2015)

- Functionality: fosters satisfaction by meeting basic functional needs.
- Reliability: fosters trust through consistent and reliable performance over time.
- Usability: fosters fondness through ease of use.
- Proficiency: fosters pride and status through increased productivity and empowerment.
- Creativity: fosters cult-like loyalty through innovation and personal enrichment.

The Hierarchy of Needs (Lidwell, William) is an established framework that outlines the five main consideration when designing an interactive experience. Each element described here is as important as the last, but often times are overlooked.
The functionality is called out as the basic function of the application must be met, this is also frequently referred to as the Minimum Viable Product (MVP). So long as the basic functionality of the dashboard is intact, a user may begin to perceive this service as a reliable one. This bring about the second need, Reliability comes for the trustworthiness of the service as well as the consistency. The recommendations that will be made for the design of government dashboards in theory could be applied to dashboards across the board creating a consistent experience for users no matter what agencies of city dashboard they may be accessing. The goal is for the aesthetics and rules of arrangement of elements in government dashboards to be so consistent that a user could recognize any dashboard as a government dashboard, and therefore a reliable one. This concept draws from concepts in branding where the mere appearance of the product brings about connotations outlined by the brand creators.

**Aesthetic-Usability Effect (Lidwell 2015)**

- Aesthetic things are often subjectively rated as easier to use, even when no usability advantage can be objectively measured.

- Aesthetic things are more effective at fostering positive attitudes than ugly things, making people more tolerant when problems are encountered.

- Aesthetic things are more likely to be tried, accepted, displayed, and repeatedly used than ugly things.

- Aspire to create aesthetically pleasing designs. It is more than ornamentation—it is an investment in user acceptance, forgiveness, and satisfaction.

As previously mentioned, an element that is in the control of the designers is the aesthetic qualities of a dashboard. These aesthetic qualities that are discussed in the Aesthetic-Usability Effect (Lidwell, William) principle outline how the appearance of a piece of work can aid in the buy-in from peers and users as there is a increased in the perceived value a project. In
addition to helping to get peer’s support, the aesthetic quality of a dashboard can also benefit the users (the public) as it encourages repeat use, and understanding of any issues that may arise in the implementation of the dashboard.

**IKEA Effect (Lidwell 2015)**

- Partially creating a thing (e.g., assembling furniture) makes it more valuable to the creator.
- People value things they personally create as much as if it had been created by an expert.
- The level of effort invested in creation corresponds to its level of valuation: high effort translates into high valuation, and low effort translates into low valuation.
- The IKEA effect only holds when tasks are completed.
- Consider the IKEA effect in product strategy and user-experience design. Engage users in the creation of products to increase their value perception.

Although users would not be able to create there own data per se, there is something to be said about the level of interactivity a user can participate in. As seen in the example of existing work in Figure 2, there are ways to engage the user in the exact visualization they are being shown. In this sense they are assembling their own unique dashboard experience and thus adding value to the experience.

**80/20 rule (Lidwell 2015)**

- 80/20 Rule A high percentage of effects in any large system is caused by a low percentage of variables.
- Applying the 80/20 rule means identifying and focusing resources on the critical 20 percent. Focusing on aspects of a design beyond the critical 20 percent yields diminishing returns.

The 80/20 rule is a concept that is most frequently applied to situations involving economics and investment but could be useful to keep in mind when tackling a large design project such
as a data dashboard. Part of what derails a project is that feature and scope creep begin to blow the project out of proportion. When the project increases in size, there are too many moving pieces and often the committee involved in the creation of the project lose sight of the most important features. The 80/20 rule can be applied by focusing a majority of time and financial support into the creation of the MVP to ensure that the project stays focused and results in a reliable product.

These theoretical principles will aid in the evaluation of dashboards, but does not do enough in the way of combating process issues. The issues designers face in the government are unique in that there are political reasons for decisions as well as who exactly becomes involved.

**Chunking (Lidwell 2015)**

- The term chunk refers to a unit of information in short-term memory—a word, or a series of numbers. Information that is chunked is easier to remember.

- For example, most people cannot remember a ten-digit number for more than 30 seconds. However, by breaking the number into three chunks (i.e., such as a phone number) recall performance is equivalent to recalling one 5-digit number.

- The original estimate of the maximum number of chunks that can be efficiently processed and recalled was $7 \pm 2$. The modern estimate is $4 \pm 1$ chunks.

This concept is crucial to the creation of dashboards as they can bombard a user with information by nature. Grouping information and visualization in a deliberate and logic way allows users to create chunks or vignettes of the overall story the agency is trying to tell about itself. For example, if the first 4 blocks of a dashboard’s visualization are about greenery in a city, then the vignette or chunk a user might get from this is that the agency is concerned with beautification of the city, and the environment. However if there similar topic visualization were scattered through a page, the user might leave the website confused at to what the agency’s focus is.
A key concept in the creation of dashboards is that of consolidation. The idea that several department, agencies, or even municipalities could contribute a diverse group of datasets into a single dashboard is the ideal situation. The data being displayed can only be a good and meaningful as the comparisons you can make with it. These compilations of diverse data allow the users - the public - to develop their own investigations into comparisons that are important for them. Although some public organizations may not see the value in collaborating with what seems to them to be unrelated organizations, the public may like to see a comparison of very specific data. The data comparison may not even be something that either agency could foresee, but on a personalized visualization level may be extremely important.

The concept of data dashboards has risen significantly in popularity in recent years due to the implementation of smart city pilots.

“there has been a move to automatically collect and produce data, often in real-time, about the city by embedding computation into the city infrastructure to produce a data-driven networked urbanism” (McArdle and Kitchin 2016).

This push toward smart cities means that there is a vast amount of data being collected automatically by smart utilities and services. As maintaining a dashboard with up to date data is a vital part of the practice, it stands to reason that these smart utilities would make a great fit for integration into dashboard implementation.

During the transitional phase where cities around the world are still moving toward upgrading their utility and tools to be more technologically advanced, there is much to be said about the state of the dashboard this data feeds into. As with the Dublin Dashboard (McArdle and Kitchin 2016), which is more of a collection of dashboards, it can be difficult to manage the data.
This is a major pain point for many dashboard developers. Not only does the website that hosts the data need to be upkept but also the sources from which the data is feeding.

“The availability of data is an important aspect of the dashboard. Urban data is typically collected for a specific purpose and not for visualization on public dashboards; as a result city data come in diverse formats from a variety of sources which creates challenges for collecting, storing, processing and visualizing the data. There are two broad categories of urban data handled by the Dublin Dashboard. The categories are differentiated by their update frequency which determines how they are processed. Data which are updated monthly, quarterly or annually are processed manually while real-time or near real-time data are handled in an automated way. In both cases, the data are stored before being rendered in the dashboard” (McArdle and Kitchin 2016).

As is made clear in the quote above, the management of datasets and their update frequencies is an important if not complicated task. This task is often overlooked as one of the ongoing parts of dashboard workloads and is therefore something to consider in the design of a dashboard.
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Case Study

By examining particular design decisions in data dashboards, guidelines and new principles were be derived. These principles attempted to take into consideration the limitations faced by the designers and the intent behind their previous decisions. The examples depicted in the following section allowed insight into the use of visual metaphor in this context and when that practice should be deemed appropriate. Using the evaluative principles outlined previously, these examples are critiqued and edited accordingly.
Overview of Evaluation Criteria

**Design Considerations**

Hierarchical of Needs
- Functionality, Reliability
- Usability, Proficiency, Creativity

Aesthetic-Usability Effect
Aesthetics as an investment in user acceptance, forgiveness, and satisfaction.

IKEA Effect
Engage users in the creation of products to increase their value perception.

80/20 rule
Applying the 80/20 rule means identifying and focusing resources on the critical 20 percent.

Chunking
Grouping Units of information to make them easier to process and remember.

**Usability Considerations**

Standardized Task
- Same steps to tasks

Printing Option
- Printable/downloadable

Structure for Comparison
- Easily scanned & compared

Fluid Layouts
- Responsiveness to device

High-Contrast
- Allows reader to see information with ease

Visual Consistency
- Visual language should follow through from website

Color Selection
- Quick and easily understood

Highlighting Information
- Call attention with limited methods

Order
- Group like or related data

Include Actual Data
- Allow download of source

Visual Change
- Graphic needed for changes over time

**Data Considerations**

Public
- Data is made available

Accessible
- Editable, multi-format datasets

Described
- Evident methodology

Reusable
- Free and easy to use

Complete
- Fully detailed data sets

Timely
- Updates are regular and stated

Managed Post-Release
- Data needs to be backed by human support.
The exploration in Figure 12 began with an investigation into the types of data being shown in data dashboards. The dashboards examined for this taxonomy were all created using different processes and involving a different number of agencies or organizations. The sample used to compile the diagram (left) was taken from a sample of five dashboard examples. The differing uses for similar data can already be seen in this small sample, and a continued investigation would further illustrate the haphazard state of visualization selections that currently exists in the field. In order to gain a full understand of what the thought process behind the visualizations was, I begin by creating a taxonomy of dashboard visualization choices. The examination is intended to look into what is being done elsewhere in the field and understand what is being considered the standard approach for certain types of data. Overall this taxonomy showed trends in chart type particularly in regards to change over time. As could have been predicted, line charts are the most common type of chart used to depict this. No matter what is changing over time, the line chart seems to be a clear choice.

Considering the trend toward plotting change over time, the data dashboard being discussed in this case study is that of the United Stated Patent Office as it has a problematic approach to the representation of time. Figure 13.

As can be seen in this dashboard, there is an extremely heavy use of a visual metaphor. In this case the metaphor is meant to represent a automobile’s speedometer. This is a case where I disagreed with the HHS Usability recommendations as it suggested that items online be made to represent real-world objects. For example, a button should be three dimensional and use shadow to convey depth. The thought behind this recommendation is that users would find what is expected from them more understandable if the object was familiar to them. Although in some cases this may be true, as in the button visuals, I felt it was a dangerous suggestion to make as it could easily be misunderstood by designers.
The use of a real world object brings about certain connotations that are not necessarily aiding in the understand of the graphic being presented. To explain, the speedometer, as the name suggests, is meant to convey speed. The indicator rotates clockwise around the circular structure as the car increases its speed. This real-world function of the speedometer may lead the public to understand that the indicator's position being in a particular position should indicate speed, or even something positive. Though this is not always the case in this situation. The speedometer metaphor here is incorrectly applied. As the indicator moves clockwise in the visualizations in Figure 13 it means that the process being studied is actually taking a longer amount of time. It seems that this choice may have been made in an attempt to adhere to all of the HHS recommendations but has created its own issues in doing so.

Figure 13: USPTO Dashboard
https://www.uspto.gov/dashboards/patents/main.dashxml
In Figure 14 a dashboard speedometer from an automobile is shown which contains a visual language that is commonly adapted into quick-to-read dashboard visualizations due to a general sense of familiarity with how it functions and its aesthetic qualities. This example shows the difference between the real world object. Now that the visualization and the real world object have been explained, the flaw in execution becomes evident. Figure 15 shows a side by side comparison that illustrates how the data is being distorted in the USPTO visualization.
The use of a similar visual motif, although flawed in this case, is a strength of this dashboard. The designers chose to carry this speedometer motif throughout the dashboard in order to allow for easy comparison. The similar form being used throughout creates a visual language that is meant to be carried throughout the entire experience.

As can be seen in this dashboard, after analysis, checks 5/11 of the boxes of applicable requirements set forth by the HHS outline see Table 1. The fact that there are many positive aspects to consider through the HHS lens even though there are major failings in others offers proof that a consolidated and interdisciplinary set of recommendations is needed. A dashboard might be able to fulfill all of the needs of legal requirements while still having serious downfalls in other realms. There are considerations to be made about the data that is behind the visualizations as well. This dashboard does a great job of adhering to accessibility guidelines such as offering the ability to print a PDF of any given selection. This capability goes a long way to helping members of the public with disabilities to use screen readers to help them obtain the information. Though there are strides made here in this regard, there are many areas in which this dashboard is failing in regard to the availability of the actual data.

<table>
<thead>
<tr>
<th>Table 1: Usability Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>✅ Standardized Task</td>
</tr>
<tr>
<td>Same steps to tasks</td>
</tr>
<tr>
<td>✅ Printing Option</td>
</tr>
<tr>
<td>Printable/downloadable</td>
</tr>
<tr>
<td>✅ Structure for Comparison</td>
</tr>
<tr>
<td>Easily scanned &amp; compared</td>
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<td>✗ Fluid Layouts</td>
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<tr>
<td>Responsiveness to device</td>
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<tr>
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<td>Visual language should follow through from website</td>
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<tr>
<td>Call attention with limited methods</td>
</tr>
<tr>
<td>✅ Order</td>
</tr>
<tr>
<td>Group like or related data</td>
</tr>
<tr>
<td>✗ Include Actual Data</td>
</tr>
<tr>
<td>Allow download of source</td>
</tr>
<tr>
<td>✗ Visual Change</td>
</tr>
<tr>
<td>Graphic needed for changes over time</td>
</tr>
</tbody>
</table>
Table 2: Open Data Considerations

- Public
  - Data is made available
- Accessible
  - Editable, multi-format
- Described.
  - Evident methodology
- Reusable
  - Free and easy to use
- Complete.
  - Fully detailed data sets
- Timely
  - Updates are regular and stated
- Managed Post-Release
  - Data needs to be backed by human support.

The Open Data Policy states that data, in some kind of raw format such as .csv, .xlsx, or .json, must be made public and accessible with clear methodology explained and managed and kept up. Although the dashboard has the capability to print the visualizations, it does not however offer the user the ability to see the numbers that are creating the visualization. In this instance it is particularly problematic as being able to see the data in raw form could have helped in the understanding of the somewhat misleading visualization.

Table 3: Design Considerations

- Hierarchy of Needs
  - Functionality, Reliability, Usability, Proficiency, Creativity
- Aesthetic-Usability Effect
  - Aesthetics as an investment in user acceptance, forgiveness, and satisfaction.
- IKEA Effect
  - Engage users in the creation of products to increase their value perception.
- 80/20 rule
  - Applying the 80/20 rule means identifying and focusing resources on the critical 20 percent.

Table 3 summarizes what is expected in a successful data dashboard in regard to the design choices that were made. These principles are large umbrella concepts that encompass a larger set of design principles. For example, the Hierarchy of Needs cites the usability of a design. In this principle, considerations of color, scale, type size, and screen adaptability are encompassed.
### Hierarchy of Needs

<table>
<thead>
<tr>
<th>Functionality</th>
<th>Page loads data correctly, and consistently. Organization separates data into separate pages which hinders comparative abilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliability</td>
<td>Webpage is stable &amp; visualizations are updated at set intervals</td>
</tr>
<tr>
<td>Usability</td>
<td>See HHS Evaluation on pg.37</td>
</tr>
<tr>
<td>Proficiency</td>
<td>Visualization do not require proficiency in statistics or data visualization to interpret</td>
</tr>
<tr>
<td>Creativity</td>
<td>Offers a unique view of data, but the visuals chosen hinder understanding</td>
</tr>
</tbody>
</table>

### Aesthetic-Usability Effect

Aesthetics wins out in the USPTO dashboard overall. Choices made to create what is thought to be a more visually appealing dashboard are made at the cost of legibility and comprehension. These aesthetic choices although well intentioned do not aid the user in their journey for information. The focus on visual metaphor in this dashboard does create a sense of forgiveness and acceptance from the user as it is evident that a real effort was made in bettering the dashboard overall. This is the second version of this dashboard and the current state of it is a direct result of public comments about lack of ability to understand to original designs.

### IKEA Effect

This dashboard does not have any features that would fall under the mentality of the IKEA effect. This effect is achieved when a user is allowed to participate in the create of the visualizations they are seeing. This function could be a simple as have a time frame toggle option. The user’s perception of co-production in this instance creates a sense of value in regard to the product at hand. Much like IKEA furniture, the tools are provided to you, and you put in a bit of work on your end to create a final product.
This dashboard has almost no interactive features and therefore fails in this regard.

**80/20 rule**

The 80/20 rule for our purposes refers to the amount of focus a dashboard can have. This rule states that there is 20% of a project to which most assets should be focused on. The rule plays very nicely into the tech world’s concept of a Minimum Viable Product. The USPTO dashboard however seems to have equally explored a variety of different topic relating to the work they do. It seems, at least from a user perspective, that their resources were evenly distributed on all areas of study and the visualizations that fall into those areas. Although one could say that is a broad-stroke representation of the work the agency does, it leaves something to be desired in the way of focus and hierarchy.

**Chunking**

This dashboard does in fact separate its like-visualization from each other but in an extremely disruptive way. The visualizations are all broken into categories in separate pages. When a section title (below) is clicked on, a new window is opened containing redundant visuals pertaining to this category. This method completely removes the user’s ability to compare data easily, and instead leave them with a series of windows to cycle through.

---

**Figure 16: USPTO Dashboard**

Chunking or categorization of USPTO dashboard visualizations

https://www.uspto.gov/dashboards/patents/main.dashxml
Design

Design First Office Action Pendency

As can be seen here, the dashboard break out into a new page containing pairs of visualizations depicting the same data. Due to the change of X-Axis scales and the arrangement of the visuals, comparisons within the category are difficult. Although redundant, the more traditional visualizations, the bar charts, are actually much clearer to understand and perhaps should stand on their own.

This figure also bring about the importance of consolidation in dashboard design. Not only does this practice apply to the potential consolidation of data sources into a single dashboard, but also, in this case, the consolidation of bar charts into a single interactive visualization.

Design Traditional Total Pendency

Design Unexamined Application Inventory

Figure 17: USPTO Category Page
Results

From this analysis of the USPTO dashboard, I have been able to determine where the strengths and weaknesses of this design are. Although the dashboard does a fairly good job of adhering to the HHS guidelines for usability, it seems to fall short when examined through a design or data lens. Based on this analysis the following changes are being proposed:

- Use metaphor sparingly, and only when appropriate to the data being represented
- Always back up your visualization by providing the data used to create it
- Grouping like data, but keep the dashboard pagination to a minimum
- Use a layout and technology that is appropriate for varying screen sizes
- Color selection is key to expedient understanding. Limit use of dark background and gradients when visualizing data
- Allow users to view subsets of the data through interactive features such as data selection
Below is a series of redesigned aspects of the USPTO dashboard according the findings from the study conducted. The results of this case study are not adequate for the redesigning of an entire dashboard as more evaluations would be needed to create a full set of recommendations. For the purposes of this exercise, the speedometer discussed earlier will be used to execute each of these principles.

Use Metaphor Sparingly, Only When Appropriate For The Data

A key issue discovered in this evaluation was the misleading nature of the speedometer metaphor. In order to create a more accurate visualization, we can reference tried and true methods for selection such as carefully considering the content being represented. What is being visualized in this example is the count of months that an object is in a pending status. Showing things such as simple counts of a variable can be shown clearly in visualizations such as bar graphs. What we are looking for in this case however is a quick and easy read of the amount of time being spent where the context of past measurements may be helpful in the comprehension of the data. Following are two
examples of visualizations that could be used in place of the metaphor that could be more easily understood by the user.

Simply extracting the number value from the speedometer visualization offers the user a much faster comprehension time. The use of this method is extremely straightforward in that it clearly highlights exactly what the take-away should be from the original visualization in question. This method also allows for an interesting use of color to aid the user in fully understanding the data being displayed. In this example that I have created, there is also the inclusion of a color ramp that should be noted. Without the inclusion of historic data for this point of information it may be difficult for a user to discern if the value indicates a positive or negative report of performance. By adding the color ramp using colors that have a widely accepted color connotation (green is good, red it bad, etc.) we can offer the user an at-a-glance impression of the performance being indicated.

“People from different languages and cultures read in different ways. For instance, Semitic cultures read from right-to-left, while most Western cultures read from left-to-right and Pacific-Oceanic cultures read vertically from top-to-bottom in columnar format. A navigation bar may be totally unsuitable on the right for one culture but may be perfectly normal for another.” (Excell, and Ali 2016)
The use of visual metaphors also brings about a cultural issue where the real-world form of the visualization does not bring about understanding equally in all users. For example, there are languages that read from different directions, making the speedometer example read quite differently. In English, we read from left to right, which implies to us that values on the right of the gauge are higher. However, if a user read in the opposite direction, their initial impression of the data may differ. This issue is another reason why flat design is a superior choice for dashboards in the government as they will be viewed by a diverse audience with differing background and places of origin.

If you could imagine for a moment if an entire dashboard employed this method, a user would be able to get a sense of the state of an agency’s performance without reading a single number. A collection of large green numbers would, for example, indicate a successful reporting period for the agency. This also address an issue commonly faced by public organizations where the expectation of literacy, more specifically statistical literacy, is significantly lower than in other fields.

Another recommendation I can make employs the use of historic data. In this case the most recent data point would be highlighted in a line chart. This method would provide the user with a visual history of performance and an understanding of improvements that may be occurring in regards to the efficiency of an organization.

Similarly the use of a color indicator in this case is useful as well. The value that needs to be indicated in this situation can be confusing to some as the high the number, the worse it is. Commonly, charts of this type are used to show things like revenue over time or something of the sort. Because this visualization is showing the count of months, with the least amount of months being the ideal situation, the connotation of the line height is actually reversed. The color indicator is an attempt to ensure understanding about the quality of the data being shown.

When visualizing data for quick reading the designers must keep in mind that the connotations the public may have can lead to confusion. The expectation of statistical literacy is low, and steps need to be taking to communicate the nuanced meanings.
Many issues of visualizing complex or confusing data such as that found in the USPTO dashboard can be solved in a very simple way -- allowing the user to see the actual data in a reasonable format. The connotations that make the pendency month count potentially confusing, could be quelled by the availability of a simple table or .csv file. This way, the user would be able to see the values that are creating the visualization and perhaps would be able to make sense of what is being shown.
Many dashboard already implement this thinking by allowing the users to be able to download the data being visualized, but USPTO has not integrated this function fully. Once a user clicks through to a specific page and navigated to the visualizations, there is an option to download the visualization as a .pdf. This may help with some accessibility issues with vision as it allows users to print out a selection of visualization for viewing off-screen, but does not address the issue of data viewing. Although this is an issue they currently face, it is also an opportunity. Many dashboard have a single download function that will download all the raw data being used in the entirety of their dashboard. This would require a fair amount of literacy to determine what data was picked for each visualization. Allowing a user to download at different levels of focus would be a more concise way of bringing about understanding for the user.

By placing simple UI elements such as download buttons using the now standard download icon, it is made clear that the user can access these data sets. Furthering the clarity of this action, a hover state could be enacted to allow the user to see what data would be download upon clicking. As seen in Figure 21, the hover effect could draw a box around the visualizations’ datasets that would be downloaded. This simple user experience change could not only allow the user to gain access to the data for their own purposes but also invoke an interest in what lies beneath.

The mockup of this feature will be added to the existing layout of the dashboard to me later integrated into the fully redesigned dashboard.
Figure 23: Filtering System

In order to bring attention to this feature it should be placed somewhere on the main page of the dashboard. For this example we will be using the topmost location available.

Ability to Filter Data

As with any dashboard, there exists too much data for any single visualization. Much like there are innumerable visualizations to be made with the data being used, there are innumerable combinations of data a user may want to compare. Whether these comparisons are to be made with data contained elsewhere in a particular dashboard or with data downloaded from a different organization it is vital that the user be able to obtain the exact subsets they are looking for.

In facilitate this and to aid users in their own explorations of datasets, a data filtering system should be implemented. Of course the robustness of this filter capability will rely heavily on the complexity of any given dashboard. In regard to the USPTO dashboard, a simple filtering by a few fairly obvious variables would increase usability and access greatly. As can be seen Figure 22, USPTO has already pre-filtered their visualizations into categories (see following section on chunking). These buckets,
and the visualizations they contain give us a good idea of the filtering options that should be made available.

This method of filtering the data as a whole entity rather than by visualization or category only, allows the public to interact with this dashboard in a new way. The dashboard, with the addition of this up-front filtering feature, can be used as a tool for research as opposed to solely an informative display.

Although many choices made in this redesign come from the mentality of flat design principles, there is more to be done than simply removing gradients and the illusion of depth. The use of dimensionality is not the only issue at hand. Additionally, there is much to be said for the selection of the visualization type itself. For example, the use of bar graphs to show the change over time in the USPTO dashboard. This design is arguably in line with flat design principles but lacks a certain visual hierarchy that can be accomplished through the application of typographic scale. When all of the gradients and textures are removed from a visualization there can be a remaining issue of hierarchy. Without the varying colors and layer of depth to help the user differentiate importance, the activation of typographical hierarchy is of vital importance. Note the size of the number 24 in Figure 24. The use of color and scale to call attention to this value guides the eye through the visualization in a logical way without the use of additional design elements.
Figure 25: Chunking USPTO

This exercise uses assets for the USPTO Dashboard as they are published today. The purpose of the exercise is to show likely groupings that can be made using the information currently available.

Due to the lack of variety in the visuals chosen for these data representations, differentiation between chunks becomes difficult. This brings to light an interesting dichotomy between the grouping of like-data and the diversity of visualization. The visuals need to differ enough that interest is held, but grouped in a way that the contents share a common theme.

Chunking of like-data

The idea of chunking, or grouping by similar attributes, can aid a user in the navigation of a dashboard. Dashboards are often packed with information and visualizations and the need for organization and grouping is called for. This chunking will be applied most noticeably in the following section about layout for responsive design.

The chunks that need to be made have already been spelled out by USPTO through their use of pagination as seen in Figure 25. These buckets of data visualizations have already been chunked, but their separation makes comparative context impossible without the use of many windows.
Pendency

Design

Special Programs
Responsive Design

At present, the USPTO dashboard is not optimized for use on mobile devices, or even for varying screen sizes. The website uses Adobe Flash Player to run its dashboard section which is not only a relatively outdated technology, but also is not compatible with some mobile phone browsers. The overall aspect ratio of the main page seems to be derived from web design standards followed in the early 1990’s when 4:3 aspect ratios were the standard. Today, the most effective screen resolution to design for is 1024×768 (Shaun 2017) and should be considered when designing websites and more specifically online data dashboard.

As of 2019, the dashboard functions on many smart phones but it is evident that the content was not optimized for such use. Although the column in the web layout adapt to the screen, the text sizes, and row content are static making for impossibly small text and illegibly visualizations See Figure 26.
Using existing content, a view of the dashboard in a responsive design using a mobile format has been created. This offers a preview of what the layout of a successful dashboard should resemble when the fluid layout is used in its development. The way visualizations and text are organized on a desktop or laptop screen should be drastically different. This type of layout means that the developers must create each element as a unique object contained in a floating division. This method may seem like a piecemeal way of building each page, but it offers the most flexibility in screen size adaptation.

First Office Action pendency is the average number of months from the patent application filing date to the date a First Office Action is mailed by the USPTO. Our goal is to reduce first action pendency to an average of 10 months by 2019. The term "pendency" refers to the fact that the application is pending or awaiting a decision.

This measure of First Office Action Pendency includes the time until a first action by the
A key aspect of designing for the use of multiple screen sizes is based on the structure of a gridded layout. The federal government has recently completed an exercise in web standardization for federal websites. In this guide, the use of grid based web layouts is discussed. (“Layout Grid | United States Web Design System” n.d.)

As can be seen in Figure 28, there are a variety of column widths that can be used for any given content. The flexibility of this layout method allows for the shuffling of data visualizations and tiles of information based on the screen size of the device in use. The columns occupied in the desktop view of a dashboard can retain their order, but shuffle to fit to any screen size as can be seen in Figure 29.
Patents Data, at a Glance

If you have any questions, comments, or feedback, please click here.

First Office Action Pendency (MONTHS)
- 16.2

Traditional Total Pendency (MONTHS)
- 23.8

Unexamined Patent Application Inventory
- 550,193

RCE Inventory
- 29,840
First Office Action pendency is the average number of months from the patent application filing date to the date a First Office Action is mailed by the USPTO. Our goal is to reduce first action pendency to an average of 10 months by 2019. The term “pendency” refers to the fact that the application is pending or awaiting a decision.

This measure of First Office Action Pendency includes the time until a first action by the USPTO, as well as anytime awaiting a reply from an applicant to submit all parts of their application.
Synthesis

“What about confusing clutter? Information overload? Doesn’t data have to be “boiled down” and “simplified”? These common questions miss the point, for the quantity of detail is an issue completely separate from the difficulty of reading. Clutter and confusion are failures of design, not attributes of information.”

(Tufte 2017)

Evaluative Principles

Design Considerations
- Hierarchy of Needs
- Aesthetic-Usability Effect
- IKEA Effect
- 80/20 rule
- Chunking

Usability Considerations
- Standardized Task
- Printing Option
- Structure for Comparison
- Fluid Layouts
- High-Contrast
- Visual Consistency
- Color Selection
- Highlighting Information
- Order
- Include Actual Data
- Visual Change

Data Considerations
- Public
- Accessible
- Described
- Reusable
- Complete
- Timely
- Managed Post-Release
In recent years, data dashboards have grown in popularity, which was the reason for this investigation. Throughout this analysis, there have been examples of dashboards that are seemingly stuck in certain design trends from around the era in which they were developed. An example of this is the aspect ratio used in the USPTO dashboard design discussed earlier in this study. Although there have been enormous developments in the technology we use to create webpages and dashboards, from the creation of online GIS services to the constant development of Javascript libraries for visualization, there are still strong visual ties back to the EIS dashboards that started this practice such as the use of statistically advanced visualization requiring previous knowledge to understand. It became clear through the examination of the state of the art that some type of formalities need to be developed in order to ensure dashboards remain effective and relevant ways to display data to diverse audiences.

Through the multi-level evaluations conducted in this processes, it becomes clear that there are many perspectives to be considered when developing a dashboard. The number of perspectives to consider are even greater when the evaluations become focused on dashboards in the public sector. Considerations include aspects of accessibility, usability, literacy, political implications, and the list goes on. Due to this multi-faceted set of restrictions on the design and development of data dashboards, the public sector has had unique struggles in creating visually compelling work in this regard.

Through the application of recommendations from multiple areas of concern such as the HHS guidelines, design principles, and general dashboard theory, it has become evident that a path can me forged which addresses many issues occurring in dashboard design. There are aspects at each level of evaluative principles that do not apply to the creation of dashboards, and the elimination of these guidelines was crucial to finding the core values of dashboard design. In order to satisfy the public’s desire for openness and transparency, while remaining true to theories and principles of design, prototyping was enacted. These prototypes made and initial attempt to remedy existing issues occurring in the dashboards that are live on the internet today. Based on the evaluation results there were key takeaways
that, when tested, proved to be fruitful in the effort to build accountability and trust between a public agency and their constituency.

A particularly interesting finding from this study is that there exists a perception that in order to create a data dashboard, one must be a subject-matter expert in the field being discussed. Although a working knowledge of the topic is typically helpful, this thought process actually contradicts what I would consider a cornerstone of dashboard development – collaboration. Throughout the study, it became clear the dashboards are in many ways consolidation tools. The dashboard should be a consolidation of related data from one or even multiple agencies. Consolidation of data in this way requires extensive collaboration with subject matter experts within one’s own organization, but at times even interdepartmentally.

There exist many resources for the development of data dashboards already, but the recommendations come from organizations that are siloed in their own fields of study. This isolation leads to many oversights in guidance and at times a bit of overstepping in relation to the dictation of aesthetic considerations. The goal and existing outcomes of the investigations conducted throughout the course of this paper sought to consolidate there resources for the sake of the designer. When considering the amount of arenas from which the guidelines are currently being generated, it is no wonder that a standardized practice of dashboard design has yet to be established. Which set of guidelines a designer may choose to follow or ignore depend entirely on where their employing organization falls on a spectrum of concern from political optics to data integrity to design aesthetics. After reviewing the numerous resources and guidelines governing public dashboard design, the consolidation and application of relevant changes have been outlined. This is the beginning of developing a master set of rules and regulations for the design of a public sector data dashboard, and will continue to be developed a sort of living documentation.
Future Work

Given the sheer number of dashboards and agencies in existence, an in-depth analysis of them all would be an enormous undertaking. This exploration is a stepping stone further critique and development in this vein. From the insights gained in this brief examinations it became evident that the concept of collaboration discussed pertained not only to the work of developing dashboards, but also that of developing their guidelines. As such, the expansion of this project will be pursued in the future with the assistance of fellow government designers and developers. This cross functional collaboration will enable a fair and even critique of existing dashboard and also for the development of usable tools that embody the recommendations made. Below are three branches of this project that make up the future body of work.

Standardization & “Brand Guide”

As discussed throughout this paper, there is a need for standardization and guidance for the creation of data dashboards in the public sector. The guidelines I hope to developed would be application to any and all governmental dashboard. The overall plan in regard to the “Brand Guide” is the standardize the general aesthetics of government dashboards to create a visualization vocabulary for the public. As it is now, the public is expected to decipher new visualizations, UI functions, and formatting with each visit to a government dashboard. The goal is that once a member of the public reads one dashboard, they can then make an easy and even comparison with a dashboard from anywhere else in the country. This aspiration would limit the workload of gathering data for the public, and would enable them to be more informed contributors to public policy and maybe even increase engagement.

The standardization method would also cut down on many deterrents public sector organizations face such as the limited access to resources. By standardizing the general aesthetics, and visualization choices, much of the work load is taken off of the designer’s hands. In doing so the project of creating a data dashboard becomes more feasible and limited the amount of competing feedback received when collaborating with multiple
departments. This feedback would be reduced simply in the fact that many decisions about the creation of the dashboard are already made.

**Partnering with Fellow Municipal Designers**

Another key topic discussed was that of collaboration between public agencies. This collaboration, I believe, should be carried through to the defining of design principles for data dashboard. Part of the reason many recommendations go unacknowledged in my opinion is that the rules are being thwarted at designers from outside of their organization and without their input. Collaborating with fellow designers could increase buy-in as the recommendations would be coming from a more rounded group of designers in a similar field.

**Generating a d3 Library**

After generating a satisfactory guide, an ideal way to encourage adoption would be to make implementation as seamless as possible. In order to do this, a library of pre-coded visualizations would be developed which adhere to the guide. These visualizations would be pre-loaded with, for example, color schemes that adhere to accessibility guidelines. In creating such a library, even more of the up-front work would be lifted off the shoulders of any one individual agency and, if desired, no editing would be required. By taking the focus of the collaborating team off of the technical aspects of coding or programming visualizations, they are free to focus on aspects of interactivity such as data filtering and download. Some of the more complicated aspects of dashboard design discussed in this paper can not be done ahead of time as they are specific to the digital infrastructure of any given organization. The ability to download and filter datasets at the click of a button, which is recommended, would depend entirely on the format of the data being used as well as on the content management systems that may be involved in the management of their web presence.
References


