GP 487 Web Mapping:

Building Bike Maps in City of Victoria using Web AppBuilder, ESRI Leaflet, & ArcGIS JavaScript API

Consulting Group 11

By:

Kristie Hu (#20712037)

Wanxin Li (#20922480)

February 20th, 2022

Background

The City of Victoria, as the most bike-friendly city in Canada, has the highest proportion of the population riding a bike for commuters and transportation (Island, 2019). The flat topography and warm weather provide a natural condition for bike riding. Based on the 2016 census data, residents in Victoria walk and cycle to work at a very high rate, 16.9% of the commuters in Victoria choose to walk and cycle to work, while Halifax as the second city only has 8.2% (Bell, 2017). The percentage of residents who cycle to work in Victoria is 6.6% (Bell, 2017). In addition, Victoria is improving the cycling routes to make a bike network to connect the facilities, schools, communities and other destinations for all ages and abilities.

User Needs

As the city received the highest Bike Score in Canadian cities in 2020 according to the rankings of Redfin, we find that the city of Victoria's bike map merely provides information about bike lane types. Though the Capital Regional District's bike map includes more information such as civic sites and parks, it is hard to focus on the city of Victoria as the region is comprised of 13 municipalities and three electoral areas. Therefore, a more comprehensive bike map would help people to obtain a sense of safety, as well as increase the efficiency of the route selection process and enhance the convenience for all cyclists in the City of Victoria.

In this study, three different web map apps of bike maps in the city of Victoria will be built on Web AppBuilder, ESRI Leaflet, & ArcGIS JavaScript API. The three apps have similar functionality but also have unique capabilities of interactive location search, safety issues & hidden danger and cyclist navigation.

Table of Contents

Data Sources

Table 1. A List of Data Sources

Feature Layers	Data description	Data type	Sources
Bike Lanes	Polylines of different types of bike lanes in City of Victoria	Vector – Line	City of Victoria Open Data Portal
Neighborhood Boundaries	Neighborhood boundaries within City of Victoria	Vector – Polygon	City of Victoria Open Data Portal
Arts and Culture Facilities	Location points of Arts and Culture Facilities in Victoria	Vector – Point	City of Victoria Open Data Portal
Sports Courts	The location of sport courts including basketball, bike skills, Tennis and other destinations	Vector – Polygon	City of Victoria Open Data Portal
Greenways (OCP)	Official Community Plan city-wide network of pathways and bikeways	Vector –Line	City of Victoria Open Data Portal
Bus Stops	Bus stop locations in the City of Victoria	Vector –Point	BC Transit Open Data
Bus Routes	Bus route information in the City of Victoria	Vector –Line	BC Transit Open Data
City Parkades	The parkades that own e-bike charging stations (owned and maintained by Victoria).	Vector – Point	City of Victoria Open Data Portal
Cyclists Crashes 2016 - 2020	The number of crashes involving cyclists in Victoria from 2016 to 2020, excludes crashes in parking lots and involving parked vehicles	csv table – point	Insurance Corporation of British Columbia
CRD Bike Repair Stations	Location of Capital Regional District bike repair stations	Vector –Point	South Island Prosperity Project
Tsunami Hazard Line (2021)	2021 Modeling of Potential Tsunami Inundation limits near City of Victoria.	Vector – Polygon	City of Victoria Open Data Portal
Public Washrooms	Location of public washrooms in City of Victoria	Vector – Point	City of Victoria Open Data Portal

Data Processing Procedure

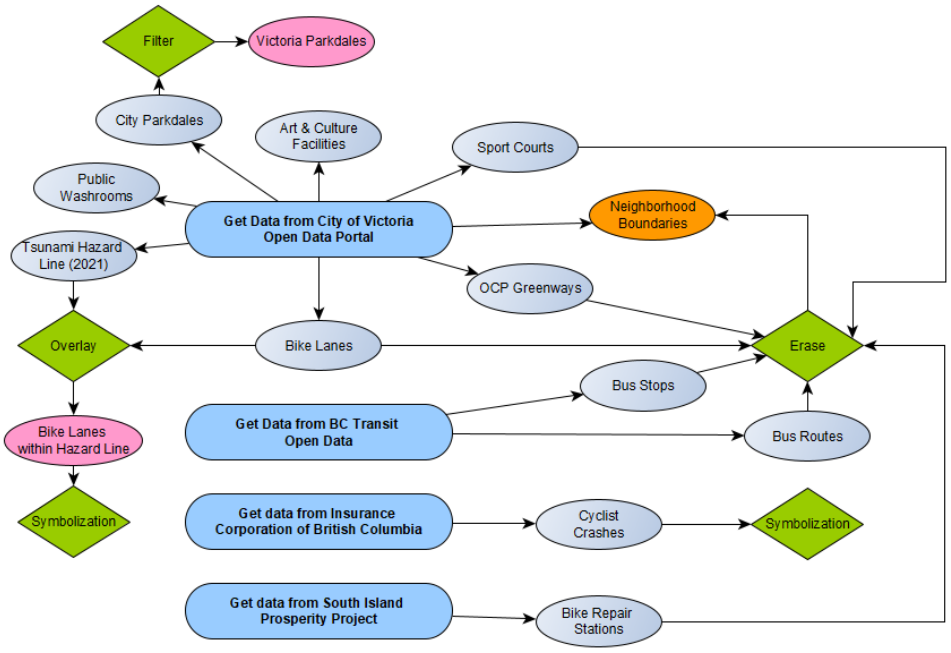
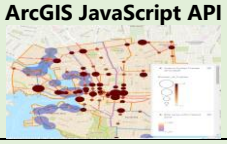


Figure 1. Data Processing & Development Flowchart

Evaluation

Table 2. Evaluation Table of the 3 Web Apps

	Development environment	Organizational requirements	Functionality	Performance
ArcGIS Web AppBuilder 	9/10	8.5/10	7/10	8/10
ArcGIS JavaScript API 	8/10	8/10	8/10	7.5/10
ESRI Leaflet 	7.5/10	8/10	8.5/10	8/10

To help customers better understand the differences between the three available web apps, a scale from 1-10 has been proposed above from development environment, organizational requirements, functionality, and performance respectively. With focusing on these 4 perspectives, a detailed evaluation and interpretation has been made below for each of the web map products:

- ArcGIS Web AppBuilder:

Nearby Services & Facilities Map (with Intensive Analysis Tools)

Development environment	Organizational requirements	Functionality	Performance
9/10	8.5/10	7/10	8/10

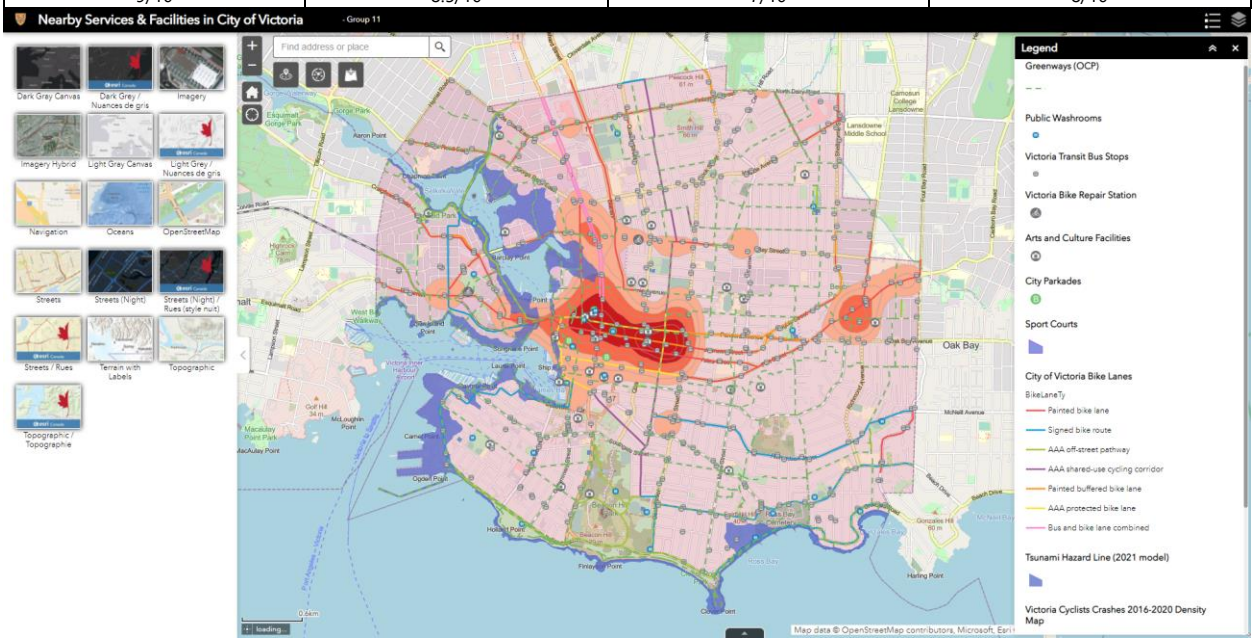


Figure 2. Web AppBuilder: Nearby Services & Facilities Map

From our evaluation result, ArcGIS Web AppBuilder has a high development environment score. Firstly, the web map app has a simple interface and clear operation buttons, which is easy to use and understand for the public. For the whole interface of the web app application, the map is in the central region of Victoria. The main function keys are located at the top right of the interface, and the legend and layer list display options are located at the top left of the interface. Users can control whether a layer is visible or not by clicking on the blue checkmark in front of each layer. For the base map option on the left, users can select any of the base maps to make it more intuitive. As figure 3 shows below, users can get detailed information by clicking the label points on the map directly. The web map app is designed for cyclists, the relevant data include different types of service facilities like bus stops, bike repair stations, arts and culture facilities, city parkdales, sports courts, and public washrooms. Users like cyclists can use this app to find these nearby services and facilities. In addition, to improve the safety of cyclists, a cyclist crashes density layer from 2016 to 2020 and the tsunami hazard line layer are added to warn cyclists of potentially risky areas. Further, the app includes a GIS-based analytics component. Providing a platform for users to continue to develop, users can not only use simple functions to look up locations, but also learn more advanced GIS analysis by adding two modules, data and analysis.

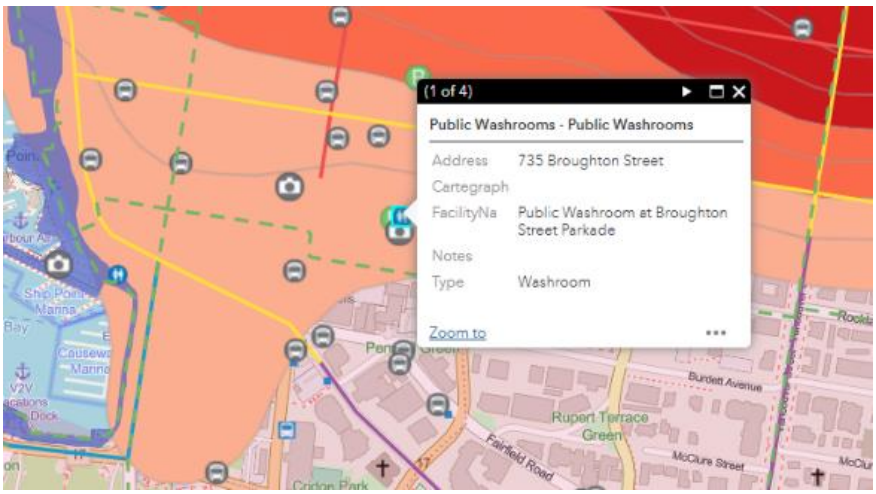


Figure 3. Sample Popups

The score of organizational requirements for ArcGIS Web AppBuilder is also at a relatively high level. First, ArcGIS Online is a free web service mapping software for noncommercial use. Users with a free public account will have access to the web map application. In addition, the web map app can be used in multi-platform such as mobile phones, computers, tablets, which can lower the threshold of public use and popularity. Loading and opening web map apps on all platforms are fast and efficient.

For the functionality part, all of the capabilities needed are available for users. The majority function of this web app application is to help people find nearby public service facilities. This function is “Near Me” and located on the first button below the search tag in figure 4. Users can set a location to search for an address on a map. Moreover, they can choose any points on the map and adjust the search distance (like 1 mile). Then, the different types of public service will show at the window, an approximate distance will also be shown to make people convenient.

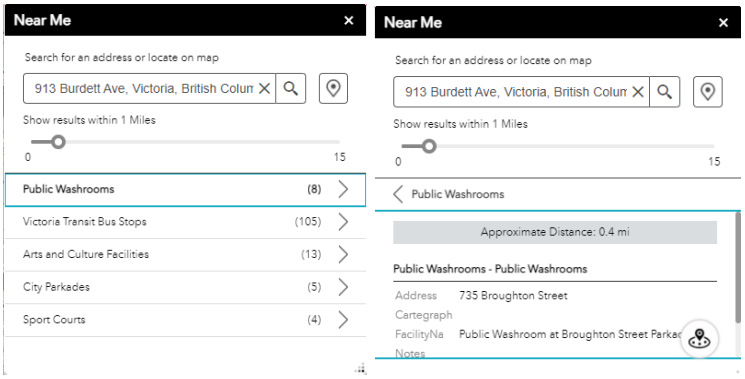


Figure 4. "Near Me" Interface

In addition to the user-friendly location search function, as figure 5 shows, this web map application also includes some GIS analysis modules and data import modules, which can be used by GIS-related staff to conduct urban spatial analysis research on the web, improving the aspect and reducing the threshold of analysis operation. The web map application also includes some GIS analysis modules and data import modules, which can facilitate GIS-related staff to conduct urban spatial analysis research on the web, improve the aspect and reduce the threshold of analysis operation. The analysis includes aggregate points, calculating density, choosing the best facilities, and creating buffers.

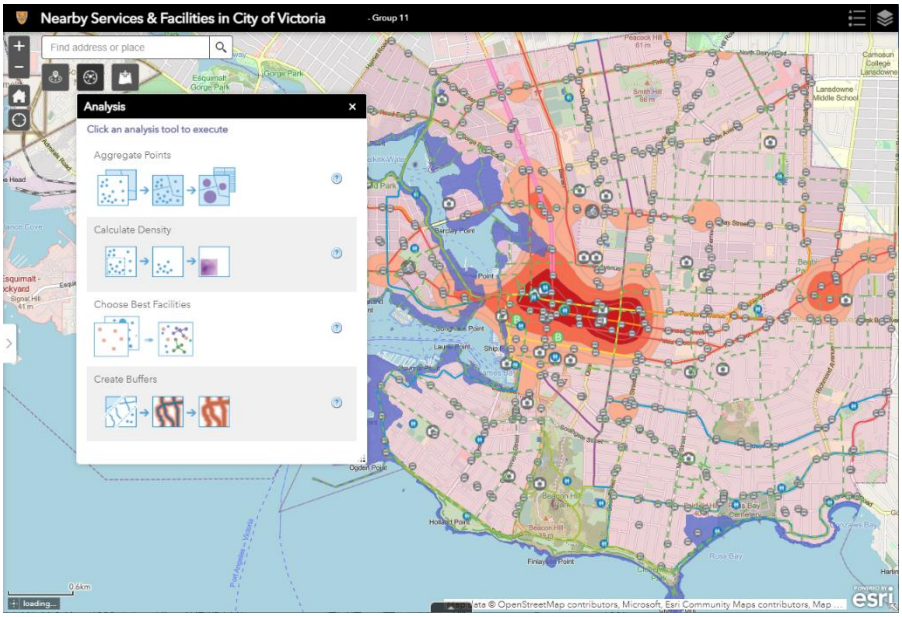


Figure 5. Intensive Analysis Tools

Moreover, as figure 6 shows, a button to add data has been added to support different types of data formats and facilitate more accurate GIS analysis. Users' own files, as well as public files and URLs of organizations they belong to, can be added, greatly increasing the flexibility and timeliness of the analysis. Combined with the latest data and analysis tools, it provides a convenient analysis platform for users. Some examples of common analysis are using buffers to determine the impact of the tsunami on bike lanes, finding the best facilities, etc.

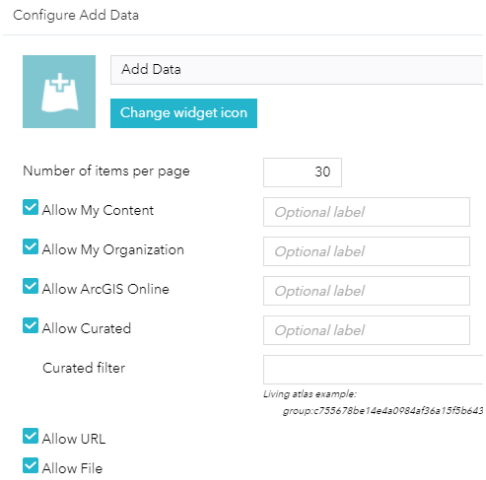


Figure 6. Add Data Interface

The performance of ArcGIS Web AppBuilder is at a good performance. After several statistics, all the content will be loaded within 5 seconds after entering the URLs, the response time is within the acceptable range. The response time for selecting layers and elements is fast. Limitations may be mainly seen when using the analysis module for GIS analysis of large amounts of data.

- ArcGIS JavaScript API:

Cycling Safety & Warning Map

Development environment	Organizational requirements	Functionality	Performance
8/10	8/10	8/10	7.5/10

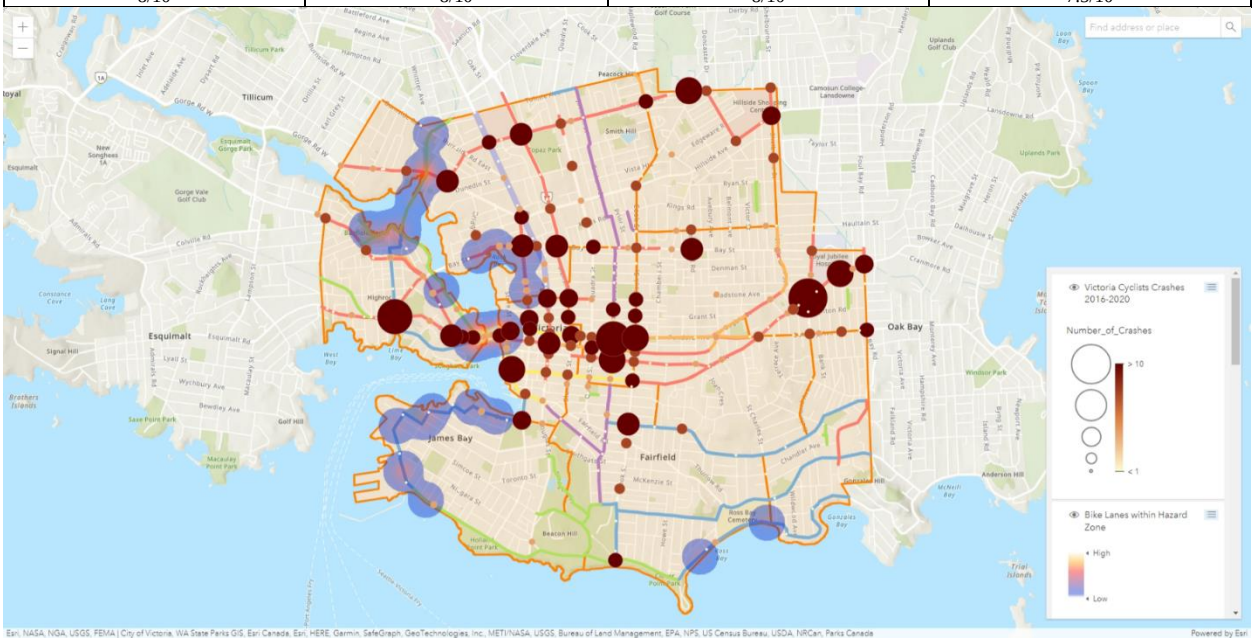


Figure 7. JavaScript API: Cycling Safety & Warning Map

The second bike map was constructed by using ArcGIS JavaScript API. The main purpose of this map is to remind people safety issues & hidden danger from: cycling accident as well as tsunami. In this occasion, the two main layers: tsunami hazard lines (including bike lanes within hazard line generated from overlay

analysis) and cyclist crashes from the past 4 years (2016 - 2020) have been emphasized and shown in different symbology manners. From figure 7, cyclist crashes in darker and bigger feature points represent higher rate & denser of bike accident at the intersection; whereas bike lanes within the proposed 2021 tsunami zone have been illustrate in thematic color-blends which lighter reddish color symbolizes bike lanes closer to the tsunami hazard zone and darker purple-ish color means the bike lanes are farther to the tsunami hazard zone.

Additionally, there are clickable popups windows showing detail information about each layer, which would be meaningful and easy for users to learn the basic tasks as well as more advanced functionality. Therefore, it is an 8/10 for the future development environment of this map. It is not a 9 since there are fields that are not necessary to show (irrelevant), like the ObjectID which is more important to GIS developers and community/ enterprise analyzer, can be eliminated to save responding time since this web map's main audience is cyclists.

7.5/10 for the overall organizational requirements since this web app was used and built under ArcGIS JS developer package; Unlike Web AppBuilder, this option would have extra financial cost for professional use; however, if the community share an enterprise ArcGIS account, it would be an easily accessible option for all the GIS users.

Moving to functionalities, as a cycling safety map, it shows clearly about the pattern of the tsunami hazard model with different warning level; and how bike crashing accidents in the past 4 years distribution within City of Victoria, which fulfill the main task of this web map. It generated an outcome with the related layers as expected. Particularly, the users might even learn and find a pattern between the occurrences of bike crashes and distance to the tsunami hazard line. According to figure 8, it is likely that bike crashes happened on bike lanes that within the tsunami hazard zone. On this occasion, relationships can be drawn and seen on this real-time updating map and help users (cyclists) avoid riding to such dangerous place and encounter accidents. Thus, the score for this map's functionalities is 8/10.

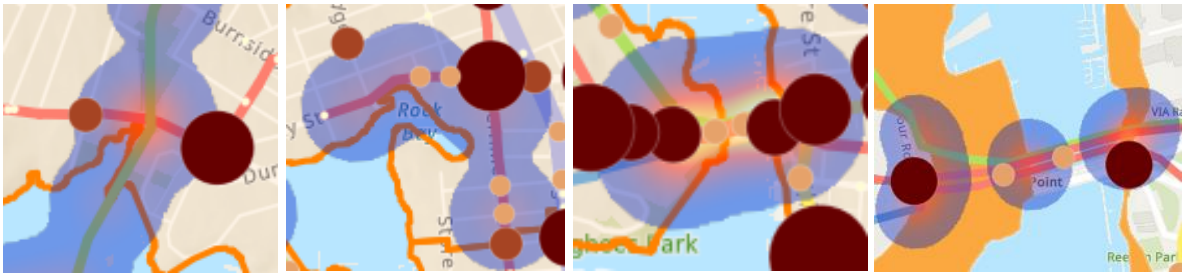


Figure 8. Cyclist Crashes vs. Tsunami Hazard Zones

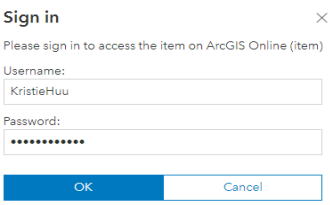


Figure 9. Forced Login Page

Last but not the least, the performance for this map only got 7.5/10. The loading & refreshing time is not the fastest among these 3 web app products; at the same time, it has a reasonable responding time (not lagging) when refreshing pages & zooming in/out the windows; However, this JS API web map has a mandatory login mechanism. To view the maps & items (Feature layers posted on ArcGIS Online), a login to ArcGIS Online is required every time. It would have large limitation if this mechanism does not get removed, and eventually cyclists would abandon this web map, and the end users will be those with ArcGIS Online account (e.g. GIS analyst).

- ESRI Leaflet:

Navigation & Address Locator Map

Development environment	Organizational requirements	Functionality	Performance
7.5/10	8/10	8.5/10	8/10

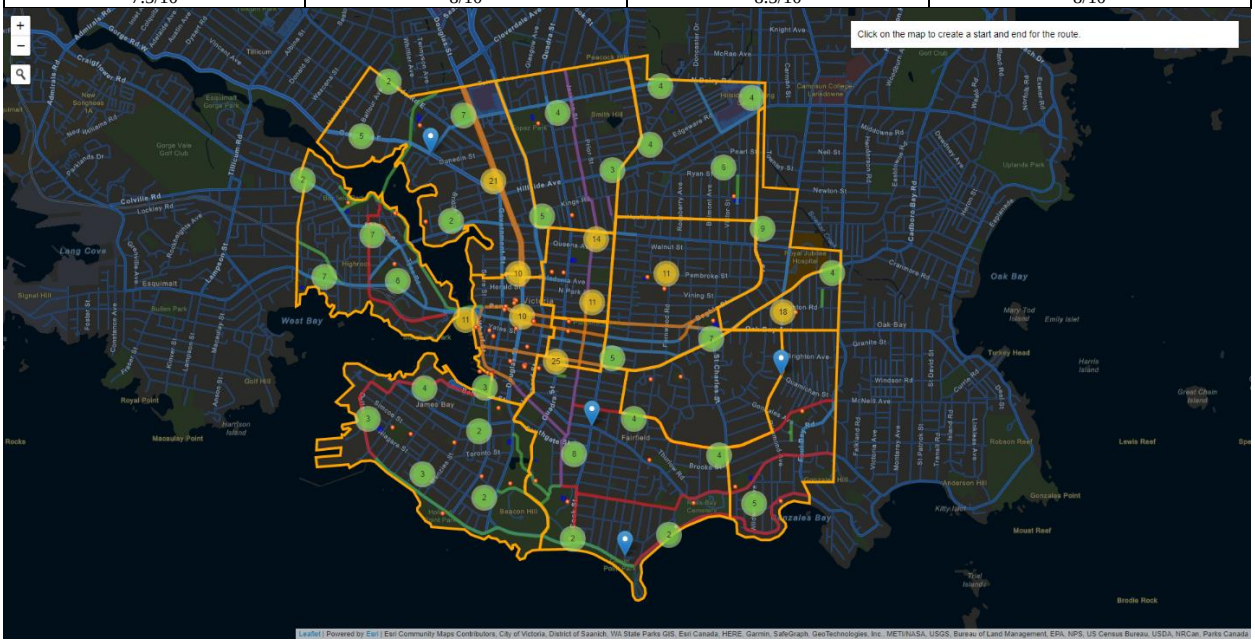


Figure 10. ESRI Leaflet: Navigation & Address Locator Map

Lastly, the third bike web app was also built upon the application of ArcGIS JavaScript. It was constructed mainly using, Leaflet, an open-source JavaScript library for building interactive web maps. The focus of this web map is navigation & address locator, and the main audiences are cyclists.

The visualization effect for other layers has been minimized in this web app since it is not an analysis-based web app. For instance, cyclist crashes layer has been shown in point clustering form since we don't want too much point concentrated on the interactive window to negatively affect the users. Selecting features is one of an easy basic function, and the symbology are easy to read & understand. Since this web app has high potential to be used in large-scale basis compared to the others (concise UI & not analysis-based), a single guiding textbox below might be too simple if users want to explore more complex functionalities. Thus, it would be much better if an individual help page (e.g. with links to Leaflet tutorials) was added. Thus, the evaluated score is 7.5/10 from development environment perspective.

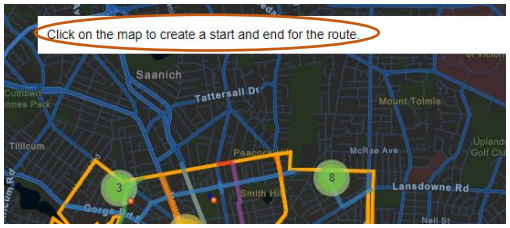


Figure 11. Guide Textbox

Similarly, this web app is coding-based using JavaScript Leaflet library, which means there would be extra fee needed for accessing the developer portal, library & packages. It would have cost for data update & maintenance; However, web mapping data update would avoid repetitive update & maintenance on each map since the data is online, and every push would be updated and loaded into record synchronously. From

organizational perspective, it would be a great option for them to adapt web mapping since the future data maintenance would have much less cost (timesaving).

As for its functionality, the output of Leaflet web app fulfills the main purpose of the app since it has a clear navigation widget to emphasize its main features in the interactive window. By clicking on map, the users can select their departure & destination, a quick navigation route with navigation tips would be generated automatically. Examples has been demonstrated below:

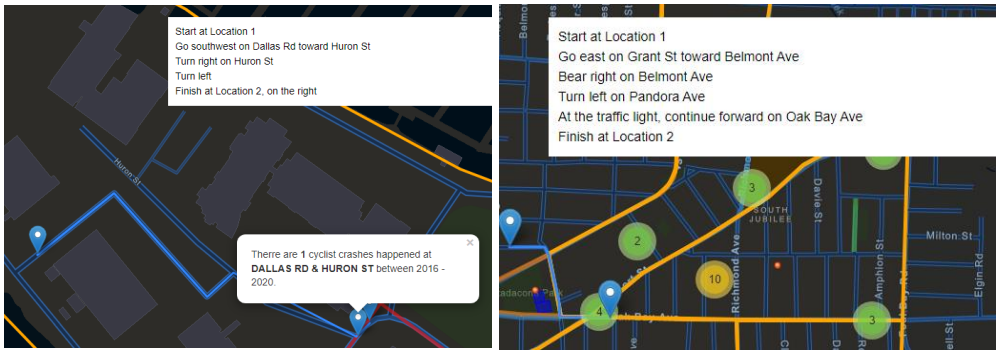


Figure 12. Navigation & Route Formation

Besides, information from layers like cyclist crashes, city parkade, art & culture facilities, public washrooms, has all been modified into user-friendly popups that contains no irrelevant information from the original dataset like below (Omitted fields from the popups). Therefore, the functionality scores 8.5/10.

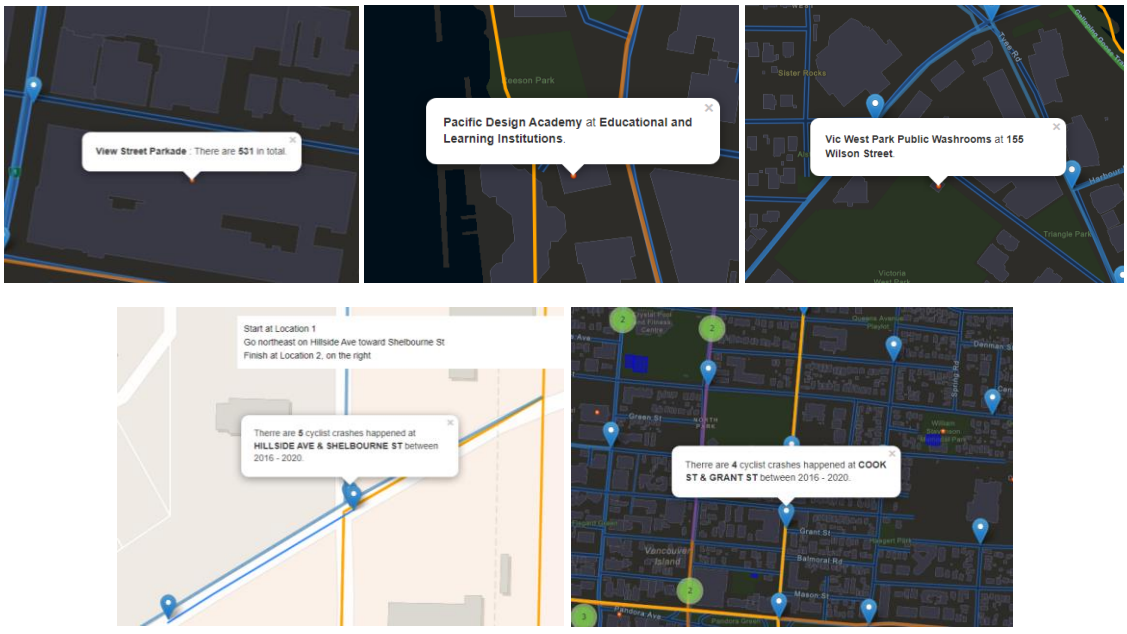


Figure 13. Updated Customized Popups Contents for Different Layers

As for the performance perspective (8/10), Leaflet web app refresh and load within a reasonable time. Due to its ease of use, ease of understanding , low cost of data maintenance, it might be adapted into a beta version to prepare for large scale usage; however, this would happen if a better Help menu can be included in the app.

Conclusion

Overall, these web apps as interactive platforms are easily accessible, operatable, and highly compatible. WebApp Builder using the ArcGIS Online ecosystem, which requires no code to build, is smooth and easy to build and is highly open and shareable. “Widgets” among the WebApp Builder allow customization of various functions including finding nearby addresses, buffer analysis, etc., simplifying the GIS analysis process. simplifies the GIS analysis process. The ArcGIS JavaScript API contains a rich open source, but the mandatory login mechanism may make it more difficult for users to use it. Similarly, ArcGIS Leaflet uses algorithm in JavaScript to support conducting various analysis and building thematic maps with different widgets. One common advantage of these three web apps is the low cost in future data update and maintenance. Changes made in online layers would directly update to web Maps which serving large scale of end users at the same time. Despite of the fact that both JavaScript API & ESRI Leaflet might require extra cost at the beginning for developer subscription, the benefits and convenience of managing online feature layers & web maps would be numerous.

Reference

Bell, J. (2017). Victoria high on cycling, less so on transit, census data show. Victoria Times Colonist. Retrieved from https://www.timescolonist.com/localnews/victoria-high-on-cycling-less-so-on-transit-census-data-show-4656638

City of Victoria. (n.d.). Cycling. Retrieved from https://www.victoria.ca/EN/main/residents/streets-transportation/walk-rolltransit/cycling.html

City of Victoria. (n.d.). Victoria's AAA Cycling Network. Retrieved from https://www.victoria.ca/EN/main/residents/streets-transportation/walk-rolltransit/cycling/victoria-s-aaa-cycling-network.html

Gehrke, S. R., Akhavan, A., Furth, P. G., Wang, Q., & Reardon, T. G. (2020). A cycling-focused accessibility tool to support regional bike network connectivity. Transportation Research Part D: Transport and Environment, 85, 102388.https://doi.org/10.1016/j.trd.2020.102388

Island, C. T. V. N. V. (2019, December 6). Victoria ranked most bike-friendly city in Canada. Vancouver Island. Retrieved January 30, 2022, from https://vancouverisland.ctvnews.ca/victoria-ranked-most-bike-friendly-city-in-canada-1.4718631

Su, J. G., Winters, M., Nunes, M., & Brauer, M. (2010). Designing a route planner to facilitate and promote cycling in Metro Vancouver, Canada. Transportation Research Part A: Policy and Practice, 44(7), 495–505. https://doi.org/10.1016/j.tra.2010.03.015

Wessel, N., & Widener, M. (2015). Rethinking the Urban Bike Map for the 21st Century. Cartographic Perspectives, (81), 6–22. https://doi.org/10.14714/CP81.1243