Lanelet2 Maps

Communitech/AVIN Project Summary

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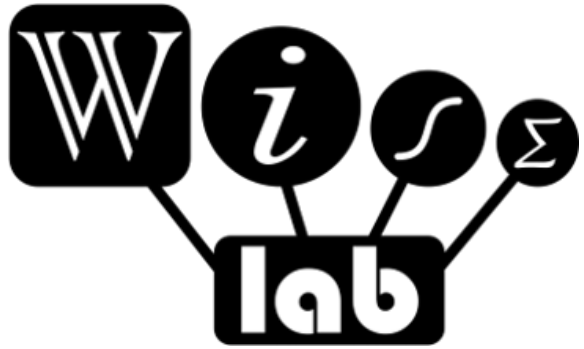
2022-03-08



Phase 1: Map generation

Goal: "Develop semi-automated procedure to translate Ecopia HD Map into Lanelet2 format"

- Developed an iterative three-step approach

1. Map design using QGIS and tagging using "lanelet2_utils" script
   - Tagging stores Lanelet2 structure using JSON annotations and incrementally modifies the resulting Lanelet2 map, which allows for testing
2. Map preparation using QGIS toolbox and our custom algorithms
   - Densifying features (adding points at a set minimum interval, e.g., 10 m)
   - Setting elevation from raster or other sources
   - Creates temporary layers
3. Map generation using "lanelet2_utils" script
   - Recreates Lanelet2 map from scratch using the JSON annotations as a guide

1. Map design using QGIS

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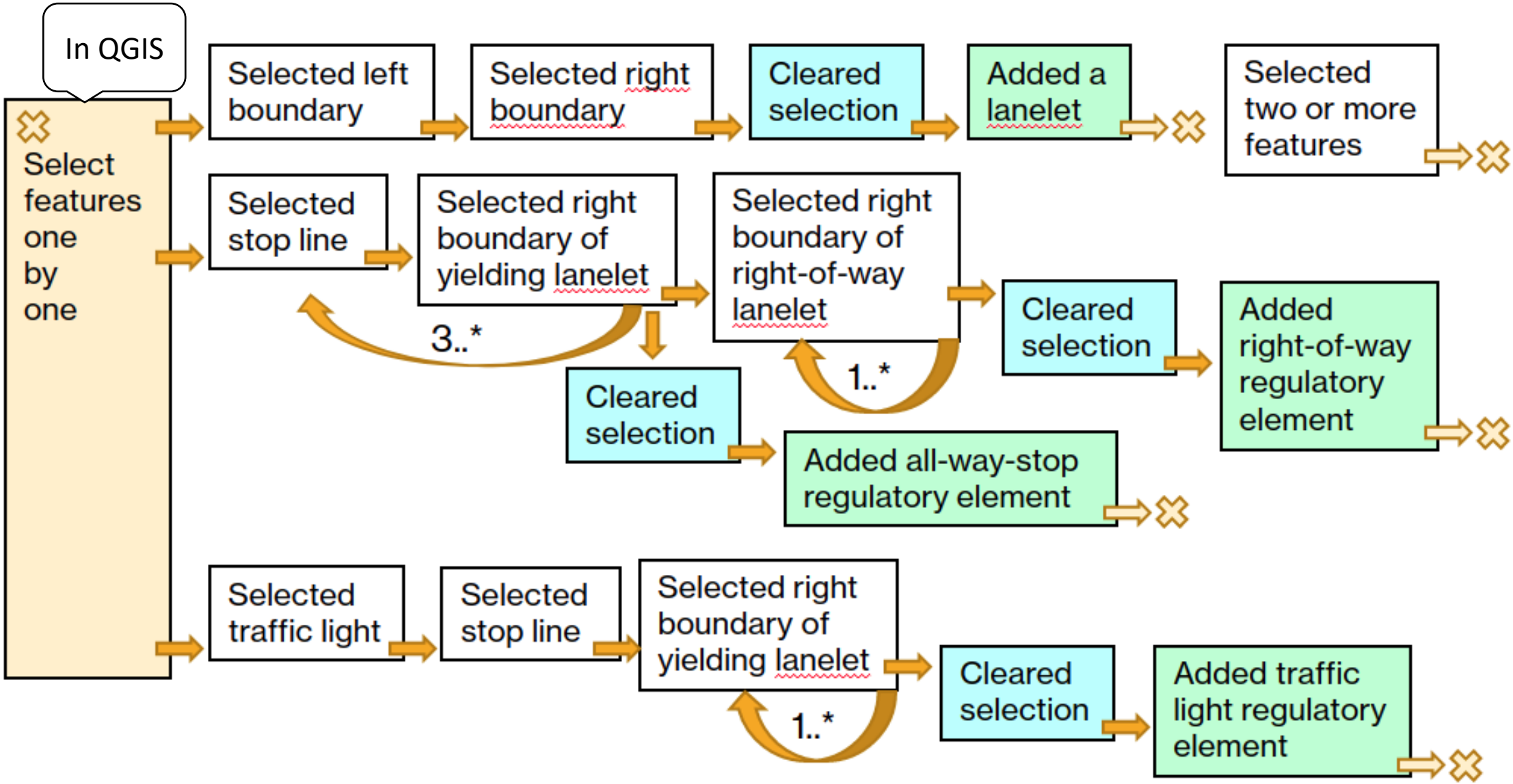
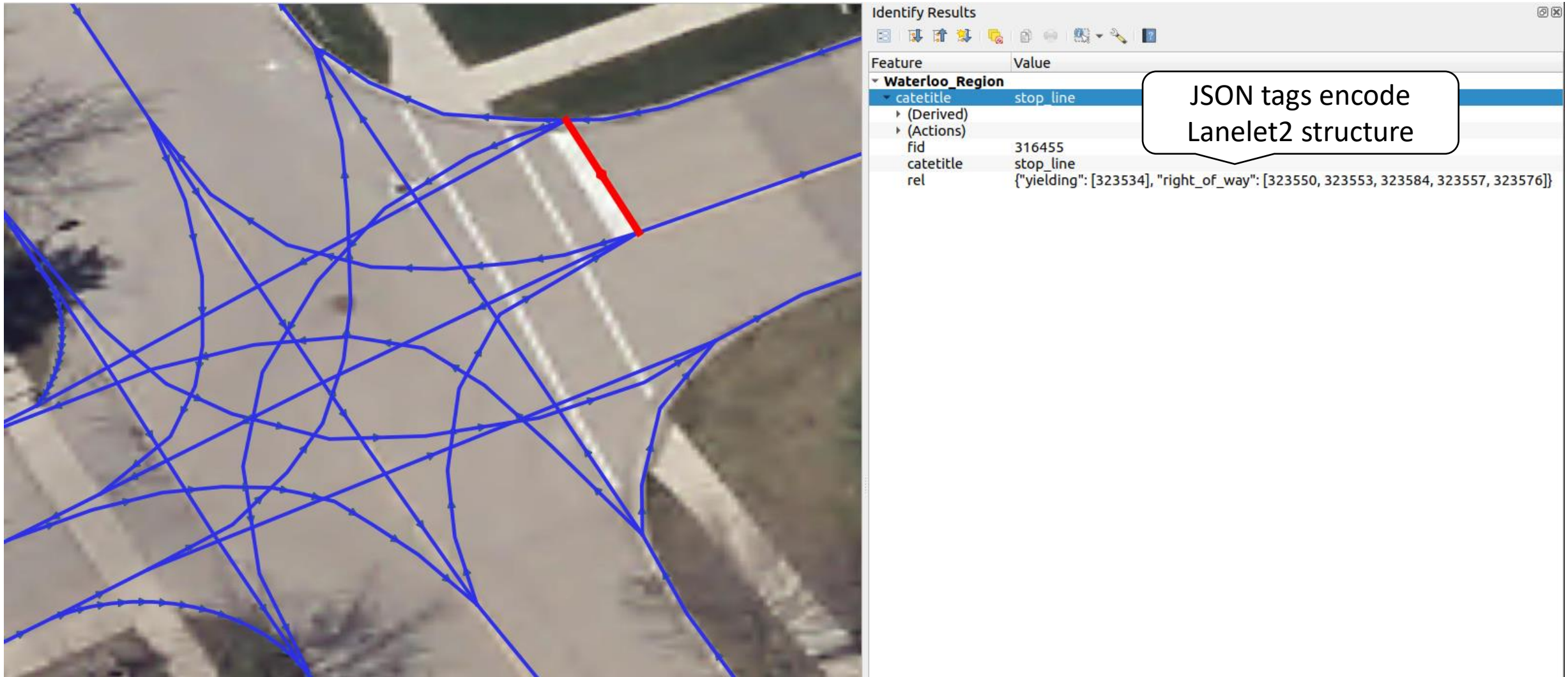
1. Tagging using "lanelet2_utils" script



1. Tagging using "lanelet2_utils" script



1. Tagging using "lanelet2_utils" script

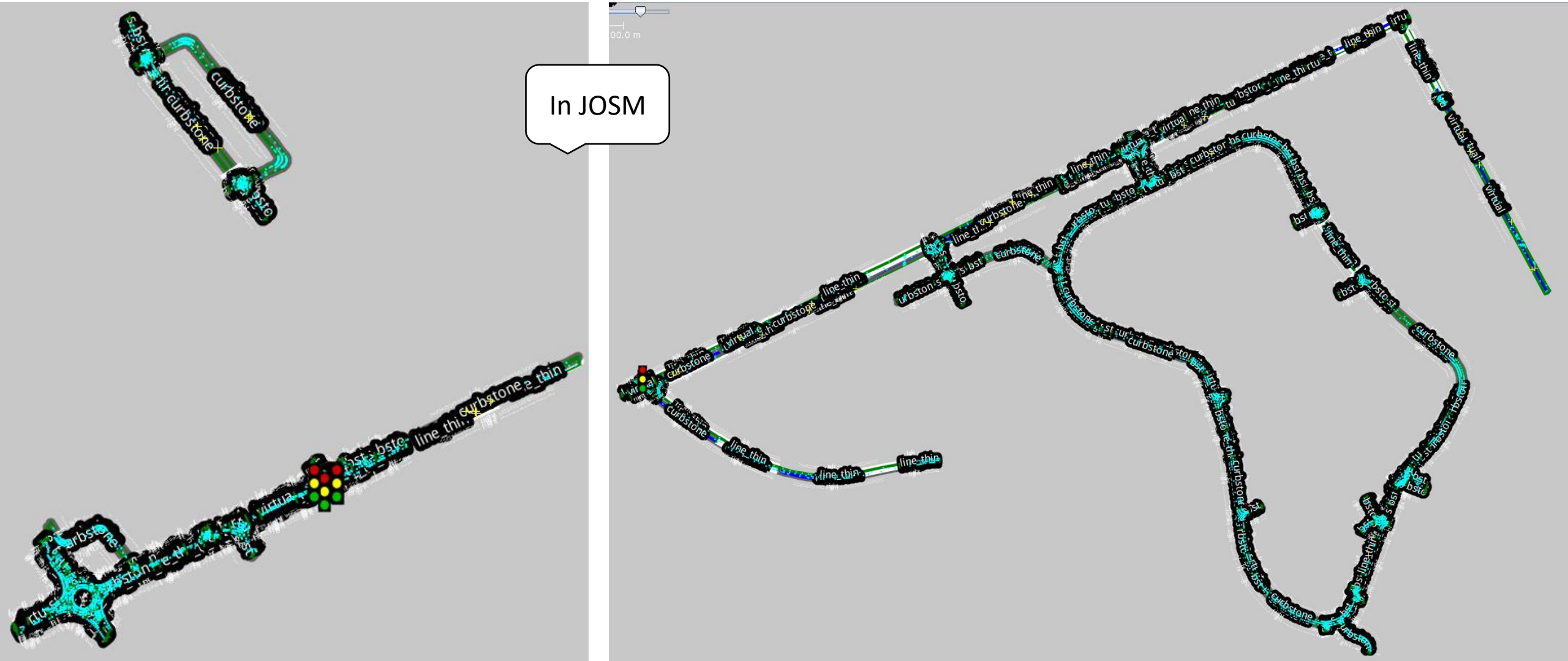
Feature	Value
Waterloo_Region	
catetitle	tr
(Derived)	
(Actions)	
fid	324169
catetitle	traffic_light
rel	{"stop_line": 323500}

Traffic light controls a stop line

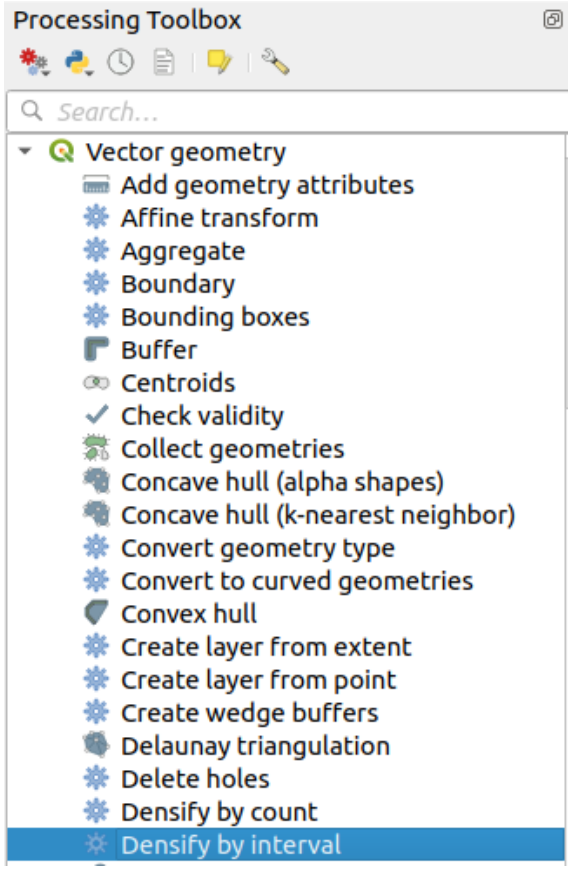
Feature	Value
Waterloo_Region	
catetitle	stop
(Derived)	
(Actions)	
fid	323500
catetitle	stop_line
rel	{"yielding": [323406, 323407]}

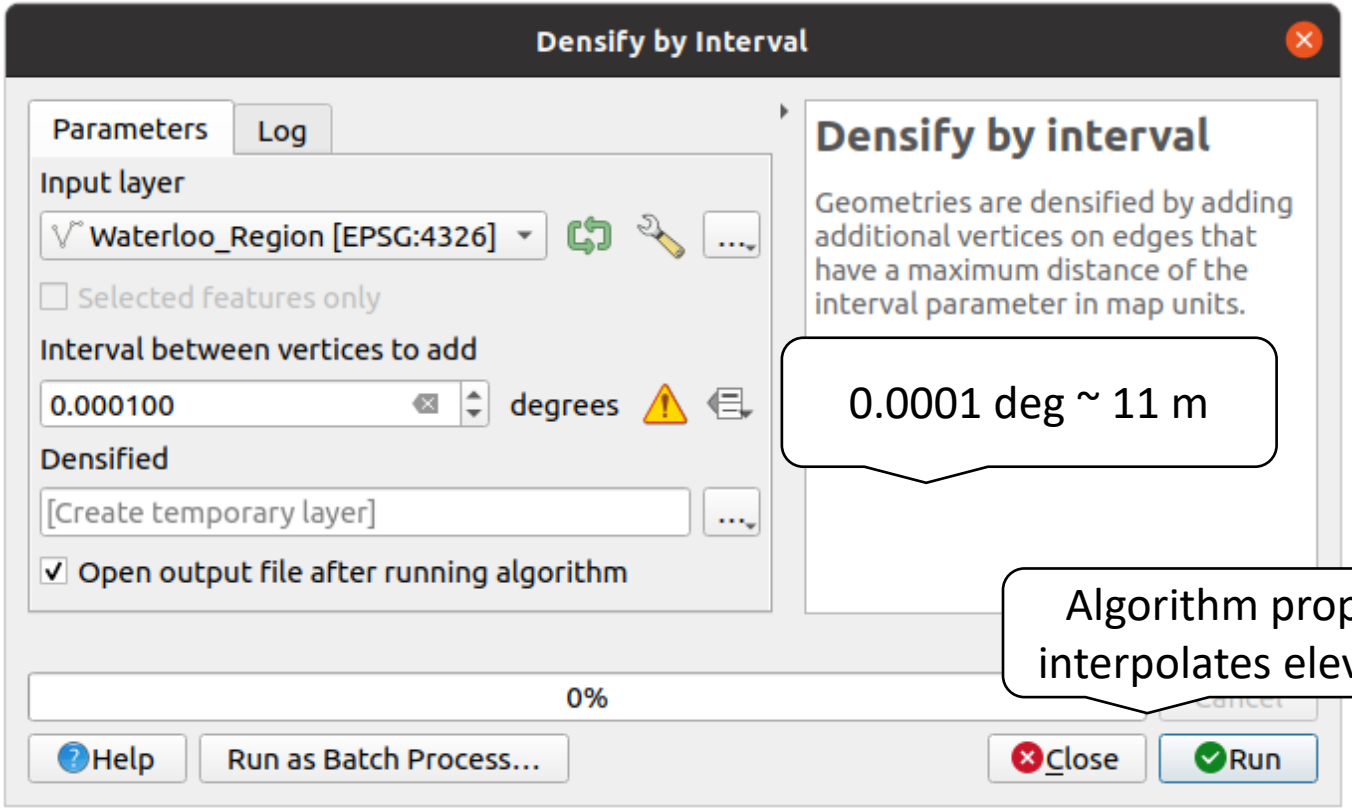
Stop line controls the yielding lanelets

1. Incrementally modifies the resulting Lanelet2 map

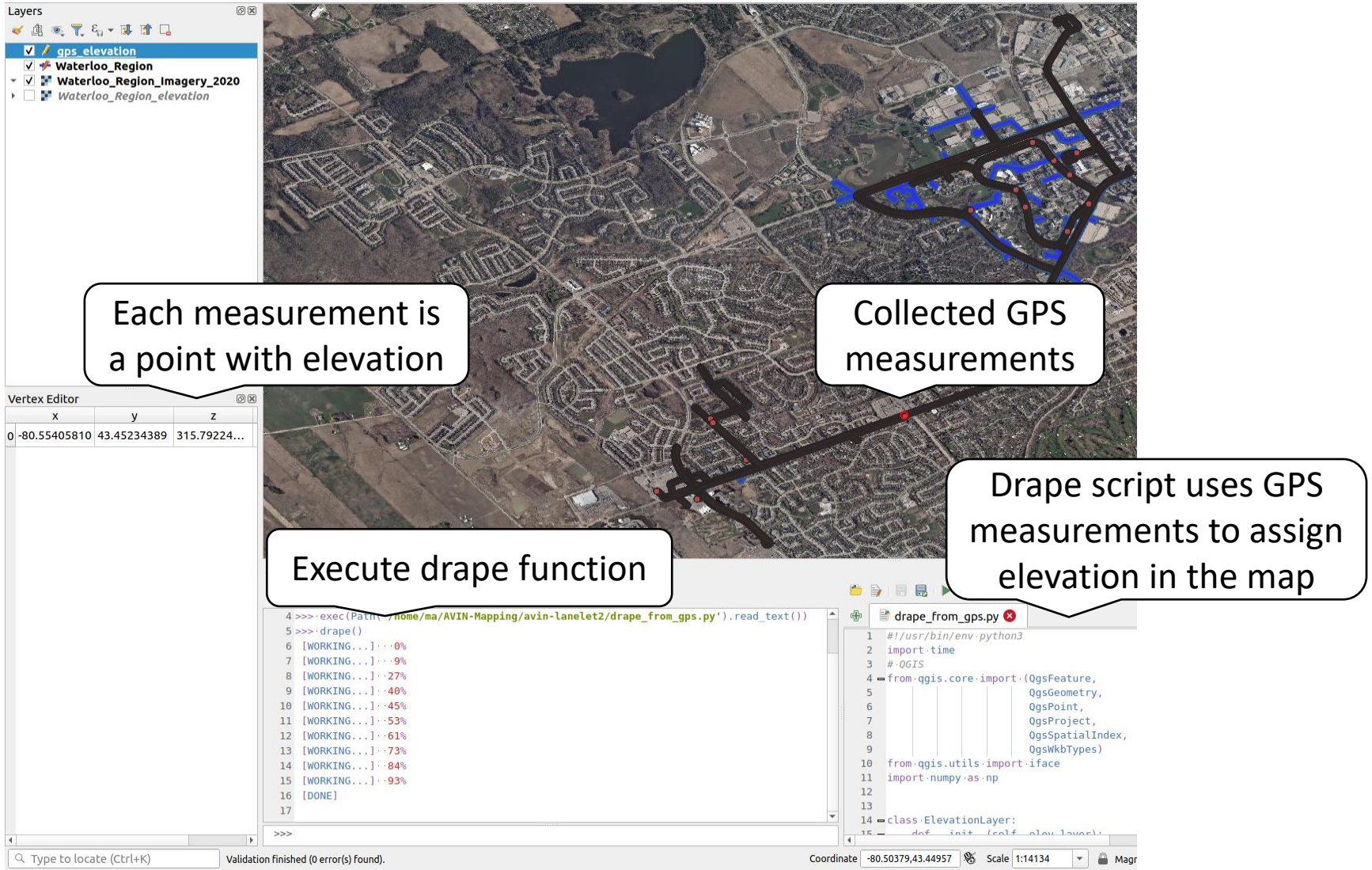


2. Map preparation using QGIS toolbox and our custom algorithms: densification

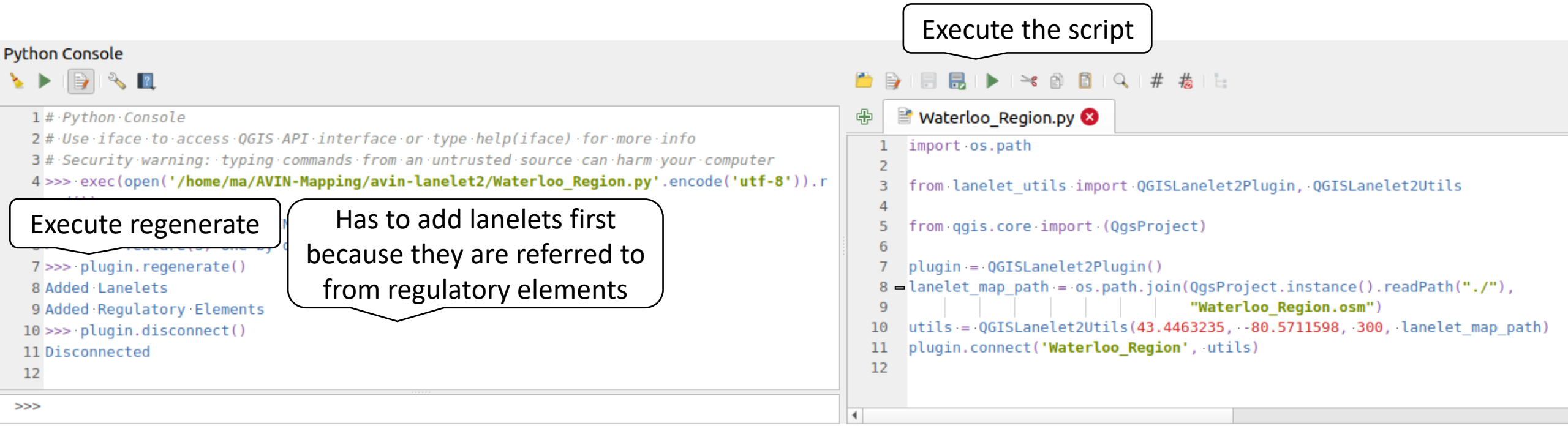




2. Map preparation using QGIS toolbox and our custom algorithms: elevation from GPS



3. Map generation using "lanelet2_utils" script



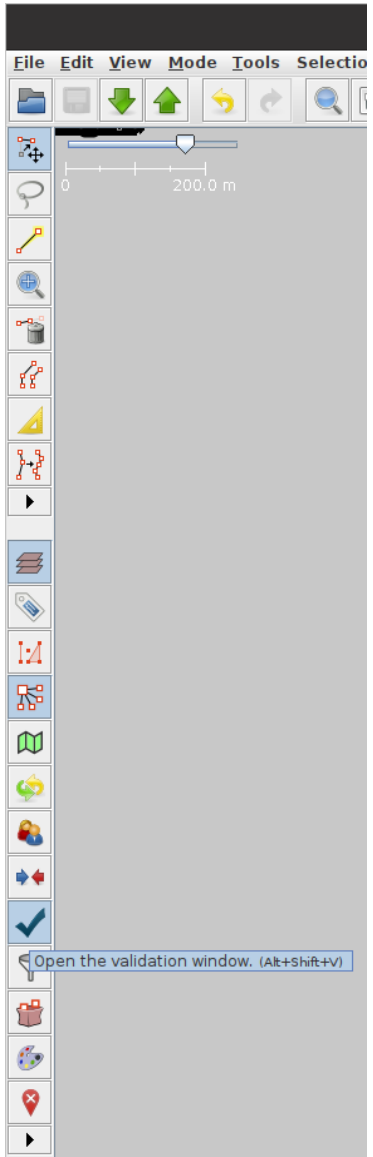
Phase 2: Map validation

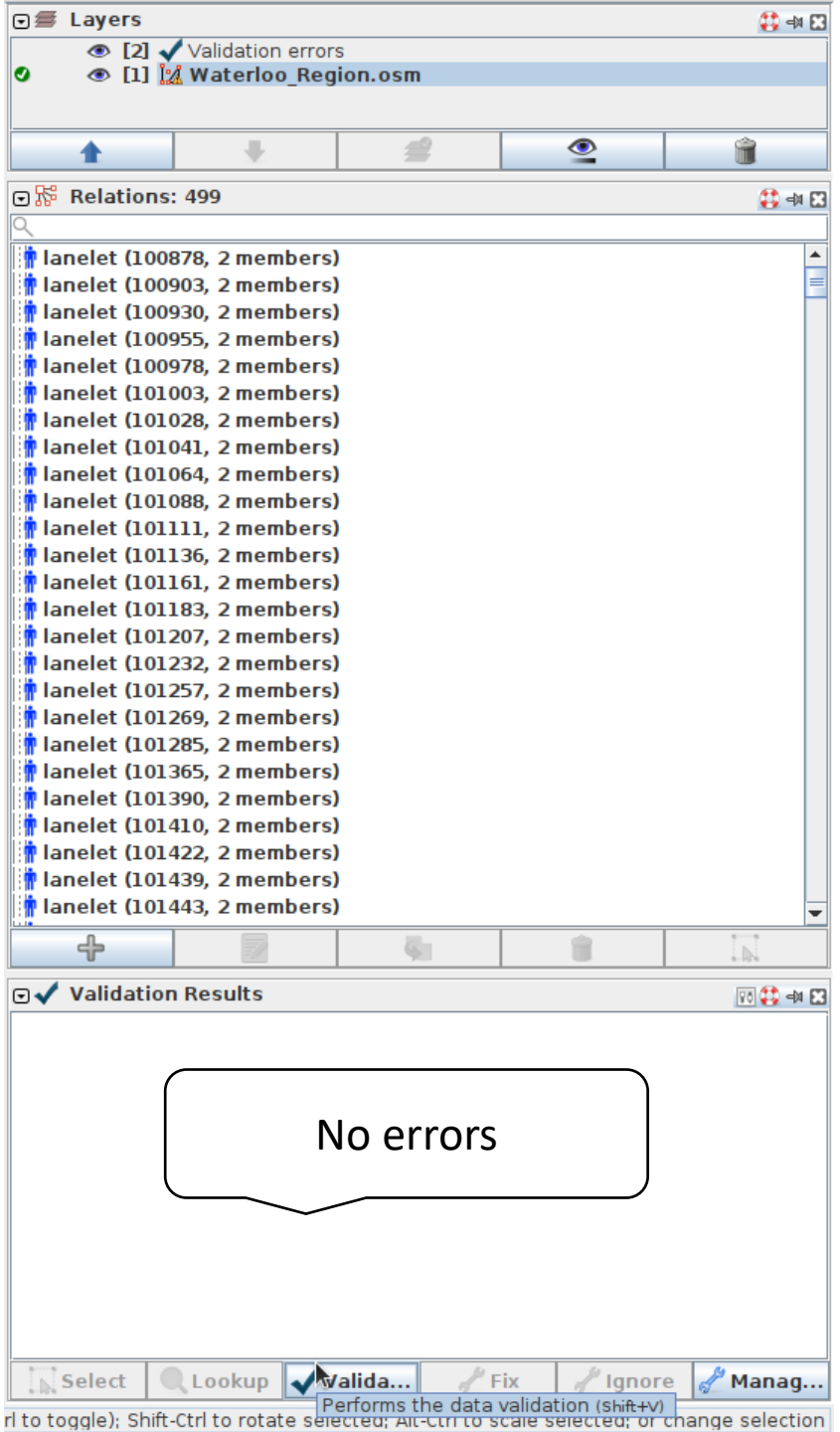
Goal: "Validate the usefulness of the Lanelet2 map for automated driving systems"

- Demonstrated a layered four-step approach to validation

1. Using JOSM
   - No duplicate nodes/ways nor other consistency issues
2. Using "lanelet2_validate" from Lanelet2 library
   - Curvature, annotation, and other Lanelet2-specific issues
3. Using GeoScenario Server
   - Map routing
   - Traffic simulations to exercise parts of the map
4. Using WISE Automated Driving System (ADS)
   - Automated drive in WISE Sim simulation and on "UW Moose" vehicle

1. Validation using JOSM





2. Validation Using "lanelet2_validate" from Lanelet2 library

Points out defects in map design and quality

```
$ lanelet2_validate Waterloo_Region.osm --lat 43.4463235 --lon -80.5711598
Error: There is a 'left' relation from 102770 to 102079, but 102770 isn't the closest lanelet the other way round [routing.graph_is_valid]
Warning: lanelet 103759 Curvature at point 103752 is bigger than 0.5. This can confuse algorithms using this map. [mapping.curvature_too_big]
Warning: lanelet 103548 Curvature at point 103547 is bigger than 0.5. This can confuse algorithms using this map. [mapping.curvature_too_big]
Warning: lanelet 102506 Curvature at point 102500 is bigger than 0.5. This can confuse algorithms using this map. [mapping.curvature_too_big]
Warning: lanelet 102506 Curvature at point 102501 is bigger than 0.5. This can confuse algorithms using this map. [mapping.curvature_too_big]
Warning: lanelet 104116 Curvature at point 104075 is bigger than 0.5. This can confuse algorithms using this map. [mapping.curvature_too_big]
Warning: lanelet 102612 Curvature at point 102600 is bigger than 0.5. This can confuse algorithms using this map. [mapping.curvature_too_big]
Warning: lanelet 102612 Curvature at point 102601 is bigger than 0.5. This can confuse algorithms using this map. [mapping.curvature_too_big]
Warning: lanelet 102612 Curvature at point 101536 is bigger than 0.5. This can confuse algorithms using this map. [mapping.curvature_too_big]
Warning: point 105869 Point is very close to point 101271. This can lead to defects in the map [mapping.points_too_close]
Warning: point 104621 Point is very close to point 104514. This can lead to defects in the map [mapping.points_too_close]
Warning: point 104[illegible]04621. This can lead to defects in the map [mapping.points_too_close]
Warning: point 101[illegible]n the map [mapping.points_too_close]
Warning: point 102[illegible]n the map [mapping.points_too_close]
Warning: point 102[illegible]n the map [mapping.points_too_close]
Warning: linestring 105916 attribute name is not a known [illegible] tag. [mapping.unknown_tags]
Warning: linestring 105916 attribute qgis_fid is not a known lanelet2 tag. [mapping.unknown_tags]
Warning: linestring 105914 attribute qgis_fid is not a known lanelet2 tag. [mapping.unknown_tags]
```

Traffic light "name" needed for GeoScenario Server

"qgis_fid" needed for lanelet_utils script

3. Using GeoScenario Server

avin-lanelet2 | scenario_suite

Name

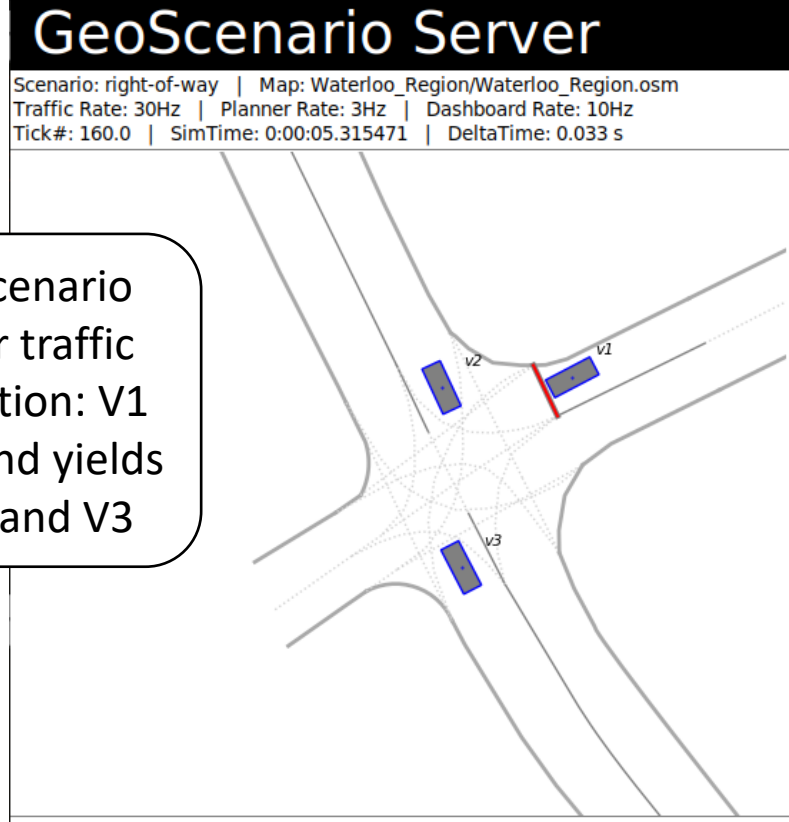
- geoscenarioserver
- log
- logs
- maps
  - Waterloo_Region
    - MapConfig.json
    - Waterloo_Region.osm
- scenarios
  - Erb-east-north
  - Erb-east-south
  - Erb-east-west
  - Erb-Erbsville-Ct-traffic-lights
  - Erb-north-east
  - Erb-south-east
  - Erb-south-south
  - Paradise-all-way-stop
  - Paradise-right-of-way
  - Ring-Road-ccw-west
  - Ring-Road-Columbia
  - Ring-Road-Will-Tutte
  - Westmount-Columbia
- scripts
  - launch.bash
  - scenario_suite_utilities.bash

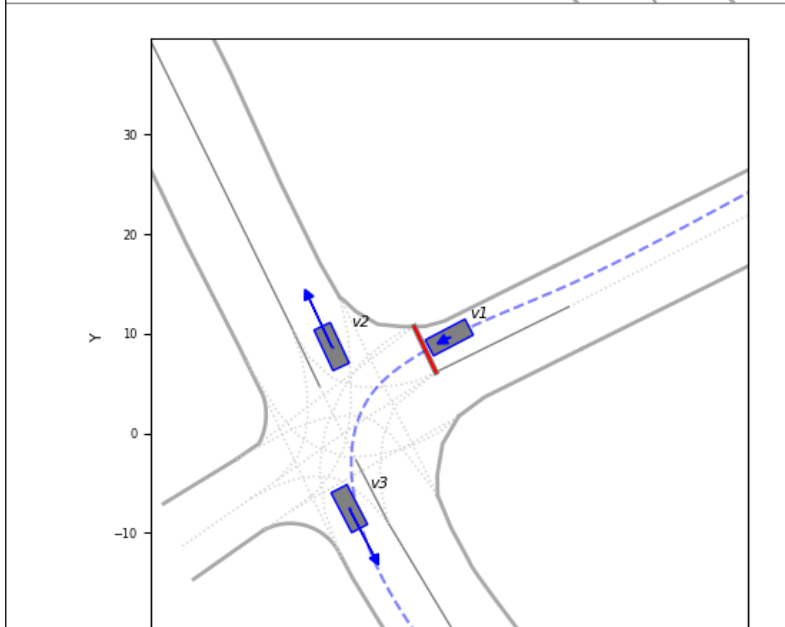
A suite of scenarios

Launch script

```
$ bash scripts/launch.bash Erb-Erbsville-Ct-traffic-lights
Using current suite.
Starting GeoScenario server for /home/ma/AVIN-Mapping/avin-lanelet2/scenario_suite/scenarios/Erb-Erbsville-Ct-traffic-lights/Erb-Erbsville-Ct-traffic-lights.osm...
I0228 10:56:25.160545 32933 GSServer.py:21] GeoScenario server START
I0228 10:56:25.160643 32933 GSServer.py:32] Btree search locations set (in order) as: ['/home/ma/wise-sim-root/submodules/geoscenarioserver/btrees']
I0228 10:56:25.160696 32933 ScenarioSetup.py:33] Loading GeoScenario file(s): /home/ma/AVIN-Mapping/avin-lanelet2/scenario_suite/scenarios/Erb-Erbsville-Ct-traffic-lights/Erb-Erbsville-Ct-traffic-lights.osm
```

GeoScenario Server traffic simulation: V1 stops and yields to V2 and V3



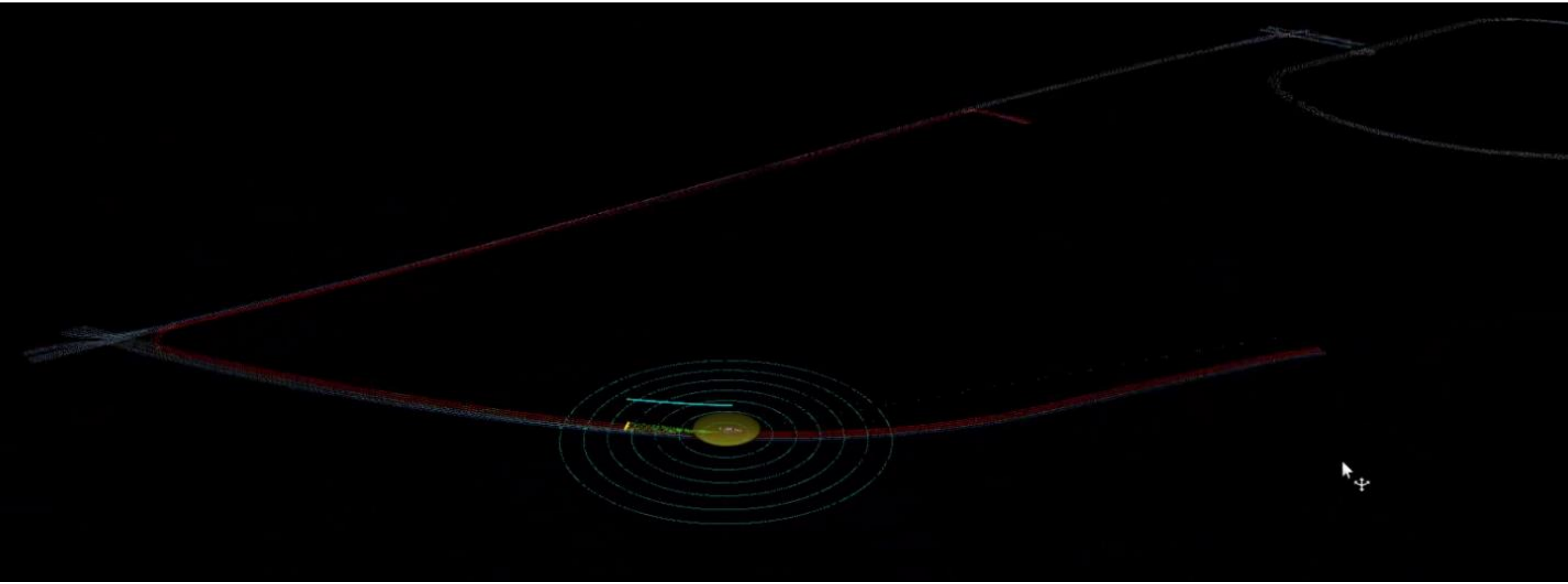


3. Using GeoScenario Server

- Traffic simulation videos are available on WISE Lab's YouTube channel's playlist

  https://www.youtube.com/playlist?list=PL9WqTe3nDulh070tpdxsxZErboYloO8Yz

4. Validation using WISE Automated Driving System (ADS): WISE Sim simulation



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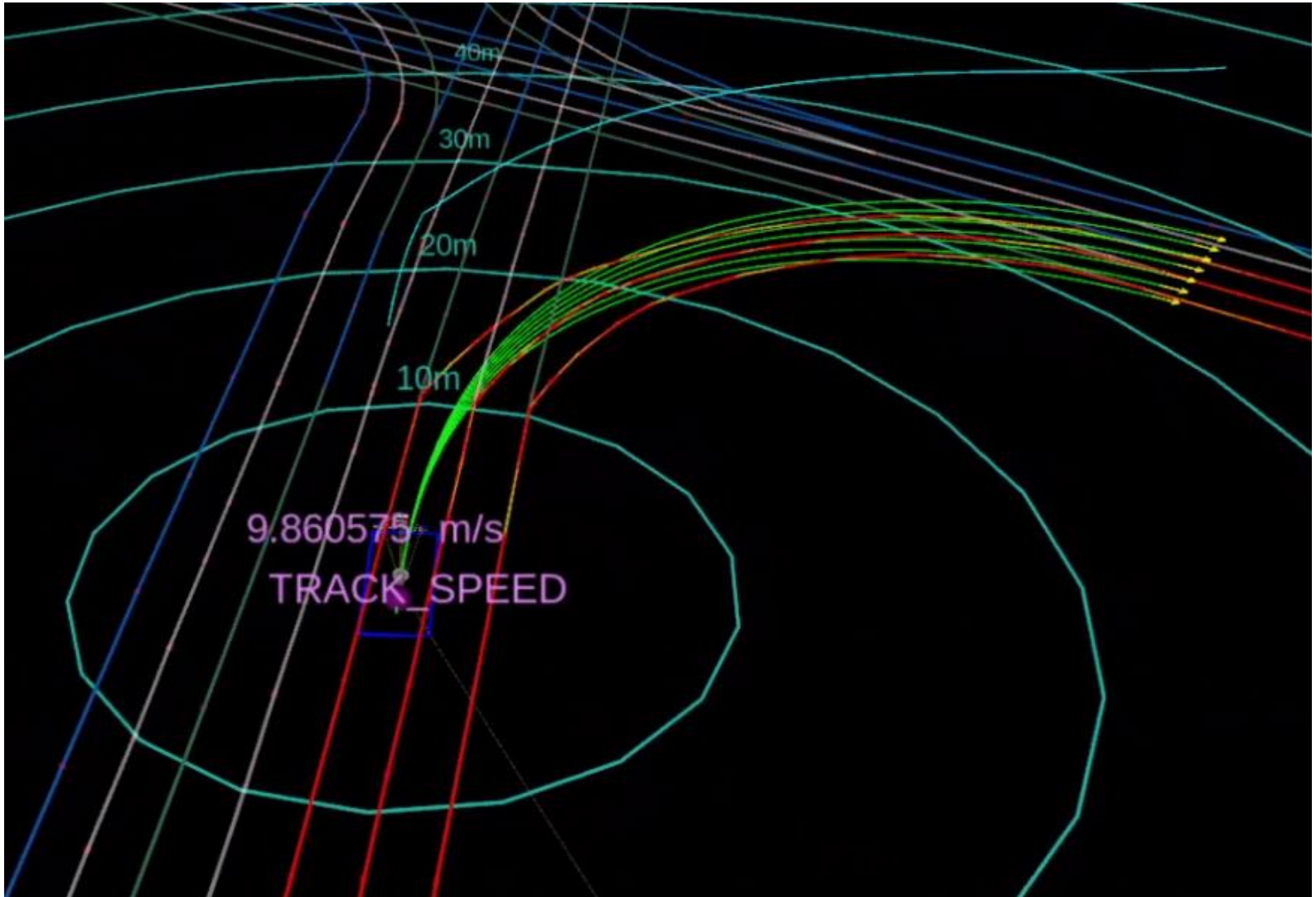

4. Validation using WISE Automated Driving System (ADS): on "UW Moose"

- Tested on "UW Moose" vehicle with WISE Automated Driving System (ADS)
- WISE ADS does not handle traffic lights and lane changes
- Lanelet2 support within WISE ADS is not complete; however, the vehicle was able to drive on sections of the map

Open-source contributions

- Fixed numerous issues in the open-source Lanelet2 library
- Submitted two pull requests
  https://github.com/fzi-forschungszentrum-informatik/Lanelet2/pull/231
  https://github.com/fzi-forschungszentrum-informatik/Lanelet2/pull/237
- Added two new map projectors ("LocalCartesian" and "Geocentric")
  - Enable WISE ADS to drive on the map and eliminates displacements
  - Will submit a pull request
- Maintain a fork of the upstream repository until fixes merged
  https://github.com/wiselabuw/Lanelet2

Thank You