



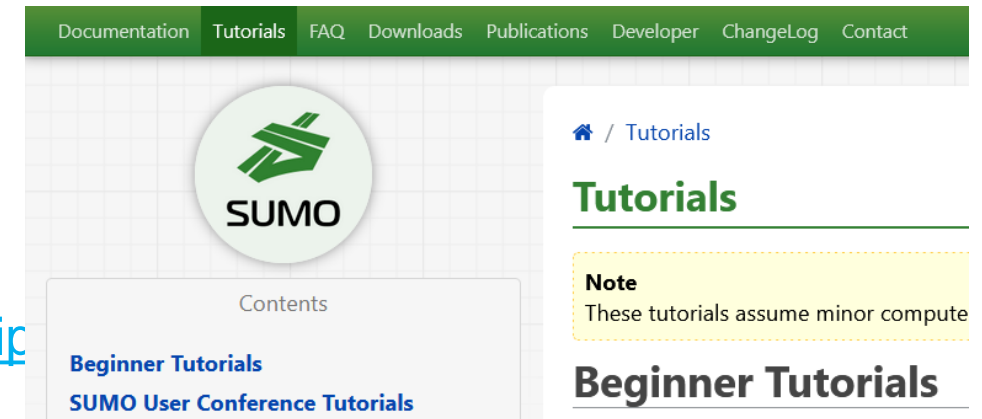
# SUMO Tutorial

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SUMO2024, Berlin

# Outline

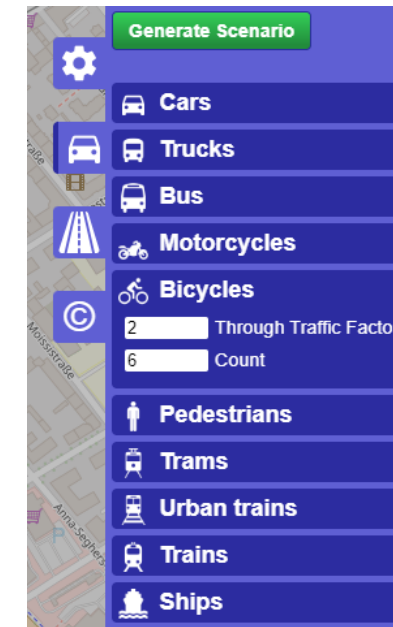


- 3-Click scenario generation with `osmWebWizard.py`
  - Investigation Scenario oddities
  - Pedestrian models
  - Flying Taxi
- 
- **Prerequisites**
    - SUMO 1.20.0
    - Python: [python.org/download/](https://python.org/download/)
    - Data files: [sumo.dlr.de/daily/sumo2024\\_tutorial.zip](https://sumo.dlr.de/daily/sumo2024_tutorial.zip)

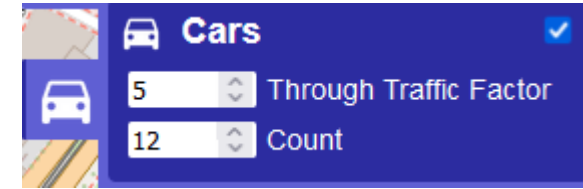


# osmWebWizard

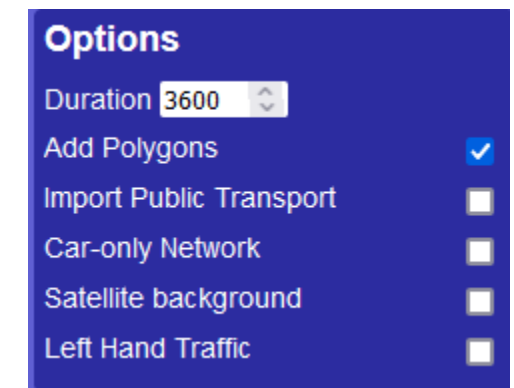
- [tools/osmWebWizard.py](https://tools/osmWebWizard.py)
- OpenStreetMap network data
- **Random traffic**
- Configure
  - Area
  - road types
  - Traffic modes
  - Traffic volume
  - Fraction of through-traffic
  - Public Transport
  - Scenario duration
  - Building Shapes and Points-of-Interest (cosmetic)
  - Satellite background (cosmetic?!)
- Generated files allow rebuilding and adapting the scenario
- Example data in `0_wizard`



# osmWebWizard - Options



- Random traffic
  - **Through traffic factor:** probability for starting / ending at the network boundary
  - **Count:** vehicles per hour per road km for this vehicle type
  - Extra features per mode:
    - Pedestrians:
      - network will have extra infrastructure (sidewalks, pedestrian crossings)
      - Urban setting will be assumed (default road speed limit 50km/h)
    - Ship: rivers, canals and ferry routes will be imported
    - Bicycle: import extra bike lanes
- Public transport
  - Import all public transport lines (trains, buses, ferries) and generate synthetic schedule
  - Pedestrians may also use public transport
- Car only: only keep passenger edges
  - + public transport if that option is active
- Satellite background: download tiles and **changes geo-projection**
  - “Web Mercator” is officially a bad projection (wrong distances)
- Lefthand: change right-of-way rules



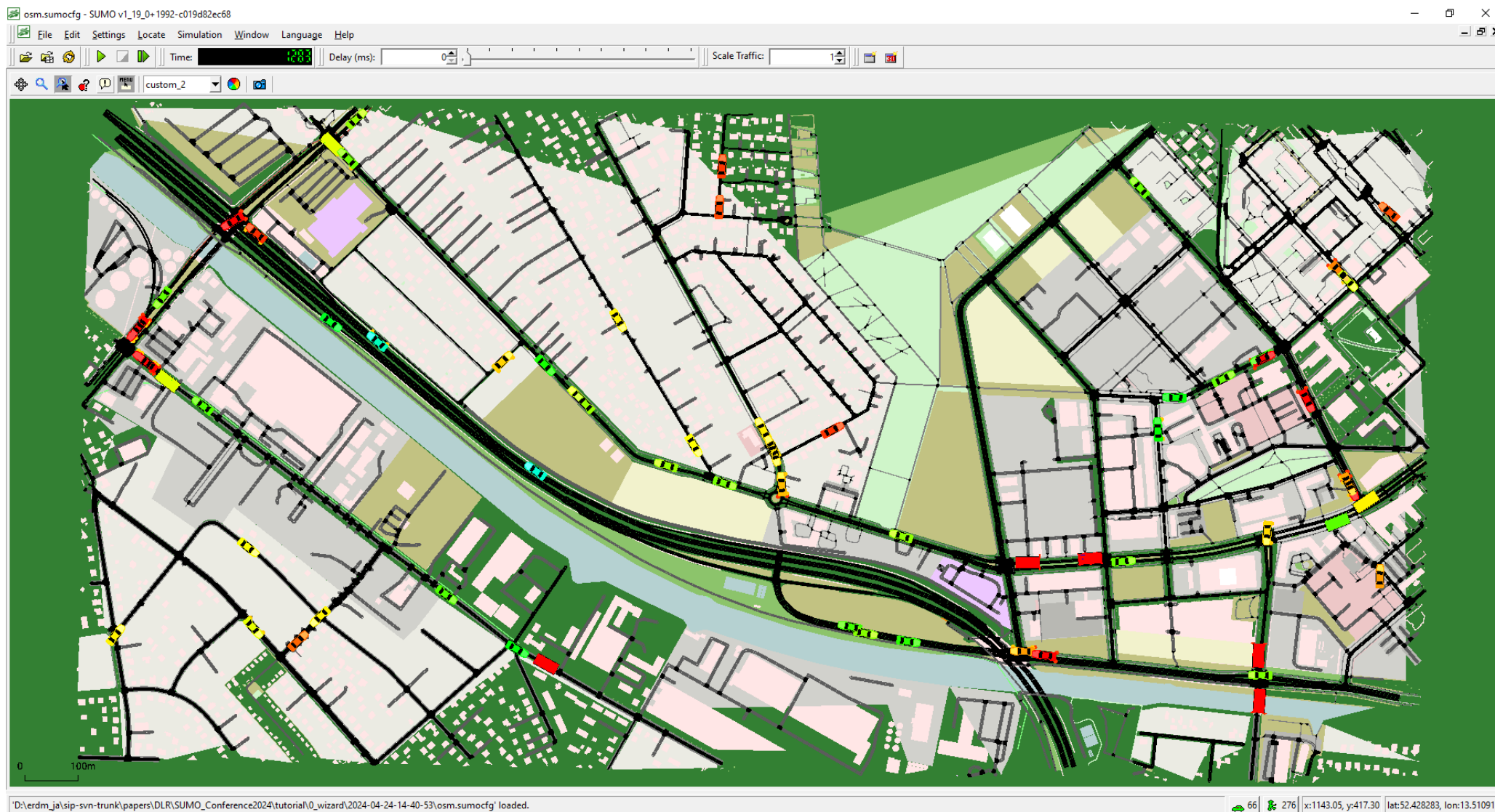
# osmWebWizard - Generated Files



- Scenario input
  - `osm.sumocfg`: configuration file (load with **sumo**, **sumo-gui**, **netedit**)
  - `osm.net.xml.gz`: simulation network
  - `osm.passenger.trips.xml`: cars (from-to)
  - `osm.pedestrian.rou.xml`: persons (intermodal travel plans)
  - `osm.poly.xml.gz`: building shapes and POIs
  - `osm.view.xml`: **sumo-gui** settings for delay, colors,...
- Rebuilding :
  - `osm_bbox.osm.xml.gz`: raw OSM data
  - `osm.netccfg`: rebuild network and stops (**netconvert**)
  - `osm.polycfg`: rebuild shapes (**polyconvert**)
  - `build.bat`: rebuilt traffic (cars, persons, public transport schedule)

folder: 0\_wizard

# osmWebWizard - Simulation





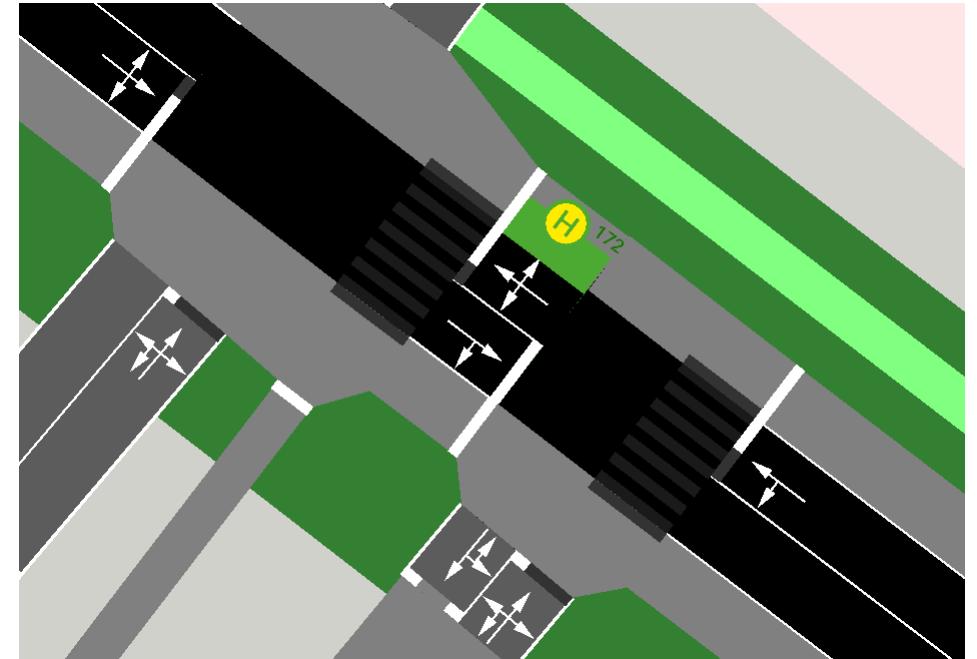
# osmWebWizard - Simulation



# Investigating Scenario Oddities

Warning: busStop '664609200' on lane '145586617#28\_1' is too short for vehicle 'pt\_bus\_172:1.0'.

- Underline words are clickable
- Stopping places currently cannot be placed on intersection
- Known issue, working as expected
- Typically won't affect simulation
  - only relevant when multiple buses stop simultaneously at the same busStop and would find enough space in reality

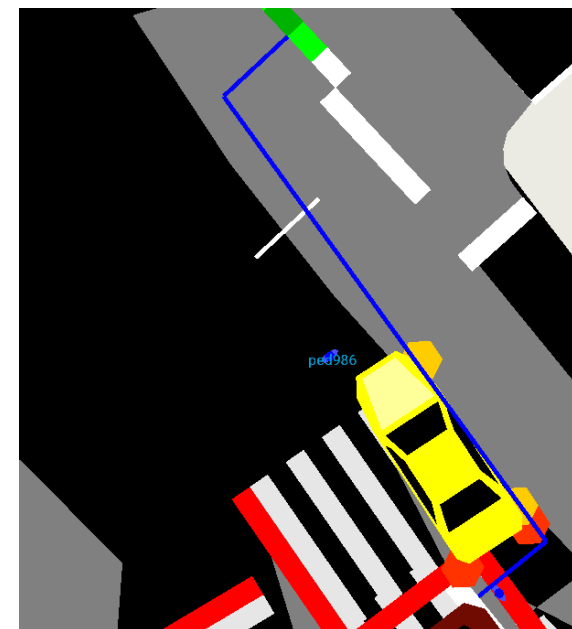
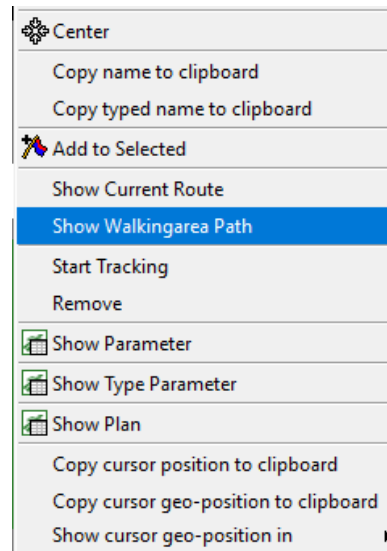




# Investigating Scenario Oddities

Warning: Person 'ped986' is jammed on edge ':cluster\_10765646267\_...\_#5more\_w0', time=3409.00.  
Warning: Person 'ped963' is jammed on edge ':cluster\_10765646267\_...\_#5more\_w0', time=3428.00.  
Warning: Person 'ped988' is jammed on edge ':cluster\_10765646267\_...\_#5more\_w0', time=3430.00.  
Warning: Person 'ped981' is jammed on edge ':cluster\_10765646267\_...\_#5more\_w0', time=3439.00.

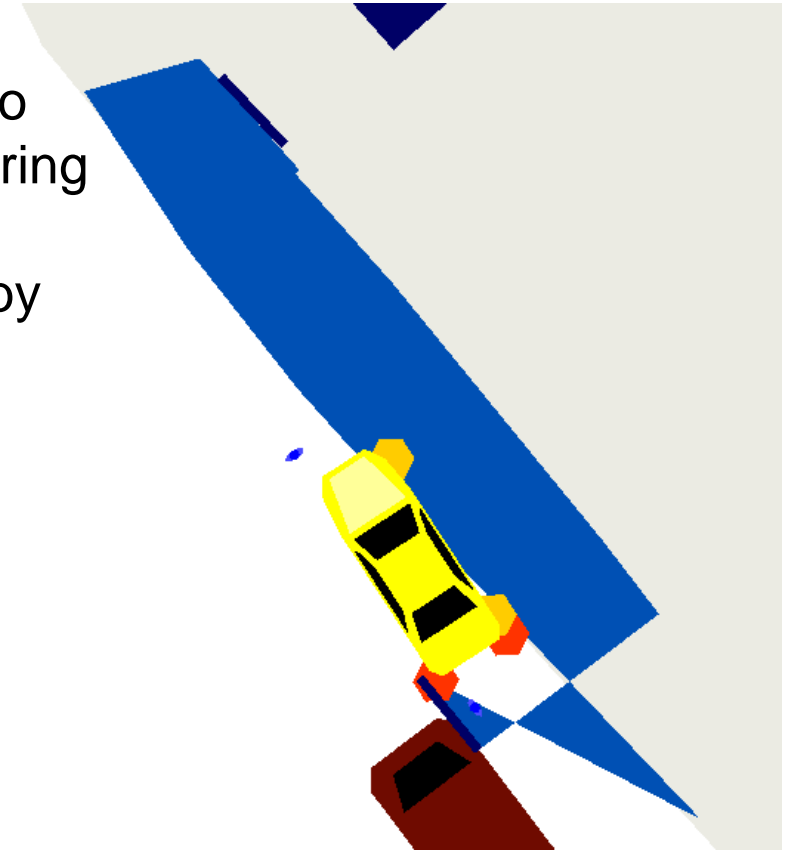
- Click on the underline time sets a breakpoint 5s before that time
  - breakpoint offset configurable in Settings->Application Settings (Ctrl+H)
- Reload + run simulation to forward to that time (Ctrl+R, S), **set delay to 0**



# Investigating Scenario Oddities

Warning: Person 'ped986' is jammed on edge ':cluster\_10765646267\_...\_#5more\_w0', time=3409.00.

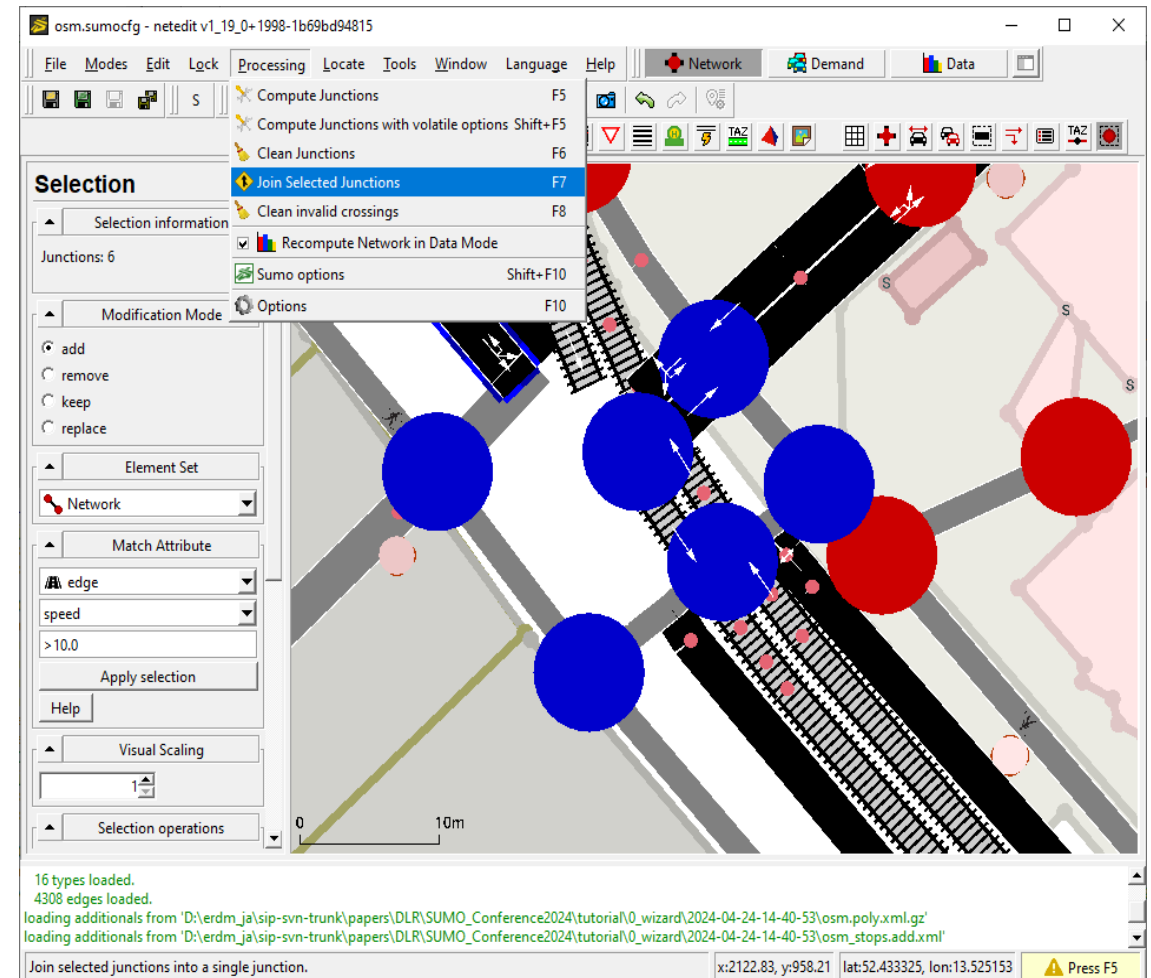
- Activate 'show-route' for that person
- Set edge coloring to "by selection" and select the warning area to better understand the geometry (Ctrl+J disables junction rendering and permits clicking on the walking area)
- Person on walking area that constitutes shared space (shared by right-turning traffic)
- Route consists of walking area -> shortEdge -> walking area -> crossing
  - shortEdge is narrower than the rest -> blocks pedestrian movement
- Walking area shape is broken
- Root cause is a malformed junction cluster
  - Correction with netedit



# Investigating Scenario Oddities - Mitigation

- Goal: Join “broken” junction cluster into a single well-shaped junction
  - Ctrl+T opens netedit
  - Selection mode (S)
  - Click on junctions that “belong” to the intersection
  - Join (F7)

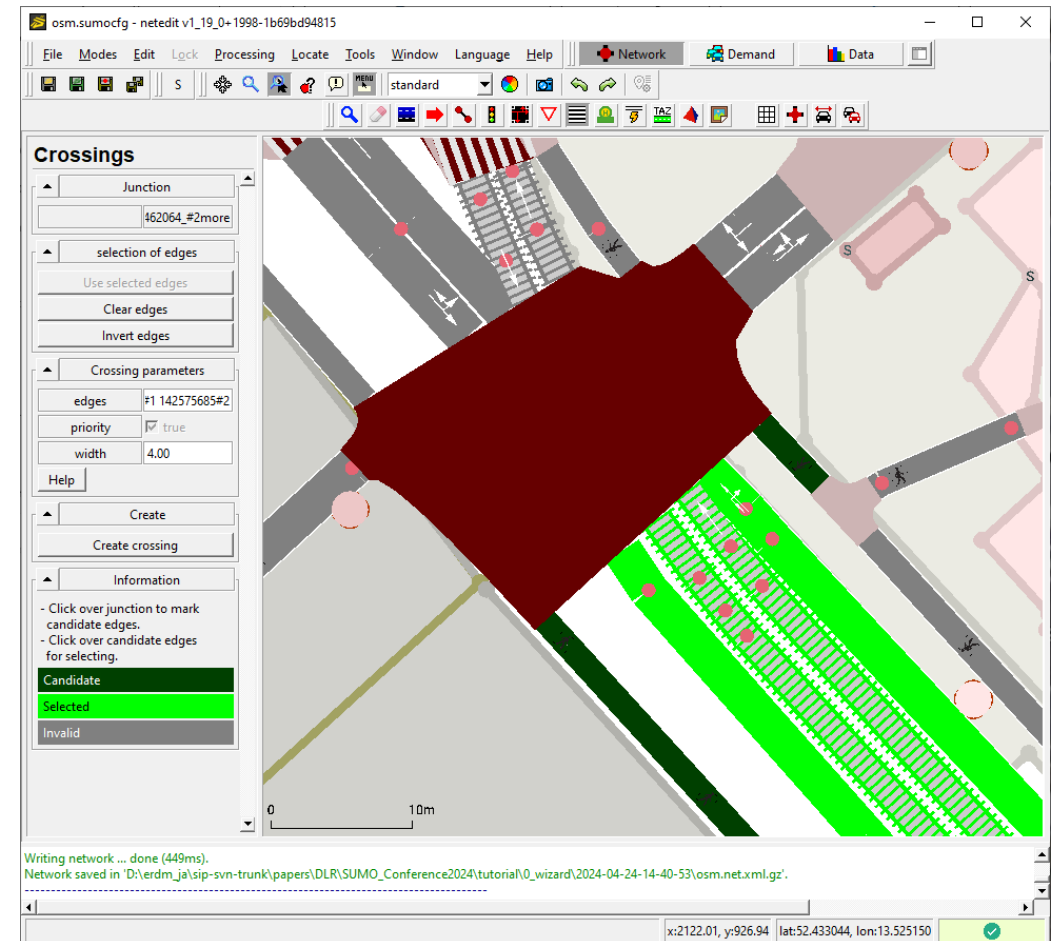
folder: 1\_netedit



# Investigating Scenario Oddities - Mitigation

- Goal: restore crossing after joining junction
  - Crossing mode (R)
  - Click on junction
  - Click on edges to be crossed
  - <ENTER>
  - Save Ctrl+S
- Rebuild traffic demand with **build.bat**
  - Make sure sumo-gui is closed

folder: 1\_netedit



# Investigating Scenario Oddities – Missed Bus



Warning: Person 'ped774' aborted waiting for 160:0 at busStop '837696912'.  
Warning: Person 'ped634' aborted waiting for 172:1 at busStop '664609198'.  
Warning: Person 'ped253' aborted waiting for M17:2 at busStop '1704693369'.  
Warning: Person 'ped306' aborted waiting for M17:2 at busStop '1704693369'.  
Warning: Person 'ped260' aborted waiting for M17:2 at busStop '1704693369'.  
Warning: Person 'ped468' aborted waiting for M17:2 at busStop '1704693369'.  
Warning: Person 'ped588' aborted waiting for M17:2 at busStop '1704693369'.  
Warning: Person 'ped584' aborted waiting for M17:2 at busStop '1704693369'.

- When only waiting persons remain and all buses have left, the simulation terminates
  - These persons missed their buses for some reason
- Find **ped774** in **osm.pedestrian.rou.xml**

```
<person id="ped774" type="ped_pedestrian" depart="2519.86">  
  <walk edges="872231977#3 ... 883118225#5" busStop="837697182"/>  
  <ride busStop="837696912" lines="160:0" intended="pt_bus_160:0.5" depart="3156.00"/>  
  <walk edges="887860359#2 ... 224769565"/>  
</person>
```

folder: 2\_catch\_bus

# Investigating Scenario Oddities – Missed Bus



Warning: Person 'ped774' aborted waiting for 160:0 at busStop '837696912'.

```
<ride busStop="837696912" lines="160:0" intended="pt_bus_160:0.5" depart="3156.00"/>
```

- Data-driven analysis: what went wrong with the walk to the busStop?
  - Run simulation with tripinfo-output:

```
sumo -c osm.sumocfg --tripinfo-output tripinfos.xml
```

```
<personinfo id="ped774" depart="2519.86" type="ped_pedestrian" speedFactor="0.77">  
  <walk depart="2520.00" departPos="0.00" arrival="3187.00" arrivalPos="2.51,,  
    duration="667.00" routeLength="638.43" timeLoss="71.27" maxSpeed="1.07"/>  
  <access stop="837697182" depart="3187.00" arrival="3201.00" duration="14.00,,  
    routeLength="15.25"/>  
  <ride waitingTime="4638.00" vehicle="NULL" depart="-1" arrival="-1" arrivalPos="-1,,  
    duration="-1" routeLength="-1" timeLoss="-1"/>  
  <walk depart="-1" departPos="13.02" arrival="-1" arrivalPos="-1" duration="-1,,  
    routeLength="-1" timeLoss="0.00" maxSpeed="1.07"/>  
</personinfo>
```

- Late by 45s
- Person walks slower than average: random speed factor from  $\mathcal{N}(\mu = 1, \sigma^2 = 0.1)$
- Also loses 71 seconds during walking (--pedestrian.striping.dawdling 0.2)

folder: 2\_catch\_bus



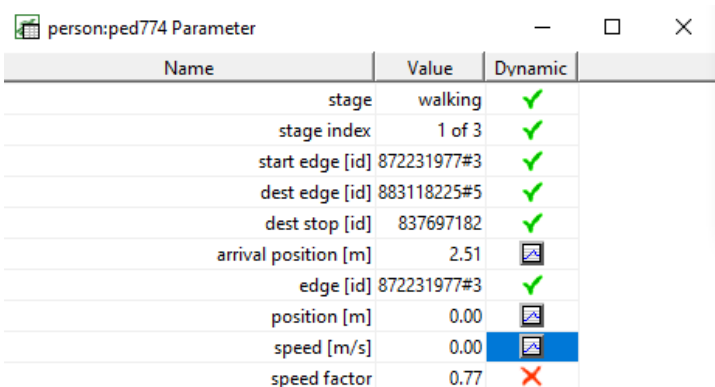
# Investigating Scenario Oddities – Missed Bus



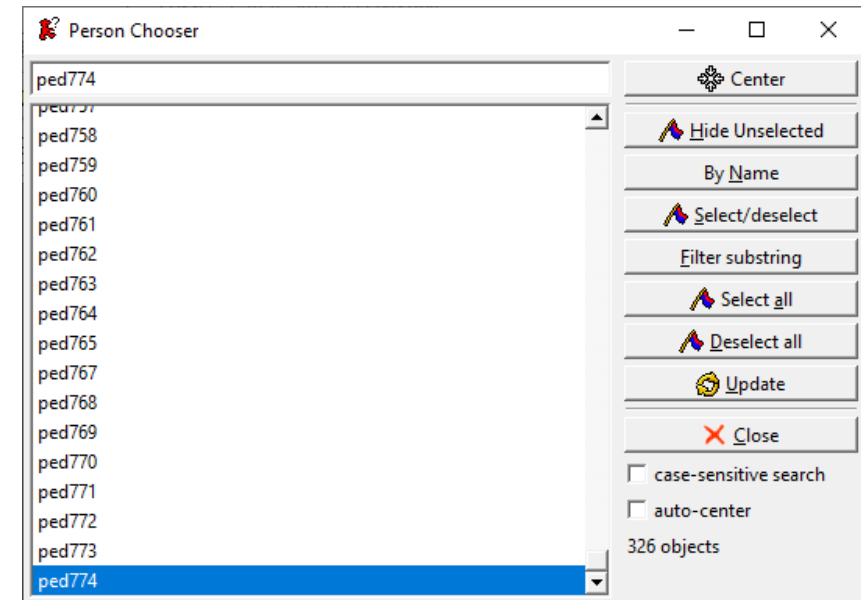
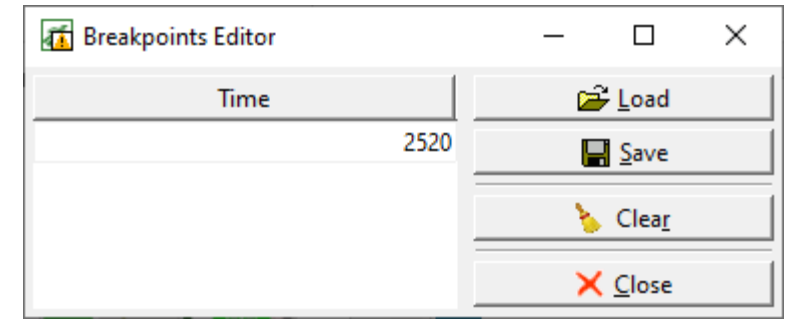
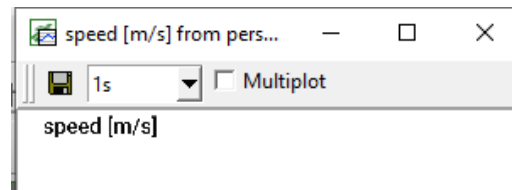
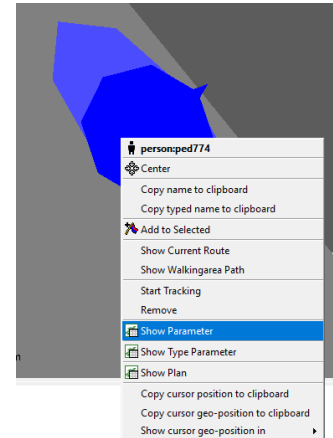
Warning: Person 'ped774' aborted waiting for 160:0 at busStop '837696912'.

```
<ride busStop="837696912" lines="160:0" intended="pt_bus_160:0.5" depart="3156.00"/>
```

- Visual analysis: what went wrong with the walk to the busStop?
  - Run simulation with sumo-gui
  - Forward to depart of ~ time=2520 (Ctrl+B)
  - Find person in locate-dialog (Shift+P)
    - Button: Center
  - Show person properties
  - “Start Tracking”



Name	Value	Dynamic
stage	walking	✓
stage index	1 of 3	✓
start edge [id]	872231977#3	✓
dest edge [id]	883118225#5	✓
dest stop [id]	837697182	✓
arrival position [m]	2.51	📍
edge [id]	872231977#3	✓
position [m]	0.00	📍
speed [m/s]	0.00	📍
speed factor	0.77	✗



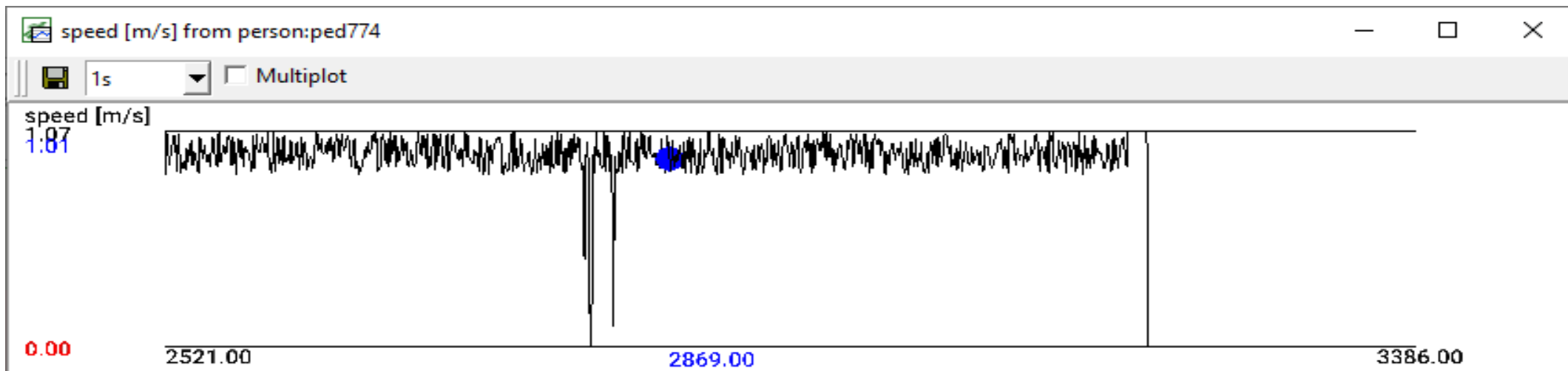
# Investigating Scenario Oddities – Missed Bus



Warning: Person 'ped774' aborted waiting for 160:0 at busStop '837696912'.

- Visual analysis: what went wrong with the walk to the busStop?
- Nothing went wrong. Person walks with ~ 90% of 77% of 1.39m/s
  - Should have planned better
  - a) `randomTrips.py -persontrip.walkfactor 0.65` (default 0.75)
  - b) `load osm.pedestrian.trips.xml` (plan intermodal route in simulation where speedFactor is known)
  - c) send another bus: `ptlines2flows.py -e 4800`

Name	Value	Dynamic
stage	walking	✓
stage index	1 of 3	✓
start edge [id]	872231977#3	✓
dest edge [id]	883118225#5	✓
dest stop [id]	837697182	✓
arrival position [m]	2.51	✗
edge [id]	872231977#3	✓
position [m]	0.00	✗
speed [m/s]	0.00	✗
speed factor	0.77	✗



folder: 2\_catch\_bus

# Investigating Scenario Oddities – Missed Bus

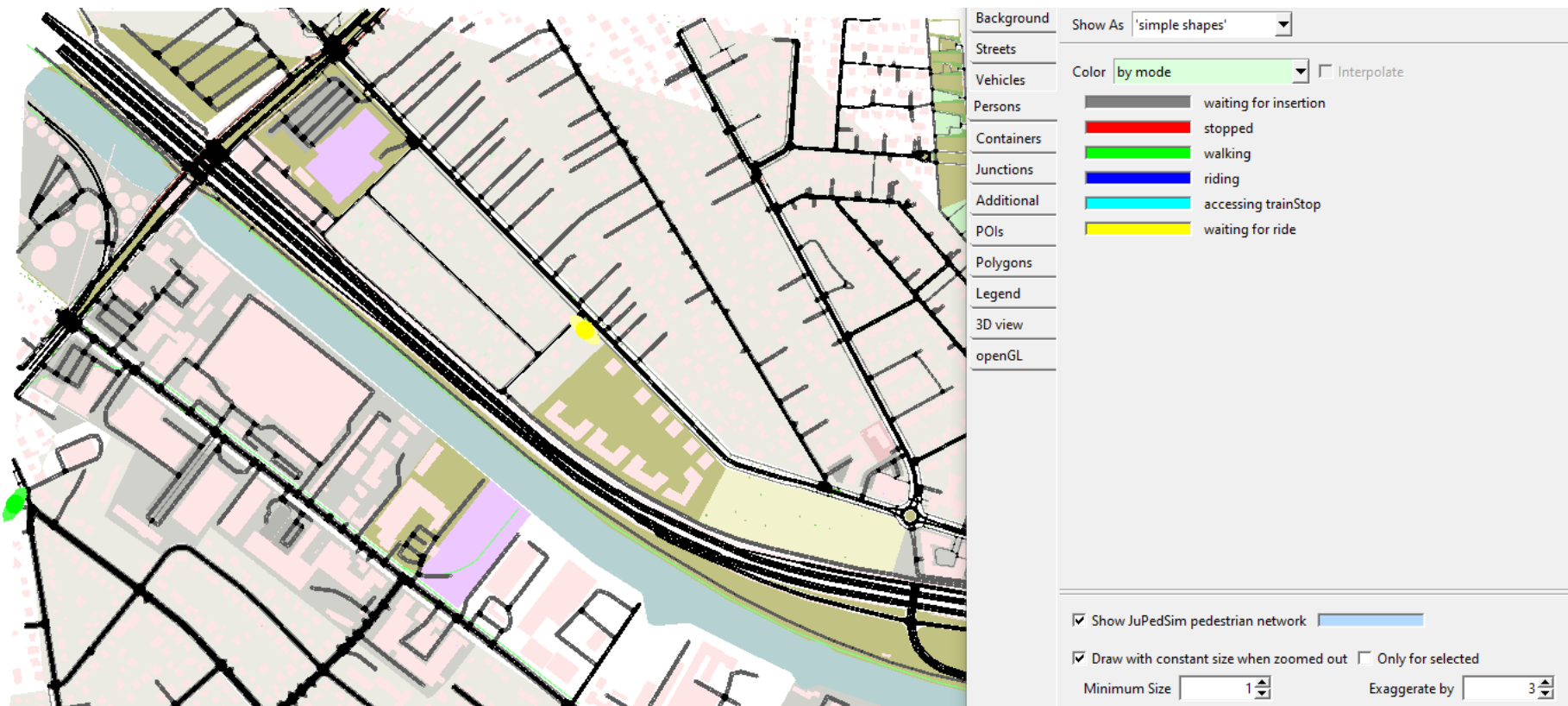


- Originally 712 rides and 9 aborted (missed bus), see **simlog1.txt**
- Mitigation attempt a) – uses **build2.bat**
  - ped774 catches the bus, but 8 other persons miss it
  - Total of 737 rides, **simlog2.txt**
- Mitigation attempt b) – uses **build3.bat** and **2.sumocfg**
  - cannot load `osm.pedestrian.trips.xml` directly (contains the full rather than the validated list) -> adding option `-validate` in **build3.bat**
  - ped774 and many others catch the bus, but 2 other persons still miss it
  - Total of 667 rides, **simlog3.txt**
- Mitigation attempt c) – uses **build4.bat**
  - ped774 and many others catch the bus, but 1 other persons still miss it
  - Total of 958 rides, see **simlog4.txt**
  - Sending even more buses solves the problem (1033 rides)

# Investigating Scenario Oddities – Late end

Simulation ended at time: 7836.00. (All vehicles have left the simulation.)

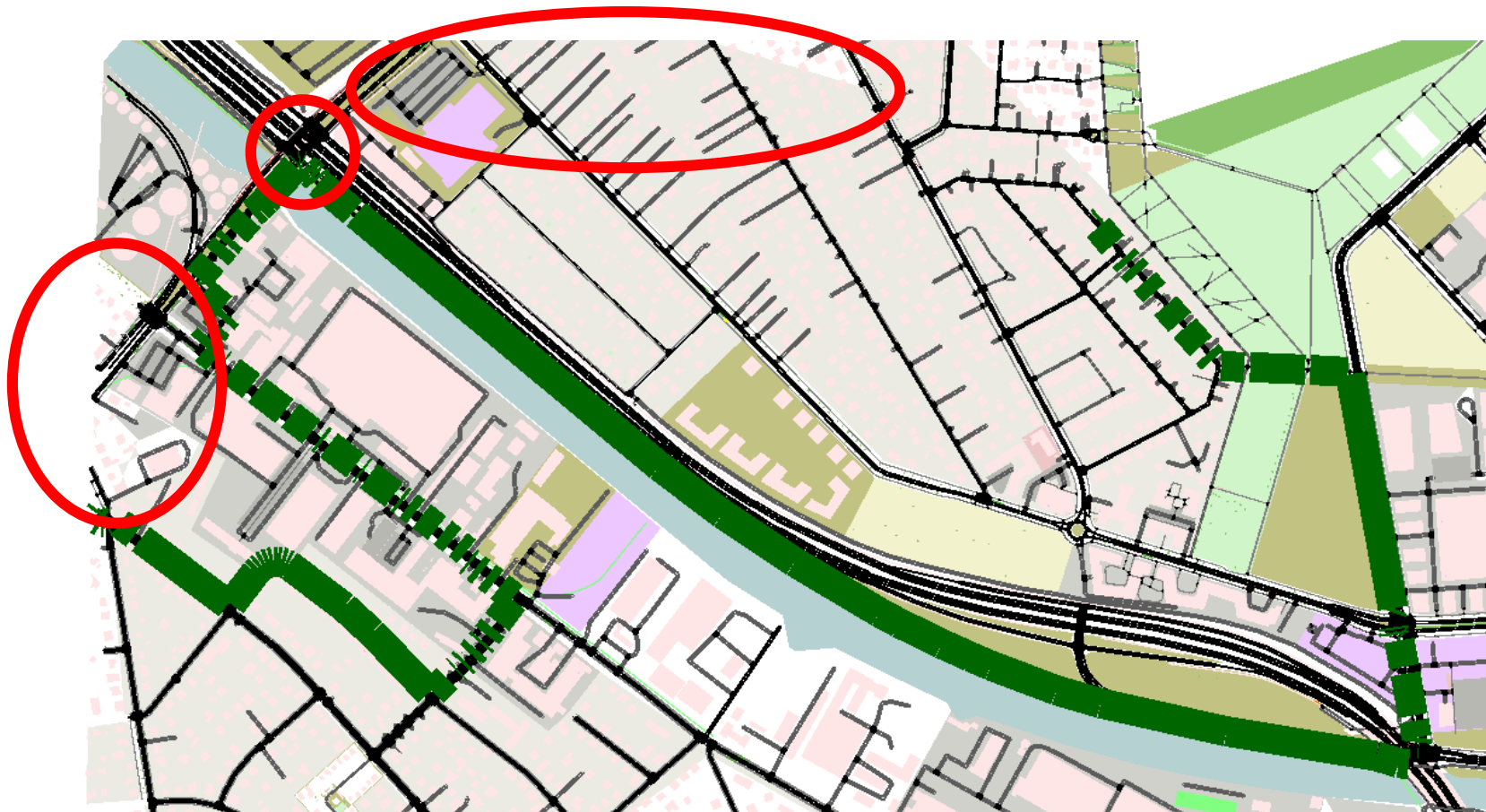
- Why does the simulation take so long?! Demand was generated for 1 hour
  - Either look into tripinfo-output for the last arrivals (that didn't abort their plans)
  - Or use sumo-gui to see who is still active 5 seconds before simulation end



# Investigating Scenario Oddities – Late end

Simulation ended at time: 7836.00. (All vehicles have left the simulation.)

```
<personinfo id="ped1100" depart="3581.20" type="ped_pedestrian" speedFactor="1.01">  
  <walk depart="3582.00" departPos="0.00" arrival="7071.00" arrivalPos="6.30"  
duration="3489.00" routeLength="4310.26" timeLoss="409.94" maxSpeed="1.40"/>
```



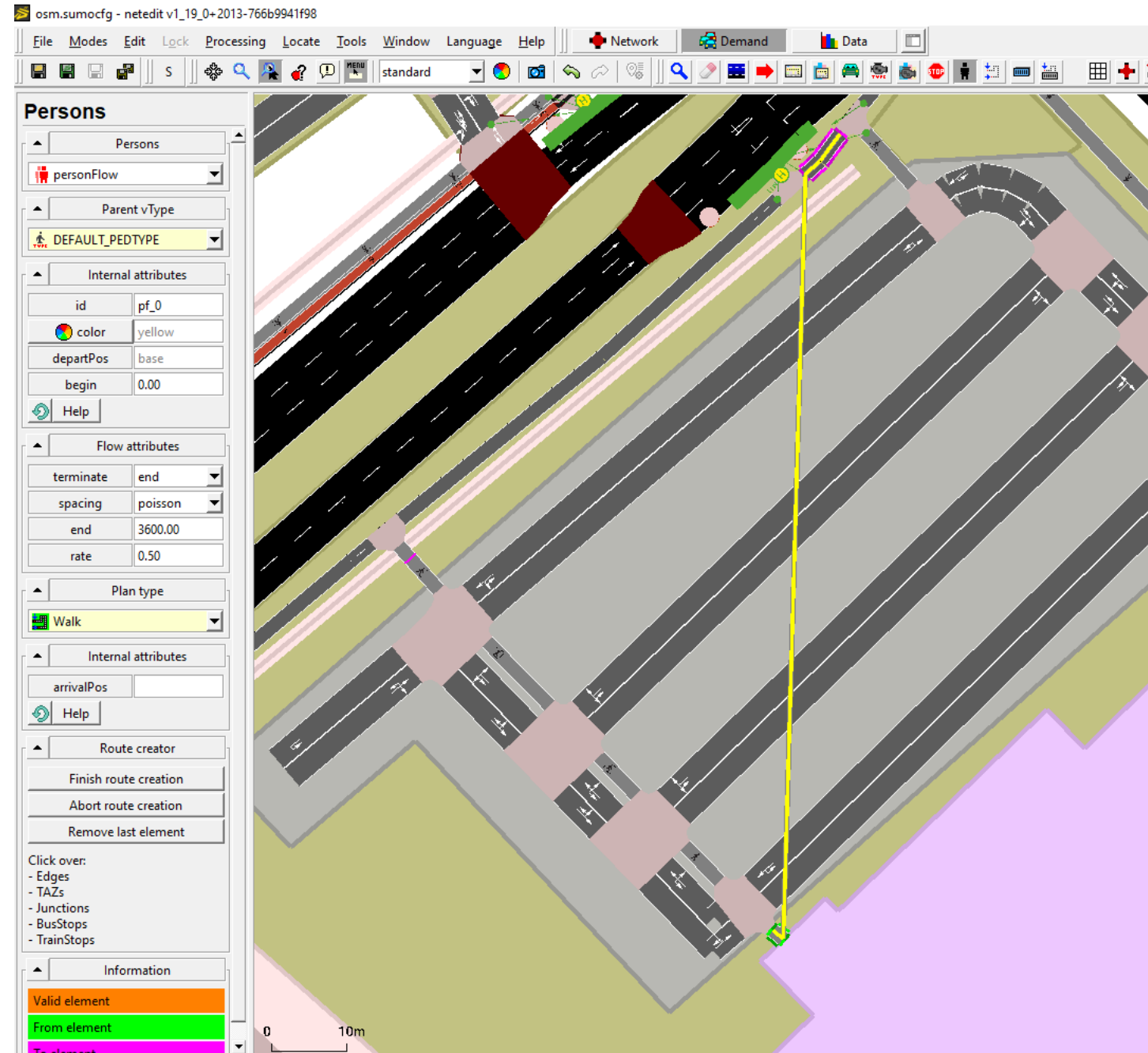
- The canal / bridges force detours
- Network cut underestimates connectivity
- Connectivity problem in the pedestrian network (missing crossing)



# Pedestrian Models

- Scenario: Spring sale of gardening supplies at the hardware store
- Personflow between Entrance and busStop
- Demand mode (F3)
- Person mode (P)
- Define personFlow with a walking-stage (one per direction)

folder: 3\_pedestrian\_models

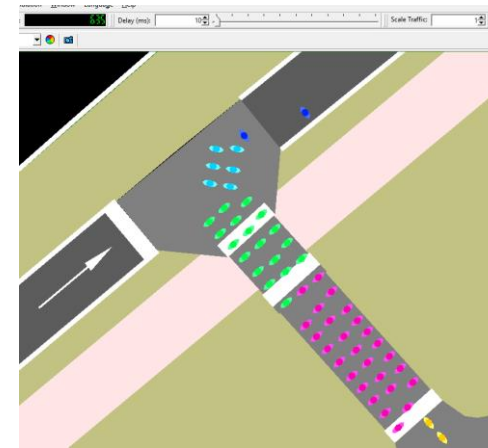




# Pedestrian Models

- (1.sumocfg) Default settings (“striping” model):
  - All persons from a flow use the same route
  - Big jam after ~10min
- (2.sumocfg) Option **--weights.random-factor 2**
  - Persons spread over the whole parking lot
  - Big jam after ~25min
- (1b, 2b.sumocfg) Option **--pedestrian.striping.reserve-oncoming 0.34**
  - Does not jam (but may, stochastically)

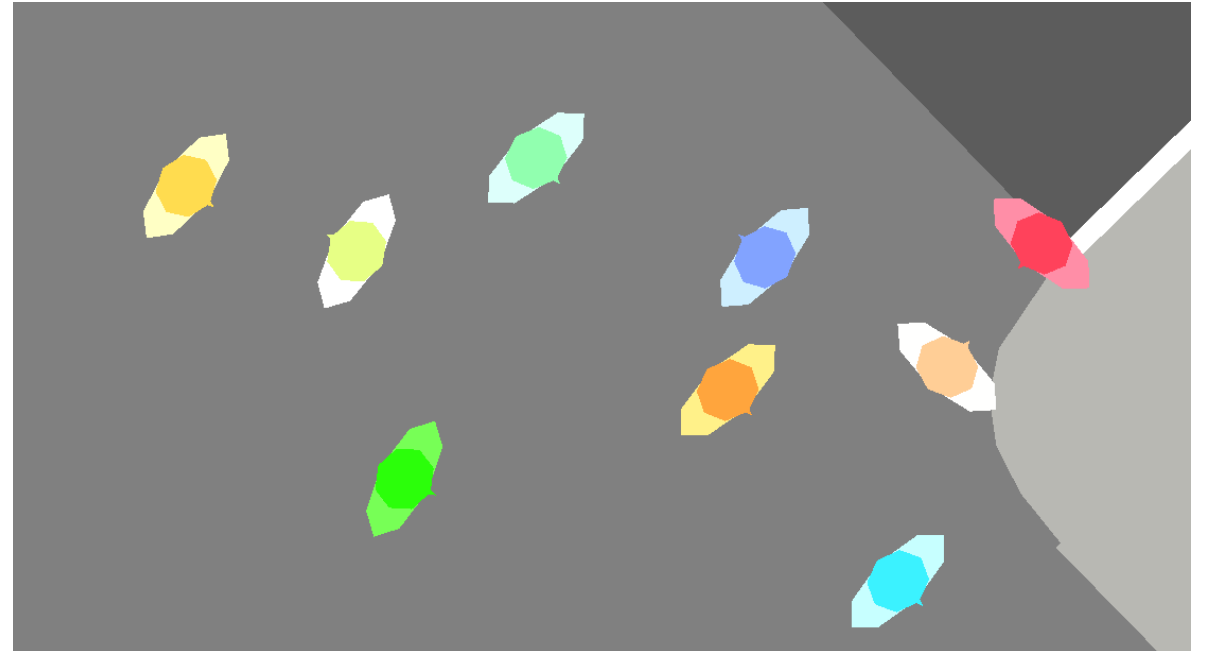
folder: 3\_pedestrian\_models



# Pedestrian Models



- (3.sumocfg) Option **--pedestrian.model jupedsim**
  - Does not jam!
  - Performance depends on total network size so it's better to only simulate the area of interest
  - Its slow (10x realtime whereas striping has ~6000x realtime speed here, 1000x if jammed)
  - **Not yet interacting with cars and traffic lights**
- (4.sumocfg) jupedsim with Option **--weights.random-factor 2**
  - You get to see social forces at play

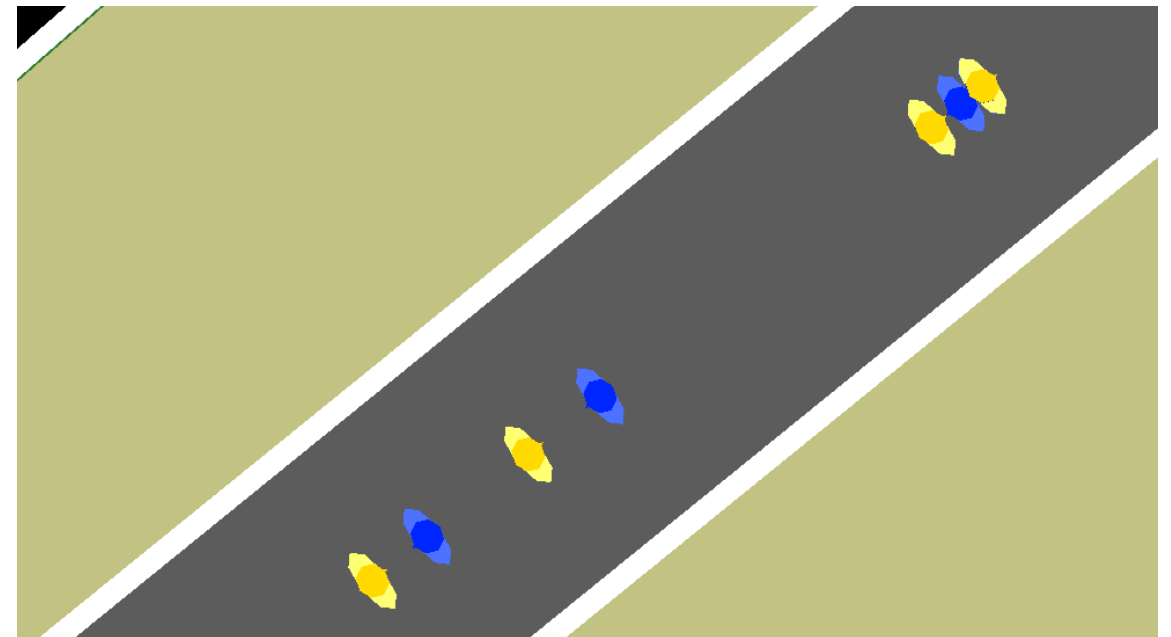


folder: 3\_pedestrian\_models

# Pedestrian Models



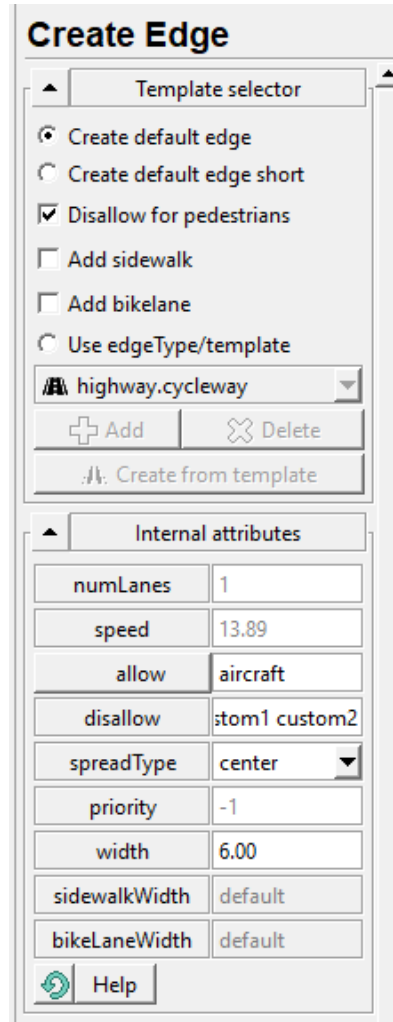
- (5.sumocfg) Option **--pedestrian.model nonInteracting**
  - At least 10 times faster than striping
  - Pedestrians jump over junctions
  - Not interacting with anything
  - Does not jam!
  - Mainly useful for connecting person stages with a rough estimate of walking time if the walking itself is not of interest



folder: 3\_pedestrian\_models

# Flying Taxis (!!!)

- Scenario has several obstacles that force detours (canal, motorway)
- Ideal testbed for futuristic mobility
- Step 0: remove taxi permissions from the network (we only want air taxi)
  - Use **buildnet.bat** (calls tools/net/patchVClasses.py)
  - Needed because taxis in sumo do not support other vClasses (i.e. aircraft yet)
- Step 1: Define take-off/landing zones
  - Create edge mode (E)
  - Edges that allow **aircraft** taxi
  - Save network



**Create Edge**

Template selector

- ☒ Create default edge
- ☐ Create default edge short
- ☒ Disallow for pedestrians
- ☐ Add sidewalk
- ☐ Add bikelane
- ☐ Use edgeType/template

highway.cycleway

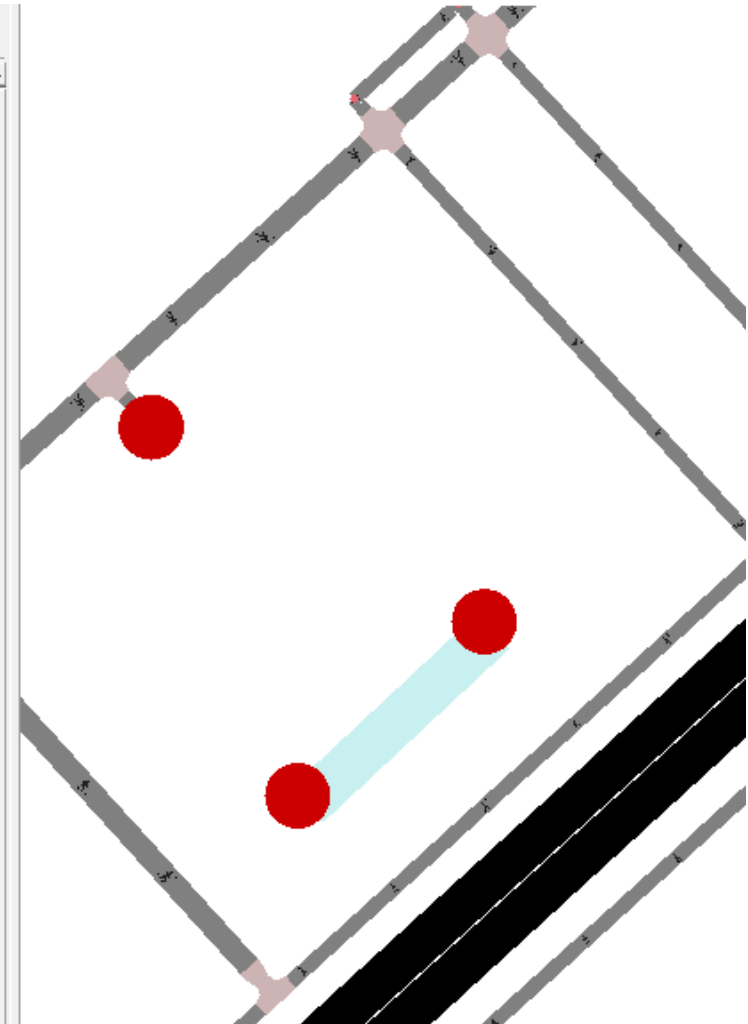
+ Add - Delete

Create from template

Internal attributes

numLanes	1
speed	13.89
allow	aircraft
disallow	stom1 custom2
spreadType	center
priority	-1
width	6.00
sidewalkWidth	default
bikeLaneWidth	default

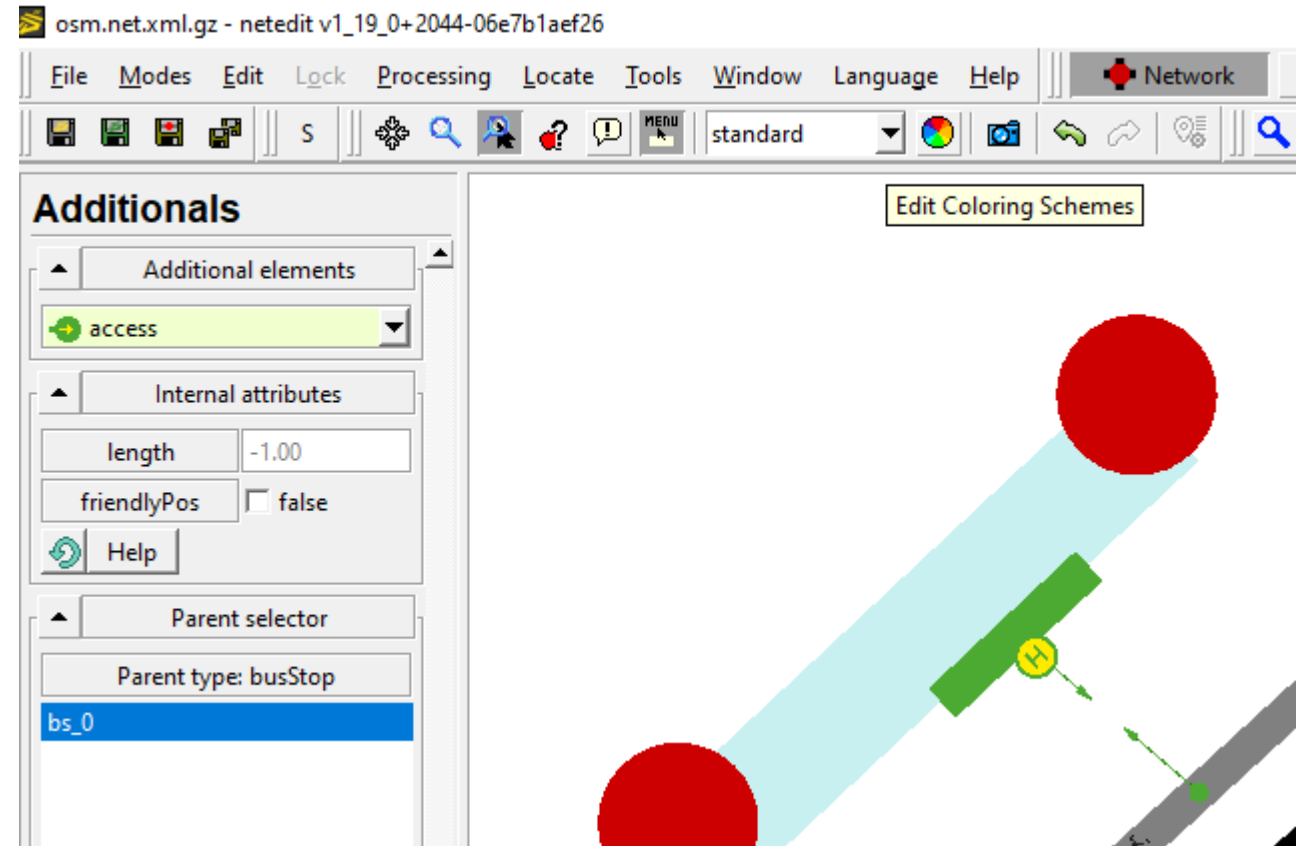
Help



folder: 4\_flying\_taxi

# Flying Taxis

- Step2: Define “busStop” and connect to the pedestrian network
  - Additional mode (A)
  - busStop on each aircraft edge
  - Access for each busStop
  - Save (Ctrl+Shift+A)



folder: 4\_flying\_taxi

# Flying Taxis

- Step 3: patch the network so that there is a point-to-point connection between each pair of airbases
  - run **buildnet.bat** (uses tool **net/buildFullGraph.py**)






folder: 4\_flying\_taxi



# Flying Taxis

- Step 4: define a service of air taxis
  - Demand mode (F3)
  - Type mode (T)
  - Vehicle mode (V)
  - Edit vehicle parameters to turn them into taxis
  - Save route file

 Edit vType

Vehicle Type attributes			
vClass	 taxi	guiShape	 aircraft
id	airtaxi	probability	1.00
color		personCapacity	4
length	6.00	containerCapacity	0
minGap	2.50	boardingDuration	0.50
maxSpeed	27.78	loadingDuration	90.00
desiredMaxSpeed	2777.78	latAlignment	center
speedFactor	normc(1.00,0.05,0.20,2.00)	minGapLat	0.12
emissionClass	HBFA3/PC_G_EU4	maxSpeedLat	1.00
width	6.00	actionStepLength	0.00

**Types**

Type Editor

Create Type

Delete Type

Copy Type

Current Type

airtaxi

Internal attributes

id	airtaxi
typeDist.	
vClass	aircraft
color	
length	5.00
minGap	2.50
maxSpeed	27.78



**Edit parameters**

Parameters		
key	value	
has.taxi.device	true	✗
device.taxi.end	7200	✗
		+

Operations

Sort

Clear

Load

Save

Help

accept cancel reset

folder: 4\_flying\_taxi

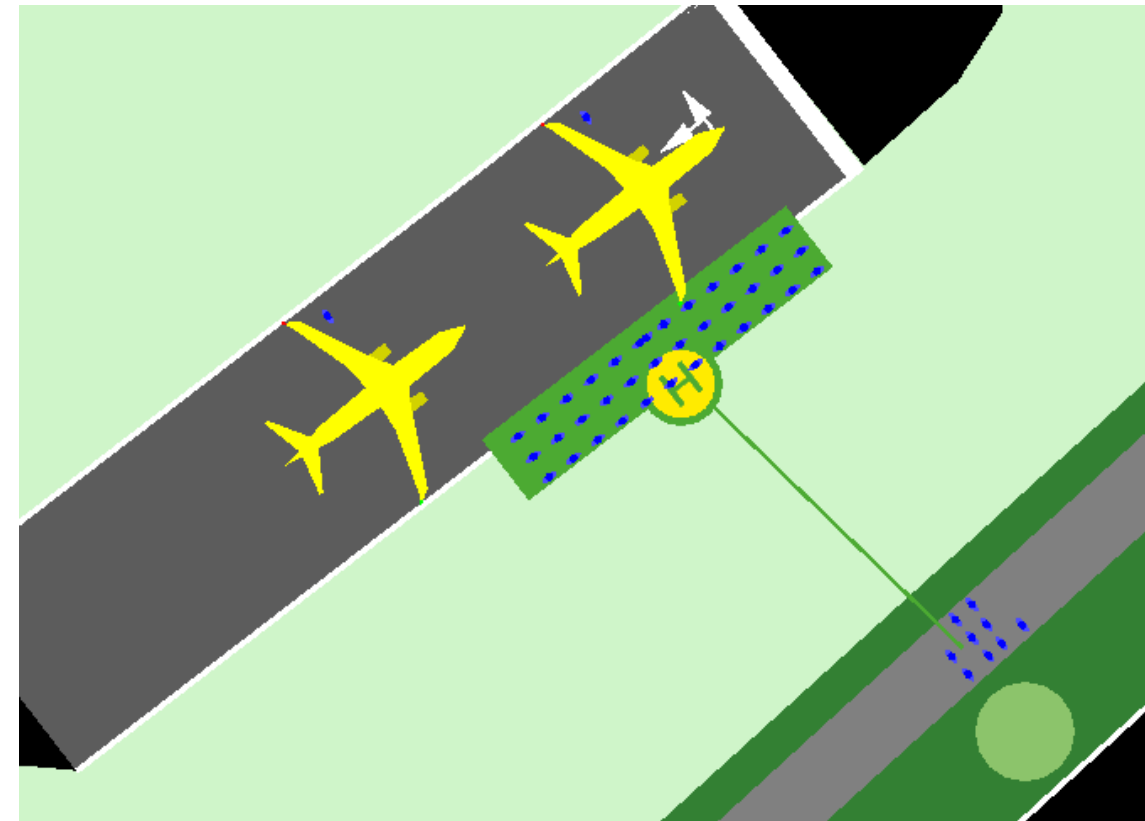
- Step 5: adapt the multimodal trip definitions to make use of the taxi service: (**build.bat**) :
  - `--trip-attributes "modes=\"public taxi\""`
  - `--additional-files`  
`osm_stops.add.xml,osm_pt.rou.xml,airstops.add.xml`
  - Define transfer locations:
    - `--duarouter-persontrip.transfer.walk-taxi ptStops`
    - `--duarouter-persontrip.transfer.taxi-walk ptStops`
  - Also patch network file name
  - Run **build.bat**

folder: 4\_flying\_taxi

# Flying Taxis



- User acceptance is good: ~30% of persons use the new airtaxi
- Service quality is bad: 3 airtaxis with 1 passenger per flight provides insufficient capacity
  - Aborted: 239, also jams
- Use ride-pooling! (**2.sumocfg**)
  - `--persontrip.default.group g0`
  - Aborted: 12
  - Ride-WaitingTime: 552.23
- Use smarter dispatch (**3.sumofg**)
  - `dispatch-algorithm greedyCloest`
  - Aborted: 3
  - Ride-WaitingTime: 350.26

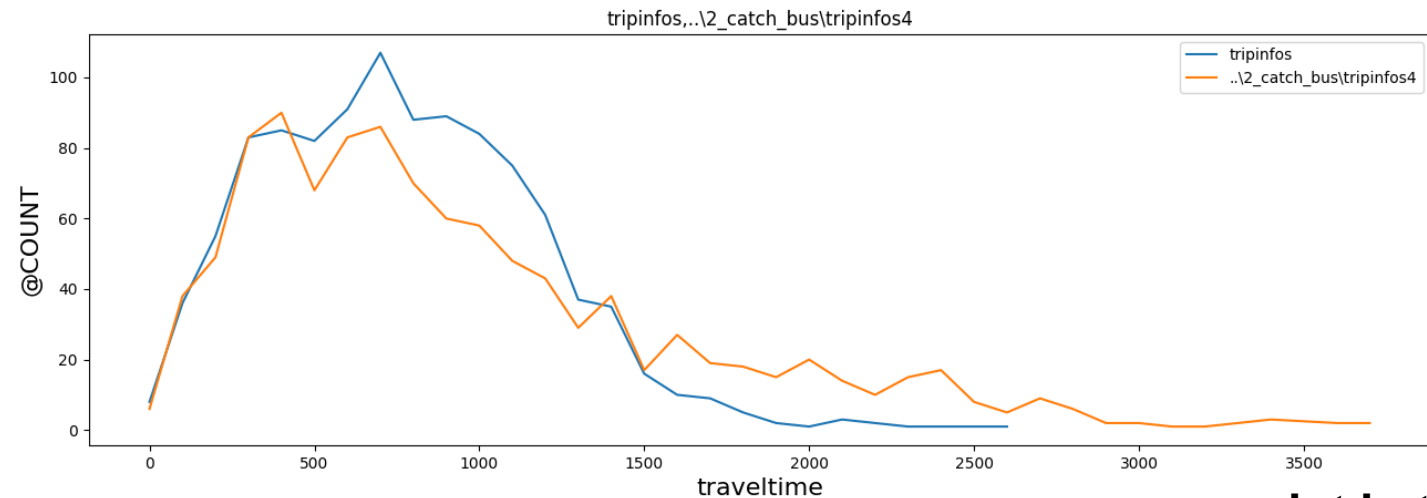


folder: 4\_flying\_taxi

# Flying Taxis - Results



- `tools\output\attributeStats.py tripinfos.xml -e personinfo -a traveltime`
- without flying taxis (2\_catch\_bus variant 4):
  - personinfo traveltime: count 1064, min -1.00 (ped634), max 3794.00 (ped986), mean 1021.18, Q1 502.00, median 840.00, Q3 1354.00, stdDev 688.93
- With flying taxis (4.sumocfg)
  - personinfo traveltime: count 1064, min -1.00 (ped1048), max 2637.00 (ped976), mean 812.55, Q1 498.00, median 785.00, Q3 1083.00, stdDev 401.08



folder: 4\_flying\_taxi

plot.bat

# Conclusion

- Use netedit to discover all the extra tools
- Use [tools/osmWebWizard.py](#) to get a quick start
- Read the documentation / FAQ at <http://sumo.dlr.de/docs>
- Report any bugs you find to [sumo-user@eclipse.org](mailto:sumo-user@eclipse.org)
- Share your scenarios and results
- Talks to us. We are always looking for project partners! [sumo@dlr.de](mailto:sumo@dlr.de)

