… I have always found that plans are useless, but planning is indispensable.

Dwight David Eisenhower

THE ESSENCE OF THE PROBLEM

The vehicle routing problem (VRP) is a problem in combinatorial optimization, computer science, and integer programming that asks:

“What is the optimal set of routes for a fleet of vehicles to deliver to a given group of customers?”

1830 ● Was mentioned in the German book **“Advice from an Old Traveling Salesman.”**

1930 ● In the 1930s, the problem was first formulated by **Carl Menger**

1954 ● In an article by **George Dantzig** and **John Ramzer** in 1959, it was applied to gasoline delivery.

THE PROBLEM: Why is this so important?

Everything consumers and businesses need is being shipped and transported from one place to another, often this includes different countries

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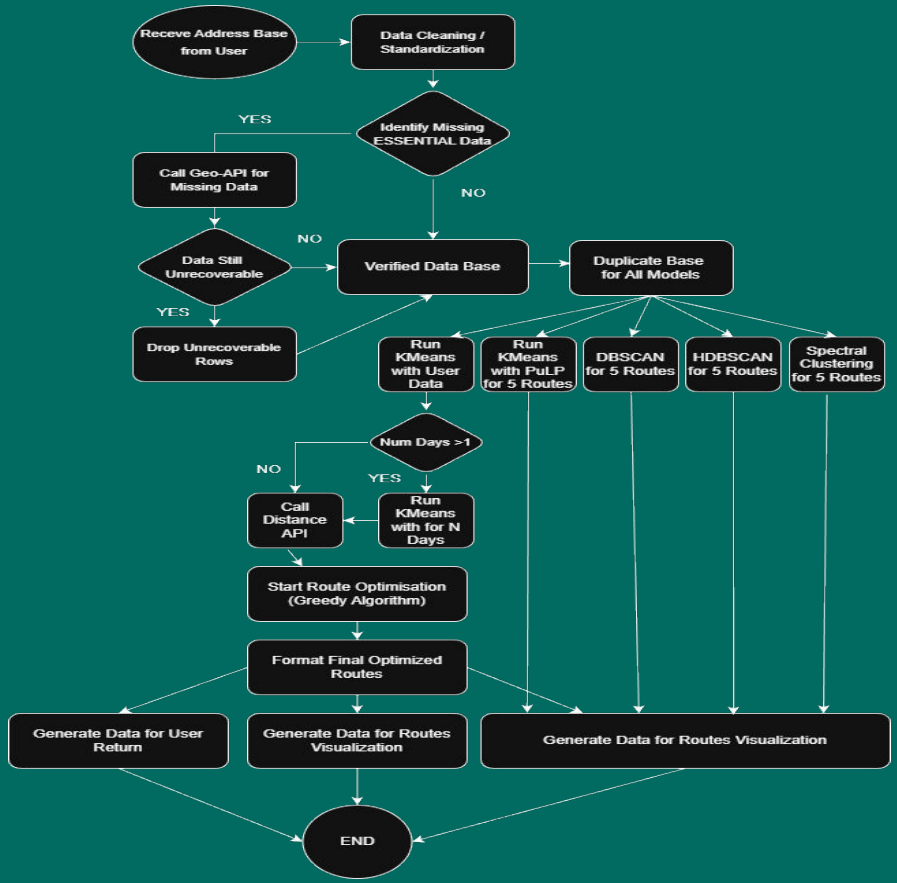
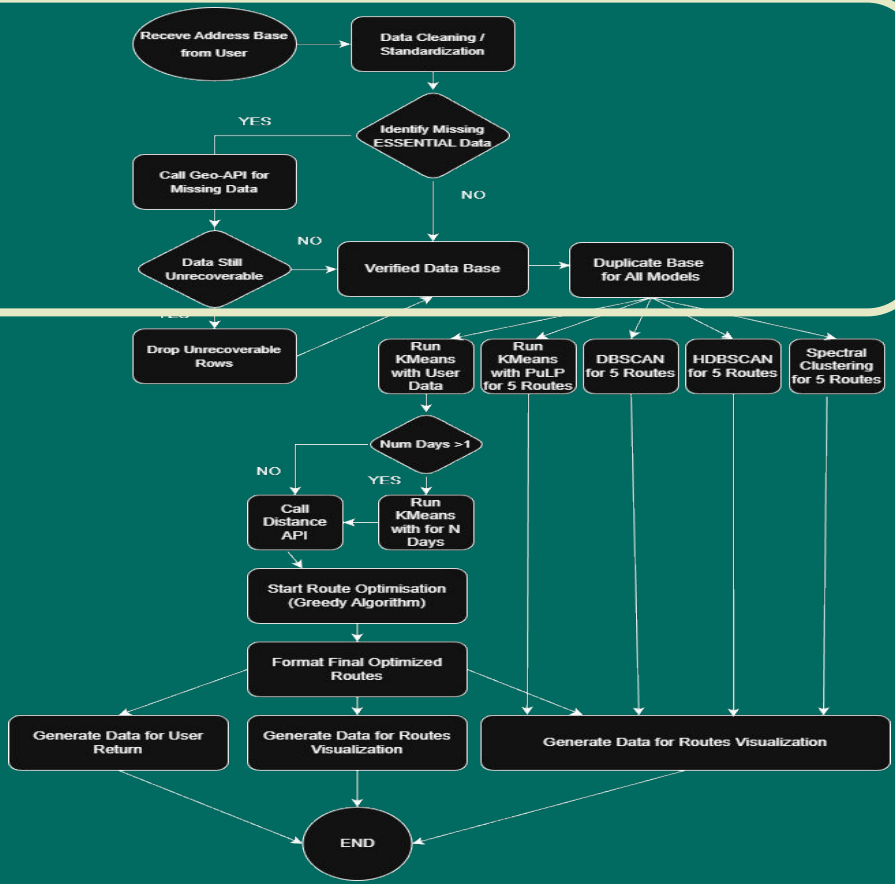
I have built routes for my sales teams dozens of times, and each time this procedure has been a huge headache for me and my colleagues.

THE **ALGORITHM & SOLUTIONS**



THE **ALGORITHM & SOLUTIONS**

- Get data from user, clean and check.
- Get missing data using API service
- Clean again



THE **ALGORITHM & SOLUTIONS**

- Get data from user, clean and check.
- Get missing data using API service
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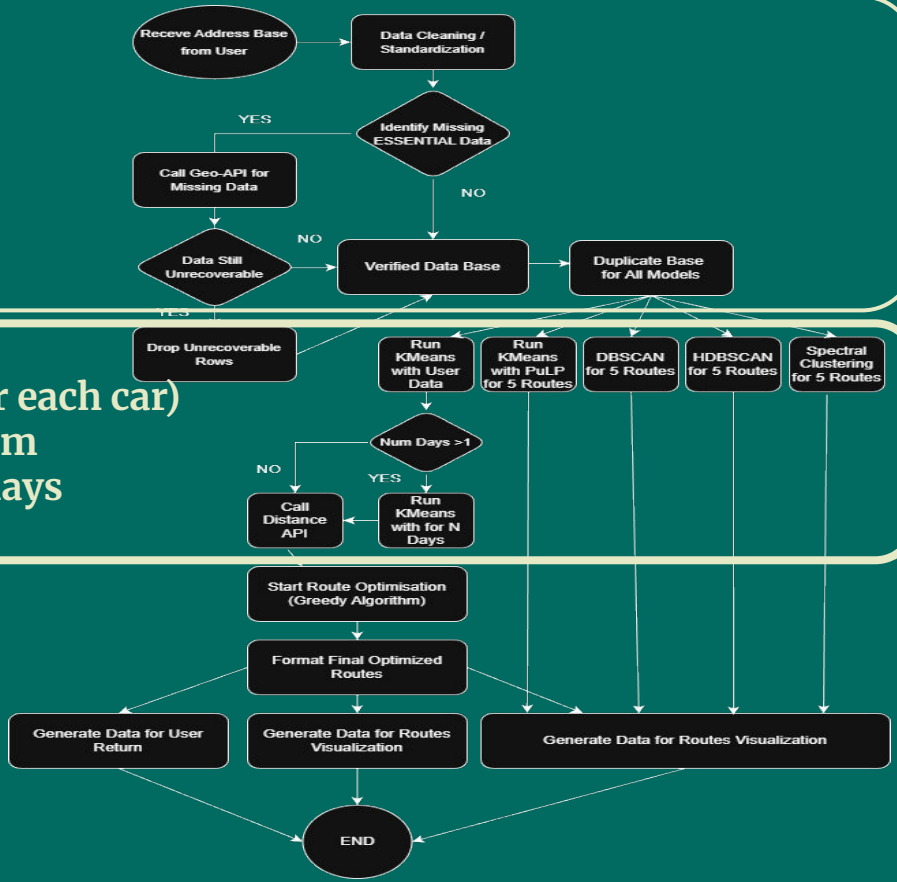
- **Using the KMeans, obtain clusters (for each car)**
- **Based on the obtained clusters, perform another clustering by the number of days**



THE **ALGORITHM & SOLUTIONS**

- Get data from user, clean and check.
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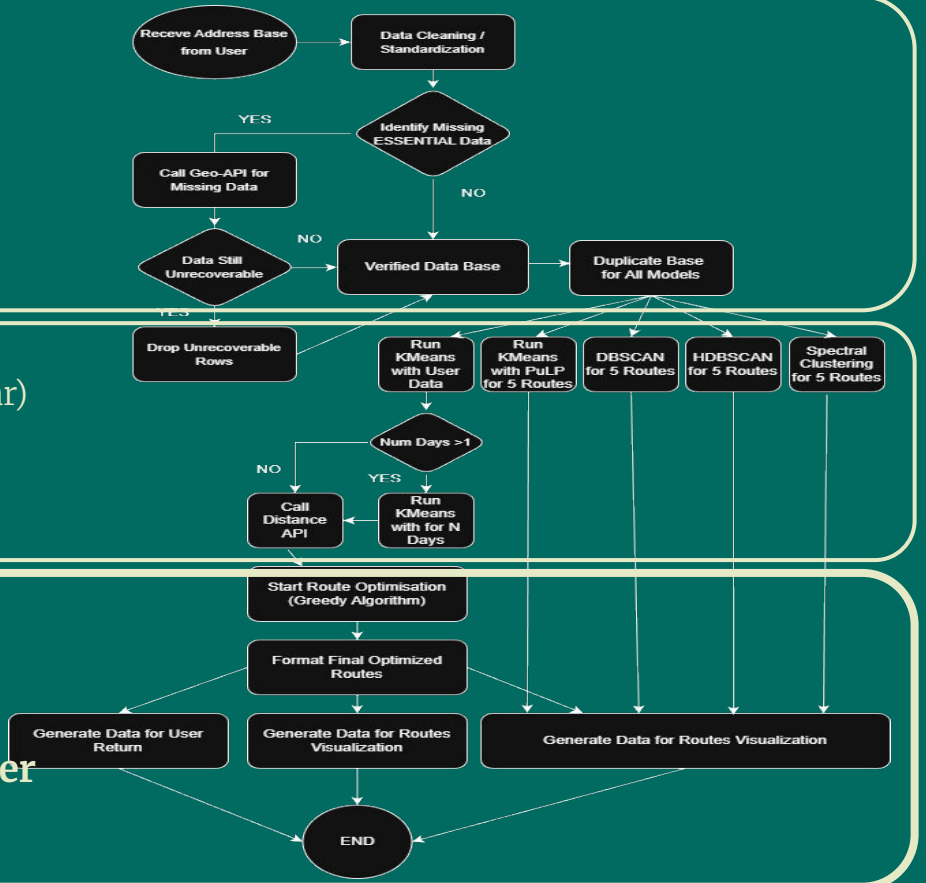
- Clean again

- Using the **KMeans**, obtain clusters (for each car)
- Based on the obtained clusters, perform another clustering by the number of days

- **Create a distance matrix**
- **Calculate the nearest neighbor (distance of each point to each point)**
- **Format the results for return to the user and plotting on the map**



THE PROJECT **LIMITATION**

geocode.maps.co:

API limitation:

Rate limit: No more than 1 request per second.

Note: If the limits are violated, the service will block the user.

OpenRoutingService:

API limitation:

Rate limit: No more than 2000 request

Local Server Limitations:

Route Limit: Maximum route distance (100 km).

Stop radius: near a point (this parameter can be changed).

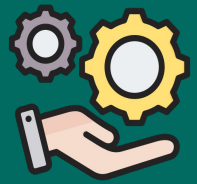
Note: If these limits are violated for:

Local Server - the route will not be displayed on the map.

API endpoint - will be blocked

THE PROJECT **TASK STATEMENT**

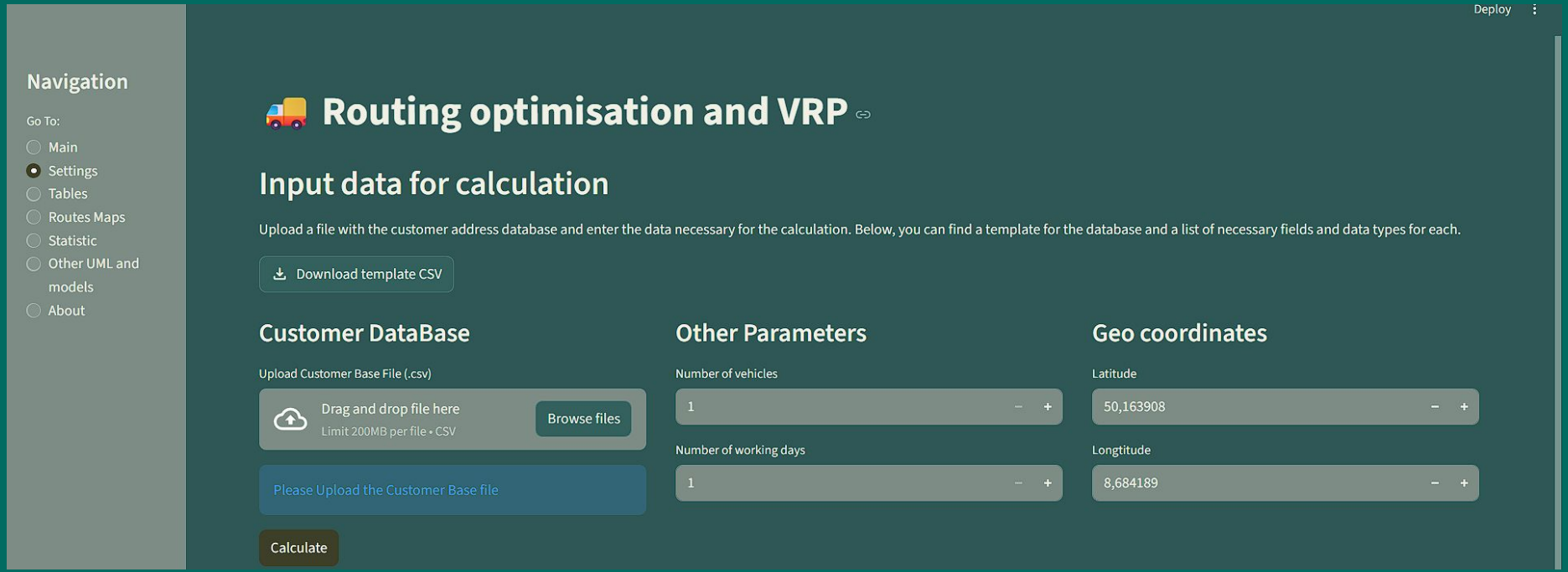
You are a restaurant owner, you need to deliver dishes to your customers?



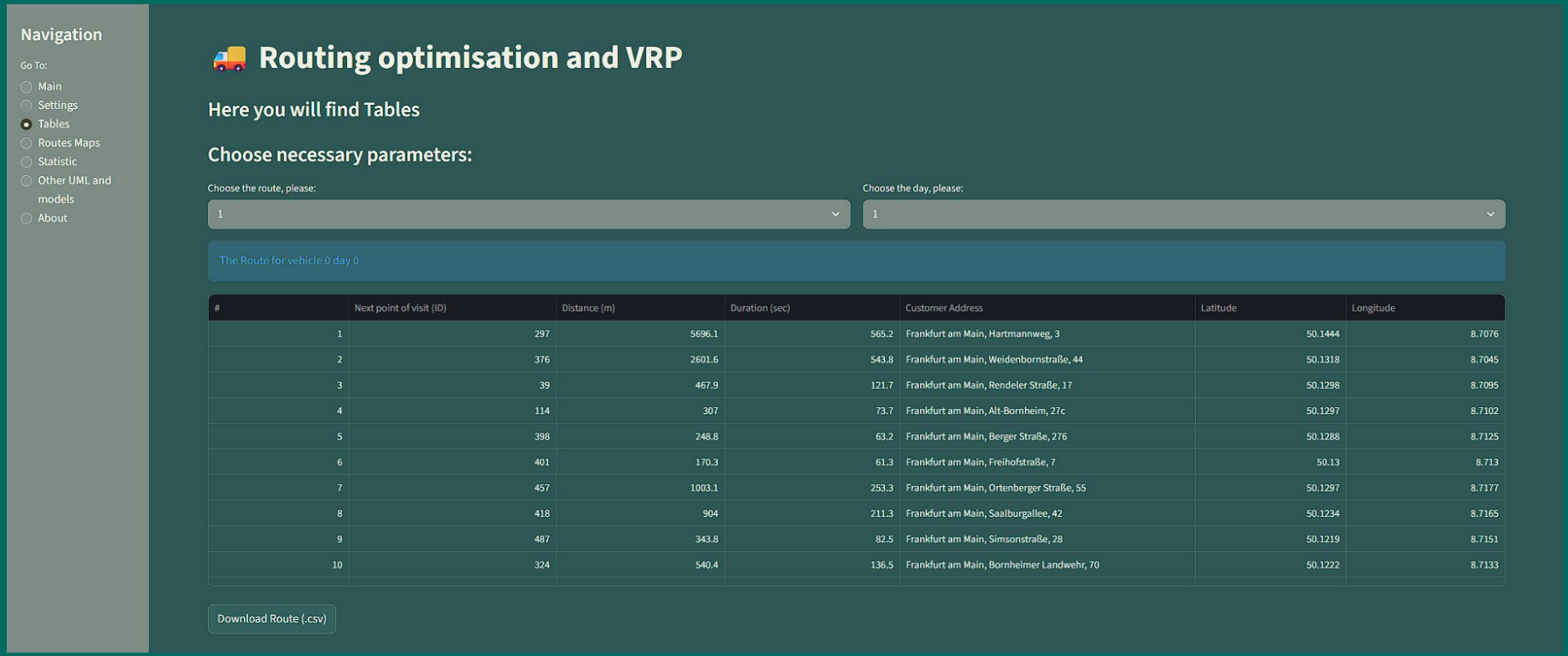
You are the owner of a small service company that repairs large household appliances?

You are the Head of sales of a distribution company who has to plan and calculate sales representatives' visits to customers on a weekly basis?

THE PROJECT **SETTINGS**

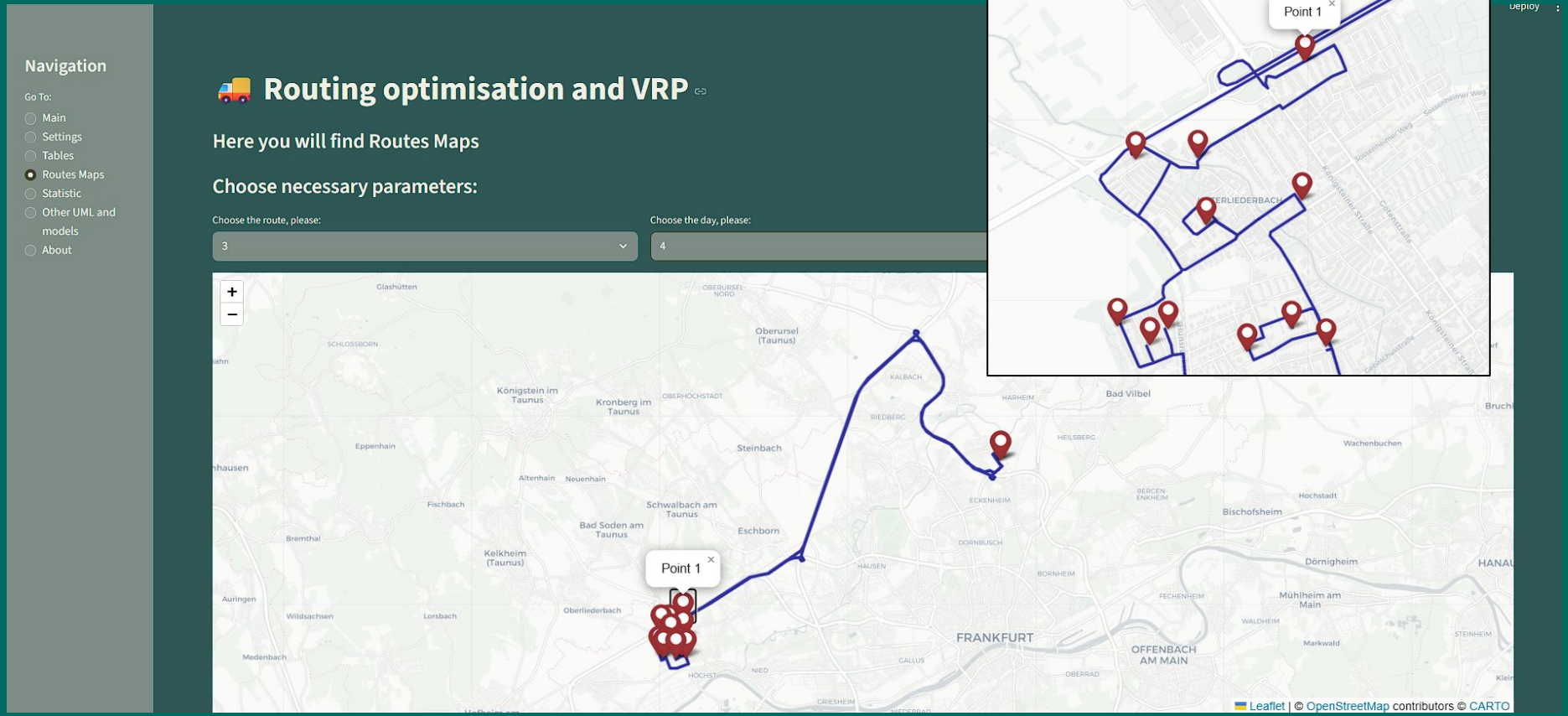


THE PROJECT **TABLES**

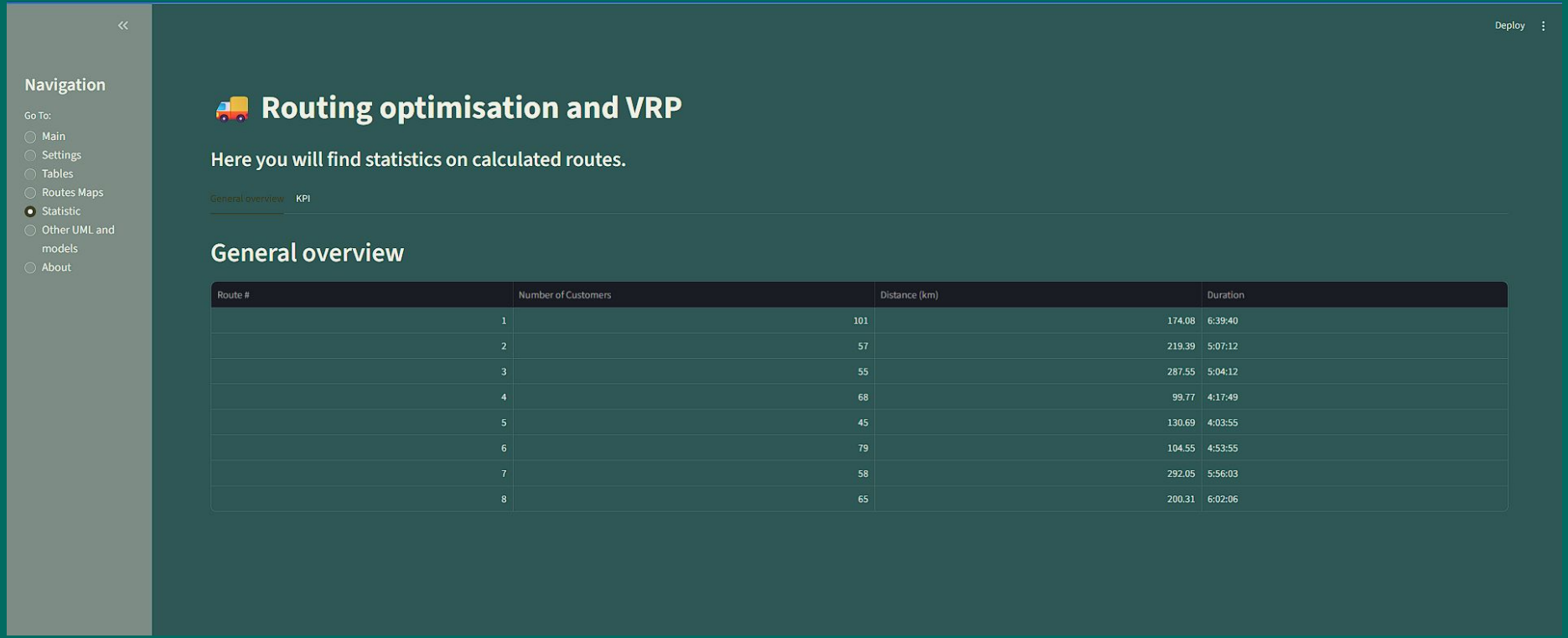


#	Next point of visit (ID)	Distance (m)	Duration (sec)	Customer Address	Latitude	Longitude
1	297	5696.1	565.2	Frankfurt am Main, Hartmannweg, 3	50.1444	8.7076
2	376	2601.6	543.8	Frankfurt am Main, Weidenbornstraße, 44	50.1318	8.7045
3	39	467.9	121.7	Frankfurt am Main, Rendeler Straße, 17	50.1298	8.7095
4	114	307	73.7	Frankfurt am Main, Alt-Bornheim, 27c	50.1297	8.7102
5	398	248.8	63.2	Frankfurt am Main, Berger Straße, 276	50.1288	8.7125
6	401	170.3	61.3	Frankfurt am Main, Freihofstraße, 7	50.13	8.713
7	457	1003.1	253.3	Frankfurt am Main, Ortenberger Straße, 55	50.1297	8.7177
8	418	904	211.3	Frankfurt am Main, Saalburgallee, 42	50.1234	8.7165
9	487	343.8	82.5	Frankfurt am Main, Simsonstraße, 28	50.1219	8.7151
10	324	540.4	136.5	Frankfurt am Main, Bornheimer Landwehr, 70	50.1222	8.7133

THE PROJECT **MAPS**

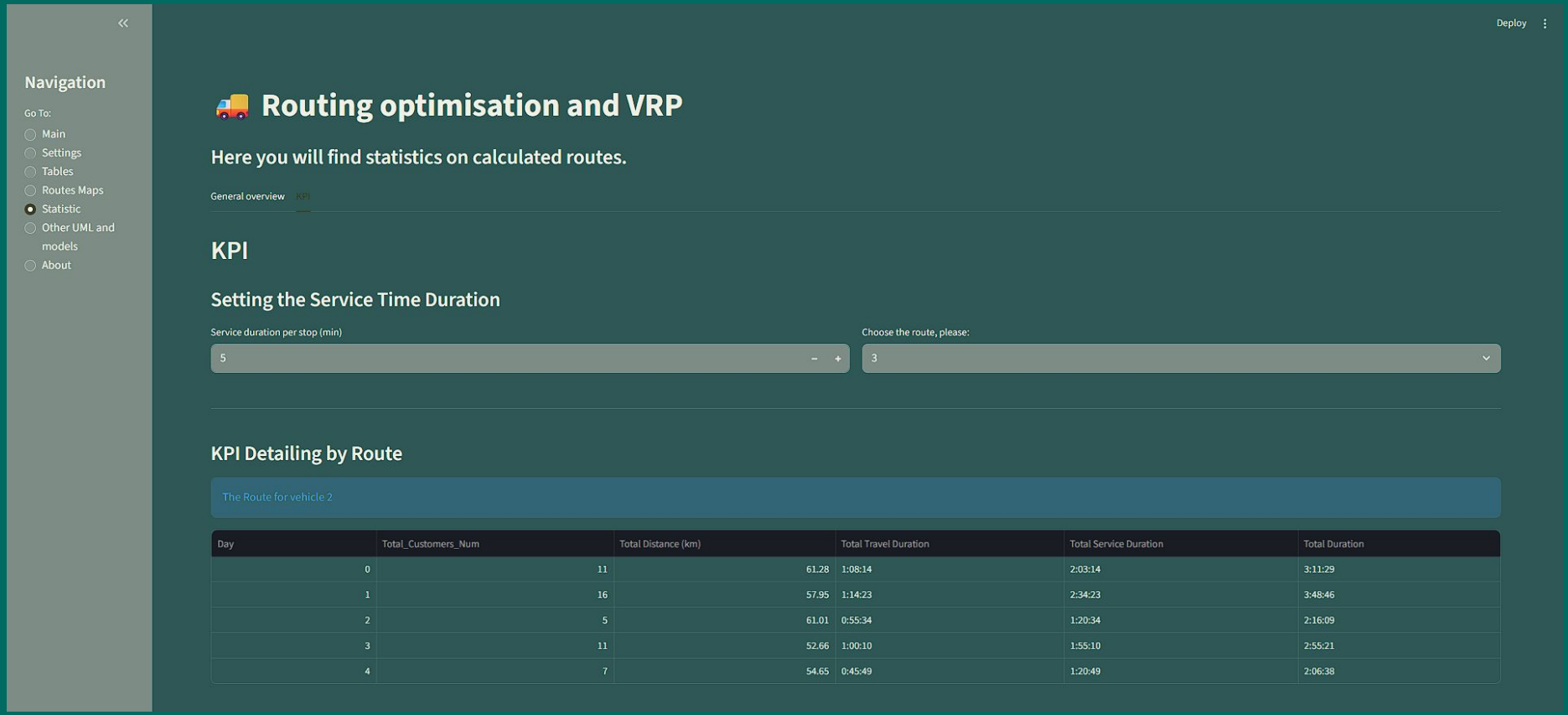


THE PROJECT **STATISTICS**

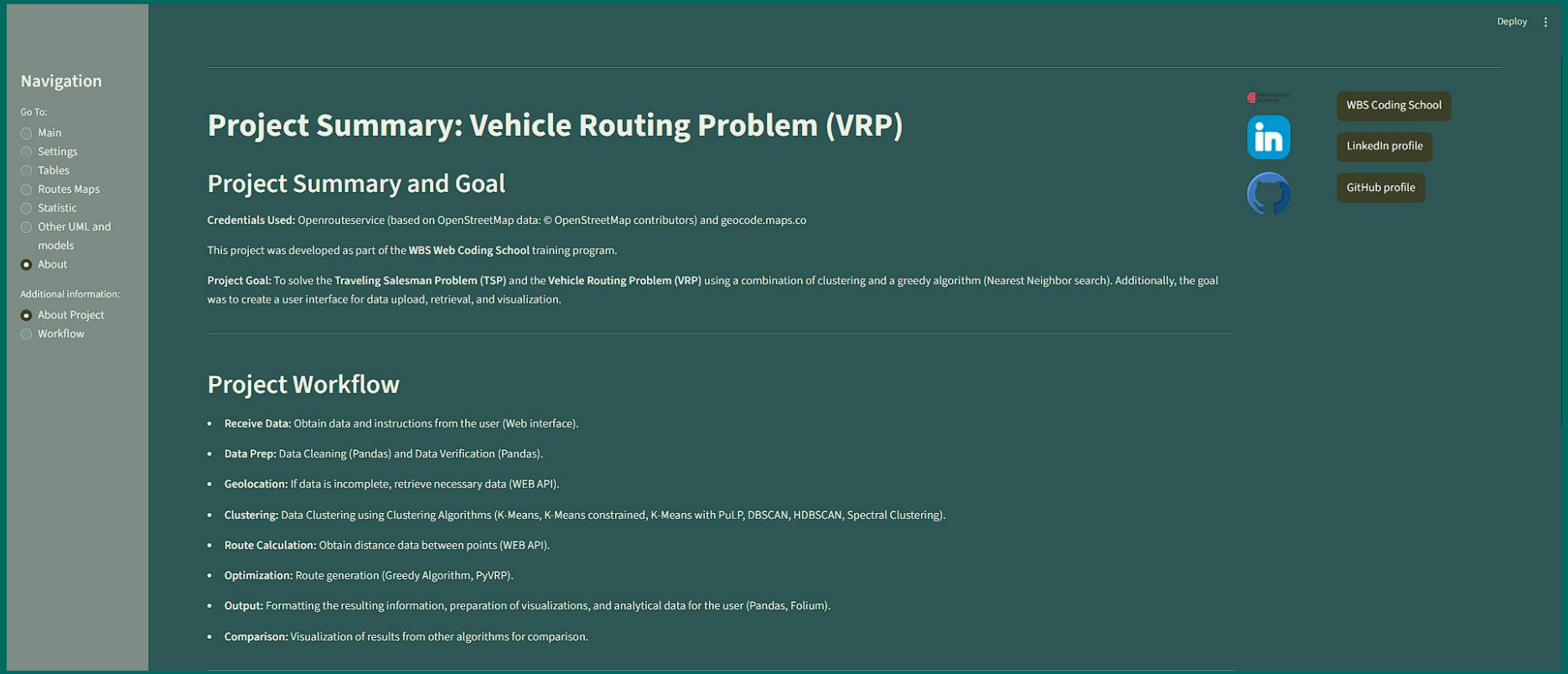


Route #	Number of Customers	Distance (km)	Duration
1	101	174.08	6:39:40
2	57	219.39	5:07:12
3	55	287.55	5:04:12
4	68	99.77	4:17:49
5	45	130.69	4:03:55
6	79	104.55	4:53:55
7	58	292.05	5:56:03
8	65	200.31	6:02:06

THE PROJECT **STATISTICS**



THE PROJECT **STATISTICS**



THE PROJECT **STATISTICS**

Navigation

Go To:

- Main
- Settings
- Tables
- Routes Maps
- Statistic
- Other UML and models
- About

Additional information:

- About Project
- Workflow

Deploy

- **Comparison:** Visualization of results from other algorithms for comparison.

Conclusions

Clustering Algorithms can be effectively utilized to solve the Traveling Salesman Problem, but with certain limitations:

1. **Closely Located Points (VRP):** For building multiple routes with a large number of closely located points, **K-Means, K-Means constrained, and K-Means with PuLP** are recommended.
2. **Distant Clusters:** For building multiple routes where points are grouped into distant clusters, **DBSCAN, HDBSCAN, and Spectral Clustering** can be used.

Constraint: Clustering (excluding the K-Means constrained algorithm) demonstrates a significant **disproportion** in cluster sizes.

Notes on API Service Limitations

Openrouteservice Server Limitations

- Maximum route distance (**100 km**).
- Stop radius near a point (this parameter can be changed).
- *Note:* If these limits are violated, the route will not be displayed on the map.

geocode.maps.co API Service Limitations

- **Rate limit:** No more than **1 request per second**.
- *Note:* If the limits are violated, the service will block the user. For significant volumes of undefined geospatial coordinates, the retrieval process will take: `(number of undefined coordinates) * 1 second`.