# NON-MOTORISED NETWORK OF GOTHENBURG_SMOG

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The non-motorized model of Gothenburg was built on the Road-Center-Line OSM (Open Street Map)[1], because the official NVDB network (Trafikverket) did not provide sufficient detail for the pedestrian network.

The original OSM road-centre-line map however required extensive amount of editing in order to become appropriate for Space Syntax analysis. The editing procedures were both automatized and manual and will be described in a following section.

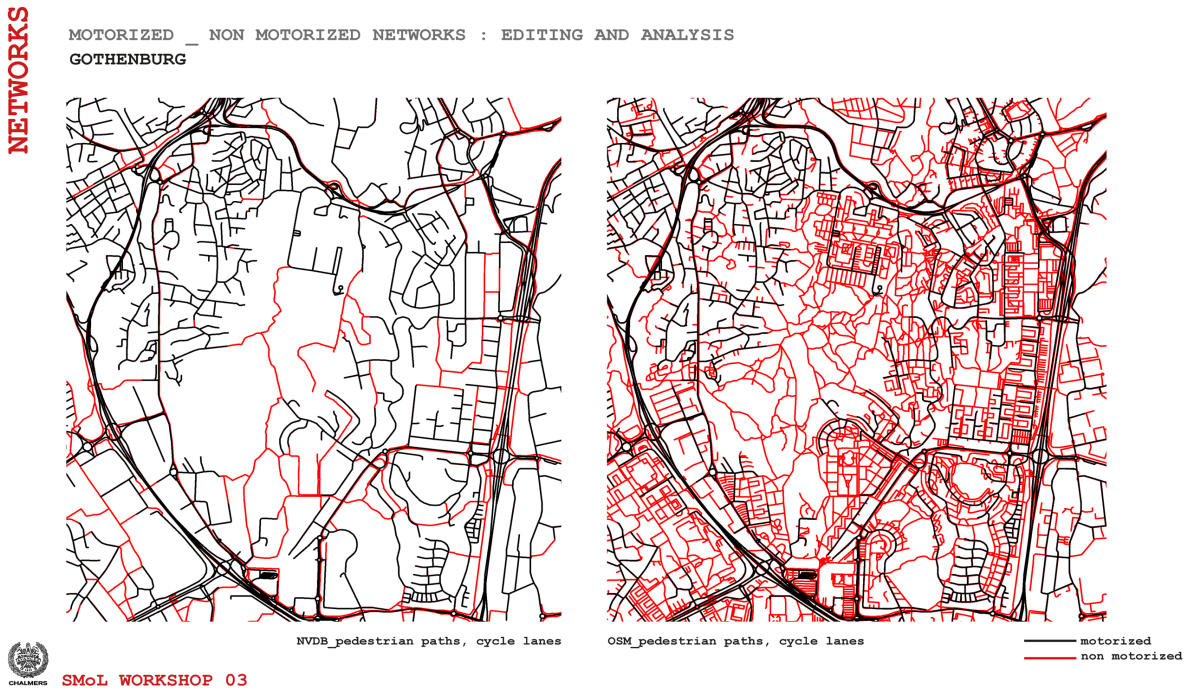


*Figure 1. NVDB and OSM, Gothenburg (red: non-motorised, black: motorised)*

The coverage of the network aims to include the whole urbanized part of the city or, in other words, the metropolitan area, which spans out of the municipal border. For this reason, we used the Urban Morphological Zone (UMZ) boundary, as they are defined by the European Environment Agency (EEA) and the Eurostat for all European cities.[2]

The editing and coverage of the Gothenburg map followed the same representational principles as the maps made for Stockholm, Eskilstuna, Amsterdam and London, in order for them to be comparable. Keep in mind that the making of the SMoG maps was part of a large research program, called "International Spatial Morphology Lab" (SMoL_Chalmers

[1] openstreetmap.org, http://download.geofabrik.de, date of download 29-4-2016
[2]Urban morphological zones (UMZ) are defined by Corine land cover classes considered to contribute to the urban tissue and function. A UMZ can be defined as "a set of urban areas laying less than 200m apart" (source: http://www.eea.europa.eu/data-and-maps/data/urban-morphological-zones-2006 (download date 13-7-2016)

University of Technology) which included a comparative study of the spatial form of 5 European cities of different scale and type. In that sense the representational choices made were dictated from the research questions, theory and methodology used in the project. Having said that, it can of course be used for other studies and have a general use and applicability, but one needs to be aware of the theoretical and methodological research background behind it.

## 1.1 Representational principles

We processed the original OSM Road-Centre-line map with two objectives: first to create line- segment maps which we could use in Space Syntax analysis (Angular segment analysis, ASA) and second, to create comparable representations of the street network in all five cities[3], both in the types of roads included as in the level of detail.[4]

The non-motorized network includes all streets and paths that are accessible for people walking or cycling, including those that are shared with vehicles. All streets where walking or cycling is forbidden, such as motorways, highways, or high-speed tunnels, are not included in the model.

All streets or paths are represented with one line irrespectively of the number of lanes or type, meaning that parallel lines representing a street and a pedestrian or a cycle path running on the side (e.g. sidewalks, bike lanes), are reduced to one line. The reason is that these parallel lines are nor physically or perceptually separated, and thus are accessible and recognized from pedestrians as one "line of movement" in the street network. If there are obstacles or great distance between parallel streets and paths, then the multiple lines remain (for example pedestrian paths in opposite sides of highways or fenced train tracks). The aim is to make a skeletal network that better represents the total space, which is accessible for pedestrians to move, irrespectively of the typical separations or distinctions of streets and paths.

Concerning the geometric representation of the street network, the SMoG Non-Motorized map is a line-segment network ready to be used in Space Syntax, Angular Segment analysis (ASA)[5].

[3] The cities included in the "International Spatial Morphology Lab" project (SMoL_Chalmers University of Technology) were Stockholm, Amsterdam, London, Gothenburg and Eskilstuna

[4] We followed the same editing and generalizing procedure for all maps aiming to remove errors and to increase comparability between networks. This process included removing duplicate and isolated lines, snapping and generalizing. The snapping threshold used was 2m (end points closer than 2m were snapped together). The generalizing threshold used was 1m (successive line segments with angular deviation less than 1m were merged into one).

[5] For more information about Angular Segment Analysis (ASA) see Hillier, B. and Iida, S. (2005), "Network effects and psychological effects: A theory of urban movement". In: van Nes, A. (ed.), Proceedings of the 5th International Symposium on Space Syntax, Delft: University of Technology Vol.1, p.553-564.

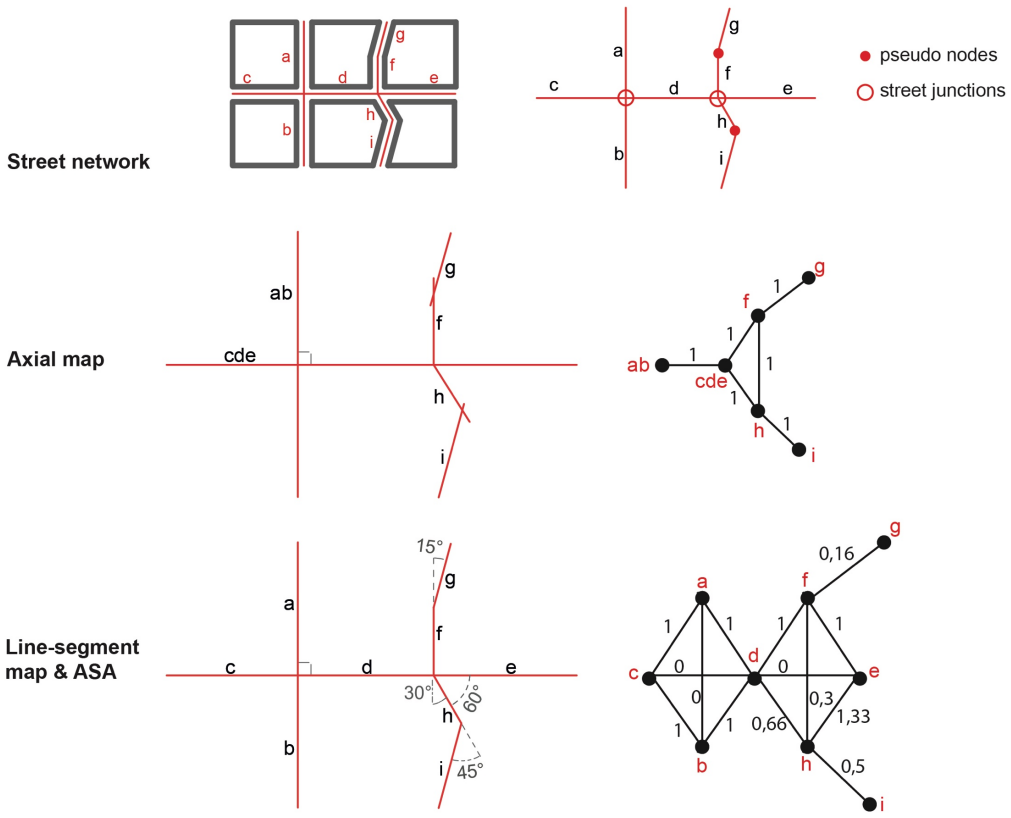


*Figure 2. Line-segment map and Axial map, from: Stavroulaki Gianna, Marcus Lars, Berghauser Pont Meta, Nilsson Leonard. (2017), 'Representations of street networks in space syntax – towards flexible maps and multiple graphs', in: Proceedings, 11th International Space Syntax Symposium, 164.1-164.16.)*

## 1.2. Processing of the OSM road-center-line map

### 1.2.1. Sorting

The original OSM dataset (roads.shp) includes all types of roads, streets and paths, from motorways to footways, paths and tracks, but even racetracks and bridleways. Every line has an attribute which defines its type. The sorting of the types to be included in the non-motorized network included two steps: one automatized and one manual.

#### 1.2.1.a. 1st sorting. Automatized sorting by attributes

Based on the attribute Type we selected the types to include in the first draft (see also attached FME file).

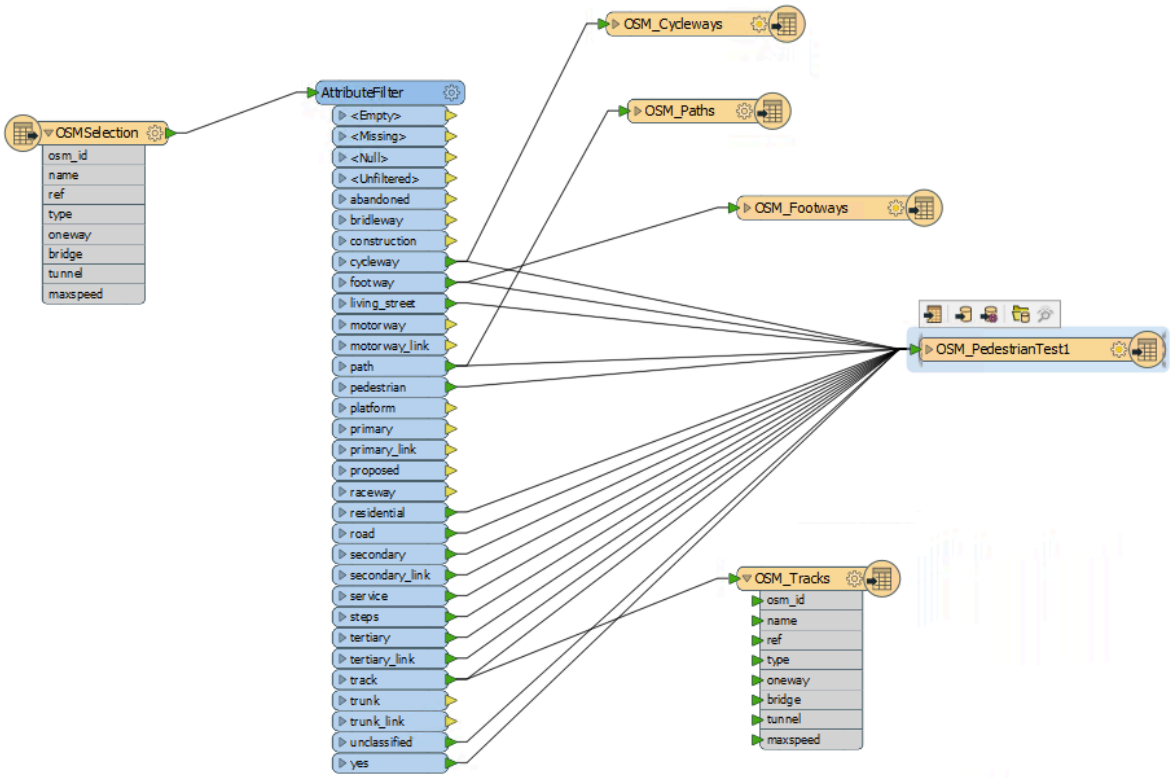


*Figure 3. FME script for the 1st step sorting*

### 1.2.1.b 2nd sorting.

However, because of the very detailed representation of all paths in the OSM even after the 1st sorting the produced network was still overdetailed and inappropriate for network analysis. Two were the main problems:

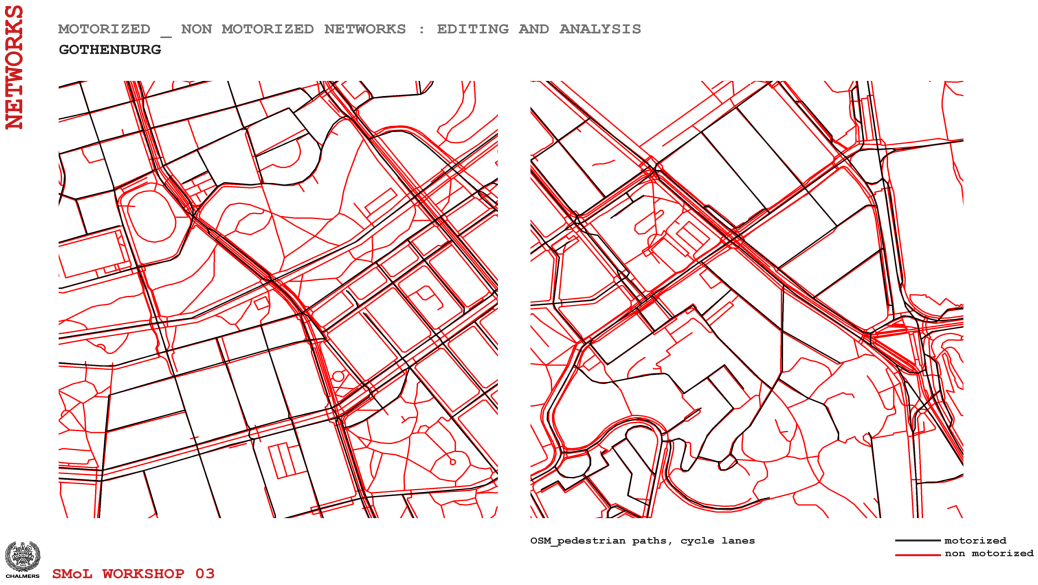


*Figure 4. Typical representation in OSM including many parallel lines to represent one street based on the traffic separation (car lanes, sidewalks, cycle lanes etc)*

a. Parallel lines representing car lanes, sidewalks and cycles lanes were included to represent one street, something which was not aligned with our representational principles, as stated in 1.1. In addition, it results in a topologically messy network (Fig.4).

However, the classification by the attribute "type" was not detailed enough to allow us to select and remove the unwanted parallel lines, such as sidewalks. For example, both sidewalks and some pedestrian paths are included in the type "footway", so we couldn't exclude the whole category to remove the sidewalks without removing important pedestrian paths. In order to take care of this problem we had to manually deleted the excessive parallel lines, while making sure we didn't create disconnections to the network. The principle followed was described in 1.1. and is shown in Fig 5.

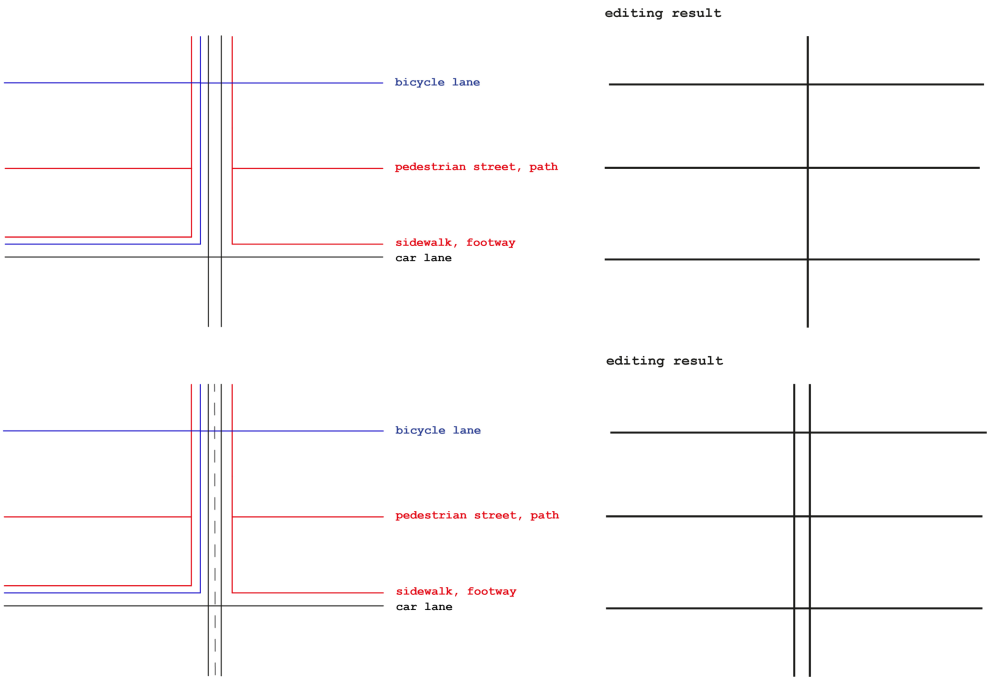


*Figure 5. Editing principles for manually removing parallel lanes without creating disconnections. Top: when there is not a physical boundary between car lanes. Bottom: when there is physical boundary between car lanes*

b. Overdetailed mapping of the tracks and paths in natural and recreational areas, including trekking paths. Not only these are only recreational paths and not part of the everyday network used by pedestrians, but this overdetailing can affect the centrality analysis.

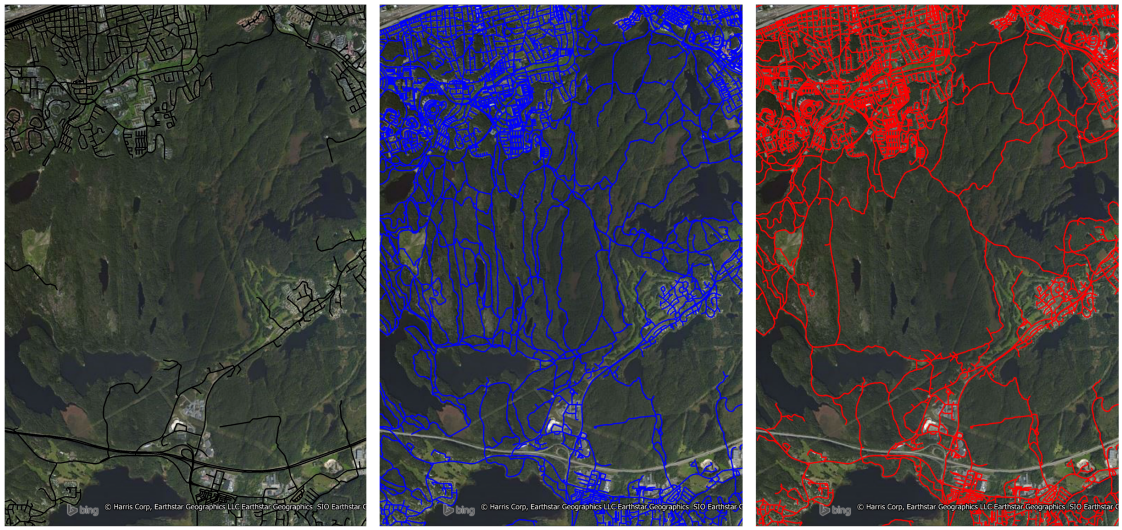


*Figure 6. Representation of tracks and footways in natural areas in NVSB, OSM and in the final SMoG non-motorised map*

In order to include only the important pedestrian paths in the Non-motorised network we used an available more detailed OSM dataset which classified the larger category "tracks" into different grades from 1to 5 (Fig 7).

| Key | Value | Element | Comment | Rendering | Photo |
|---|---|---|---|---|---|
| **tracktype** | grade1 | | Solid.<br>Usually a paved or sealed surface. See Sealed road. | | |
| **tracktype** | grade2 | | Solid.<br>Usually an unpaved track with surface of gravel. See Gravel road. | | |
| **tracktype** | grade3 | | Mostly solid.<br>Even mixture of hard and soft materials.<br>Almost always an unpaved track. | | |
| **tracktype** | grade4 | | Mostly soft.<br>Almost always an unpaved track prominently with soil/sand/grass, but with some hard or compacted materials mixed in. | | |
| **tracktype** | grade5 | | Soft.<br>Almost always an unpaved track lacking additional materials, same surface as surrounding terrain. | | |
| **tracktype** | *<no value>* | | *If no tracktype tag is present, the track is rendered with a dot-dash line style (as shown right).* | | *Photo not applicable* |

*Figure 7. Classification of type:tracks (from https://wiki.openstreetmap.org/wiki/Key:tracktype)*

We removed track types with grade 3,4 and 5. However, some unwanted tracks remained because were classified as type:path. The final step was to check and manually remove those tracks.

### 1.2.2. Editing of geometric features.

After the final selection of street types to be included in the non-motorized network, the resulted road-center-line map had to be processed in order to become a line-segment map appropriate for Angular Segment Analysis (ASA) in PST software.

The editing procedure included:
Removing of duplicate and isolated lines, snapping and generalizing. The snapping threshold used was 2m (end points closer than 2m were snapped together). The generalizing threshold used was 1m (successive line segments with angular deviation less than 1m were merged into one).

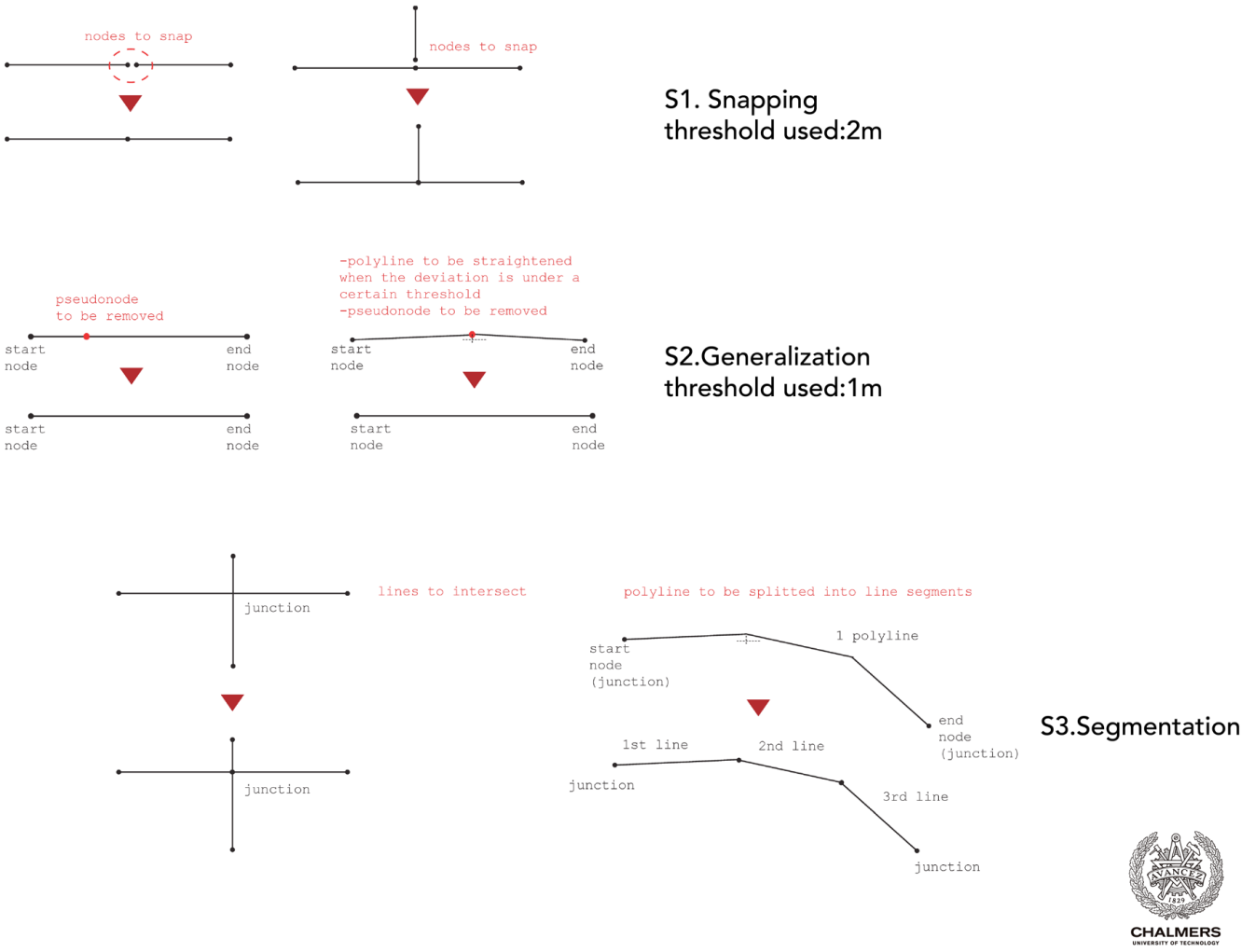


*Figure 8. Editing procedure*

The final editing step included the correct representation of the "unlink points", meaning the line intersections which represent non-level crossings, as for example in bridges and tunnels, underpasses and overpasses. The correct way of representation in order for the network to be properly analyzed in PST (Place Syntax Tool) is shown in Fig.9.

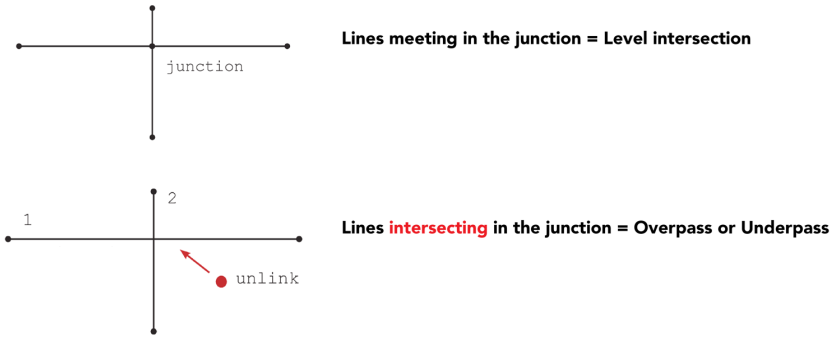


*Figure 9. Representation of level and non-level intersections*

Keep in mind that a separate point layer with the Unlink locations needs to be prepared and included in the Space Syntax analysis in PST.

The editing procedure was done using FME software, using the script shown in Fig10. Although it worked for the editing of the general network, it created problems with the representation of the non-level intersections (unlinks), which had to be fixed manually.

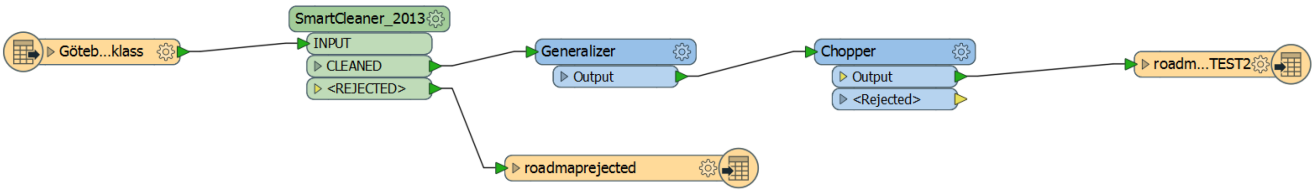


*Figure 10. FME script used for the general editing*

To be noted, that the whole editing procedure to produce a line-segment map from a road-center-line map, including the proper editing of the non-level intersections has been implemented in the new PST version, available for QGIS and Mapinfo (smog.chalmers.se). The functionality to be used is called "Create segment map" (Fig 11). The details of this function can be found in the PST documentation.

07.
Software
for creating
line-segment maps

S1. Error fixing
a. Remove duplicates
b. Remove isolated lines
c. Snapping

S2. Generalization

S3. Segmentation

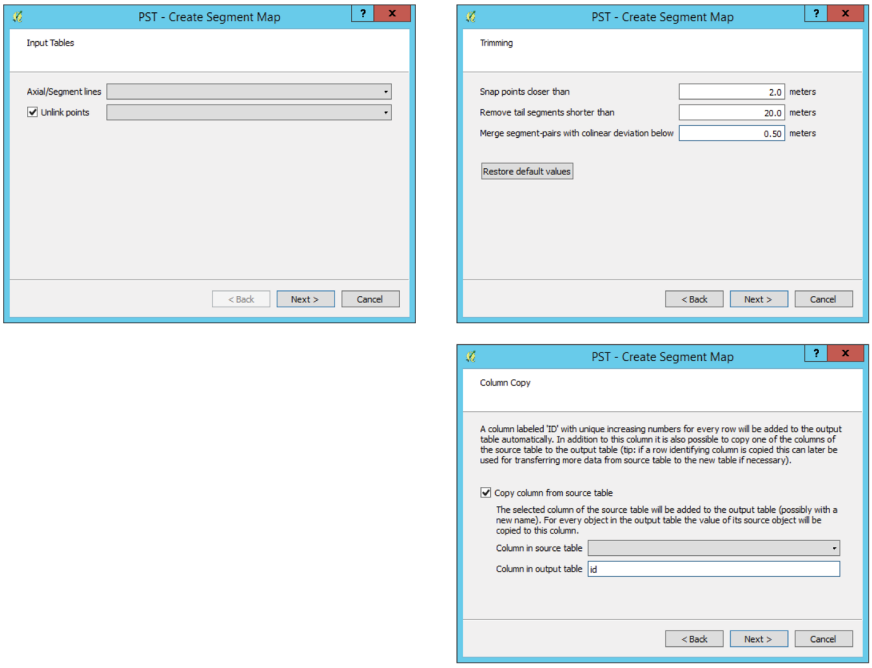


*Figure 11. PST function "Create segment map"*

PLEASE NOTE:

<u>When using the network credit</u>:

- For the non-motorised network, Berghauser Pont, M., G. Stavroulaki, K. Sun, E. Abshirini, J. Olsson, L. Marcus (2017). Quantitative comparison of the distribution of densities in three Swedish cities, *ISUF 2017 XXIV international conference*, October 2017 in Valencia.