

# **Integrating OpenStreetMap with Public Transport Network Format NeTEx using the JOSM Editor**

Projekt Arbeit 2

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Spring Semester 2020

# *Abstract*

Keywords: *OSM, JOSM, NeTEx, CEN, Plugin, Transport, XML, Java.*

# *Acknowledgements*

Foremost, I would like to express my sincere gratitude towards my advisor [Prof. Stefan Keller](#) for assisting and motivating me throughout the whole journey of creating this project. Without his guidance and persistence, this project would have been hardly possible.

Besides my advisor, I would also like to thank [Raphael Das Gupta](#) for assisting me in the technical parts of the software and for always being ready to lend a hand in the difficult tasks.

My sincere appreciation also goes to some of the [SBB](#) employees, specifically: [Richard Lutz](#), [Matthias Günter](#) and especially [Adrian Aeschbacher](#) for being concise with the software requirements, for monitoring my work and for their encouragement and insightful help.

Last but not least, I want to thank my family for always being there for me and for continuously encouraging me to be the best version of myself.

# Declaration of Authorship

I hereby declare that:

- This thesis and the work reported here was composed by and originated entirely from me unless stated otherwise in the assignment of tasks or agreed otherwise in writing with the supervisor.
- All information derived from the published and unpublished work of others has been acknowledged in the text and references are correctly given in the bibliography.
- No copyrighted material has been used illicitly in this work.

Place, Date

Signature

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# Chapter 1

## Introduction

The documentation for this project is split into four main parts. The first chapter gives an introduction to the goals and requirements that this project was initially set to meet. It also explains some of the important technologies & tools, keywords and notations that are crucial to this project.

The second chapter has to do everything with the architecture and the design of the application. It explains about the technologies that were used, the reason why they were used and the benefits of using those technologies for this project.

After the things above have been clarified, the third chapter explains about the actual technical implementation aspects of the plugin. It mostly explains about some of the important methods/approaches that were used to achieve the goal of this plugin and the reason why those methods were decided to be used. It also explains about the main technical notations about the project, what they mean and how they were used in the benefit of this project work.

The fourth and final chapter presents the results that were achieved from this project work and the outlook of it. It also wraps up with a conclusion about the project and my personal reflection on this whole project work.

## 1.1 Requirements

The main objective for this project is creating an [OpenStreetMap \(OSM\)](#) plugin for the [Java OpenStreetMap Editor \(JOSM\)](#) editor that converts the OSM data into an XML format called [NeTEx](#), which stands for Network Timetable Exchange and is a [CEN](#) technical standard for exchanging public transport information.

The plugin takes existing OSM data, converts it into NeTEx and then logs important information such as errors, warnings regarding the OSM transport data and the NeTEx conversion into the JOSM application map layer.

The main tasks include (priority sorted):

- Creating a JOSM friendly plugin that converts OSM data into the NeTEx format.
- Improving further NeTEx conversions by suggesting different OSM edits that benefit the NeTEx conversion.
- Incorporating the NeTEx conversion and the improvement suggestions with the JOSM default workflow.

The plugin sticks to the official NeTEx and OSM rules throughout its whole creation and workflow. It is also built under the official JOSM development guidelines and it maximally utilizes the native JOSM methods and libraries that are key to this plugin.  
TBD...(License)



## 1.2 OpenStreetMap - OSM

[OpenStreetMap \(OSM\)](#) is a project to build a free geographic database of the world. Its aim is to eventually have a record of every single geographic feature on the planet. While this started with mapping streets, it has already gone far beyond that to include footpaths, buildings, waterways, pipelines, woodland, beaches, postboxes, and even individual trees. Along with physical geography, the project also includes administrative boundaries, details of land use, bus routes, and other abstract ideas that aren't apparent from the landscape itself. [1]

OpenStreetMap is powered by open-source software such as editing software, various APIs etc. One can extract very sophisticated information from the geographical data the OSM consists of. Various users (end-users, developers, maintainers etc.) all around the world contribute daily to improving the geographical data in OSM and to improving the ease of use of such data and information. The OSM data can be used in multiple ways such as producing paper and electronic maps, integrating such data into your own applications and route planning.

There are already a lot of famous users that utilize OSM such as: [Facebook](#), [Craigslist](#), [Seznam](#) etc. OSM is *community-driven* and the community of contributors mainly consists of enthusiast mappers, GIS professionals, humanitarians and many more. It is also *open-data*, which means that anyone can freely use OSM for any purpose as long as OSM and its contributors are credited. The OSM map data can be used for web sites, mobile apps and various hardware devices.

## 1.3 Java OpenStreetMap Editor - JOSM

[Java OpenStreetMap Editor \(JOSM\)](#) is an extensible editor for OSM for Java [2]. It is open-source and developer using the Java programming language. It is a desktop application that offers a lot of options and is used for editing OSM data and their meta-data tags. It has a steep learning curve and may look complex at first sight, but it's very popular because of its continuous contributions, its plugins and its stability. Even though OSM has many editors, JOSM is considered to be one of the most advanced and professional ones (hence the steep learning curve). It is maintained under the [GNU General Public License v3.0](#).

JOSM Plugins extend or modify the basic features of the JOSM editor. They are created from enthusiastic developers all around the world, under the JOSM application. There is a repository of plugins maintained in JOSM where users can pick and choose which plugin they want to add to their JOSM editor. If some plugin is not available in the repository (which it should be), it can be installed manually pretty easily.

## 1.4 Network Timetable Exchange - NeTEx

[Network Timetable Exchange \(NeTEx\)](#) is a [CEN](#) Technical Standard for exchanging Public Transport schedules and related data. It provides a means to exchange data for passenger information such as stops, routes timetables and fares, among different computer systems, together with related operational data. It can be used to collect and integrate data from many different stakeholders, and to reintegrate it as it evolves through successive versions. [3]

It is divided into three parts:

- **Part 1 - Network Topology:** Describes the Public Transport Network topology.
- **Part 2 - Timing Information:** Describes Scheduled Timetables.
- **Part 3 - Public Transport Fares:** Covers Fare information.

NeTEx is intended to provide a European wide standard for exchanging Public Transport data for Passenger Information. It is based on the CEN [Transmodel](#) which is the CEN European Reference data model for public transport.

# Chapter 2

## Architecture and Design

This chapter describes a little bit about the overview of the plugin, the programming language that was used, how the plugin is deployed, what it needs in order to be executed successfully etc. It also describes why that specific programming language and the libraries were chosen and the main reasons sitting behind those decisions.

[The Plugin](#) section of this chapter describes the plugin in a more-depth manner, some of the libraries that were used, how it is bundled together and the components that are crucial to the plugin.

### 2.1 Overview

The plugin is developed and built using the [Java](#) programming language (Java Platform SE 8), which is fully compliant with the JOSM development environment (JOSM also supports higher Java versions). The plugin is developed as a "separate" component from JOSM, which can be manually added/installed to an existing JOSM application environment.

The plugin is ultimately deployed as a single `.jar` file, which contains all the necessary components, dependencies and libraries that the plugin needs in order to execute successfully. This jar file however, does not serve its purpose if executed solely, it requires a JOSM application environment and must be executed from it in order for it to serve its purpose. It is a relatively heavy `.jar` file because of the XML components that it has bundled within, which boil down to a Java Model of the whole NeTeX XML schema containing all its components, their necessary interrelations and methods.

## 2.2 Design Decision - Programming Language

This plugin was built using the Java programming language, version 8.

Java is a powerful general-purpose programming language. It is used to develop desktop and mobile applications, big data processing, embedded systems, and so on. According to Oracle, the company that owns Java, Java runs on 3 billion devices worldwide, which makes Java one of the most popular programming languages. [4]

The reason why this plugin was chosen to be built and developed using Java is because of JOSM, it runs on Java, so everything under it must run on Java too, including the plugins. All of the JOSM plugins are developed inside the JOSM environment as separate .jar files and must use JOSM native Java methods in order to be executed and incorporated within JOSM.

It is also an Object-Oriented programming language, which runs under ANY operating system (because of its compiler) and uses inheritance and abstract methods (Object Oriented programming principles), which turned out to be very useful and neat for the nature of this plugin.

Here's a snippet of Java code & syntax example of a Java Program that computes the quotient and the remainder of a division: [5]

```
public class QuotientRemainder {  
  
    public static void main(String[] args) {  
  
        int dividend = 25, divisor = 4;  
  
        int quotient = dividend / divisor;  
        int remainder = dividend % divisor;  
  
        System.out.println("Quotient = " + quotient);  
        System.out.println("Remainder = " + remainder);  
    }  
}
```

And the result from running the program would be:

```
Quotient = 6  
Remainder = 1
```

## 2.3 The Plugin

[JOSM Plugins](#) extend or modify the feature set of the JOSM editor. [6]

That is the main purpose of these plugins. They are created by the JOSM community of developers and they tend to improve JOSM usability by adding extra or "missing" functionality, or in the most cases, by adding a completely new feature that interacts with JOSM components but serves an exclusive purpose.

There exist plugins for improving the look & feel of drawing different shapes of objects within JOSM, for converting OSM data into various formats (which is our case), for exporting OSM data into formats such as PDF or GPX, for showing additional important information to some users etc.

This plugin is a single executable .jar file which runs under JOSM and is executed within it. It is developed by following the official JOSM development guidelines and OSM rules. The plugin, if installed on the JOSM environment, is first executed using a JOSM native library which takes care of plugin initialization, execution and error handling. After loaded into JOSM, depending on the nature of the plugin, it can interact with any component within JOSM, in this case, the plugin is a single option on the toolbar menu that simply takes the currently loaded map data in the main map layer and converts it into the NeTEx format.

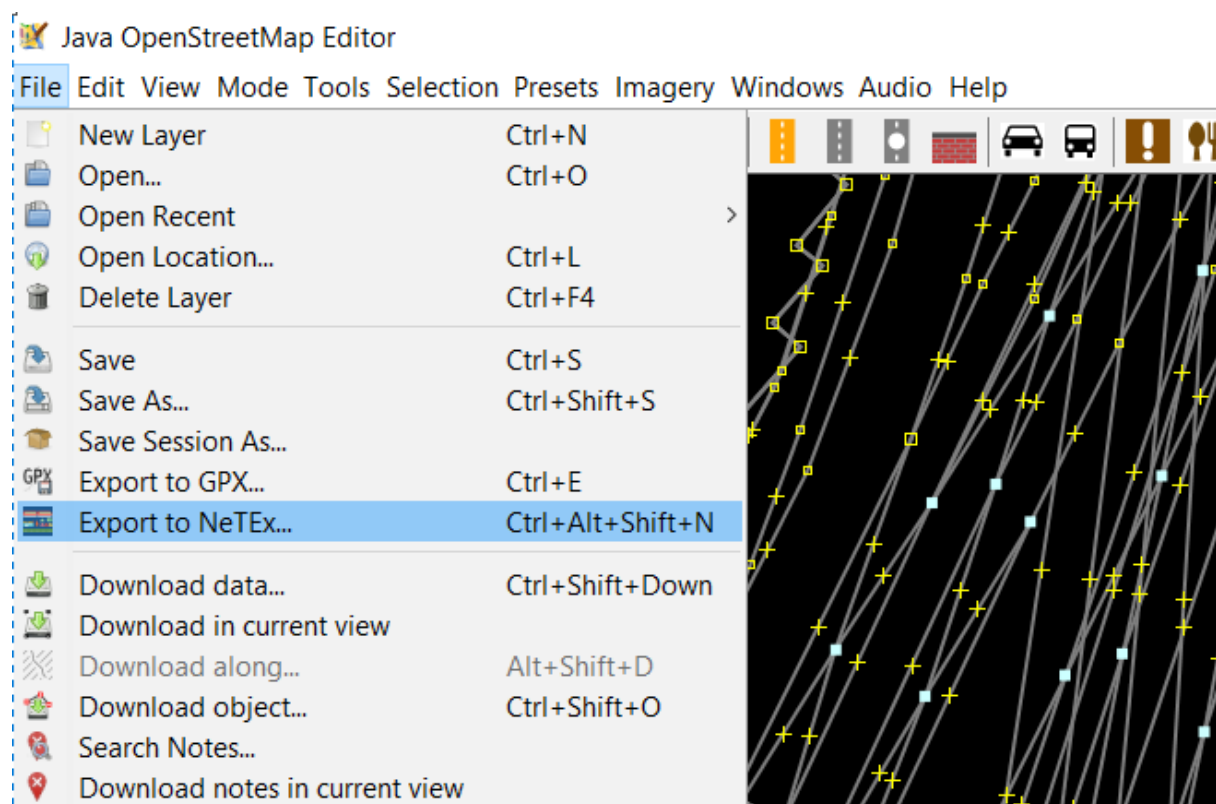


FIGURE 2.1: The location of the NeTEx Converter plugin within the JOSM toolbar



be fully compliant and convertible by the plugin. After the corrections, the next NeTEx conversions will be much more improved and informative.

```
7009 <StopPlace id="ch:1:StopPlace:8509000">
7010 <Name>Chur</Name>
7011 <PrivateCode>org:osm:node:2522151337</PrivateCode>
7012 <Centroid>
7013 <Location>
7014 <Longitude>9.5296459</Longitude>
7015 <Latitude>46.8535563</Latitude>
7016 <Altitude>585</Altitude>
7017 </Location>
7018 </Centroid>
7019 <AccessibilityAssessment>
7026 <equipmentPlaces>
7208 <PublicCode>8509000</PublicCode>
7209 <StopPlaceType>railStation</StopPlaceType>
7210 <quays>
7525 <pathLinks>
8649 <pathJunctions>
9497 </StopPlace>
```

FIGURE 2.3: A snippet of an exported NeTEx document from the plugin (Location of the exported data - Chur, Switzerland)

# Chapter 3

## Implementation

### 3.1 Overview

This part of the documentation describes how the project was implemented in more-detailed and technical manner. It shows some of the key approaches that were used to solve some of the major conversion obstacles. It explains what kind of data OSM contains and how that data was used in conjunction with the plugin to produce an XML document compliant with the NeTEx schema. As we know, OSM data is not very consistent, since it's updated by the community, which means that a lot of extra measures and conditions had to be taken in order to avoid and solve problems of data inconsistency.

This section will also cover some of the important techniques and tools that were used to test, document the plugin, generate artifacts from the plugin etc. It will also cover the code repository and the CI/CD aspects, which for this application, were hosted/-maintained on project called [GitLab](#), which is hosted under an open-source license.

### 3.2 OpenStreetMap Data

Elements (or objects) are the basic components of OpenStreetMap's conceptual data model of the physical world. They consist of:

- Nodes (defining points in space)
- Ways (defining linear features and area boundaries)
- Relations (which are sometimes used to explain how other elements work together).

All of the above can have one or more associated tags (which describe the meaning of a particular element). [\[7\]](#)



## 3.2.1 Data Types

### 3.2.1.1 Node

A node represents a specific point on the earth's surface defined by its latitude and longitude. Each node comprises at least an id number and a pair of coordinates.

Nodes can be used to define standalone point features. For example, a node could represent a park bench or a water well.

Nodes are also used to define the shape of a way. When used as points along ways, nodes usually have no tags, though some of them could. For example, *highway=traffic.signals* marks traffic signals on a road, and *power=tower* represents a pylon along an electric power line.

A node can be included as member of relation. The relation also may indicate the member's role: that is, the node's function in this particular set of related data elements. [7]

### 3.2.1.2 Way

A way is an ordered list of between 2 and 2,000 nodes that define a polyline. Ways are used to represent linear features such as rivers and roads.

Ways can also represent the boundaries of areas (solid polygons) such as buildings or forests. In this case, the way's first and last node will be the same. This is called a "closed way".

Note that closed ways occasionally represent loops, such as roundabouts on highways, rather than solid areas. The way's tags must be examined to discover which it is.

Areas with holes, or with boundaries of more than 2,000 nodes, cannot be represented by a single way. Instead, the feature will require a more complex multipolygon relation data structure. [7]

### 3.2.1.3 Relation

A relation is a multi-purpose data structure that documents a relationship between two or more data elements (nodes, ways, and/or other relations). Examples include:

- A route relation, which lists the ways that form a major (numbered) highway, a cycle route, or a bus route.
- A turn restriction that says you can't turn from one way into another way.
- A multipolygon that describes an area (whose boundary is the 'outer way') with holes (the 'inner ways').

Thus, relations can have different meanings. The relation's meaning is defined by its tags. Typically, the relation will have a 'type' tag. The relation's other tags need to be interpreted in light of the type tag.

The relation is primarily an ordered list of nodes, ways, or other relations. These objects are known as the relation's members.

Each element can optionally have a role within the relation. For example, a turn restriction would have members with "from" and "to" roles, describing the particular turn that is forbidden.

A single element such as a particular way may appear multiple times in a relation. [7]

### 3.2.2 Usage of OpenStreetMap Data

All the OpenStreetMap data types explained in the [Data Types](#) can represent various transport-related objects. These data types can represent various transport-related information for the plugin:

- A node can represent a bus station, a bus stop, a train station, elevators near train stations etc.
- A way (be that closed or open ways), can represent footpaths near stations, various steps or ramps that are located in the train station that lead to train platforms, bus platforms etc. They can also represent bus platforms or even train platforms in some cases.
- A relation has children, those children can be of any type, they can even be relations themselves. Relations represent train platforms, bus routes, train routes and require special care from the plugin in order to serve their purpose.

All of this OSM data is contained in the JOSM editor and the plugin has access to JOSM interfaces in order to manipulate such data, which is of course, necessary for the conversion.

The plugin initially checks every visible element within the JOSM map layer and checks their tags. Their tags then represent what kind of an element that is and if it is relative to our plugin. After that, the plugin finds the relative elements and their type, and then depending on the type, different NeTEx objects are created. While the NeTEx objects are being created, the conversion algorithm adds various attributes to those objects depending on the tags that they contain, what they are close to and their importance to the related transport information. Different elements that are found at later stages can be related to previously identified relative elements, when that happens, the algorithm finds the connection of those elements and relates/fixes them accordingly.

### 3.3 Java OpenStreetMap Editor

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### 3.4 NeTeX Conversion

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### 3.5 XML Binding Framework

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### 3.6 Testing

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### 3.6.1 Unit Testing

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### 3.7 Code Repository and the CI/CD Pipeline Feature

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Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Donec odio elit, dictum in, hendrerit sit amet, egestas sed, leo. Praesent feugiat sapien aliquet odio. Integer vitae justo. Aliquam vestibulum fringilla lorem. Sed neque lectus, consectetur at, consectetur sed, eleifend ac, lectus. Nulla facilisi. Pellentesque eget lectus. Proin eu metus. Sed porttitor. In hac habitasse platea dictumst. Suspendisse eu lectus. Ut mi mi, lacinia sit amet, placerat et, mollis vitae, dui. Sed ante tellus, tristique ut, iaculis eu, malesuada ac, dui. Mauris nibh leo, facilisis non, adipiscing quis, ultrices a, dui.

### 3.8 Document Preparation System

Suspendisse vitae elit. Aliquam arcu neque, ornare in, ullamcorper quis, commodo eu, libero. Fusce sagittis erat at erat tristique mollis. Maecenas sapien libero, molestie et, lobortis in, sodales eget, dui. Morbi ultrices rutrum lorem. Nam elementum ullamcorper leo. Morbi dui. Aliquam sagittis. Nunc placerat. Pellentesque tristique sodales est. Maecenas imperdiet lacinia velit. Cras non urna. Morbi eros pede, suscipit ac, varius vel, egestas non, eros. Praesent malesuada, diam id pretium elementum, eros sem dictum tortor, vel consectetur odio sem sed wisi.

Sed feugiat. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Ut pellentesque augue sed urna. Vestibulum diam eros, fringilla et, consectetur eu, nonummy id, sapien. Nullam at lectus. In sagittis ultrices mauris. Curabitur malesuada erat sit amet massa. Fusce blandit. Aliquam erat volutpat. Aliquam euismod. Aenean vel lectus. Nunc imperdiet justo nec dolor.

# Chapter 4

## Results

### 4.1 Achievements

Fusce mauris. Vestibulum luctus nibh at lectus. Sed bibendum, nulla a faucibus semper, leo velit ultricies tellus, ac venenatis arcu wisi vel nisl. Vestibulum diam. Aliquam pellentesque, augue quis sagittis posuere, turpis lacus congue quam, in hendrerit risus eros eget felis. Maecenas eget erat in sapien mattis porttitor. Vestibulum porttitor. Nulla facilisi. Sed a turpis eu lacus commodo facilisis. Morbi fringilla, wisi in dignissim interdum, justo lectus sagittis dui, et vehicula libero dui cursus dui. Mauris tempor ligula sed lacus. Duis cursus enim ut augue. Cras ac magna. Cras nulla. Nulla egestas. Curabitur a leo. Quisque egestas wisi eget nunc. Nam feugiat lacus vel est. Curabitur consectetur.

Suspendisse vel felis. Ut lorem lorem, interdum eu, tincidunt sit amet, laoreet vitae, arcu. Aenean faucibus pede eu ante. Praesent enim elit, rutrum at, molestie non, nonummy vel, nisl. Ut lectus eros, malesuada sit amet, fermentum eu, sodales cursus, magna. Donec eu purus. Quisque vehicula, urna sed ultricies auctor, pede lorem egestas dui, et convallis elit erat sed nulla. Donec luctus. Curabitur et nunc. Aliquam dolor odio, commodo pretium, ultricies non, pharetra in, velit. Integer arcu est, nonummy in, fermentum faucibus, egestas vel, odio.

## 4.2 Reflection

Sed commodo posuere pede. Mauris ut est. Ut quis purus. Sed ac odio. Sed vehicula hendrerit sem. Duis non odio. Morbi ut dui. Sed accumsan risus eget odio. In hac habitasse platea dictumst. Pellentesque non elit. Fusce sed justo eu urna porta tincidunt. Mauris felis odio, sollicitudin sed, volutpat a, ornare ac, erat. Morbi quis dolor. Donec pellentesque, erat ac sagittis semper, nunc dui lobortis purus, quis congue purus metus ultricies tellus. Proin et quam. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Praesent sapien turpis, fermentum vel, eleifend faucibus, vehicula eu, lacus.

Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Donec odio elit, dictum in, hendrerit sit amet, egestas sed, leo. Praesent feugiat sapien aliquet odio. Integer vitae justo. Aliquam vestibulum fringilla lorem. Sed neque lectus, consectetur at, consectetur sed, eleifend ac, lectus. Nulla facilisi. Pellentesque eget lectus. Proin eu metus. Sed porttitor. In hac habitasse platea dictumst. Suspendisse eu lectus. Ut mi mi, lacinia sit amet, placerat et, mollis vitae, dui. Sed ante tellus, tristique ut, iaculis eu, malesuada ac, dui. Mauris nibh leo, facilisis non, adipiscing quis, ultrices a, dui.

## 4.3 Results & Conclusion

Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Donec odio elit, dictum in, hendrerit sit amet, egestas sed, leo. Praesent feugiat sapien aliquet odio. Integer vitae justo. Aliquam vestibulum fringilla lorem. Sed neque lectus, consectetur at, consectetur sed, eleifend ac, lectus. Nulla facilisi. Pellentesque eget lectus. Proin eu metus. Sed porttitor. In hac habitasse platea dictumst. Suspendisse eu lectus. Ut mi mi, lacinia sit amet, placerat et, mollis vitae, dui. Sed ante tellus, tristique ut, iaculis eu, malesuada ac, dui. Mauris nibh leo, facilisis non, adipiscing quis, ultrices a, dui.

Morbi luctus, wisi viverra faucibus pretium, nibh est placerat odio, nec commodo wisi enim eget quam. Quisque libero justo, consectetur a, feugiat vitae, porttitor eu, libero. Suspendisse sed mauris vitae elit sollicitudin malesuada. Maecenas ultricies eros sit amet ante. Ut venenatis velit. Maecenas sed mi eget dui varius euismod. Phasellus aliquet volutpat odio. Vestibulum ante ipsum primis in faucibus orci luctus et ultrices posuere cubilia Curae; Pellentesque sit amet pede ac sem eleifend consectetur. Nullam elementum, urna vel imperdiet sodales, elit ipsum pharetra ligula, ac pretium ante justo a nulla. Curabitur tristique arcu eu metus. Vestibulum lectus. Proin mauris. Proin eu nunc eu urna hendrerit faucibus. Aliquam auctor, pede consequat laoreet varius,



eros tellus scelerisque quam, pellentesque hendrerit ipsum dolor sed augue. Nulla nec lacus.

# Appendix A

## Installation

Sed commodo posuere pede. Mauris ut est. Ut quis purus. Sed ac odio. Sed vehicula hendrerit sem. Duis non odio. Morbi ut dui. Sed accumsan risus eget odio. In hac habitasse platea dictumst. Pellentesque non elit. Fusce sed justo eu urna porta tincidunt. Mauris felis odio, sollicitudin sed, volutpat a, ornare ac, erat. Morbi quis dolor. Donec pellentesque, erat ac sagittis semper, nunc dui lobortis purus, quis congue purus metus ultricies tellus. Proin et quam. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Praesent sapien turpis, fermentum vel, eleifend faucibus, vehicula eu, lacus.

Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Donec odio elit, dictum in, hendrerit sit amet, egestas sed, leo. Praesent feugiat sapien aliquet odio. Integer vitae justo. Aliquam vestibulum fringilla lorem. Sed neque lectus, consectetur at, consectetur sed, eleifend ac, lectus. Nulla facilisi. Pellentesque eget lectus. Proin eu metus. Sed porttitor. In hac habitasse platea dictumst. Suspendisse eu lectus. Ut mi mi, lacinia sit amet, placerat et, mollis vitae, dui. Sed ante tellus, tristique ut, iaculis eu, malesuada ac, dui. Mauris nibh leo, facilisis non, adipiscing quis, ultrices a, dui.

Morbi luctus, wisi viverra faucibus pretium, nibh est placerat odio, nec commodo wisi enim eget quam. Quisque libero justo, consectetur a, feugiat vitae, porttitor eu, libero. Suspendisse sed mauris vitae elit sollicitudin malesuada. Maecenas ultricies eros sit amet ante. Ut venenatis velit. Maecenas sed mi eget dui varius euismod. Phasellus aliquet volutpat odio. Vestibulum ante ipsum primis in faucibus orci luctus et ultrices posuere cubilia Curae; Pellentesque sit amet pede ac sem eleifend consectetur. Nullam elementum, urna vel imperdiet sodales, elit ipsum pharetra ligula, ac pretium ante justo a nulla. Curabitur tristique arcu eu metus. Vestibulum lectus. Proin mauris. Proin eu nunc eu urna hendrerit faucibus. Aliquam auctor, pede consequat laoreet varius, eros tellus scelerisque quam, pellentesque hendrerit ipsum dolor sed augue. Nulla nec lacus.

Suspendisse vitae elit. Aliquam arcu neque, ornare in, ullamcorper quis, commodo eu, libero. Fusce sagittis erat at erat tristique mollis. Maecenas sapien libero, molestie et, lobortis in, sodales eget, dui. Morbi ultrices rutrum lorem. Nam elementum ullamcorper leo. Morbi dui. Aliquam sagittis. Nunc placerat. Pellentesque tristique sodales est. Maecenas imperdiet lacinia velit. Cras non urna. Morbi eros pede, suscipit ac, varius vel, egestas non, eros. Praesent malesuada, diam id pretium elementum, eros sem dictum tortor, vel consectetur odio sem sed wisi.

# Appendix B

## OSM Data

Suspendisse vel felis. Ut lorem lorem, interdum eu, tincidunt sit amet, laoreet vitae, arcu. Aenean faucibus pede eu ante. Praesent enim elit, rutrum at, molestie non, nonummy vel, nisl. Ut lectus eros, malesuada sit amet, fermentum eu, sodales cursus, magna. Donec eu purus. Quisque vehicula, urna sed ultricies auctor, pede lorem egestas dui, et convallis elit erat sed nulla. Donec luctus. Curabitur et nunc. Aliquam dolor odio, commodo pretium, ultricies non, pharetra in, velit. Integer arcu est, nonummy in, fermentum faucibus, egestas vel, odio.

Sed commodo posuere pede. Mauris ut est. Ut quis purus. Sed ac odio. Sed vehicula hendrerit sem. Duis non odio. Morbi ut dui. Sed accumsan risus eget odio. In hac habitasse platea dictumst. Pellentesque non elit. Fusce sed justo eu urna porta tincidunt. Mauris felis odio, sollicitudin sed, volutpat a, ornare ac, erat. Morbi quis dolor. Donec pellentesque, erat ac sagittis semper, nunc dui lobortis purus, quis congue purus metus ultricies tellus. Proin et quam. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Praesent sapien turpis, fermentum vel, eleifend faucibus, vehicula eu, lacus.

Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Donec odio elit, dictum in, hendrerit sit amet, egestas sed, leo. Praesent feugiat sapien aliquet odio. Integer vitae justo. Aliquam vestibulum fringilla lorem. Sed neque lectus, consectetur at, consectetur sed, eleifend ac, lectus. Nulla facilisi. Pellentesque eget lectus. Proin eu metus. Sed porttitor. In hac habitasse platea dictumst. Suspendisse eu lectus. Ut mi mi, lacinia sit amet, placerat et, mollis vitae, dui. Sed ante tellus, tristique ut, iaculis eu, malesuada ac, dui. Mauris nibh leo, facilisis non, adipiscing quis, ultrices a, dui.

Morbi luctus, wisi viverra faucibus pretium, nibh est placerat odio, nec commodo wisi enim eget quam. Quisque libero justo, consectetur a, feugiat vitae, porttitor eu, libero. Suspendisse sed mauris vitae elit sollicitudin malesuada. Maecenas ultricies eros sit amet ante. Ut venenatis velit. Maecenas sed mi eget dui varius euismod. Phasellus aliquet volutpat odio. Vestibulum ante ipsum primis in faucibus orci luctus et ultrices

posuere cubilia Curae; Pellentesque sit amet pede ac sem eleifend consectetuer. Nullam elementum, urna vel imperdiet sodales, elit ipsum pharetra ligula, ac pretium ante justo a nulla. Curabitur tristique arcu eu metus. Vestibulum lectus. Proin mauris. Proin eu nunc eu urna hendrerit faucibus. Aliquam auctor, pede consequat laoreet varius, eros tellus scelerisque quam, pellentesque hendrerit ipsum dolor sed augue. Nulla nec lacus.

Suspendisse vitae elit. Aliquam arcu neque, ornare in, ullamcorper quis, commodo eu, libero. Fusce sagittis erat at erat tristique mollis. Maecenas sapien libero, molestie et, lobortis in, sodales eget, dui. Morbi ultrices rutrum lorem. Nam elementum ullamcorper leo. Morbi dui. Aliquam sagittis. Nunc placerat. Pellentesque tristique sodales est. Maecenas imperdiet lacinia velit. Cras non urna. Morbi eros pede, suscipit ac, varius vel, egestas non, eros. Praesent malesuada, diam id pretium elementum, eros sem dictum tortor, vel consectetuer odio sem sed wisi.

# Appendix C

## NeTEx Data

Suspendisse vitae elit. Aliquam arcu neque, ornare in, ullamcorper quis, commodo eu, libero. Fusce sagittis erat at erat tristique mollis. Maecenas sapien libero, molestie et, lobortis in, sodales eget, dui. Morbi ultrices rutrum lorem. Nam elementum ullamcorper leo. Morbi dui. Aliquam sagittis. Nunc placerat. Pellentesque tristique sodales est. Maecenas imperdiet lacinia velit. Cras non urna. Morbi eros pede, suscipit ac, varius vel, egestas non, eros. Praesent malesuada, diam id pretium elementum, eros sem dictum tortor, vel consectetur odio sem sed wisi.

Sed feugiat. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Ut pellentesque augue sed urna. Vestibulum diam eros, fringilla et, consectetur eu, nonummy id, sapien. Nullam at lectus. In sagittis ultrices mauris. Curabitur malesuada erat sit amet massa. Fusce blandit. Aliquam erat volutpat. Aliquam euismod. Aenean vel lectus. Nunc imperdiet justo nec dolor.

Etiam euismod. Fusce facilisis lacinia dui. Suspendisse potenti. In mi erat, cursus id, nonummy sed, ullamcorper eget, sapien. Praesent pretium, magna in eleifend egestas, pede pede pretium lorem, quis consectetur tortor sapien facilisis magna. Mauris quis magna varius nulla scelerisque imperdiet. Aliquam non quam. Aliquam porttitor quam a lacus. Praesent vel arcu ut tortor cursus volutpat. In vitae pede quis diam bibendum placerat. Fusce elementum convallis neque. Sed dolor orci, scelerisque ac, dapibus nec, ultricies ut, mi. Duis nec dui quis leo sagittis commodo.

Aliquam lectus. Vivamus leo. Quisque ornare tellus ullamcorper nulla. Mauris porttitor pharetra tortor. Sed fringilla justo sed mauris. Mauris tellus. Sed non leo. Nullam elementum, magna in cursus sodales, augue est scelerisque sapien, venenatis congue nulla arcu et pede. Ut suscipit enim vel sapien. Donec congue. Maecenas urna mi, suscipit in, placerat ut, vestibulum ut, massa. Fusce ultrices nulla et nisl.

Etiam ac leo a risus tristique nonummy. Donec dignissim tincidunt nulla. Vestibulum rhoncus molestie odio. Sed lobortis, justo et pretium lobortis, mauris turpis condimentum augue, nec ultricies nibh arcu pretium enim. Nunc purus neque, placerat id, imperdiet sed, pellentesque nec, nisl. Vestibulum imperdiet neque non sem accumsan

laoreet. In hac habitasse platea dictumst. Etiam condimentum facilisis libero. Suspendisse in elit quis nisl aliquam dapibus. Pellentesque auctor sapien. Sed egestas sapien nec lectus. Pellentesque vel dui vel neque bibendum viverra. Aliquam porttitor nisl nec pede. Proin mattis libero vel turpis. Donec rutrum mauris et libero. Proin euismod porta felis. Nam lobortis, metus quis elementum commodo, nunc lectus elementum mauris, eget vulputate ligula tellus eu neque. Vivamus eu dolor.

# Appendix D

## Project Management

### D.1 Organization

Fusce mauris. Vestibulum luctus nibh at lectus. Sed bibendum, nulla a faucibus semper, leo velit ultricies tellus, ac venenatis arcu wisi vel nisl. Vestibulum diam. Aliquam pellentesque, augue quis sagittis posuere, turpis lacus congue quam, in hendrerit risus eros eget felis. Maecenas eget erat in sapien mattis porttitor. Vestibulum porttitor. Nulla facilisi. Sed a turpis eu lacus commodo facilisis. Morbi fringilla, wisi in dignissim interdum, justo lectus sagittis dui, et vehicula libero dui cursus dui. Mauris tempor ligula sed lacus. Duis cursus enim ut augue. Cras ac magna. Cras nulla. Nulla egestas. Curabitur a leo. Quisque egestas wisi eget nunc. Nam feugiat lacus vel est. Curabitur consectetur.

Suspendisse vel felis. Ut lorem lorem, interdum eu, tincidunt sit amet, laoreet vitae, arcu. Aenean faucibus pede eu ante. Praesent enim elit, rutrum at, molestie non, nonummy vel, nisl. Ut lectus eros, malesuada sit amet, fermentum eu, sodales cursus, magna. Donec eu purus. Quisque vehicula, urna sed ultricies auctor, pede lorem egestas dui, et convallis elit erat sed nulla. Donec luctus. Curabitur et nunc. Aliquam dolor odio, commodo pretium, ultricies non, pharetra in, velit. Integer arcu est, nonummy in, fermentum faucibus, egestas vel, odio.

### D.2 Planning and Coordination

Sed commodo posuere pede. Mauris ut est. Ut quis purus. Sed ac odio. Sed vehicula hendrerit sem. Duis non odio. Morbi ut dui. Sed accumsan risus eget odio. In hac habitasse platea dictumst. Pellentesque non elit. Fusce sed justo eu urna porta tincidunt. Mauris felis odio, sollicitudin sed, volutpat a, ornare ac, erat. Morbi quis dolor. Donec pellentesque, erat ac sagittis semper, nunc dui lobortis purus, quis congue purus metus ultricies tellus. Proin et quam. Class aptent taciti sociosqu ad litora torquent



per conubia nostra, per inceptos hymenaeos. Praesent sapien turpis, fermentum vel, eleifend faucibus, vehicula eu, lacus.

Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Donec odio elit, dictum in, hendrerit sit amet, egestas sed, leo. Praesent feugiat sapien aliquet odio. Integer vitae justo. Aliquam vestibulum fringilla lorem. Sed neque lectus, consectetur at, consectetur sed, eleifend ac, lectus. Nulla facilisi. Pellentesque eget lectus. Proin eu metus. Sed porttitor. In hac habitasse platea dictumst. Suspendisse eu lectus. Ut mi mi, lacinia sit amet, placerat et, mollis vitae, dui. Sed ante tellus, tristique ut, iaculis eu, malesuada ac, dui. Mauris nibh leo, facilisis non, adipiscing quis, ultrices a, dui.

## D.3 Workflow

Morbi luctus, wisi viverra faucibus pretium, nibh est placerat odio, nec commodo wisi enim eget quam. Quisque libero justo, consectetur a, feugiat vitae, porttitor eu, libero. Suspendisse sed mauris vitae elit sollicitudin malesuada. Maecenas ultricies eros sit amet ante. Ut venenatis velit. Maecenas sed mi eget dui varius euismod. Phasellus aliquet volutpat odio. Vestibulum ante ipsum primis in faucibus orci luctus et ultrices posuere cubilia Curae; Pellentesque sit amet pede ac sem eleifend consectetur. Nullam elementum, urna vel imperdiet sodales, elit ipsum pharetra ligula, ac pretium ante justo a nulla. Curabitur tristique arcu eu metus. Vestibulum lectus. Proin mauris. Proin eu nunc eu urna hendrerit faucibus. Aliquam auctor, pede consequat laoreet varius, eros tellus scelerisque quam, pellentesque hendrerit ipsum dolor sed augue. Nulla nec lacus.

Suspendisse vitae elit. Aliquam arcu neque, ornare in, ullamcorper quis, commodo eu, libero. Fusce sagittis erat at erat tristique mollis. Maecenas sapien libero, molestie et, lobortis in, sodales eget, dui. Morbi ultrices rutrum lorem. Nam elementum ullamcorper leo. Morbi dui. Aliquam sagittis. Nunc placerat. Pellentesque tristique sodales est. Maecenas imperdiet lacinia velit. Cras non urna. Morbi eros pede, suscipit ac, varius vel, egestas non, eros. Praesent malesuada, diam id pretium elementum, eros sem dictum tortor, vel consectetur odio sem sed wisi.

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