

Data Visualization Assignment

Jessica Harris Tiffany Woodley

April 2019

Contents

1	Introduction	4
1.1	About our dataset	4
1.2	Profile of the type of user	4
2	Overview and analysis of related work	5
2.1	Literature 1	5
2.2	Literature 2	7
2.3	Literature 3	9
3	Visual Queries	10
4	Detailed description of design	12
4.1	Overview	12
4.2	Step 1	13
4.2.1	Design Overview	13
4.2.2	Strengths and Weaknesses	14
4.3	Step 2	17
4.3.1	Design Overview	17
4.3.2	How Previous Issues were addressed	17
4.3.3	Strengths and Weaknesses	20
4.4	Step 3	23
4.4.1	Design Overview	23
4.4.2	Interaction Overview	26
4.4.3	Final Design in Black and White	27
4.4.4	How Previous Issues were addressed	28
4.4.5	Strengths and Weaknesses	29
5	Conclusions and future work	33
6	Team work allocations	33

List of Figures

1	Literature Review 1 Overview	5
2	Literature Review 1 Filtered by Airline	6
3	Literature Review 1 Filtered by Airport	6
4	Literature Review 2 Overview	7
5	Literature Review 2 Interaction	8
6	Literature Review 3 Overview	9
7	Literature Review 3 Filtered by Airline	10
8	Ranking of Visual Queries	10
9	Design Process Flowchart	12
10	Step 1 Design	13
11	Step 2 Design	17
12	Distinct Airline Symbols	19
13	Final Design	23
14	Final Design with Interaction	26
15	Final Design in Black and White	27

List of Tables

1	Step 1 Strengths and Weaknesses	16
2	Step 2 Strengths and Weaknesses	22
3	Design Considerations for the final design, based on the content of Lecture 7 [3]	25
4	Final Design Strengths and Weaknesses	32

1 Introduction

Air travel has become more accessible for leisure travellers and is often a necessity for business people. Delays and cancellations have the power to ruin a person's travels. Our visualisation intends to help both leisure and business travellers avoid these wherever possible so that flights can be purely functional instead of a source of unnecessary stress.

1.1 About our dataset

Our data set consists of flight logs for approximately 280 000 flights in the USA in 2015. While the original data set contained 46 columns, the information of interest in this case related to airlines, delays (time and cause) and routes (origin and destination airports, city and state).

1.2 Profile of the type of user

Leisure travellers, especially tourists unfamiliar with the USA and their local carriers, may be overwhelmed by the choice of domestic carriers. It is difficult to make a choice as to which carrier to use when one does not have any prior experience to rely on. Delay information is important for leisure travellers who might have to catch a connecting flight, which – the case of tourists – may be a long-haul flight with considerable cost attached. It is therefore imperative to avoid delays on the preceding local flights. In most cases, tourists are responsible for their own travel costs and it would be useful for them to be able to identify the most on-time airline within their budget. Business travellers often have busy schedules in which every moment is accounted for. Flight delays could cause meetings to be missed and may disrupt the entire day's schedule. For people who conduct business across the country, it is essential for their carrier of choice to be prompt, as time spent delayed costs the business money. It may be worthwhile then for the business to use a more expensive carrier, if that carrier has a good record of on-time arrivals.

2 Overview and analysis of related work

2.1 Literature 1

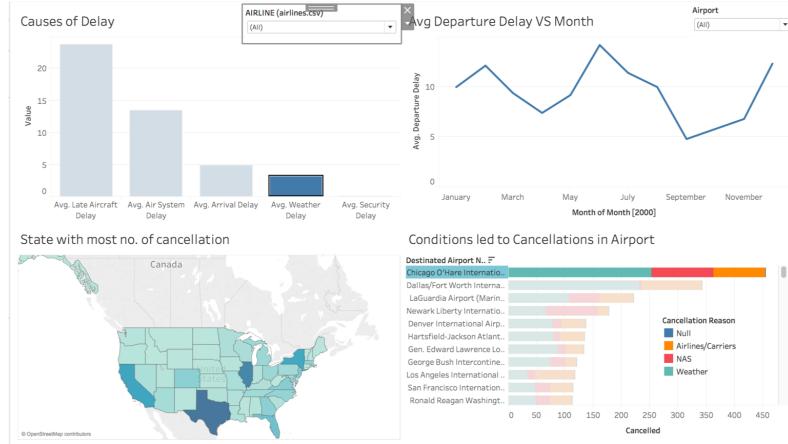


Figure 1: Literature Review 1 Overview

The first literature review [2] comprises of a dashboard with multiple graphs as seen in Figure 1. The element we liked most was the map which gave us an idea of the severity of delays per state. The fact that we could see when in the year would be the best times to fly was also found useful. These are two elements we wanted to try incorporate into our design. The stacked bar graphs make it quite difficult to compare the different types of delays across the airports, but this information is still something we would like to display more effectively.

Listed are some of the different channels and how the visualization makes use of them.

- **Colour**

The visualization doesn't have a large usage of color with many of the graphs only making use of a single color. The stacked bar graph uses colors of the same saturation not helping the distinction between the different stacks. The standard bar graph attempts to pop out a single bar by dropping the saturation of the others, this would have been more effective with a brighter more distinct color

- **Depth**

The greyed out areas of the map in the background makes the blue USA pop out as the area seems raised creating depth.

- **Texture**

The visualization didn't make use of this channel

- Shape

The shape of the USA map is distinct and allows the user to know what country the visualization is based on.

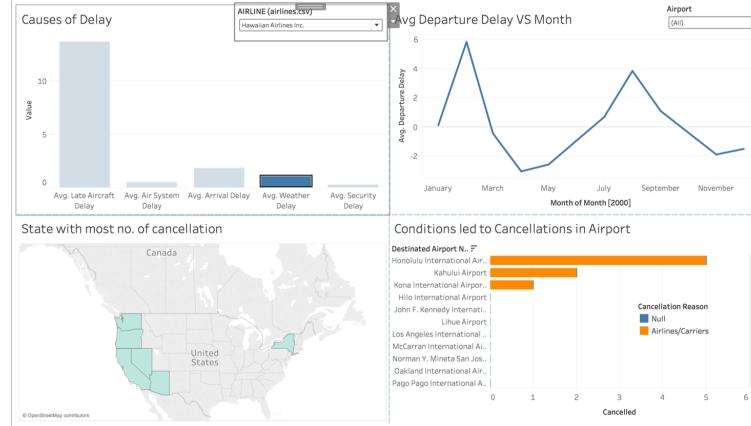


Figure 2: Literature Review 1 Filtered by Airline

The dashboard is interactive, it filters the information based on both airport and airline. Figure 2 shows the dashboard filtered by airline, this is very useful as you can see exactly which states the airline operates in. This gives information about about the airline specific delays and how it operates. Since this allows the dashboard to portray specific information about each airline and airport, the cost of interaction is worth the outcome. It also has a static overview so you can see the most important information first then click for details on demand.

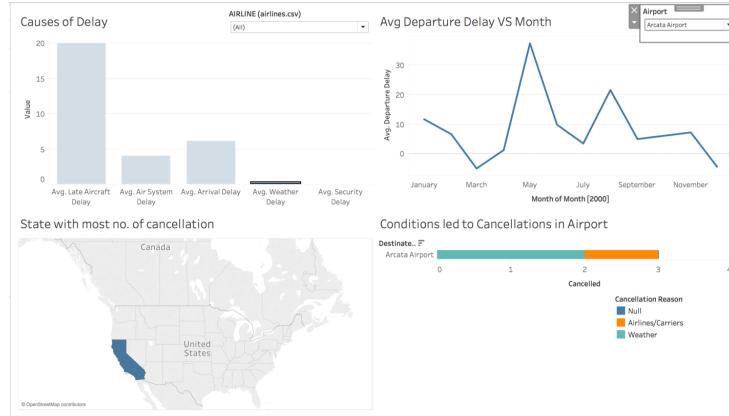


Figure 3: Literature Review 1 Filtered by Airport

Figure 3 shows the dashboard filtered by airport. The map highlights the state where the airport is located, this helps the user visualize where in America the airport is located.

2.2 Literature 2



Figure 4: Literature Review 2 Overview

The second review design [1] as seen in Figure 4 is an interactive online tool that allows for the visualization of on-time vs delayed/cancelled flights at major centres in the USA. Figure X shows the static view of the visualization. One of its major limitations is that it only shows flight data for the past 24 hours.

- Colour

Red and green were used to show delayed/cancelled and on-time flights, respectively. This is in keeping with the negative/positive colour associations in Western culture, where this visualisation is aimed.

- Shape

In terms of the design's use of shape, circles were used to provide information on the relative number of delay/cancelled and on-time flights at each centre. The use of circles is not particularly effective, as they are essentially glorified pie charts. Humans find it easier to compare quantities based on relative lengths of lines, rather than portions of a circle. The use of a 2D quantity the form of the coloured-in portion of each circle – is being used to represent a one-dimensional quantity, the number of flights, which is not good practise.

- Texture

The only texture present in this visualisation is in the weather patterns in background. It would have been better if this had been shown only in greyscale, as the green colour present in the weather patterns interferes with the green of the circles, making the proportion of on-time flights appear greater. It is misleading to have the weather patterns shown in green, as green has a positive association in Western culture, while the presence of these weather patterns is likely to cause delays, which are negative. As such, there is a mixing of metaphors in terms of the colour choices for the weather systems.

- Depth

colour makes the circles appear as if they closer, with respect to the grey map in the background. Initially, we thought there was also use of depth in the timeline, in the form of occlusion. Solid on solid is not effective for overlapping items as it doesn't allow for identification of the trends in the occluded data. We later realised that the timeline actually shows a stacked plot of the number of delayed/ cancelled and on-time flights for the past 24 hours. Having the red portion of the plot positioned above the green in the stacked plot leads can imply that there is more of it, hence our initial confusion. It was only when considering that all of the circles in Figure 4 are mostly green that we realised our error. This is most definitely a shortcoming of the design. The absence of units on the y-axis of the timeline is also potentially misleading.

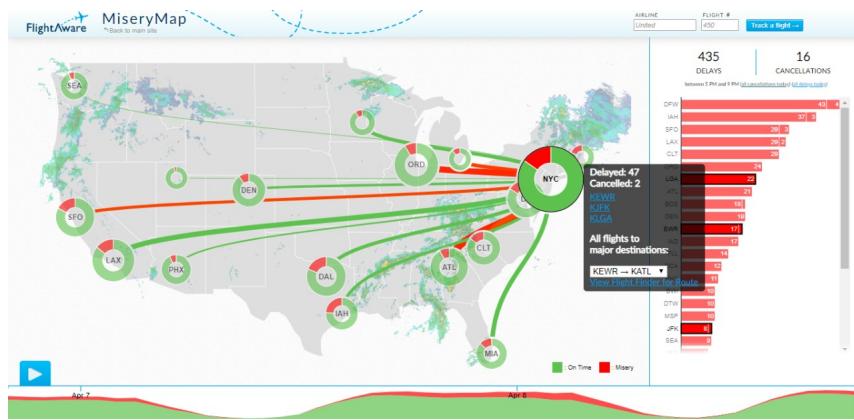


Figure 5: Literature Review 2 Interaction

Clicking on any one of the city centres reveals details on demand, as shown in Figure 5. Coloured lines appear, revealing the routes from that city by the coloured lines joining it to various destinations. The lines are coloured based on the extent of the delay experienced on each route. The number of delayed and cancelled flights is specified in the pop-up box.

2.3 Literature 3

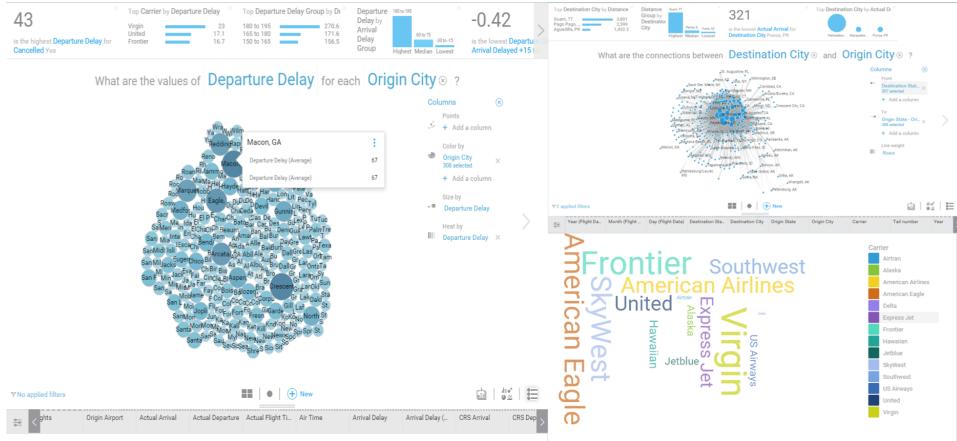


Figure 6: Literature Review 3 Overview

Reviewed Design 3 [4] did not have a dashboard page, making it difficult to get an idea of what data was available to be explored. Multiple pages of the design were combined to give the overview shown in Figure 6. In the overview, it was completely unclear as to the connections between different origin and destination airports, as there was just a web of lines. However, when these were filtered by airline, as shown in Figure 7, it gave a good idea of the areas a given airline operates in. We liked this concept and decided to incorporate it into our design, with some modifications. In this example, the cities were not overlaid on a map, making it difficult to locate the flights routes.

- Colour

Different saturations of blue were used to indicate the values of departure delay for each origin city. The differences between the saturations used are not sufficient, making it difficult to distinguish the different delay values. With respect to the word cloud, where size of the airline name indicates its relative frequency, one would expect the names written in bigger font to pop out more. However, use of yellow on white counters this pop-out effect due to its low luminance contrast.

- Shape

The size of the circles was also used to provide information on the values of departure delay for each origin city. Hence, two channels – colour and shape – are being used to represent the same value, which is a waste of a channel. The use of circles is not particularly effective, as humans find it easier to compare quantities based on relative lengths of lines, rather than portions of a circle. Once again, a 2D quantity is being used to represent a one-dimensional quantity, which is not good practise.

- Texture

There was no use of texture in this design.

- Depth

The names of airlines shown in the word cloud have a pictorial depth cue – perspective. Airlines with fewer flights appear in a smaller font size, making them appear further back on the page, thus implying that they are less important.

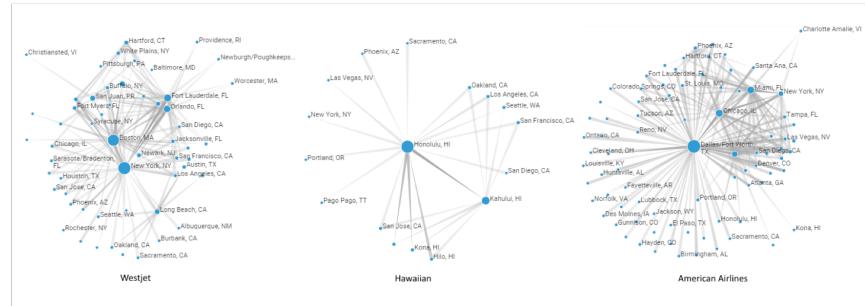


Figure 7: Literature Review 3 Filtered by Airline

3 Visual Queries

RANKING		VISUAL QUERY
1		What is the best airline to travel with?
1.1		Most cost effective airline?
1.2		Most on time airline?
2		Which is the best state to travel from?
2.1		Which state has the shortest delays?
2.2		Which state has the most traffic?
3		When is the best time to travel?
3.1		When in the year is the best time to travel?
3.2		When in the year is the best time to travel from each state?
3.3		What is the best time of day to travel?
4		What are the main causes of delays?
4.1		Are delays caused by weather?

Figure 8: Ranking of Visual Queries

When travelling to a new destination, especially when you're unfamiliar with the domestic carriers, the first question that comes to mind is: "Which one is best; which should I choose?". There are several factors that can affect this decision. Two major factors are the cost and reliability of the airline. In this case, the reliability of the airline can be measured by its average delay.

While business travellers might not have much choice in terms of which state to travel from, leisure travellers might want to plan their trip to avoid states particularly prone to large delays or avoid periods of high traffic.

The decision of which airline to choose hinges on several factors; the importance of these varies depending on the traveller. Are they travelling on a budget or more concerned about wasting their time on delays? Someone on a tight budget will be looking for answers to questions relating to the relative cost of the different airlines to find the best value for money.

The thought of large, chaotic airports may cause anxiety for some. Knowing how much air traffic passes through each state and how it influences the delays can be very useful when planning a route around the States. How busy an airport is also dependent on the time of day – if you are travelling for leisure and are a bit more flexible with your times, it could be beneficial to book flights outside of the peak times for a more relaxed journey.

If a state is notorious for bad weather conditions at a given time of year, it might be a good idea to avoid it in your holiday plans. Not only would you reduce your chance of being affected by delays, but you would also reduce the risk of weather ruining your trip.

4 Detailed description of design

4.1 Overview

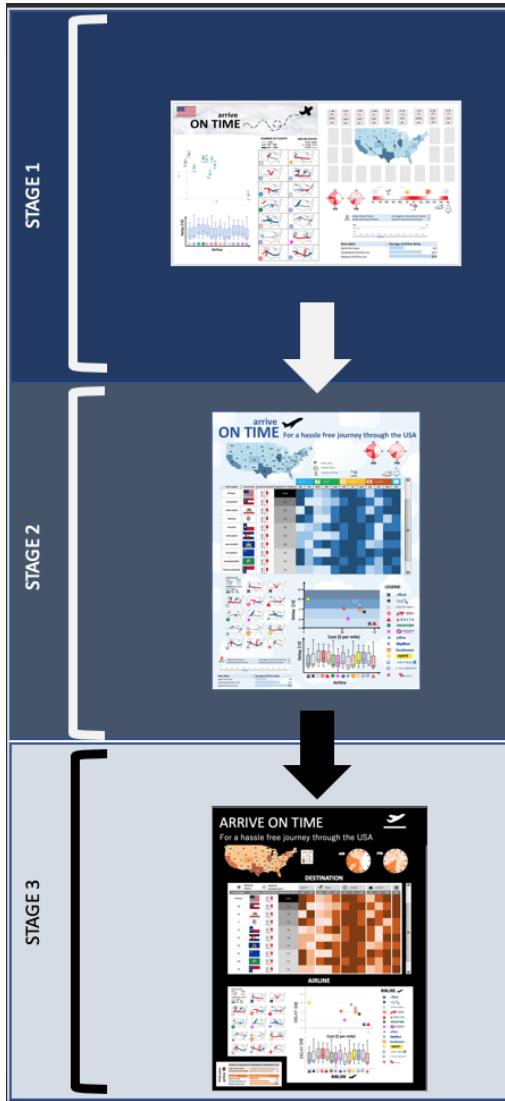


Figure 9: Design Process Flowchart

The flowchart in Figure 9 shows the process of the design and how it improved over time. The steps have been inserted below each other for easy comparison. This gives perspective before the detailed explanation of the designs in the sections to come.

4.2 Step 1

4.2.1 Design Overview

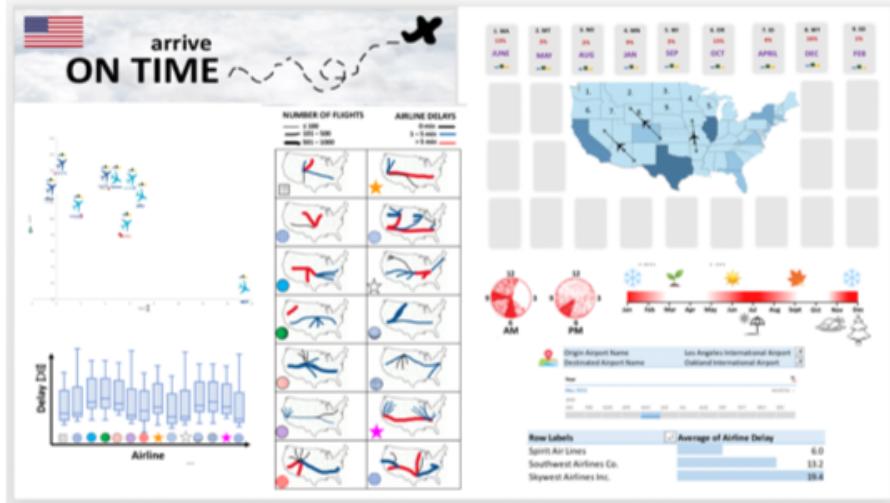


Figure 10: Step 1 Design

The initial combined visualisation design is shown in Figure 10. Each element of the design is listed in Table 1, together with its strengths and weaknesses. The fact that the content of the visualisation relates to air travel is suggested by the cloud image, aeroplane graphic and USA flag in the header.

Initially, we had planned to use each airline's logo as its identifier, whenever information about it appeared in the visualisation, as shown in the scatterplot in Figure 10. However, as this visualisation is based on American data, most of the airlines have a blue and red livery. This means that the logos are not easily distinguishable from one another, which makes answering visual queries quite difficult and slow. As such, it was recommended that we extend our use of the symbols from the boxplot and route map by airline to include the scatterplot as well. In this round of presentations, the execution of the airline symbols was still lacking; mostly stars and circles were used so the symbols were not sufficiently distinct.

The interactive airline finder allows the user to choose the best airline for their specific trip, having already considered all the information displayed earlier in the visualisation. The inputs are intended Origin and Destination airports and the month of intended travel. The output is a list of airlines that service that route, ordered by ascending average airline delay.

4.2.2 Strengths and Weaknesses

Element of the design	Strengths	Weaknesses
Background	<ul style="list-style-type: none"> The clouds provide gist 	<ul style="list-style-type: none"> They are only present in header
Header	<ul style="list-style-type: none"> The flag provides gist that we're dealing with flights in USA The aeroplane provides gist about the nature of the content - relating to air travel 	<ul style="list-style-type: none"> The aeroplane is perhaps too "fun" considering visualization is about delays
Big map showing delays	<ul style="list-style-type: none"> The map gives good overview of delays per state The map allows user to orientate the delays visually on the map 	<ul style="list-style-type: none"> There is no indication of state names of the map - if a user is unfamiliar with the USA, they would have to search for the info card to find the name
Info cards surrounding big map	<ul style="list-style-type: none"> The info cards allow user to access a lot more information about each state without overcrowding the map 	<ul style="list-style-type: none"> The info cards do not allow for easy comparison between states The info cards only show information about the worst month - they do not show how delays change over the year The cause of delay bar charts do not have symbols, so the user must look to the legend every time The colours of bars in bar chart are not sufficiently distinct

Heatmap clocks	<ul style="list-style-type: none"> The clocks give clear indication of the times of day when delays tend to occur 	
Heatmap timeline	<ul style="list-style-type: none"> The timeline gives clear indication of the times of day when delays tend to occur 	
Route maps by airline	<ul style="list-style-type: none"> The route maps contain multidimensional information, with number of flights represented by binned width of line and average delay shown by color 	<ul style="list-style-type: none"> The positioning of legend in two columns above the two columns of maps implies that we looking at two different things
Delay vs cost scatter-plot	<ul style="list-style-type: none"> The scatterplot allows user to easily distinguish which airlines are best value for money 	<ul style="list-style-type: none"> The use of aeroplanes as scatter points is confusing as it is unclear as to where exactly the point lies The airline logos next to scatter points are distracting and not distinguishable The orientation of planes is not easy to identify
Delay vs airline box-plot	<ul style="list-style-type: none"> The boxplot carries a lot of information, not only about average delays but the best- and worst-case scenarios 	<ul style="list-style-type: none"> The blue color of boxplots does not contain any information The delay axis is not consistent with the scatterplot

Legend of airline symbols	<ul style="list-style-type: none"> This is a better option than using airline logos 	<ul style="list-style-type: none"> The symbol choices are not yet sufficiently visually distinct - they would not work in greyscale
Interactive airline finder	<ul style="list-style-type: none"> This allows user to choose the best airline for their specific trip 	

Table 1: Step 1 Strengths and Weaknesses

4.3 Step 2

4.3.1 Design Overview

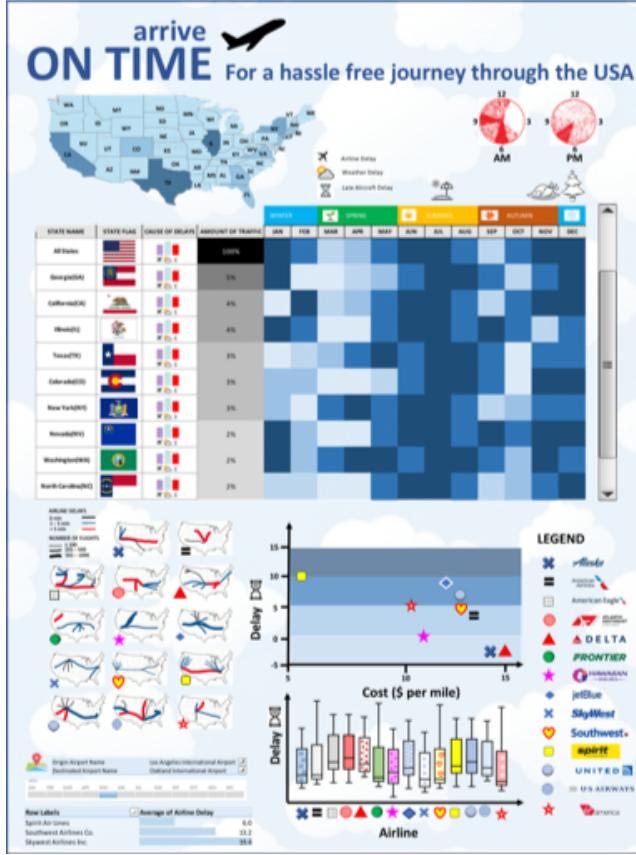


Figure 11: Step 2 Design

4.3.2 How Previous Issues were addressed

The visualisation design presented during the second round of presentations is shown in Figure 11. Each element of the design is listed in Table 2, together with its strengths and weaknesses. The fact that the content of the visualisation relates to air travel is suggested by the cloud image, aeroplane graphic and map of the USA located near the header.

Based on Presentation 2, several comments were made with respect to labels and use of symbols. It was recommended that the symbol used in header should rather be used next to the “Airline” label wherever it appears in the visualisation, to facilitate visual queries. Additionally, our lack of choice of fonts was criticised, as default fonts were used. It was recommended that different fonts be used for “Airline” and “Delay”, and that these should be used consistently throughout the design. The beach, turkey and tree symbols had been included above the heatmap timeline to denote summer holidays,

Thanksgiving, and Christmas. The intention was to provide visual cues to explain greater air traffic at certain times of the year. It was recommended that these were a bit gimmicky and not worth including in the final design.

This design uses grouping in space to address the confusion surrounding the route maps by airline. These maps are now grouped in a block rather than 2 columns, which had previously created confusion as it implied that different things were being considered in each column. The Gestalt principle of proximity was used to show that they are all related. Furthermore, the key describing the map line colours and thickness was stacked rather than adjacent to each other to reinforce this.

In terms of colour, a blue background of varying intensity was added to the scatterplot in an effort to visually bin the values of the average delay. However, as pointed out in the comments from Presentation 2, the presence of the background colour interferes with the airline symbols, making them harder to identify as colour is relative, not absolute. The use of dotted lines was recommended as an alternative. In this design iteration, the box and whisker plot has been modified so that boxes contain patterns associated with the airline's symbol to help identify which bar belongs to which airline.

The original interactive airline finder was included in bottom left-hand corner but was shrunk considerably compared to the previous design in Step 1. Comments from Presentation 2 indicated that its function was unclear as it disappeared into the background, particularly given the blue colour of the bars. Due to its placement, it is not obvious that it is a separate entity from the maps above it. A further comment was that, for consistency, the interactive timeline slider should match the timeline of the heatmap timeline, as both refer to the same time period.

In this iteration of the design, distinct symbols were created for the airlines using multiple channels as seen in Figure 12. Shape, colour, texture (patterns) and depth were used to create an easily distinguishable symbol for each airline. Inspiration for each symbol was drawn from the airline logo. An effort was made to link the symbol to the airline's logo, wherever possible, to encourage associations with the airline without having to check the legend too frequently. In this design, the airline logos were used in the legend, as opposed to merely the airline name, as recommended in comments from Presentation 1.

In the big map, state abbreviations were used instead of numbers in this design to make identifying the state easier. The info cards were replaced with a scrollable table, which allows for easier comparison of the states as well as comparison to the average over all states. The full name of each state was used, and its distinct state flag was included to help the user to quickly find the state they are looking for. Although the state flags will be more commonly known to locals, they are the most distinct way of distinguishing between states as the outline of the states can be quite similar. A heatmap across the months gives the user a much more comprehensive overview of the delays over the year. The seasons were grouped using colour and were identified using symbols. A grey colour gradient was used to indicate the amount of traffic that passed through each state.

The colours used in the bar graphs to represent the different causes of delays were changed to be more distinct both from each other and the surrounding elements in the design. This was accomplished by using changes to both colour and saturation.



Figure 12: Distinct Airline Symbols

4.3.3 Strengths and Weaknesses

Element of the design	Strengths	Weaknesses
Background	<ul style="list-style-type: none"> The clouds provide gist 	
Header	<ul style="list-style-type: none"> The flag provides gist that we're dealing with flights in USA The aeroplane provides gist about the nature of the content - relating to air travel 	
Big map showing delays	<ul style="list-style-type: none"> The map gives good overview of delays per state The map allows user to orientate the delays visually on the map 	
Heatmap clocks	<ul style="list-style-type: none"> They give a clear indication of the times of day when delays tend to occur 	
Heatmap line/table	<ul style="list-style-type: none"> The timeline has been extended so it not only shows the delays for the USA as a whole but also the breakdown of delays per state Interactive element is included - tourist info for each state given in an info card that appears on click 	<ul style="list-style-type: none"> The colours used to indicate seasons is unnecessary - they imply connection to the same colors appearing elsewhere in the visualization The symbols showing major holidays are unnecessary

Route maps by airline	<ul style="list-style-type: none"> The route maps contain multidimensional information, with number of flights represented by binned width of line and average delay shown by color 	
Delay vs cost scatter-plot	<ul style="list-style-type: none"> The scatterplot carries a lot of information, not only about average delays but the best-and worst-case scenarios The delay axis is consistent with boxplot 	<ul style="list-style-type: none"> The coloured bins in background interfere with colour of data points, as color is relative and therefore depends on its surroundings
Delay vs airline box-plot	<ul style="list-style-type: none"> The boxplot carries a lot of information, not only about average delays but the best-and worst-case scenarios The delay axis is consistent with scatterplot The boxes contain a colour and pattern that closely resembles the airline's symbol, allowing for quicker identification on required plots 	
Legend of airline symbols	<ul style="list-style-type: none"> This is a better option than using airline logos The symbol choices are visually distinct, making use of shape, colour, pattern and depth - would now work in greyscale 	<ul style="list-style-type: none"> The word "Legend" probably not the best choice of heading - "Airline" would be more appropriate

Interactive airline finder	<ul style="list-style-type: none"> This allows user to choose the best airline for their specific trip The bars give a quick visual representation of how the delays of various airlines compare for a given route 	<ul style="list-style-type: none"> The timeline slider should match the one above the timeline heatmap, as they are referring to the same thing The colour of the bars disappears into the background The function is unclear - based on it's proximity to the maps, one assumes it is somehow linked
-----------------------------------	--	--

Table 2: Step 2 Strengths and Weaknesses

4.4 Step 3

4.4.1 Design Overview

The overview of our final design in given in Figure 13 and design considerations are listed in Table 3.

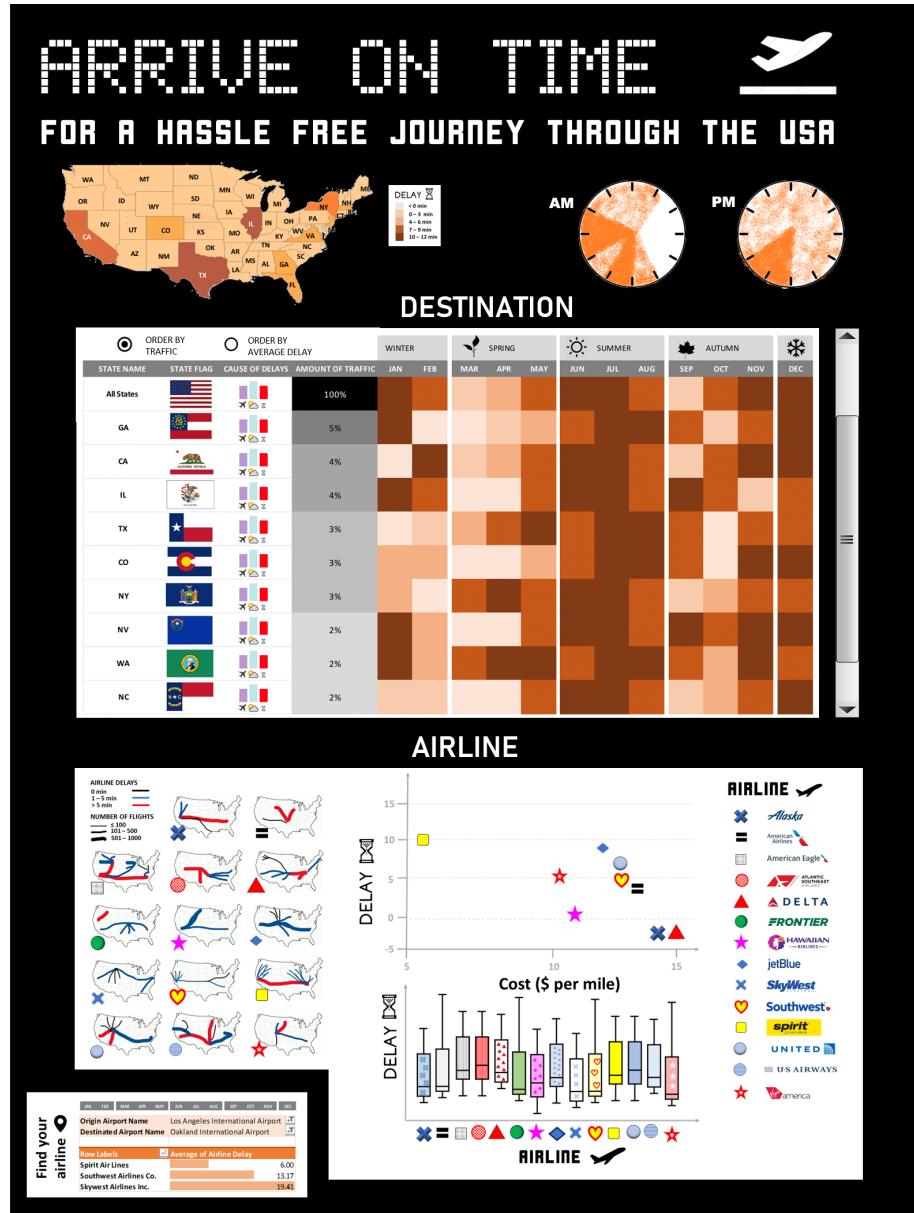


Figure 13: Final Design

Design Considerations	Discussion
Expressiveness principle <p><i>The channel should express all of, and only, the information in the data set attributes</i></p>	<ul style="list-style-type: none"> • Orange is used for all delays(except for exception discussed previously) • The font and symbols are kept constant
Efficacy principle <p><i>The most important attributes should be encoded with the most effective channels.</i></p>	<ul style="list-style-type: none"> • The most important channel is position - we used this to direct the user through the stages of planning a journey, from choosing a destination, to identifying the best airline for that journey, as they view the page vertically
Magnitude Channel <p><i>Used to show ordered attributes</i></p>	<ul style="list-style-type: none"> • Colour saturation was used to show varying degrees of delay • The different saturations are binned to ensure discriminability
Identity Channel <p><i>Used for categorical attributes</i></p>	<ul style="list-style-type: none"> • We used colour hue, shape, pattern and depth to create visually distinct symbols for airlines
Separability <p><i>Some channels depend on or interact with each other</i></p>	<ul style="list-style-type: none"> • As size interacts with many channels, we kept the relative size of the airline symbols and the blocks in the heatmap timeline constant throughout the design • The interaction between size and color was our justification for diverging from our orange colour scheme representing delays in the case of the route maps by airline
Pop-out	<ul style="list-style-type: none"> • The depth channel was used for pop-out of the interactive airline finder in the bottom-left corner. It gives the user the perspective that it is closer on the page

Grouping	<ul style="list-style-type: none"> Containment is the strongest cue. The white boxes around each section separate information regarding destination, airline and the interactive airline finder Gestalt principle in terms of proximity was used in that related visualizations were grouped together
Relative judgement	<ul style="list-style-type: none"> White backgrounds were used behind all data graphics to prevent the background from creating relative color judgements
No unjustified 3D	<ul style="list-style-type: none"> This was avoided
No unjustified 2D	<ul style="list-style-type: none"> We used 2D representation of delay on the map. This was justifiable as it also conveyed information about the geographical location
Eyes beat memory	<ul style="list-style-type: none"> We tried to keep the visualization largely static Scrolling was required due to the large number of states but still allows for many states to be viewed at once Interaction is not required to access any crucial information
Details on demand	<ul style="list-style-type: none"> Info cards on each state are available when user clicks on state abbreviation or flag Interactive airline finder provides list of airlines operating on specific route, ordered by increasing delay Radio buttons allow user to toggle between the order of the table
Function then form	<ul style="list-style-type: none"> We first ensured the functionality of the design, as our main purpose was effective communication, before considering gist

Table 3: Design Considerations for the final design, based on the content of Lecture 7 [3]

4.4.2 Interaction Overview

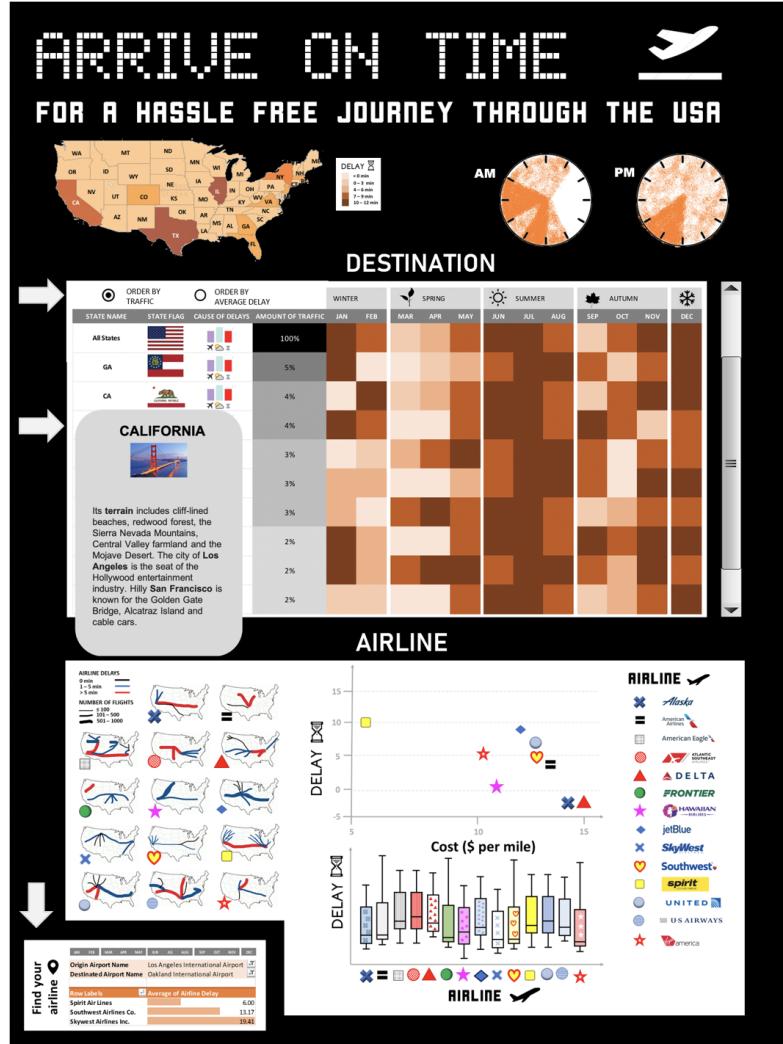


Figure 14: Final Design with Interaction

The final design includes three interactive elements, indicated with arrows in Figure 14. The first being info cards which pop up if a user hovers over either the state abbreviation or flag. The card gives the user extra information about the state such as its full name and attractions. The second element is the interactive airline finder which provides a list of airlines operating on a specific route ordered by their delay. The third element is the ability to order the table by either the amount of traffic or average delay, this can be done by clicking on a the corresponding radio button.

4.4.3 Final Design in Black and White

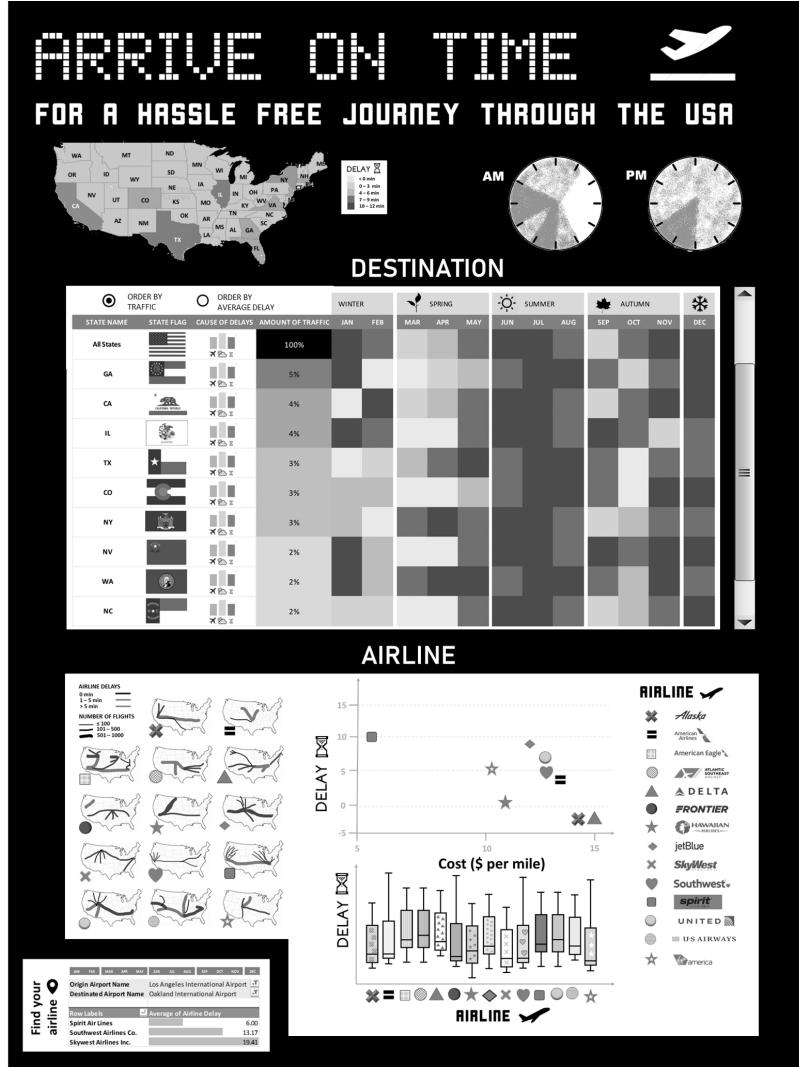


Figure 15: Final Design in Black and White

The main elements of the design are able to be portrayed in black and white as seen in Figure 15 this is due to the fact that:

- The color saturation bins used for delays are still distinguishable
- The airline symbols are still distinct from one another as many channels were used to make sure they were uniquely identifiable.

4.4.4 How Previous Issues were addressed

The overall gist of the final design varies greatly from previous design iterations. A black background is now used, in conjunction with an LED board font, to create the sense of a departures board at an airport. This is enhanced by the inclusion of the departures symbol in the header, rather than a generic image of an airliner. The departures symbol provides gist, as this is an easily-recognisable symbol in the field of air travel, as it is used in airports worldwide. We moved away from the blue colour scheme, with orange now being used to indicate delay. This is a good choice as it has an association with amber traffic lights, which have an almost-worldwide association with “caution” or “wait”. These changes are appropriate, given that our visualisation deals with air travel delays specifically, rather than air travel in general.

The design considerations that were used in the creation of this visualisation are discussed in Table 3. In terms of the heatmap timeline, binning was used to ensure that 5 distinguishable saturations of orange were used, as the human eye is rather bad at distinguishing shades on a continuum. Instead of using different colours to represent the seasons, a grey bar is used together with distinct, representative symbols of the seasons, as the colours used in Step 2 were quite distracting. A thin line was also included between the seasons to help show the distinct groupings. The state names in the heatmap were changed to abbreviations so that they correspond with the labels on the big map, making visual queries between the heatmap and map easier. Info cards with the full state name and other relevant information about the state pop up if you hover over a state abbreviation, for users who are unfamiliar with the various states. Toggle capability was added to allow the heatmap/ table to be ordered by either amount of traffic or severity of the average delay, allowing a user to change the ordering based on what they consider to be more important. Lastly, a key was added to indicate the associated delay with each colour bin.

White backgrounds were used behind plots to ensure that the background did not interfere with the symbols, as colour is relative rather than absolute. Colour, shape, texture and depth were all used to create airline symbols that are visually distinct, as showed in Step 2. Grouping of various related design elements in space ensures that the user intuitively understands that they are related (Gestalt principle).

As indicated in Table 4, the main weakness of our final design is that for the cluster of route maps by airline, the colours indicating delay time are not consistent with those used elsewhere in the visualisation. This was a case where a compromise had to be made. Elsewhere in the visualisation, flight delays were grouped into 5 bins, indicated by an orange colour with 5 different saturations. While the differences between these saturations was clearly visible in the larger elements of the visualisation, such as the big map showing delays and the heatmap timeline, this did not translate well to the much smaller maps. As colour is relative and not absolute, changes to surroundings and use of lines of different widths may hinder accurate identification of the correct bin. It was decided to simplify the problem by grouping the delay time into only 3 bins. The risk of incorrectly identifying the bin category of line was mitigated by choosing 3 different colours to represent the 3 delay bins.

4.4.5 Strengths and Weaknesses

Element of the design	Strengths	Weaknesses
Background	<ul style="list-style-type: none"> The black background gives more of a <i>departure board</i> gist 	
Header	<ul style="list-style-type: none"> The LED font enhances <i>delay board</i> gist The <i>Departures</i> symbol provides gist 	
Big map showing delays	<ul style="list-style-type: none"> The map gives good overview of delays per state The map allows user to orientate the delays visually on the map 	
Heatmap clocks	<ul style="list-style-type: none"> This gives a clear indication of the times of day when delays tend to occur 	

Heatmap line/table	time- line	<ul style="list-style-type: none"> The table not only shows the delays for the USA as a whole but also the breakdown of delays per state An interactive element is included - tourist info for each state given in an info card that appears on click The table gives a clear indication of the average flight delay over the year Symbols are used to indicate seasons - in grey so colour doesn't imply any unintended meaning 	<ul style="list-style-type: none"> The state flags are not particularly useful for tourists who are unfamiliar with the USA
Route maps by air-line		<ul style="list-style-type: none"> The route maps contain multidimensional information, with number of flights represented by binned width of line and average delay shown by color The positioning of legend makes it clear that both dimensions of information apply to all maps 	<ul style="list-style-type: none"> The colours indicating delay could have been changed to match the binned orange colours used elsewhere in the visualization to represent delay
Delay vs cost scatter- plot		<ul style="list-style-type: none"> The scatterplot carries a lot of information, not only about average delays but the best-and worst-case scenarios The delay axis is consistent with boxplot The bins are shown by dotted lines instead of color 	

Delay vs airline box-plot	<ul style="list-style-type: none"> The boxplot carries a lot of information, not only about average delays but the best- and worst-case scenarios The delay axis is consistent with scatterplot The boxes contain a colour and pattern that closely resembles the airline's symbol, allowing for quicker identification on required plots 	
Legend of airline symbols	<ul style="list-style-type: none"> This is a better option than using airline logos The symbol choices are visually distinct, making use of shape, colour, pattern and depth - would now work in greyscale We changed the heading from "Legend" to "Airline" and included symbol for airline 	

Interactive airline finder	<ul style="list-style-type: none"> • This allows user to choose the best airline for their specific trip • The timeline corresponds to that of the timeline heatmap • Spacing was used for pop-out. Relative positioning on the page makes it appear further forward than the rest of the content. By separating it in terms of space, we are emphasising that it is a separate element of the design (Gestalt principle) 	
-----------------------------------	--	--

Table 4: Final Design Strengths and Weaknesses

5 Conclusions and future work

Our final design is a clear, understandable visualisation that allows for user exploration. It is useful in that the primary visual queries can be answered easily. Colour, shape, texture and depth were employed to improve the ease of answering visual queries. The associations of colour were carefully considered to motivate the choice of colour scheme for the visualisation.

- Implement this design for other countries, specifically South Africa, given a similar data set.
- Include a predictive capacity in the interactive route planner, to better inform the user's choice of airline for a future date.
- Toggle main delay map per airline to highlight which states the airline operates in.

6 Team work allocations

The workload was split evenly between group members. Each member was responsible for finding 2 – 3 suitable designs for the literature review. The most suitable ones were chosen from this selection of references. Although the initial designs were designed individually, much of the subsequent work was done together in group sessions as we enjoyed being able to bounce ideas off each other during the creative process. Even when working individually in an attempt to improve on the design for Step 3, we sent designs back and forth constantly to get input from each other. Even where one person was responsible for a given task, input was always obtained from the other group member before finalising. This worked well for us, as we both felt that the designs and presentations were a true reflection of the work we had each contributed.

Step 1	Both worked on separate designs and compiled them together
Step 2	Each modified our own elements and compiled them together
Step 3	Simultaneously worked on final design and bounced ideas back and forth
Report	Split up sections but worked together on larger explanations

References

- [1] Miserymap. <https://flightaware.com/miserymap/>. Accessed: 2019-03-20.
- [2] Moses Anderson. Data visualisation of flight delays with tableau. <https://medium.com/@mosesandersonong/data-visualisation-of-flight-delays-with-tableau-40aa6abf676b>. Accessed: 2019-03-20.
- [3] Michelle Kuttel. Lecture notes in channel efficacy(lecture 7), March 2019.
- [4] Stacker McKinley. Visualizing network data to illustrate airline delays. <https://www.ibm.com/communities/analytics/watson-analytics-blog/visualizing-network-data-to-illustrate-airline-delays/>. Accessed: 2019-03-20.