TFL Tube Population

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Contents

Introduction

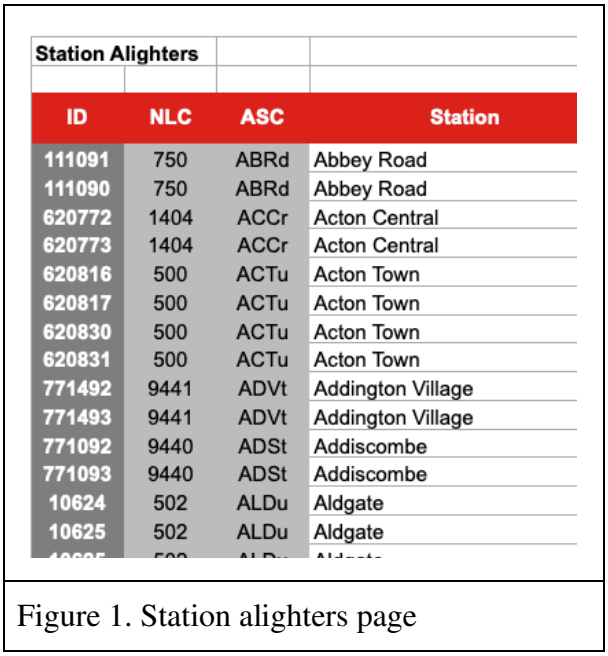
The project is about the people count on TFL's (transport for London) underground transportation system, nicknamed the tube. The idea came from personal experience going on the tube at random and being met with a surprising amount of people on the platform. When having to take transport at a specific time, for example to get to a class or work in the morning, one can learn to expect a certain amount of other commuters, but when having no obligations it would be nice to know what is the ideal time to get to the station to encounter minimal foot traffic or even if there is a different station or tube line that might make for a more comfortable commute.

With this in mind, the project displays the tube's population data in a series of bar graphs. Each line is represented by its own graph, each station on the line represented by a bar, and the population count represented by the bars' heights (see figure 30). All the graphs are shown on a website which allows its users to select a specific time of day, day of the week, and tube line to customise their graphs, as well as simply press a play button to see how the people count changes throughout the week or hover over the graphs to get individual information about each station (name, zone, exact count). As such people can use this data to better plan their commute for the most ideal experience on the London underground transport system.

Data

The data has been acquired from TFL's own open data sources, specifically the daily averages taken from 2022, as that was the most recent available data at the time this project was done (TFL, 2020). TFL's current system splits their yearly statistics into 5 files, each day of the week with Tuesday, Wednesday, and Thursday grouped together (the average of the three, not the

total) as their data is very similar. Each file is split into 8 data table pages which provide different information. The project only uses the numbers of people who enter and exit a given station (taken from the ticket scanner counts), which technically ignores the people who are at a station to transfer between tube lines. Those statistics are also made available by TFL in the form of platform boarders and alighters but was still omitted from the project for simplicity reasons; the boarders and alighters data has individual data points for each platform at each station and since different stations have different numbers of platforms this made the dataset too large. Additionally, counting both boarders and alighters will double count people who transferred within the station (count for alighting the first train and again for boarding the next train), but only counting one of the two either ignores the people who passed through the station on their way out or on the way in. Either way, the data will be inaccurate, and so only the entries and exits data was used.



Station Alighters

ID	NLC	ASC	Station
111091	750	ABRd	Abbey Road
111090	750	ABRd	Abbey Road
620772	1404	ACCr	Acton Central
620773	1404	ACCr	Acton Central
620816	500	ACTu	Acton Town
620817	500	ACTu	Acton Town
620830	500	ACTu	Acton Town
620831	500	ACTu	Acton Town
771492	9441	ADVt	Addington Village
771493	9441	ADVt	Addington Village
771092	9440	ADSt	Addiscombe
771093	9440	ADSt	Addiscombe
10624	502	ALDu	Aldgate
10625	502	ALDu	Aldgate

Figure 1. Station alighters page

It is worthy to note also that since the information is taken from the ticket scanners, those who avoid paying the tube fare will not be counted. TFL estimates for fare evaders to account for 3.9% of all transport users (TFL, 2024a).

Another omission made for simplicity of both the data and visualisation was zone constraints. Since the tube reaches all over the greater London area, the project only uses statistics for stations under fare zone 4 for more concise data (cutting the dataset from 500+ stations to 182). This ensures the data actually refers to the city that people associate London

with, rather than the technical city borders, and allows for the data visualisation to be easier to understand, as there are less points of data to take in at once.

TFL collects its data over autumn yearly “with days affected by major disruptions, events and closures excluded. These typical day counts generally represent a busier time of the year with more consistent travel patterns” (TFL, 2023). In addition to saving the counts in 15 minute intervals, the data is also saved (by TFL) into 6 time periods that were used for the project: Early (5:00-7:00), AM Peak (7:00-10:00), Midday (10:00-16:00), PM Peak (16:00-19:00), Evening (19:00-22:00), and Late (22:00-5:00). The summation of the entries and exits were used for the final project, to account for all the people who are at the station because they were going somewhere, and all the people who are at the station because they just arrived at their destination, which shows the total foot traffic.

Inspiration

Ideal travel times research showed little to no information about specific times or days in which the tube population changes, other than the fact that the tube is less occupied outside of peak hours (5:00-7:00 and 16:00-19:00) (The London Pass, 2014; Marble Arch, 2020). However, TFL has its own fairly recent TFL Go app which has live information on how busy a station is among its other functions (TFL, 2020b).

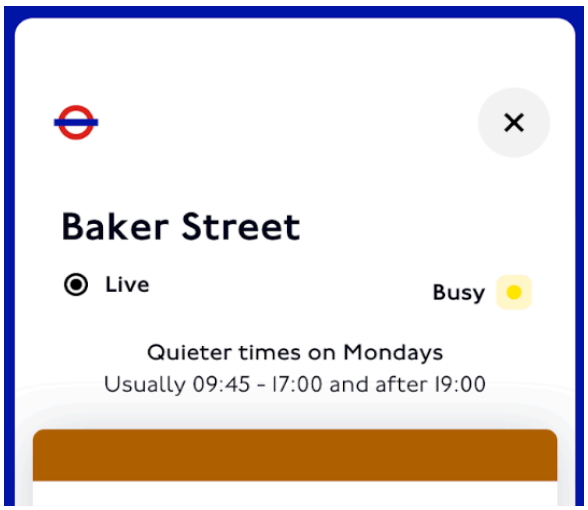


Figure 2. TFL Go Iphone view (Apple, 2020)

Figure 3. TFL Go Android view (Google, 2021)

Although useful, it doesn't allow its users to compare different stations, lines, or times of day unless they check the app repeatedly throughout the day and compare manually. Another feature the app is missing is actual numbers. The app does not explain if a station being busy is in reference to itself, all stations, other stations in the area, other stations on the line, etc. To ensure the project takes from these improvements, all of the tube line bar graphs use the same scale for easier comparisons and each station also has additional information available with exact people counts.

Another project that covers this project is Gwilym Lockwood's "Where do Passengers get on and off the Tube" (Lockwood, 2018). Lockwood created a geographically accurate tube map, with each tube line's thickness depending on the population in each station along it. It also has additional information about entries versus exits at each station, allowing the user to notice patterns of people flowing either in or out of the station, rather than just the total count.

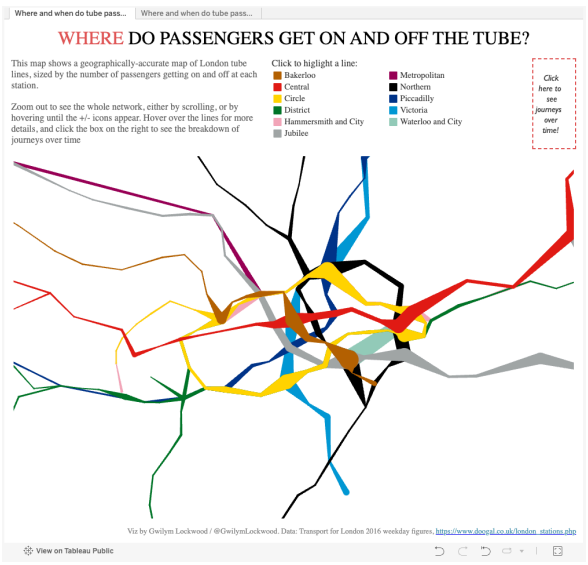


Figure 4. Lockwood's Geographical Map (Lockwood, 2018)

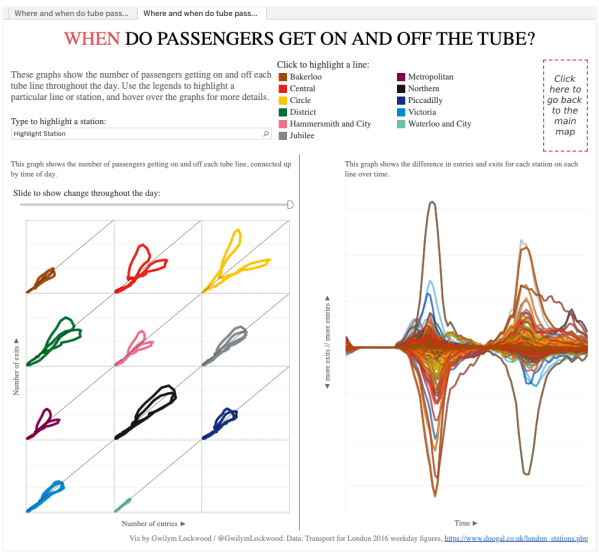


Figure 5. Lockwood's entries/exits graphs (Lockwood, 2018)

The entries versus exits feature is a nice one that gives more information than the way the population project processes the data, however, the overall representation is a bit messier or more difficult to understand especially upon initial inspection. With tube users being accustomed to the tube map, the geographical map becomes a bit confusing, especially given that the TFL map was especially created for clarity (TFL, 2014a). Additionally, the information is not shown with respect to time. The map is static and shows no changes over any time period, and the individual tube line graphs (left side of figure 5) can only show change over time if the user manually changes the time slider on top. Instead, the final project will both allow the user to pick a specific time and to animate the graph to show visually changes over the days of the week.

Output

The project's intended audience are tube users; people who live in London and take the tube on a fairly regular basis. As such, many design choices were made to fit with TFL's design standards so they are easily recognisable for the average commuter (more on this in Design

Process). The intended output, as previously mentioned, will show how busy specific stations and tube lines are throughout the week. This information should allow the intended audience to plan their commute accordingly so as to make the most comfortable experience on the tube.

Development

Data Filtration

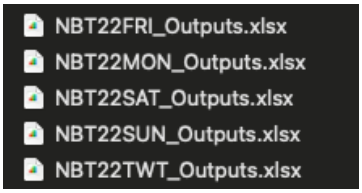


Figure 6. XLSX files

Most of the data filtration was done manually and then sorted in the code into dictionaries that could be easily used in the project. The initial data came in five XLSX files, the fall statistics for 2022, sorted into individual files per day of the week (Tuesday, Wednesday, and Thursday were grouped together, as previously mentioned). From each file, two pages (entries and exits) were taken and copied into a google sheets file, with individual pages for each of the ten statistics inputs.

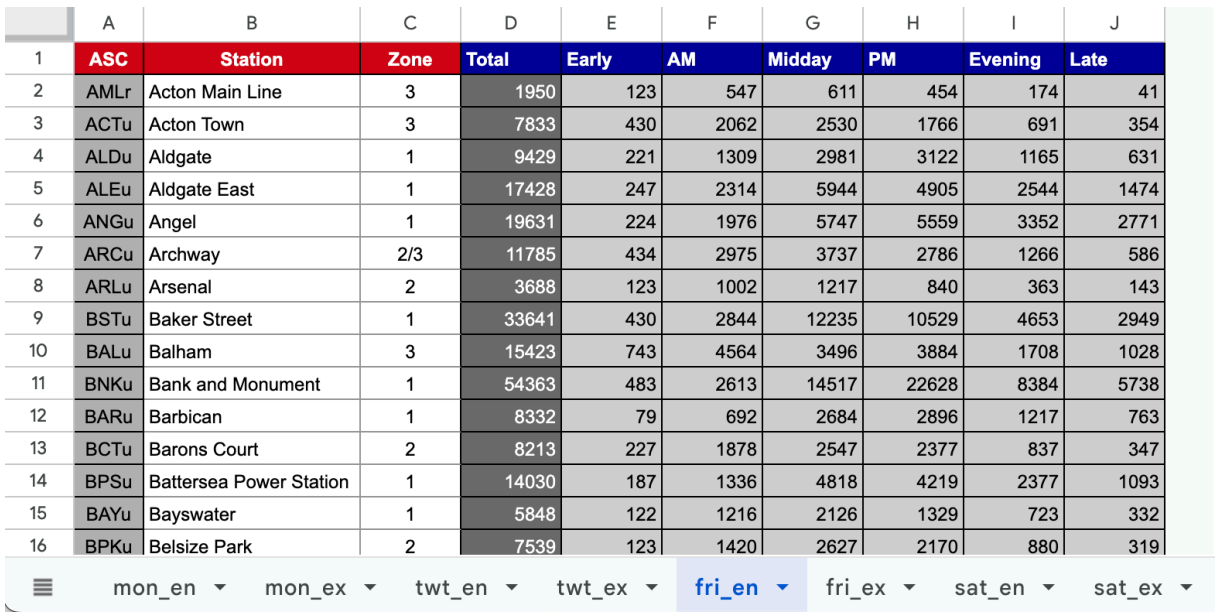
	A	B	C	D	E	F	G
1	**Station Entries**						
2							
3	**NLC**	**ASC**	**Station**	**Fare Zone**	**Total**	**Early**	**AM Peak**
4	**750**	ABRd	Abbey Road	2/3	2,198	175	
5	**1404**	ACCr	Acton Central	3	3,090	179	
6	**3000**	AMLr	Acton Main Line	3	1,950	123	
7	**500**	ACTu	Acton Town	3	7,833	430	
8	**9441**	ADVt	Addington Village	4	0	0	
9	**9440**	ADSt	Addiscombe	4	0	0	
10	**502**	ALDu	Aldgate	1	9,429	221	
11	**503**	ALEu	Aldgate East	1	17,428	247	
12	**850**	ALSd	All Saints	2	2,458	76	
13	**505**	ALPu	Alperton	4	3,744	465	
14	**506**	AMEu	Amersham	9	2,486	272	
15	**9442**	AMPt	Ampere Way	4	0	0	

mon_en | mon_ex | twt_en | twt_ex | fri_en | fri_ex | sat_en | sat

Figure 7. Google sheet with the individual pages

From this data that was unnecessary to the project was removed, such as the national location code (NLC in figure 7), miscellaneous titles, unused totals, and unused stations (non

London underground stations). Although the initial plan was to go through the detailed 15 minute increments that TFL provides, there was a worry of there being too much data to process which will make for a less smooth user experience and a jerkier animation. Instead, the six daily time periods (mentioned in Data) that TFL uses for their standards were also used for the project. Additionally as previously mentioned the data was limited for stations under zone 4, resulting in a cleaner and more manageable dataset.



	A	B	C	D	E	F	G	H	I	J
1	ASC	Station	Zone	Total	Early	AM	Midday	PM	Evening	Late
2	AMLr	Acton Main Line	3	1950	123	547	611	454	174	41
3	ACTu	Acton Town	3	7833	430	2062	2530	1766	691	354
4	ALDu	Aldgate	1	9429	221	1309	2981	3122	1165	631
5	ALEu	Aldgate East	1	17428	247	2314	5944	4905	2544	1474
6	ANGu	Angel	1	19631	224	1976	5747	5559	3352	2771
7	ARCu	Archway	2/3	11785	434	2975	3737	2786	1266	586
8	ARLu	Arsenal	2	3688	123	1002	1217	840	363	143
9	BSTu	Baker Street	1	33641	430	2844	12235	10529	4653	2949
10	BALu	Balham	3	15423	743	4564	3496	3884	1708	1028
11	BNKu	Bank and Monument	1	54363	483	2613	14517	22628	8384	5738
12	BARu	Barbican	1	8332	79	692	2684	2896	1217	763
13	BCTu	Barons Court	2	8213	227	1878	2547	2377	837	347
14	BPSu	Battersea Power Station	1	14030	187	1336	4818	4219	2377	1093
15	BAYu	Bayswater	1	5848	122	1216	2126	1329	723	332
16	BPKu	Belsize Park	2	7539	123	1420	2627	2170	880	319

Figure 8. Cleaned google sheet

In the code, the statistics were saved into individual station objects each containing four variables: station name, station zone, a people count array, and a lines array for all the tube lines available from said station. The first google sheets page (mon_en, i.e., Monday entries) created all of the station objects, and every consequent page either added to the summation of the last few index points (exit pages) or added new index points (entry pages). By the end each station had a count array with 30 indexes: 6 time periods a day for 5 days - indices 0 through 5 represent

Monday's data, 6-11 Tuesday/Wednesday/Thursday, 12-17 Friday, 18-23 Saturday, and 24-29 Sunday.

Figure 9. Object creation

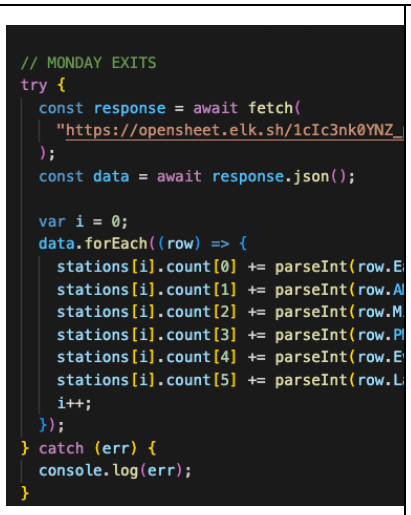


Figure 10. Adding exit data

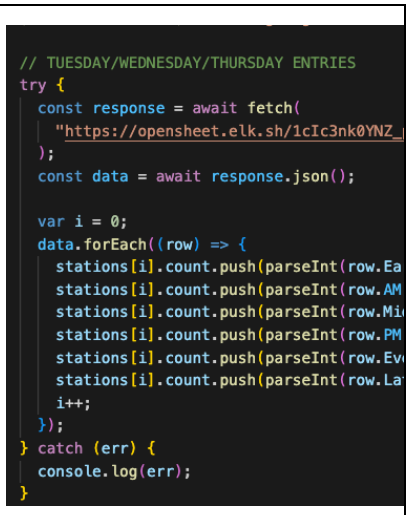


Figure 11. Adding entry data

Other information that was manually found and added to the code are station names by line. Each tube line was researched individually and the names for each of the stations on the line were copied in order (either from north to south or from west to east, as that is the way TFL sorts their station on tube line car maps; see figure 13) within the previously mentioned fare zone confines. These string arrays were used for two main things: interchange information and the general graphing.

Figure 12. Tube line string arrays

At the end of the data processing, an interchange function is called, which handles the "lines" array each station has. For each of the tube line string arrays, the function loops over the array, finds the station object that corresponds to the name, and adds the current tube line to the lines array. This information is

later used for the station information, to be able to know what tube lines are available at a given station.

For the general graphs, the project initially requires the user to select a tube line before graphing the information. This happens because the graph uses the aforementioned tube line string arrays to graph all the necessary tube stations as the order is important for the visualisation to be clear. So again the tube line arrays are used to get all the right station objects in the right order, so that the counts arrays can be used as the inputs for the bar graphs.

Design Process

Most of the project visualisations are entirely done with D3.js, the data visualisation JavaScript library. The main project visualisation is a bar graph (initial sketch in figure 30), as it feels like a relatively effective way to show the difference between stations, between zones, and between times visually with all of the tube stations on a given set next to each other. The idea was to use the individual official TFL tube line maps that the target audience is familiar with from its tube experience. Since most of the the maps are straight all the way through or at least within the pre-established fare zone constraints (notice in figure 13 the map only becomes complex halfway through zone 5, which will be entirely ignored in the project), they can be easily used as the range or x-axis of a bar graph.

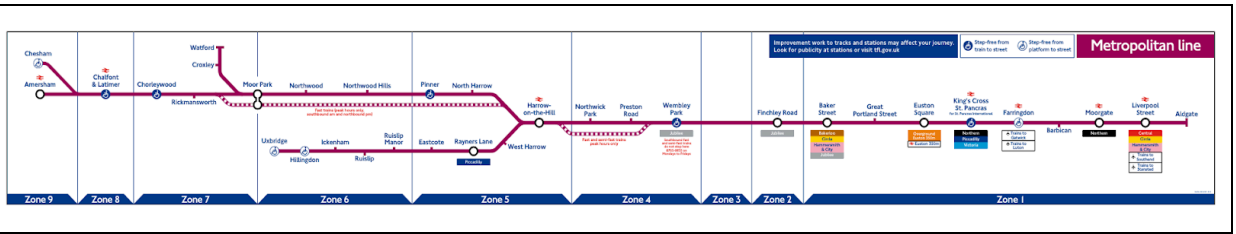


Figure 13. Metropolitan line car line diagram (TFL, 2024b)

The first step in the process was to use the already sorted data and D3 to create a bar graph, initially just using one randomly selected index as the animation was not done yet. Basic HTML code was used to make a drop down menu with all the tube lines (figure 14) who's output will be used in the graphing function (figure 15), as explained in the Data Filtration section.

```html
<!-- tube lines drop down menu -->
<label for="lineSelect">Choose a Line:</label><br />
<select name="line" id="lineSelect">
  <option value="" disabled selected>Select</option>
  <option value="bak">Bakerloo</option>
  <option value="cen">Central</option>
  <option value="cir">Circle</option>
  <option value="dis">District</option>
  <option value="hac">Hammersmith & City</option>
  <option value="jub">Jubilee</option>
  <option value="met">Metropolitan</option>
  <option value="nor">Northern</option>
  <option value="pic">Piccadilly</option>
  <option value="vic">Victoria</option>
  <option value="wac">Waterloo & City</option>
</select>
```

Figure 14. HTML drop down menu for tube line selection

```js
/**
 * Ensures code isn't called before data is set.
 * Called in getData()
 */
function getCode() {
  // tube menu selector
  $("#lineSelect").change(function (event) {
    // set the data
    dataset = [];
    const line = getLine(event.target.value);
    for (let i = 0; i < line.length; i++) {
      dataset[i] = getStation(line[i]);
    }
    graph(dataset);
  });
}
```

Figure 15. JS takes drop down selection and gives the corresponding data to the graph function

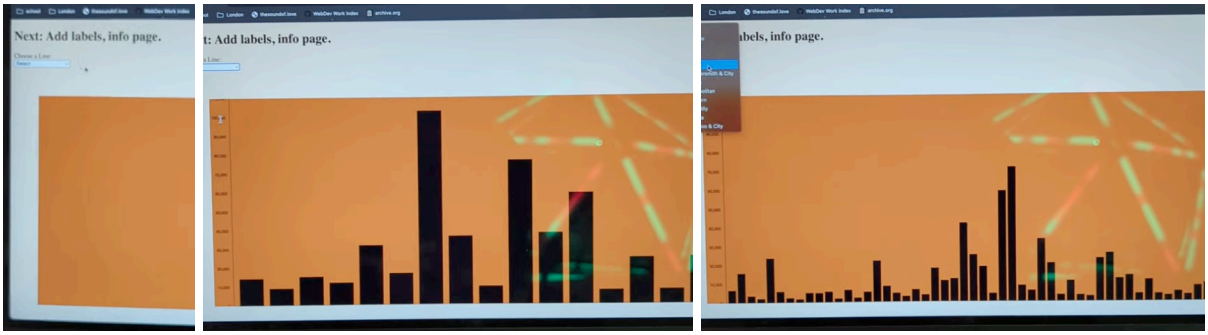


Figure 16. The result of figures 14 and 15

The next steps taken were styling. Clearly the results in figure 16 are not the most visually pleasing, but more importantly they are not made with the target audience in mind. Since the project is for TFL users and about TFL's data, it made sense to use TFL's design standards (TFL, 2014b) as those are the visuals most recognizable to the audience. As such, the font was changed to TFL's standard font, "Johnston 100" (TFL, 2022a) and the colours of the website

changed to match the TFL corporate colours and London underground line colours (TFL, 2022b).

Since the website needs to handle all the data processing, it will not be responsive as soon as it loads with the data needing a few additional seconds to process after the webpage itself is ready. To combat this, a loading message was added so the user is aware of when the website is fully ready and interactive. This was done by hiding the text at the end of the get data function (figures 9, 10, and 11), or when the data is done loading.

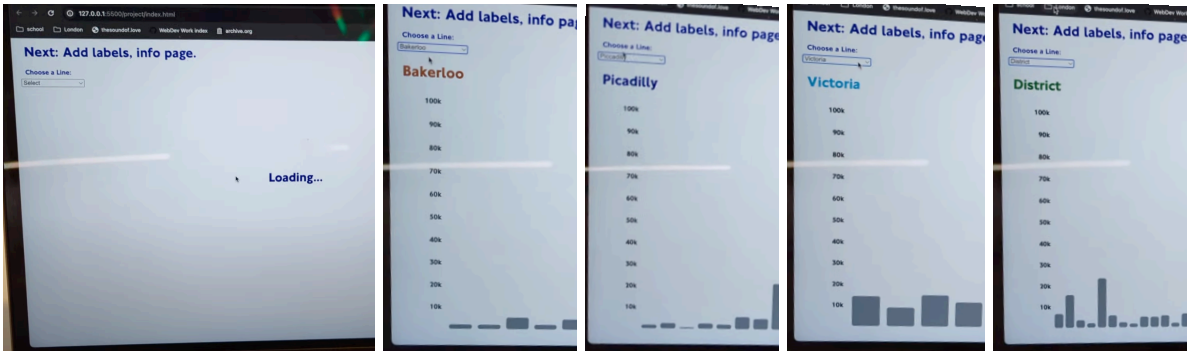


Figure 17. Website with TFL font, colours, and a loading feature

Now that some TFL styling has been added, the next step was going back to the initial idea of using the tube car line maps as the x-axis for the bar graphs (see figure 13). Most lines were straight but a few (central, district, northern, and picadilly) had some split routes. Other than this, the official car line maps are too busy because of all the information they need to contain (station

Figure 18. Complex section of district car line map (Last Train, 2020)

Figure 19. Edited district line map

name, interchanges, etc.). Since these pieces of information are planned to be handled in a separate way, new more minimalistic maps were made for each tube line. For the aforementioned complex lines, photoshop was used to edit the official map (ensure no stations are directly on top of one another), without changing the familiar shape of the line too much (see differences between figure 18 and 19).

The new maps - or the original ones when no edits were needed - were used as guidelines to recreate the maps on figma (figure 20). Three sizes of the maps were created to resolve any stretching effect made when resizing the webpage, and were chosen to respond to the three expected devices to be used: computer, tablet, and mobile phone. Screenshots of the webpage at those individual sizes were used as a reference to where the bars were located for each line so that the ticks on the map can line up with the graph as needed (figure 21). The different sizes not only benefit in terms of aesthetics, but also for clarity, notice how much better and more accurate the well fitted map (figure 23) looks than the ill fitted one (figure 22). This, and other responsive sized elements (the graphs themselves, any titles and text) allows the project to be more accessible to different devices which makes it more widely accessible in general.

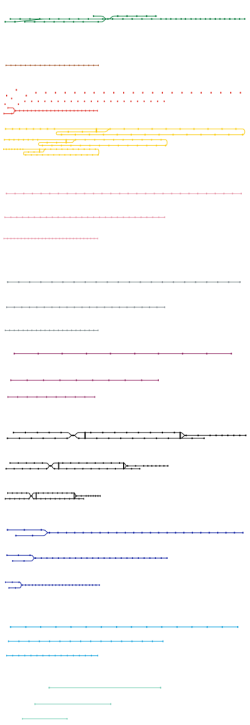


Figure 20. Figma simplified line car maps

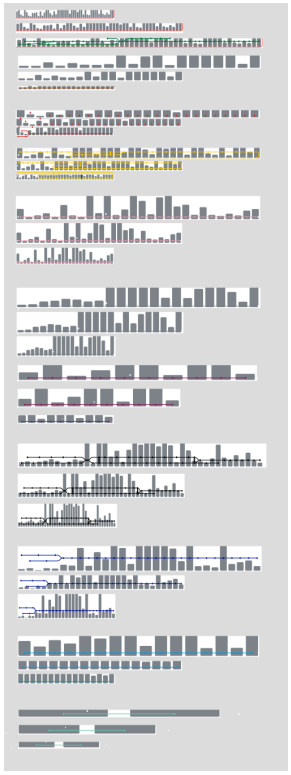


Figure 21. Maps with integrated bar graph screenshots

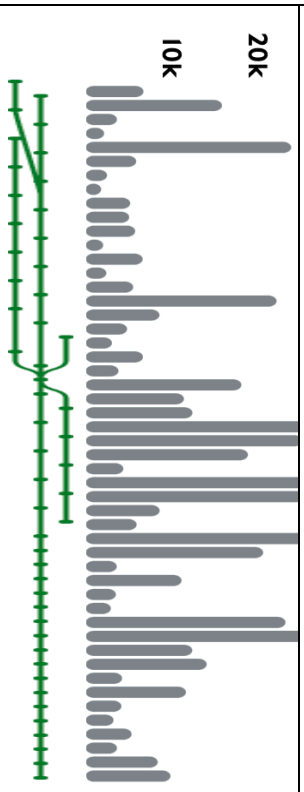


Figure 22. Large district line map on small graph

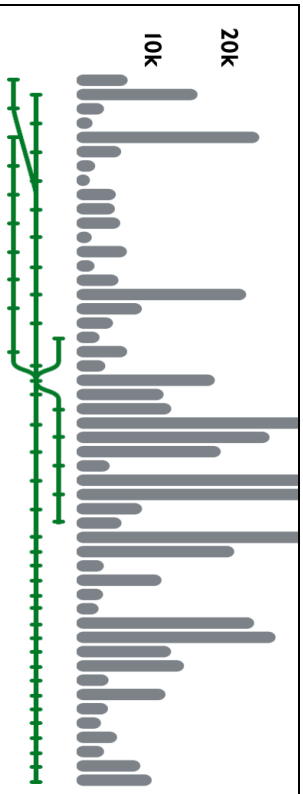


Figure 23. Small district line map on small graph

The next few progress points of the design focused on making the project more interactive and more informative. Until this point only one time was used, so drop down menus for the day of the week and time of day were added to let the user find out information about a specific time they are interested in. Along with the drop down menus an additional title was added alongside the name of the line to display what time is shown. This was done by calculating the index that corresponds to the time requested (figures 9, 10, and 11) and using this information both to graph the right data and to display the correct time (notice the text update function in picture 3 of figure 24).

Figure 24. Time and day drop down menus and the corresponding HTML and JS code

Now that the code worked and all the different times of day graphed properly, the animation feature was added. To do so, two buttons (play and stop) were created to start and stop the animation which alternatively hide and show each other on the page for clarity purposes, (the two alternate in the same place making them appear as one button). When pressing play, the button also hides the time drop down menus to avoid any issues that may be caused by resetting the count in the middle of the animation, and when pressing stop, that button both shows the drop down menus that were hidden and resets them so that they are not showing the last selection which likely no longer corresponds to the graph on screen.

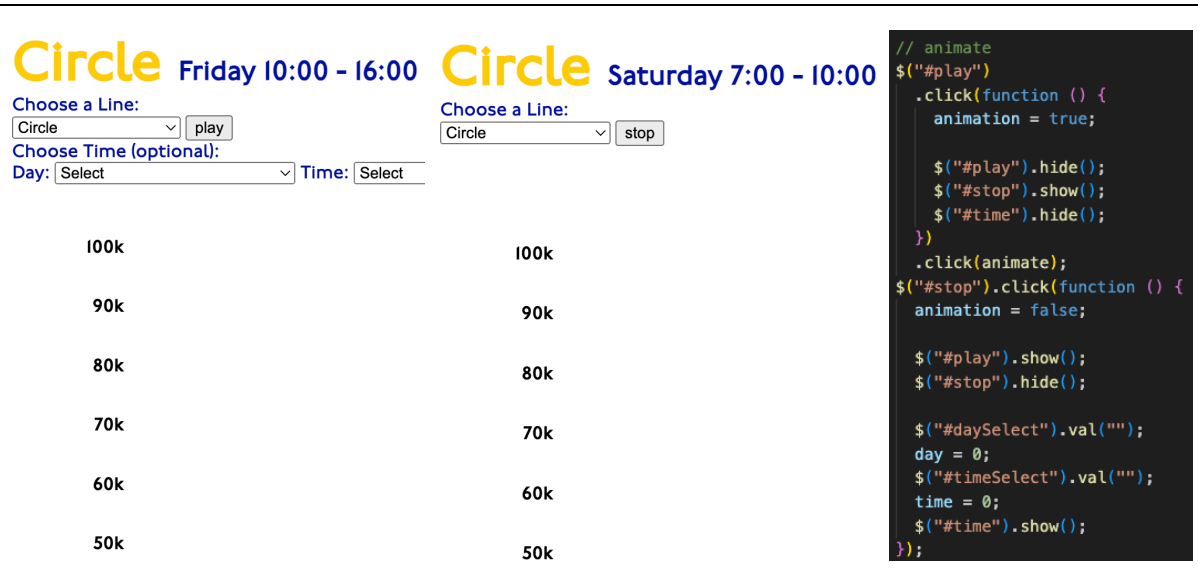


Figure 25. Alternating play/stop button and corresponding code

```
/**
 * animates the graph
 */
function animate() {
  if (animation) {
    text_update();
    svg
      .selectAll(".bar")
      .transition()
      .duration(900)
      .attr("y", (d) => {
        return y(d.count[index]);
      })
      .attr("height", (d) => {
        return h - y(d.count[index]);
      });
    index = index < 29 ? index + 1 : 0;
    setTimeout(animate, 900);
  }
}
```

Figure 26. Animation JS code

As for the animation itself, the feature relies on the D3 transition function, using it in a recursive animation function which increments both the index of the data displayed and the corresponding time text to be printed, resetting when reaching the end of the station count array (resetting at the end of the week to the beginning of the week) to be able to have an infinite loop. With this fully functioning, the time drop down menus are no longer required but more of an additional feature for those who wish to use it, which explains the added “optional” note as seen in figure 25.

While the bar graphs are relatively straightforward and minimal for clarity purposes, there is not much information that they provide due to this minimal look. Other than the numbers on the side for a general reference to the quantities delt there was no information about what bar corresponds to what station, where it is, what the actual number is, etc. To solve this issue, D3’s tooltip was used to create a text box with additional information for a given station when hovering over the bar that represents it. Among the information was the station’s name, fare zone, exact count, and interchanges; in other words, the information that the simplification of the car line maps removed. The get images function seen in the JS code creates a string dependent on the number of lines available at the input station and colours the individual hash marks in the colour that corresponds to the line. This representation was chosen to resemble the way interchanges are represented in the car line maps, with colourful bars corresponding to each

available tube line or other modes of transport (see figures 13 and 18). The initial plan was to add small images to the tooltip for each line, but the tooltip would crash when attempting to implement images in it, so colourful hash marks were chosen instead to achieve a similar effect with only text. Notice also that the colour of the highlighted bar is one of the aforementioned TFL corporate colours, the regular bars are Corporate Grey and the highlighted bar is Corporate Dark Grey (TFL, 2022b).

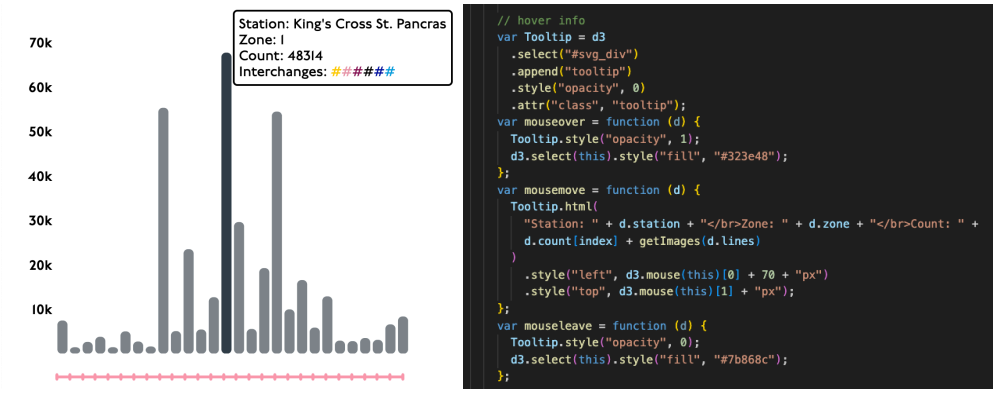


Figure 27. Tooltip in use and corresponding code

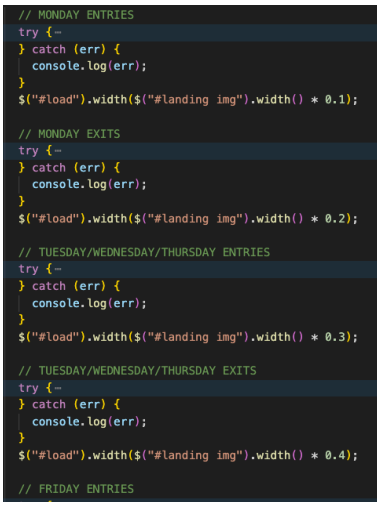


Figure 28. Part of JS code responsible for loading bar width

Lastly, to create a more well rounded experience and make the project self explanatory, a landing page was created. Instead of the loading text that was previously mentioned, a loading bar was made in the image of the TFL underground roundel (TFL, 2022a), replacing its bar which typically contains station names with a classic loading bar. To create it, the TFL roundel was photoshopped to leave a window where the bar is. Under it an HTML div, coloured the same classic blue, was made to change its width according to the amount of data

processed. Since there are exactly 10 calls to the data API (5 entries and 5 exits) the width was simply updated after each call to add a tenth of the total width of the roundel's bar. Additionally a "ready" roundel image was made with the loading bar's dimensions to cover it when the data processing is done and make it look like a button to instinctively make the user want to click it, which hides the landing page and shows the project itself. To make the project self explanatory a short description of the data and the way to use the project was added on top of the loading bar. Initially there was no ready roundel button to hide the landing page and it was automatically hidden after the data finished processing, but to be more user friendly and accessible, the clicking function was added so that the user can take however long needed to read and process the information on the page, before clicking to move on.

Discarded Prototypes

There were two main prototypes that were discarded. The first was the initial idea for the project visualisation which was abandoned prior to the beginning of the project's coding. The alternative idea was to have a three dimensional bar graph using the full underground tube map as the base, and having bars coming up from it along the z-axis for each station point (figure 29). This idea, however, creates a very confusing visualisation which would have been both difficult to implement and difficult to read and understand once implemented. As such, the idea was abandoned for the visualisation that has been implemented for the project itself (see early figure 30 for the initial sketch of the concept). The other prototype was one for the formatting of the established visualisation for either rotated devices or smaller devices, any situation where the graphs would be viewed in a portrait frame rather than landscape. The idea was for the graphs to be displayed rotated so that the bar graph is vertical rather than horizontal, that way the bars

would not be forced into too skinny of a width and the project would retain its clarity throughout different devices. While the idea itself was sound, the implementation of it proved too complex and so it was abandoned as well. Due to the way the D3 library establishes its bar graphs, this would be more than simple rotation and would require having two separate graphs and alternating between each based on the rotation needed. On top of that, all of the corresponding functions used (the graph function, the animation function) would require a rotated duplicate, as most of the inputs switch (between width and height, x and y axis, domain and range, etc.) Instead the sizing was just made to be responsive to the size of the screen (see figure 31) and although a bit cramped for thin format devices, the graphs are still legible.

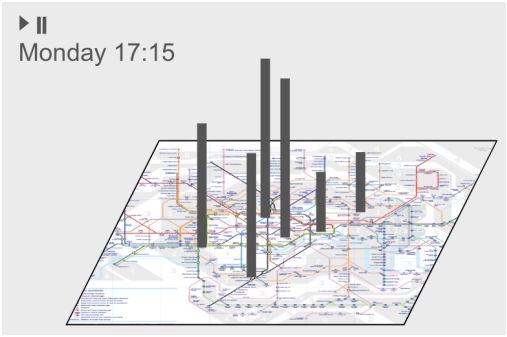


Figure 29. 3D bar graph concept sketch

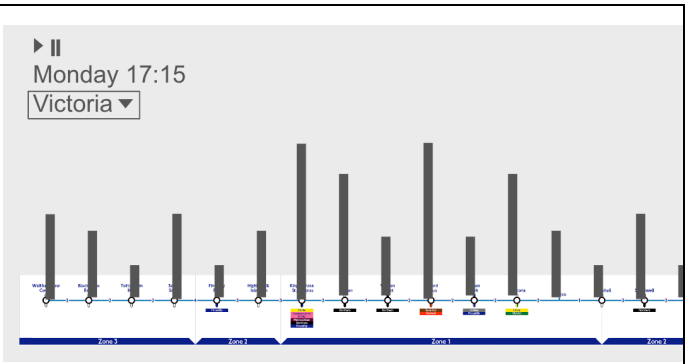


Figure 30. First concept sketch for final project

Final Outcome

The final outcome is a web page which uses TFL's open source crowding data and design standards to produce a data visualisation with features that are familiar to its target audience. The website is accessible across multiple devices, uses accessible colours, and utilises HTML's alternative text feature to label elements as necessary so they can be accessible to screen readers.

Links

Website walkthrough video can be found on youtube: https://youtu.be/7Gsnki-JNZg

Project git page: https://git.arts.ac.uk/23043904/visualisation/tree/main/project

Images

Figure 31. The webpage in various size formats

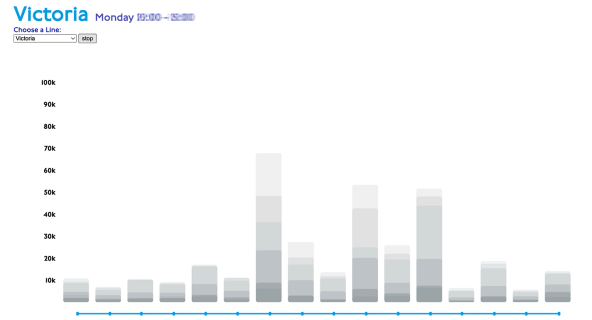


Figure 32. Victoria line animation visual

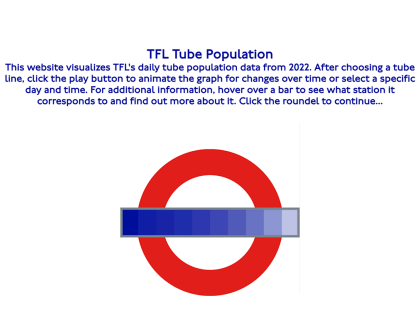
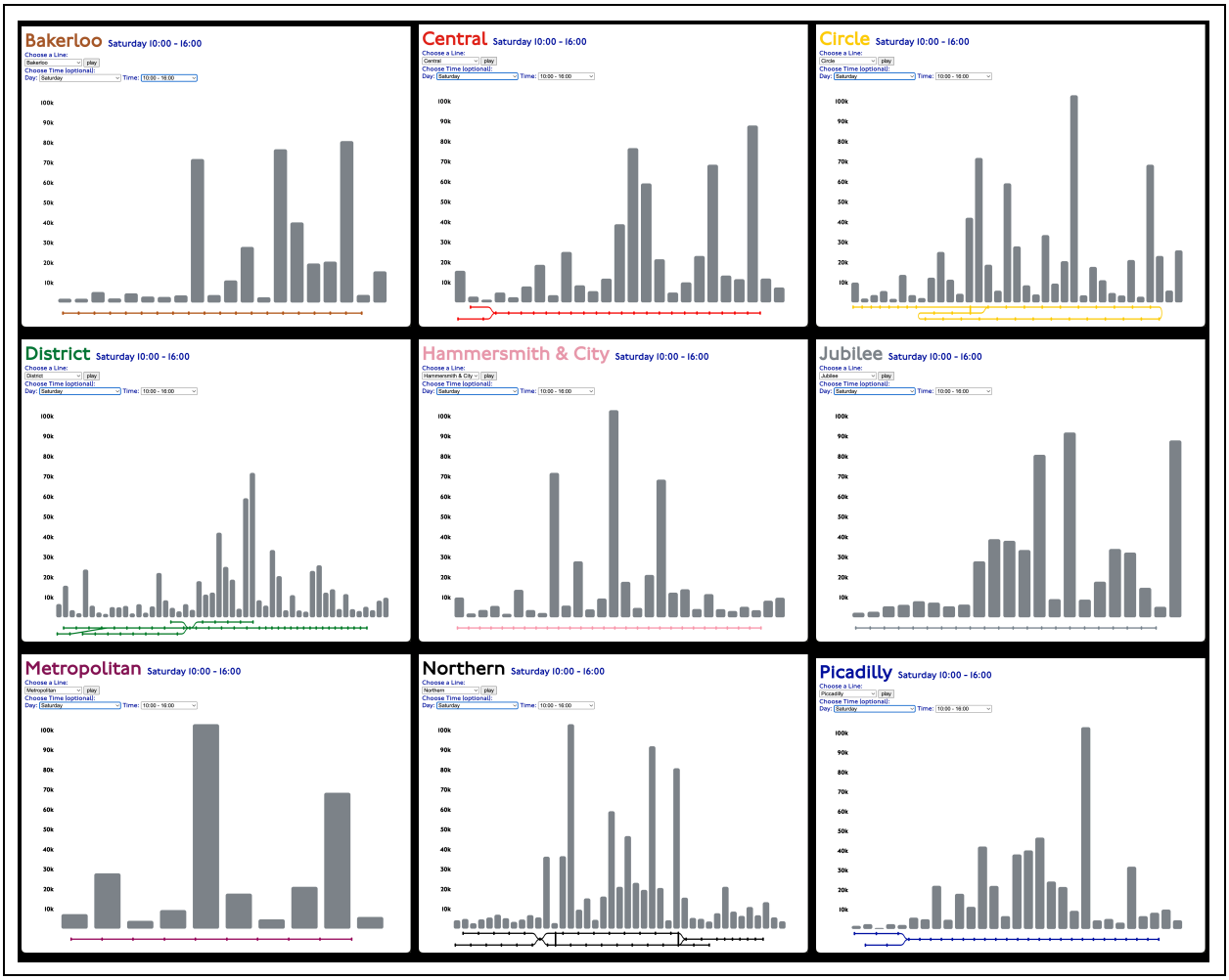


Figure 33. Loading bar animation visual



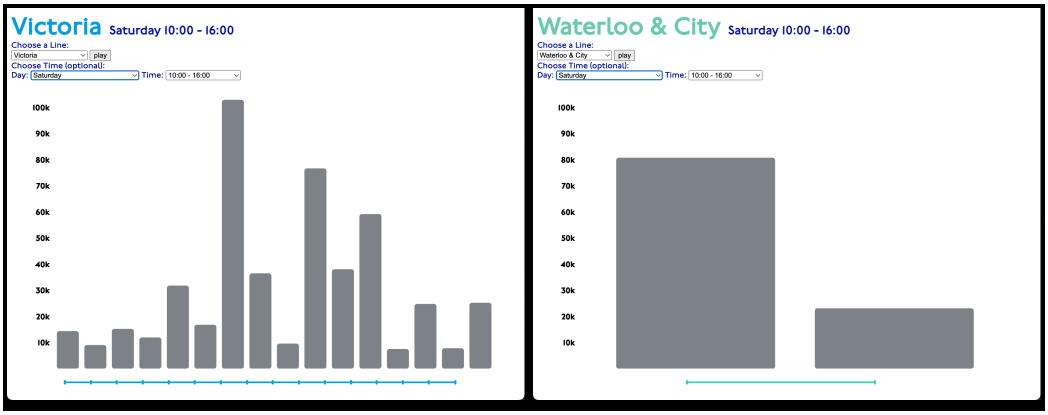


Figure 34. All tube lines at busiest hour (Saturday mid-day)

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