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# **Agent-based modeling and simulation of public transport to identify effects of network changes on passenger flows**

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# Introduction

- **Changes in public transport**
- **Impact on crowdedness**
- **Simulation of boat traffic through the canals<sup>[1]</sup>**

<sup>[1]</sup> Jeroen van der Does de Willebois. Assessing the impact of quay-wall renovations on the nautical traffic in Amsterdam. Master's thesis, TU Delft, 2019

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# Agent-based modeling

- **Agents**
    - Rules
    - Goals
  - **Passengers**
  - **Vehicles**
  - **Agents act in an environment**
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# Agent types



**Type 1:** prefers the shortest route



**Type 2:** prefers minimal amount of transfers



**Type 3:** prefers minimal waiting time

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# Sub-network

Tram 24 and 12 + Metro 50, 52 and 53

networkx



maps.amsterdam.nl





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# GVB data

## Origin and sub-trip data examples

| Date                 | Hour          | OriginCode | OriginName         | Trips |
|----------------------|---------------|------------|--------------------|-------|
| 1/1/2018 12:00:00 AM | 09:00 - 09:59 | 00005      | Muiderpoortstation | 10    |

Origin stations (data also available for destination)

| Date                 | Hour          | OriginCode | OriginName         | DestinationCode | DestinationName  | Trips |
|----------------------|---------------|------------|--------------------|-----------------|------------------|-------|
| 1/1/2018 12:00:00 AM | 09:00 - 09:59 | 02158      | Adm. de Ruijterweg | 05011           | Centraal Station | 10    |

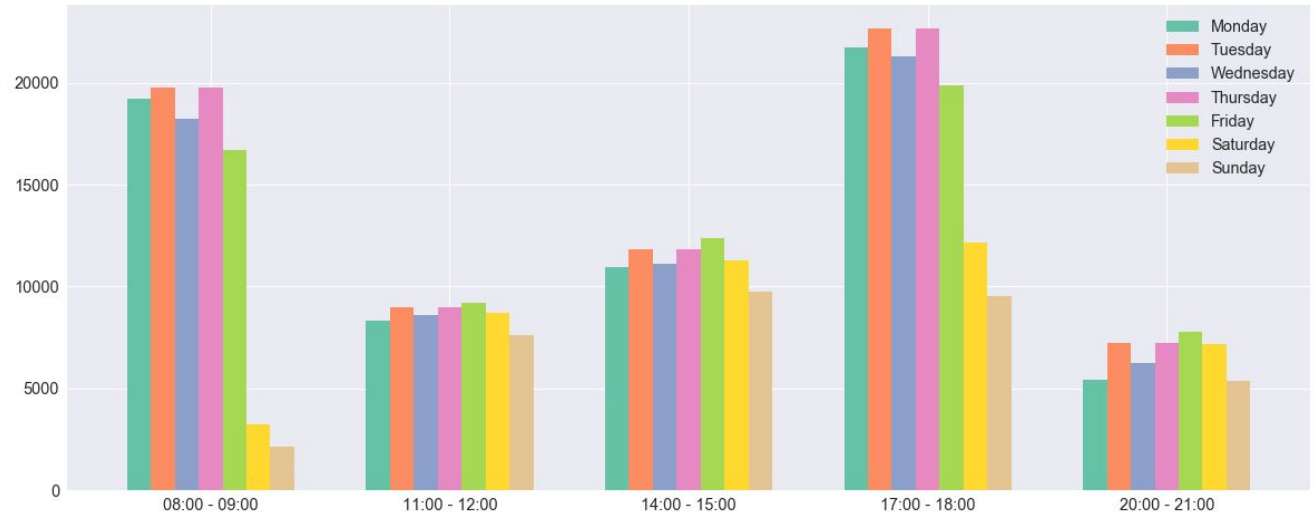
Sub-trips

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# GVB data

**Average number of passengers per hour, per weekday\***



**\* numbers are corrected for the lines that were used for this research**

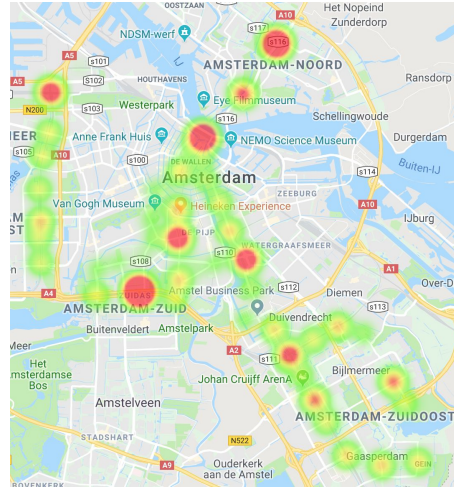
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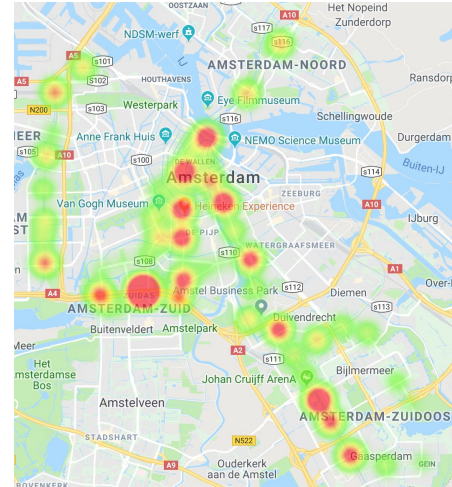
# GVB data

Passenger distribution on a weekday, 08:00 - 09:00\*

Origin



Destination



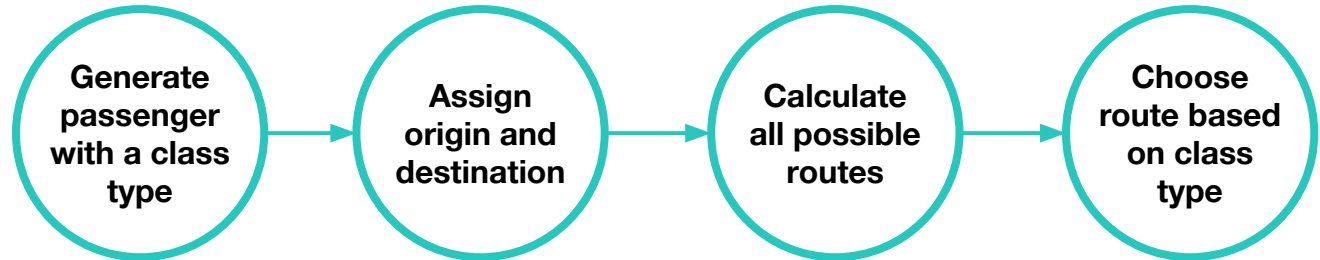
\* numbers are corrected for the lines that were used for this research

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# Passengers

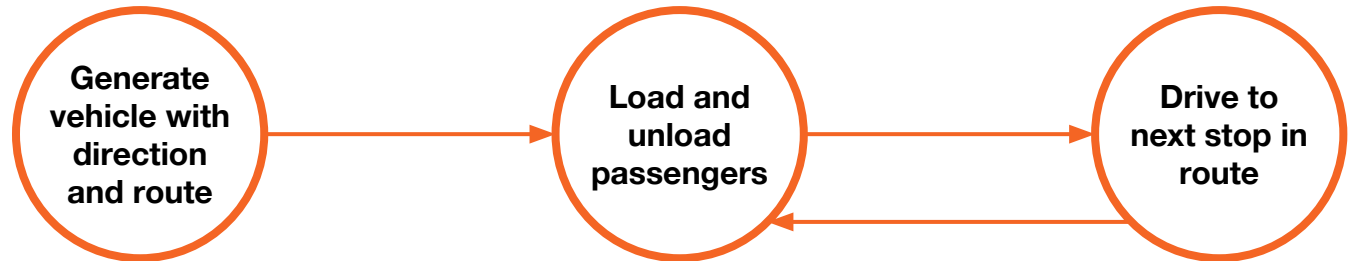
Number of passengers based on GVB data



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# Vehicles

For all lines, for every X minutes (X = frequency)



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# Changes in public transport

## **Scenario 1** *(baseline)*

- Vehicles are driving according to schedule
- Generating passengers based on distributions
- Week- and weekend day
- 08:00 - 09:00, 11:00 - 12:00, 14:00 - 15:00, 17:00 - 18:00, 20:00 - 21:00

## **Scenario 2**

- Scenario 1, with one exception:
- During every simulated hour, **tram 12** is malfunctioning for 30 minutes

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# Results / Origin

- Mean average error ranges from 4 to 24
- Highest error during rush hours on weekdays

| Station       | GVB data | Simulation | Error |
|---------------|----------|------------|-------|
| Station Zuid  | 3817     | 3068       | 749   |
| Bijlmer Arena | 469      | 467        | 2     |

Example for a good and bad fit on a weekday 08:00 - 09:00

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# Results / Destination

- Mean average error ranges from 5 to 45
- Highest error during rush hours on weekdays

| Station      | GVB data | Simulation | Error |
|--------------|----------|------------|-------|
| Station Zuid | 5133     | 4062       | 1071  |
| Station RAI  | 453      | 452        | 1     |

Example for a good and bad fit on a weekday 08:00 - 09:00

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# Results / Sub-trips

- Mean average error ranges from 13 to 36
- Highest error during rush hours on weekdays

| Trip                            | GVB data | Simulation | Error |
|---------------------------------|----------|------------|-------|
| Centraal Station - Weesperplein | 1359     | 369        | 990   |
| Europaplein - Station Zuid      | 116      | 118        | 2     |

Example for a good and bad fit on a weekday 08:00 - 09:00

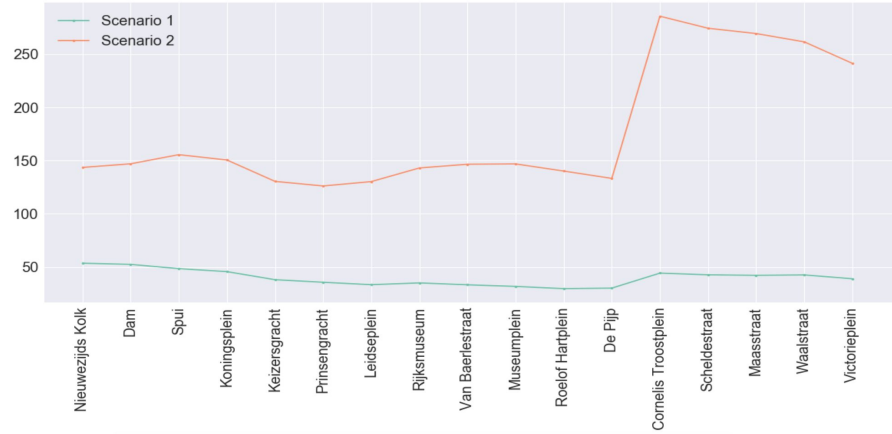
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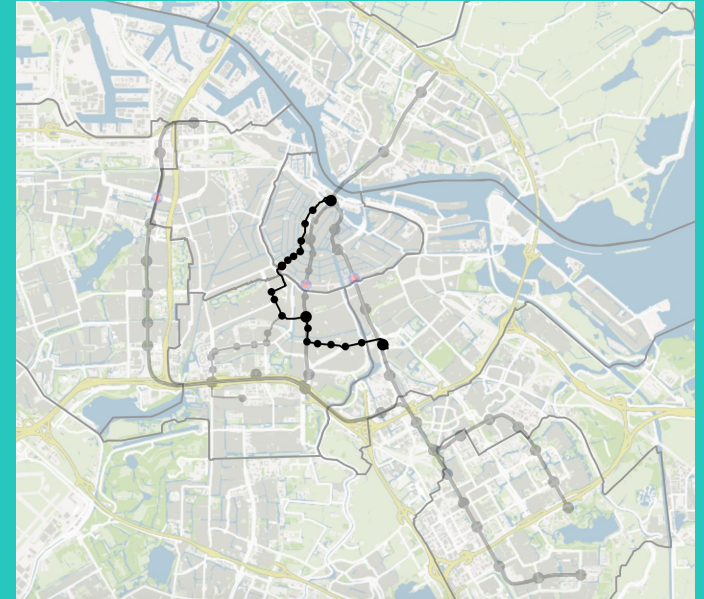
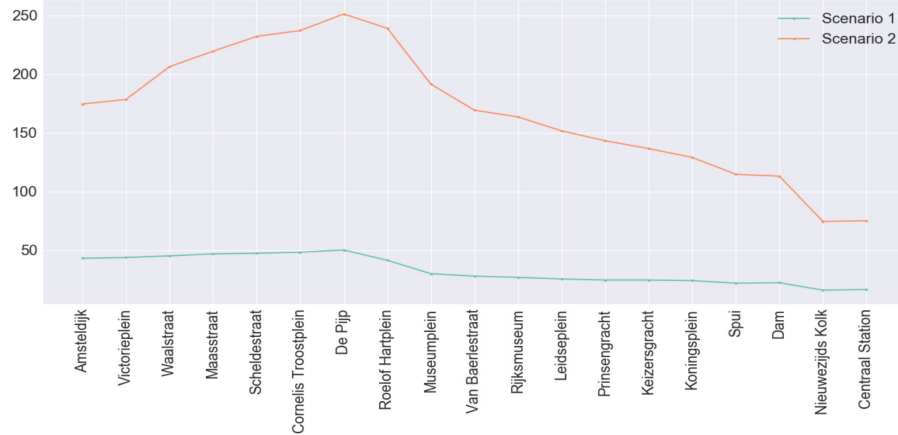
# Results / Trip information

- **Scenario 1 vs. Scenario 2**
  - **Waiting time, transfers and trip duration**
    - Waiting time showed more outliers
    - No clear effect on transfers and trip duration
  - **Occupancy of vehicles**
    - All lines, except metro line 50, were influenced
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## To Amstelstation (08:35)



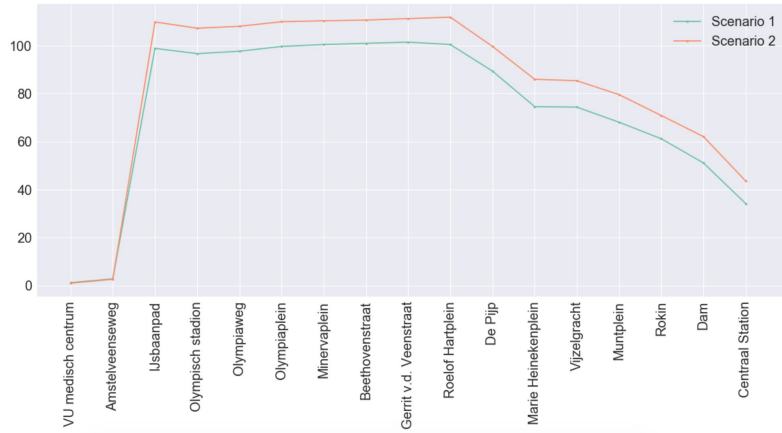
## To Centraal station (08:33)



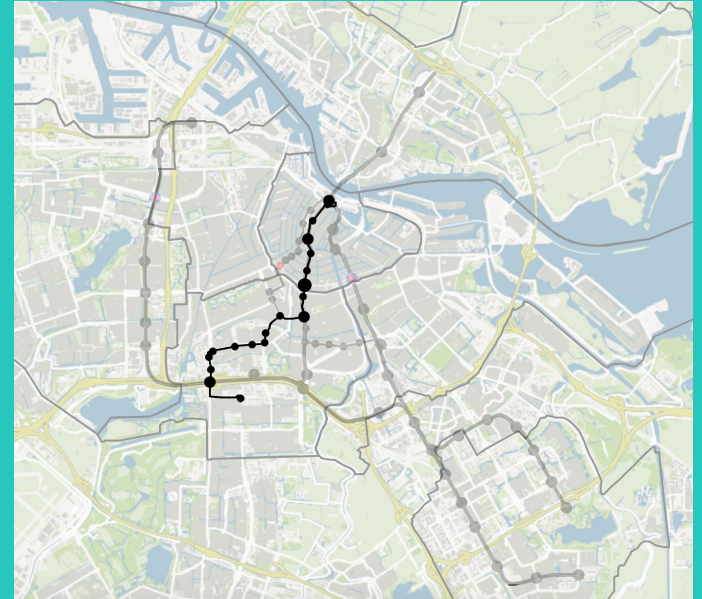
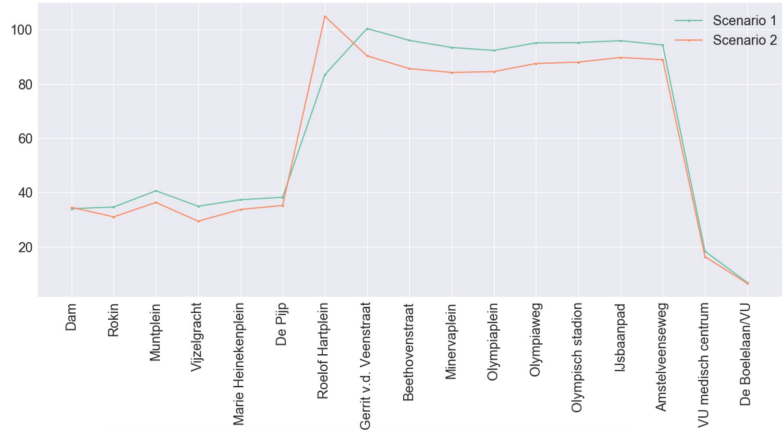
# Tram 12\*

\*malfunctioning during 08:00 - 08:30

## To Centraal station (08:25)

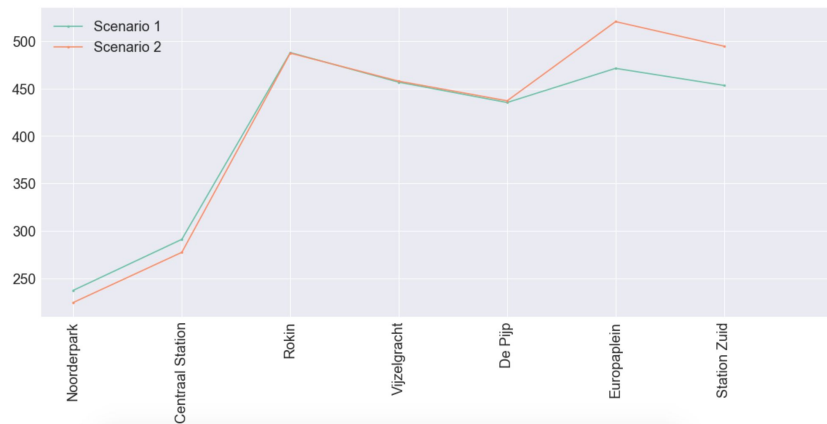


## To De Boelelaan/VU (08:24)

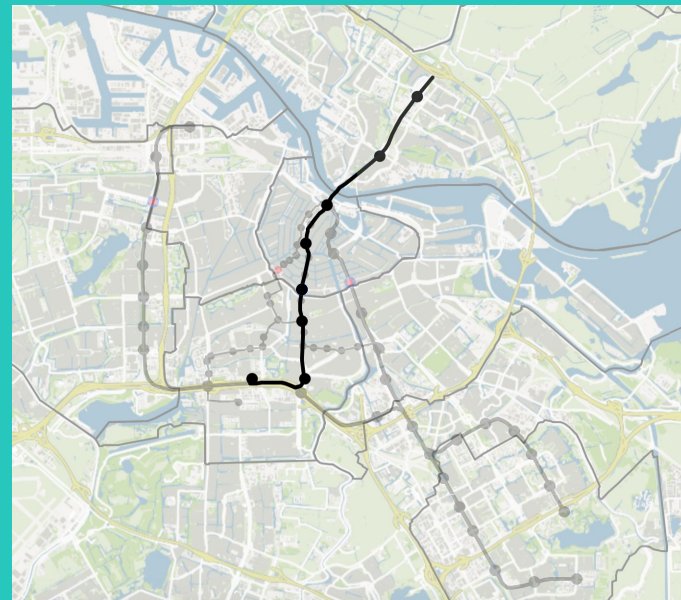
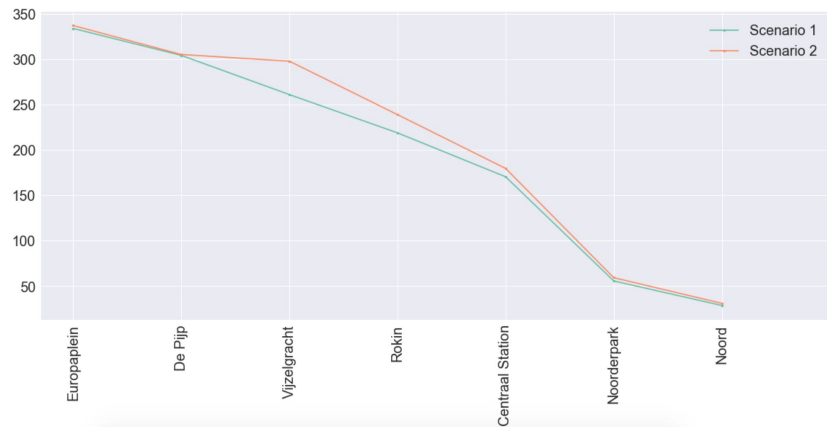


# Tram 24

### To Station Zuid (08:36)

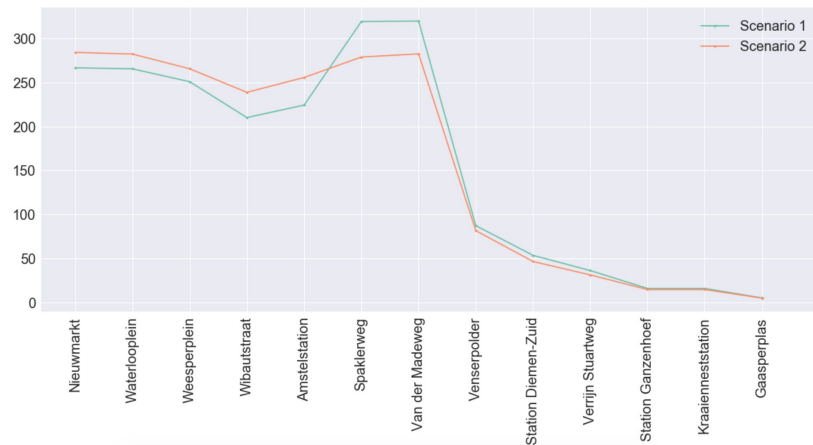


### To Station Noord (08:41)

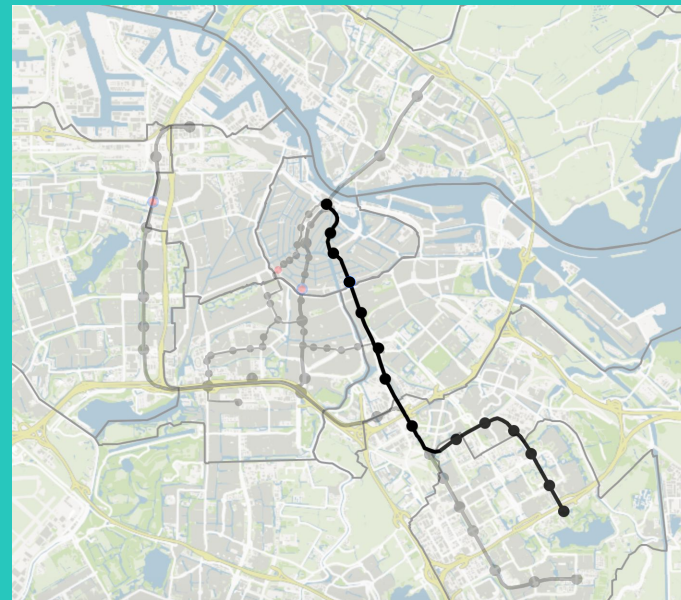
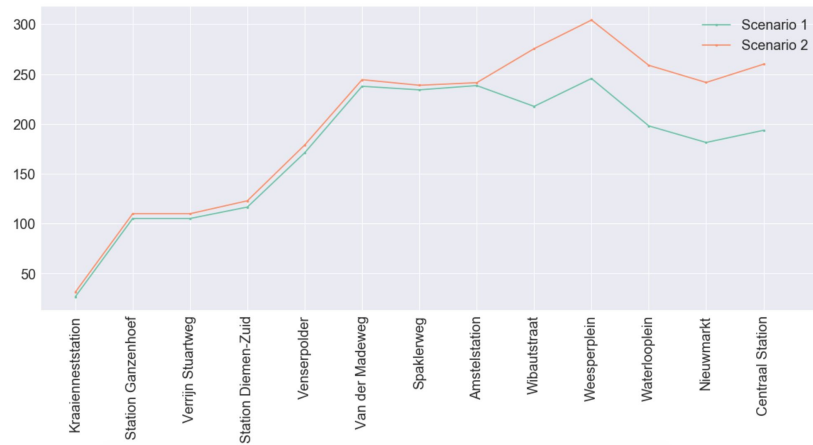


# Metro 52

## To Gaasperplas (08:03)



## To Centraal Station (08:33)



# Metro 53

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# Discussion

- **Data limitations**
    - Sub-trips
    - Origin and destination not matched
  - **Sub-network**
  - **Passenger behaviour**
  - **Contribution**
    - **GVB: critical lines and testing changes**
    - **Municipality: crowdedness as a result of changes**
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# Conclusion

- **Further research**
    - Apply this methodology to the complete network
    - Route choice behaviour research
    - What does **crowdedness** mean?
  - **Model offers a lot of opportunities and a clear baseline performance**
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# **Acknowledgements**

**Thank you for your  
attention.**