Universidad de Castilla-La Mancha

Escuela Superior de Informática

Algebra & Discrete Mathematics

Incremental Laboratory Practice: Navigation System

2021/2022

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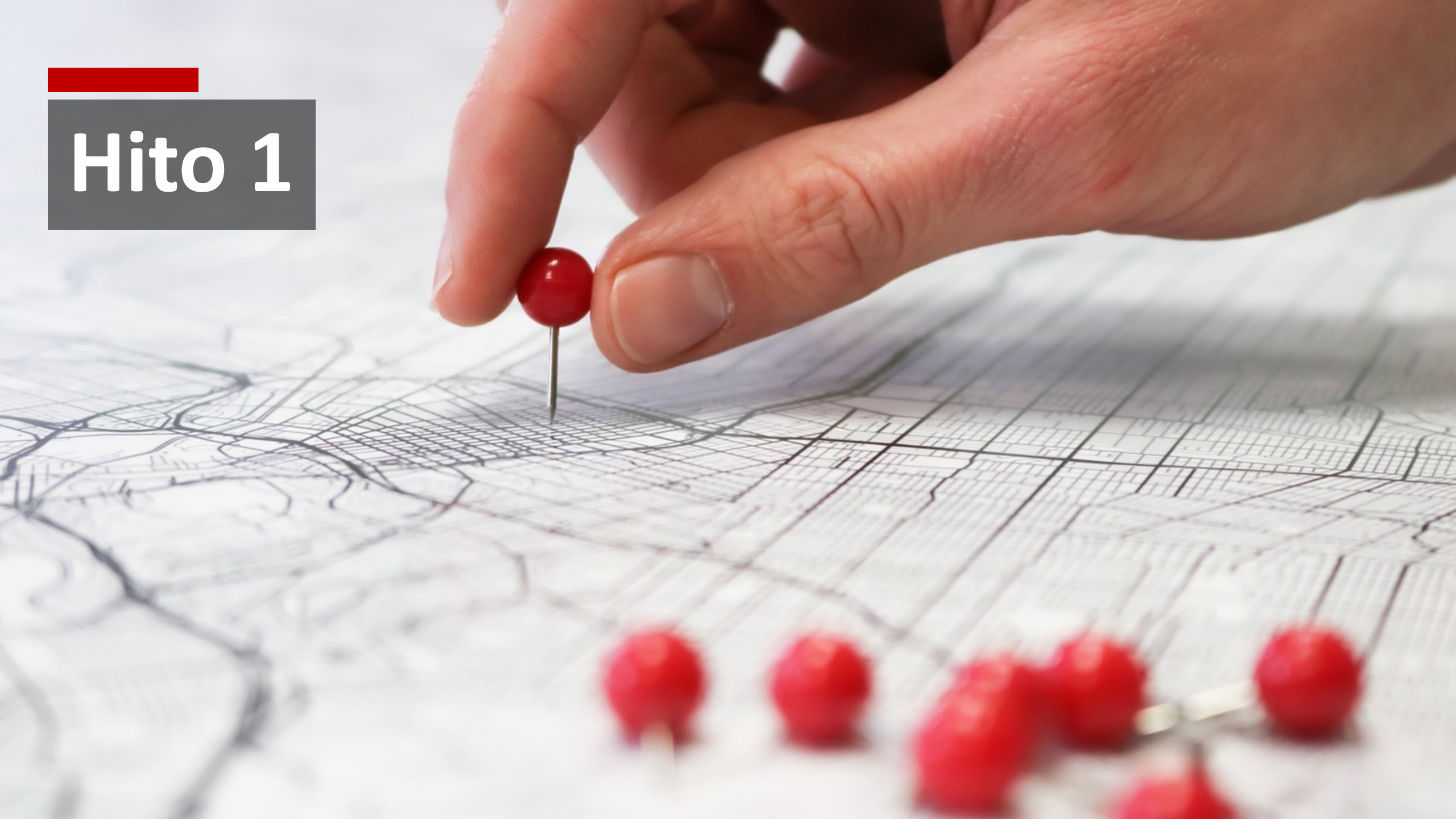
Grading

55 %	20 %	15 %	10 %
Final test Compulsory Can be retaken	**Lab practice** Optional Can be retaken	**Lab exams** Compulsory Can be retaken	**Class work** Optional Can be retaken
Friday 20 May	Sunday 22 May	During the practical sessions	Sunday 22 May
Retaken on: Tuesday 28 June	Sunday 26 June	Tuesday 28 June	Sunday 26 June

Hito 1



Relación: Ciudad Real (348267)

Versión #10

fixed wikidata tag

Editado hace más de 1 año por howtech · Conjunto de cambios #90499584

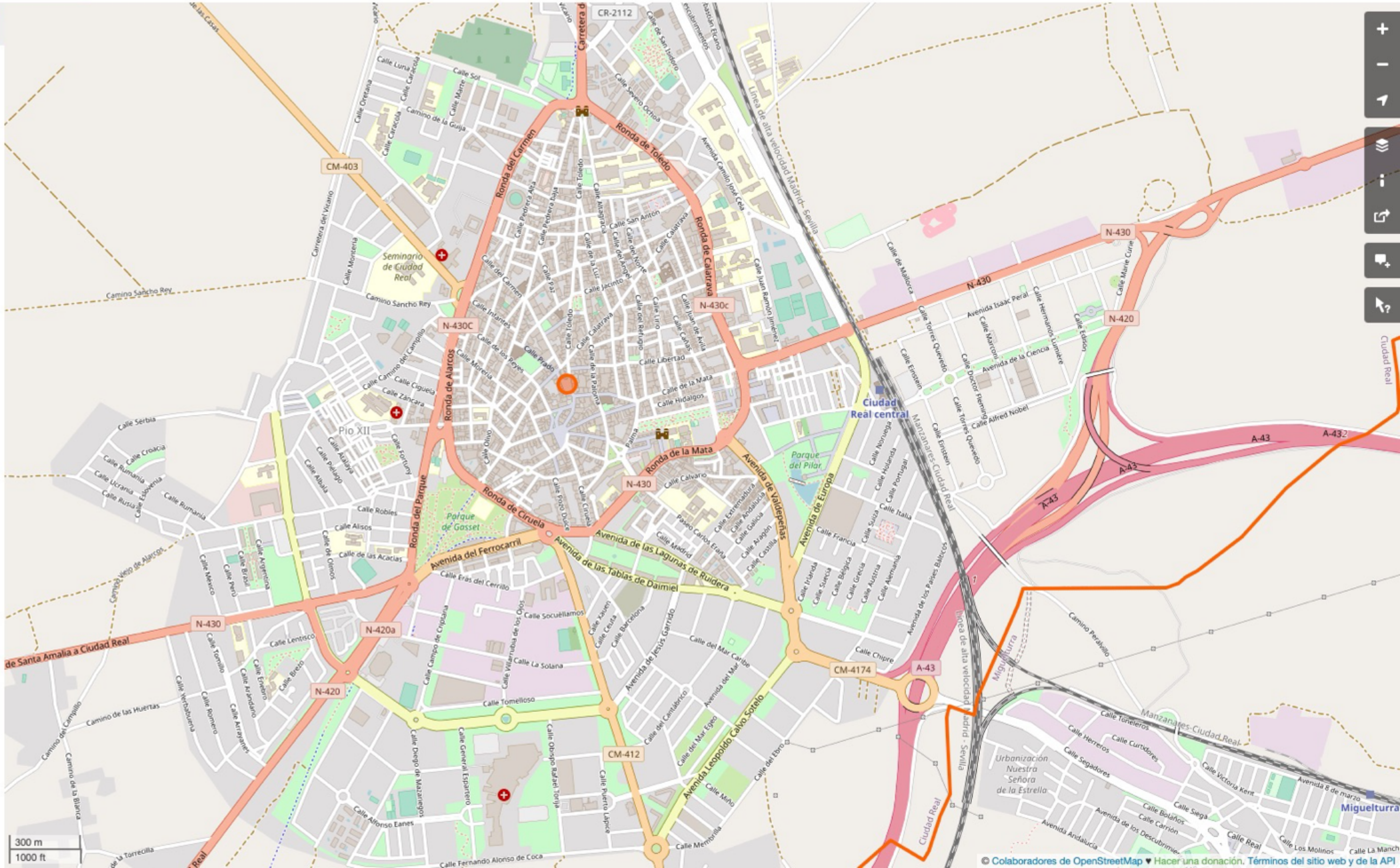
Etiquetas

admin_level	8
alt_name:ar	سيوداد ريال
boundary	administrative
idee:name	Ciudad Real
ine:municipio	13034
name	Ciudad Real
name:ar	ثيوداد ريال
name:el	Θιουδάδ Ρεάλ
name:ru	Сьюдад-Реаль
population	74345
population:date	2009
source	BDLL25, EGRN, Instituto Geográfico Nacional
type	boundary
wikidata	Q56241563
wikipedia	es:La Solana (Ciudad Real)

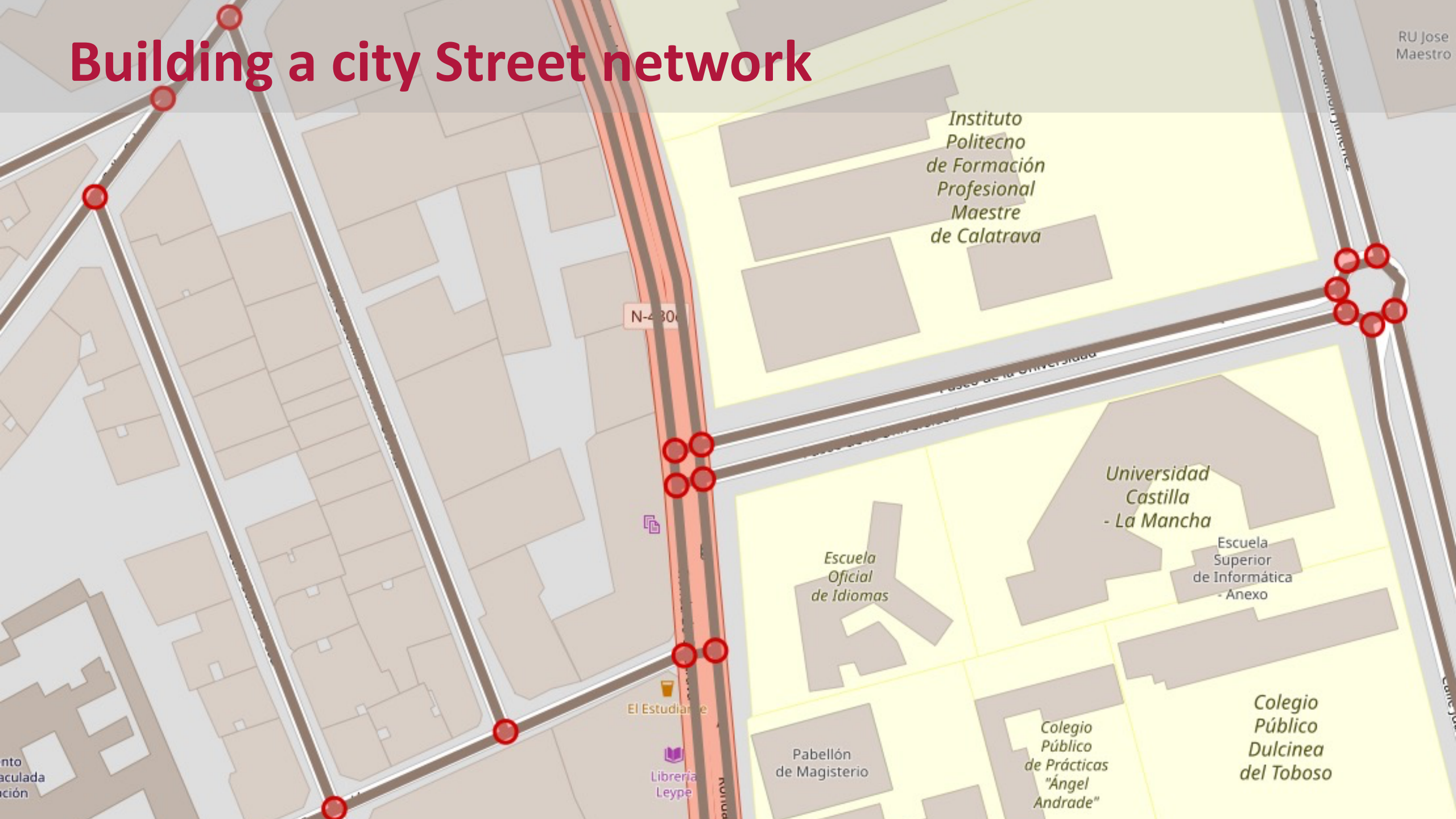
Parte de

▼ 1 relación

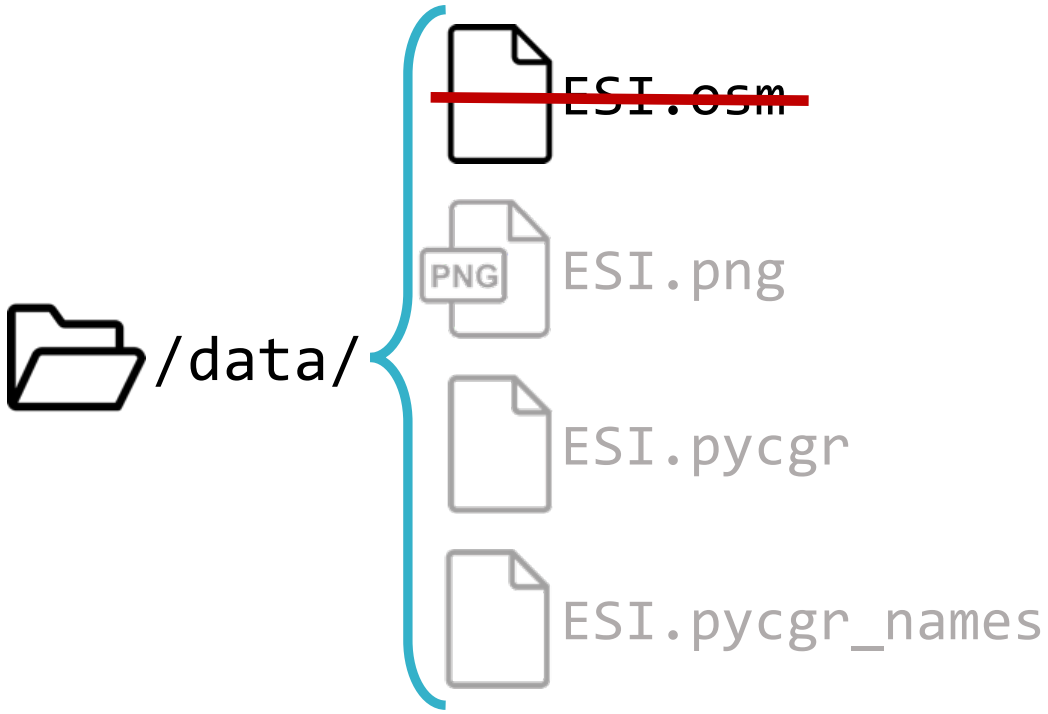
Relación Campo de Calatrava (6370267) (como subarea)



Building a city Street network

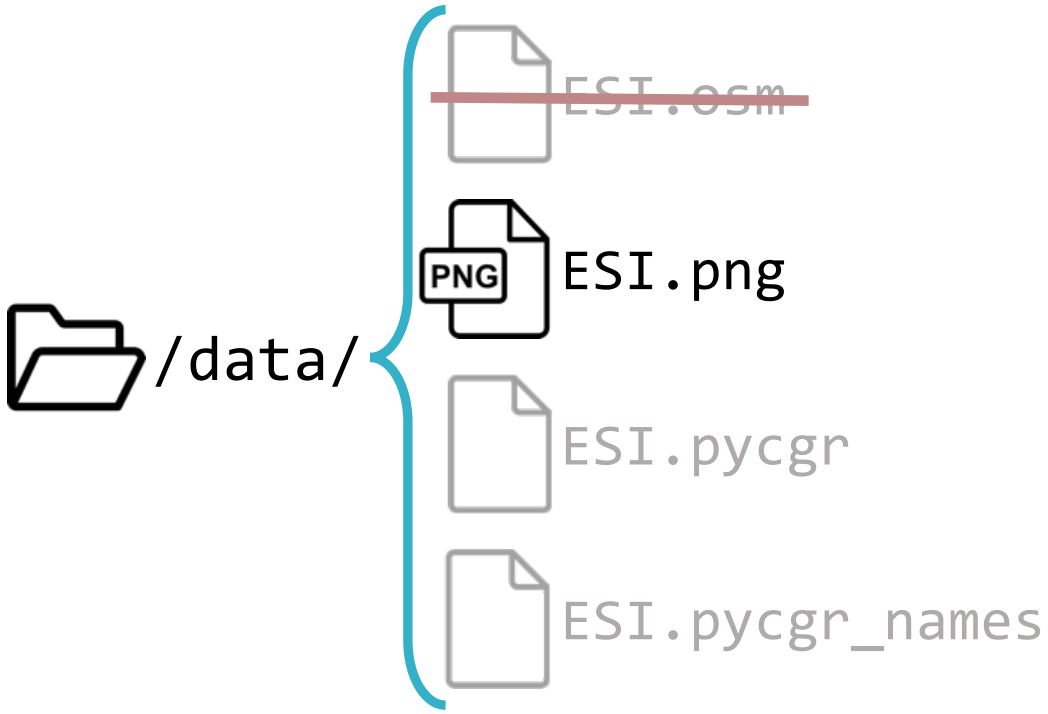


Building a city Street network

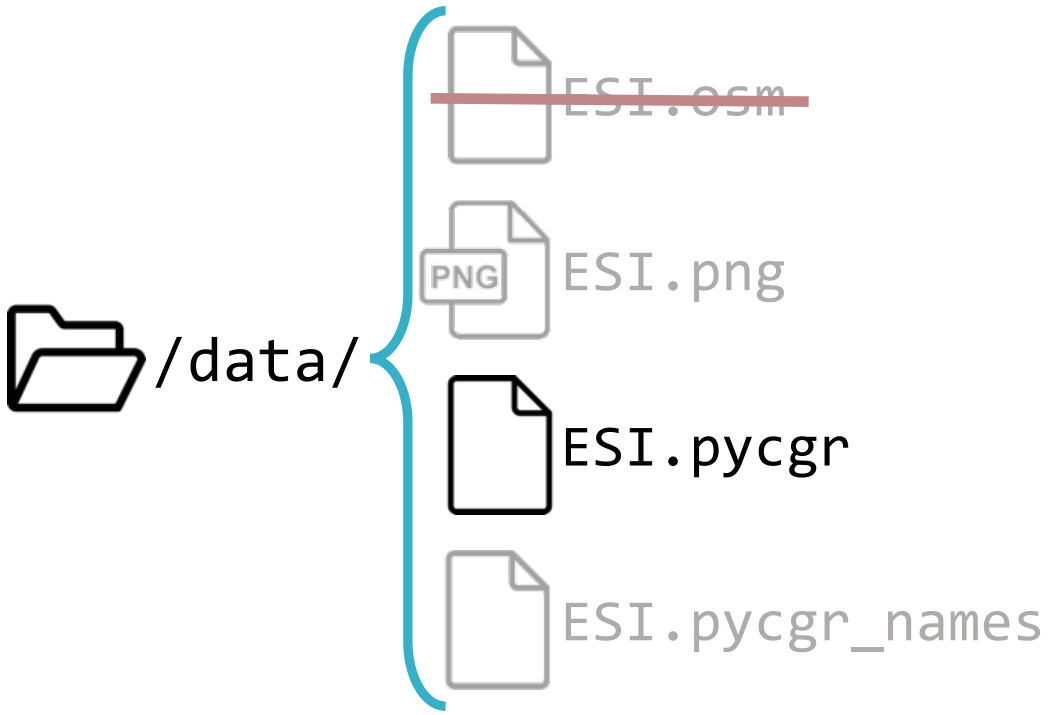



```
<?xml version="1.0" encoding="UTF-8"?>
<osm version="0.6" generator="CGImap 0.8.6 (3065361 spike-06.openstreetmap.org)"
copyright="OpenStreetMap and contributors"
attribution="http://www.openstreetmap.org/copyright"
license="http://opendatacommons.org/licenses/odbl/1-0/">
 <bounds minlat="38.9871000" minlon="-3.9272000" maxlat="38.9940000" maxlon="-
3.9140000"/>
 <node id="162036412" visible="true" version="5" changeset="11819556" timestamp="2012-06-
06T21:01:24Z" user="ilvidel" uid="670354" lat="38.9865852" lon="-3.9203760"/>
 <node id="162036416" visible="true" version="4" changeset="11819556" timestamp="2012-06-
06T21:01:24Z" user="ilvidel" uid="670354" lat="38.9881633" lon="-3.9213007"/>
 <node id="162036421" visible="true" version="4" changeset="11819556" timestamp="2012-06-
06T21:01:24Z" user="ilvidel" uid="670354" lat="38.9907814" lon="-3.9217245"/>
 <node id="162036427" visible="true" version="4" changeset="11819556" timestamp="2012-06-
06T21:01:24Z" user="ilvidel" uid="670354" lat="38.9919613" lon="-3.9222026"/>
 <node id="247377468" visible="true" version="3" changeset="15771354" timestamp="2013-04-
18T09:36:53Z" user="Ropino" uid="42123" lat="39.0005164" lon="-3.9216758">
  <tag k="converted_by" v="Track2osm"/>
 </node>
 <node id="247377501" visible="true" version="3" changeset="15772961" timestamp="2013-04-
18T12:37:33Z" user="Ropino" uid="42123" lat="39.0359973" lon="-3.9203378">
  <tag k="converted_by" v="Track2osm"/>
 </node>
```

Building a city Street network

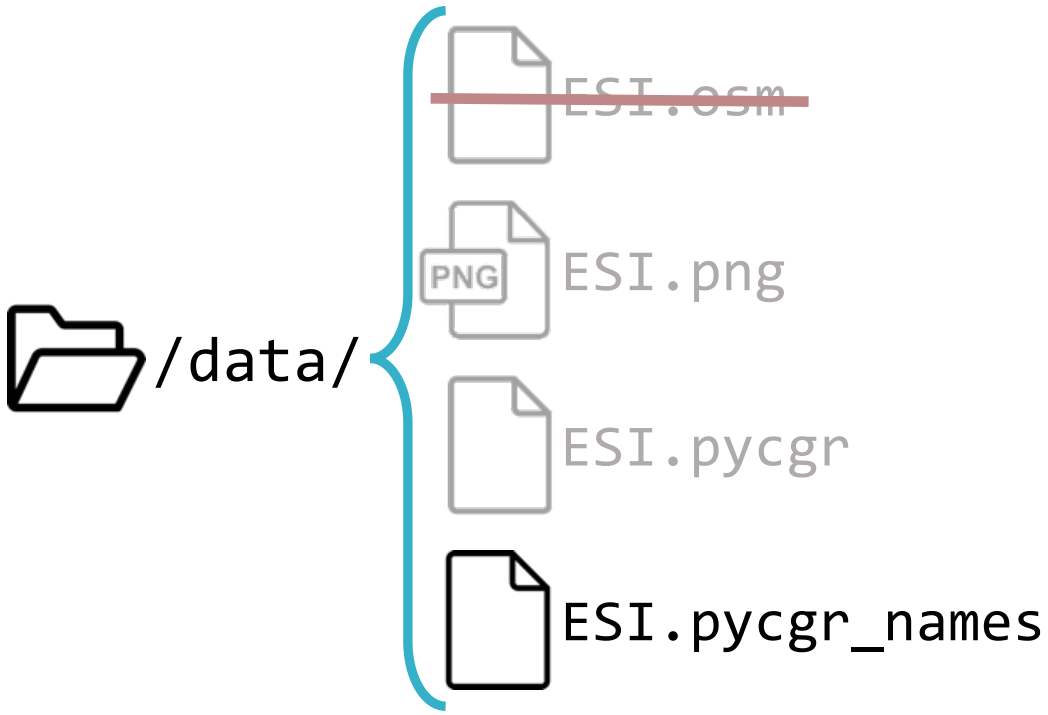


Building a city Street network




```
# Road Graph File v.0.4
# number of nodes
# number of edges
# node_properties
# ...
# edge_properties
# ...
409
472
0 38.9865852 -3.920376
1 38.9881633 -3.9213007
2 38.9907814 -3.9217245
3 38.9919613 -3.9222026
4 38.9936147 -3.9210588
5 38.9925133 -3.9225193
...
13 55 82.24 residential 20 0
55 54 107.99 residential 20 0
54 202 51.85 residential 20 0
202 57 70.26 residential 20 0
57 22 62.98 residential 20 0
22 226 64.77 residential 20 0
226 379 41.78 residential 20 0
```

Building a city Street network



Calle Altagracia
Calle Altagracia
Calle Altagracia
Calle Altagracia
Calle Altagracia
Calle Altagracia
Calle Altagracia
Calle Altagracia
Calle Altagracia
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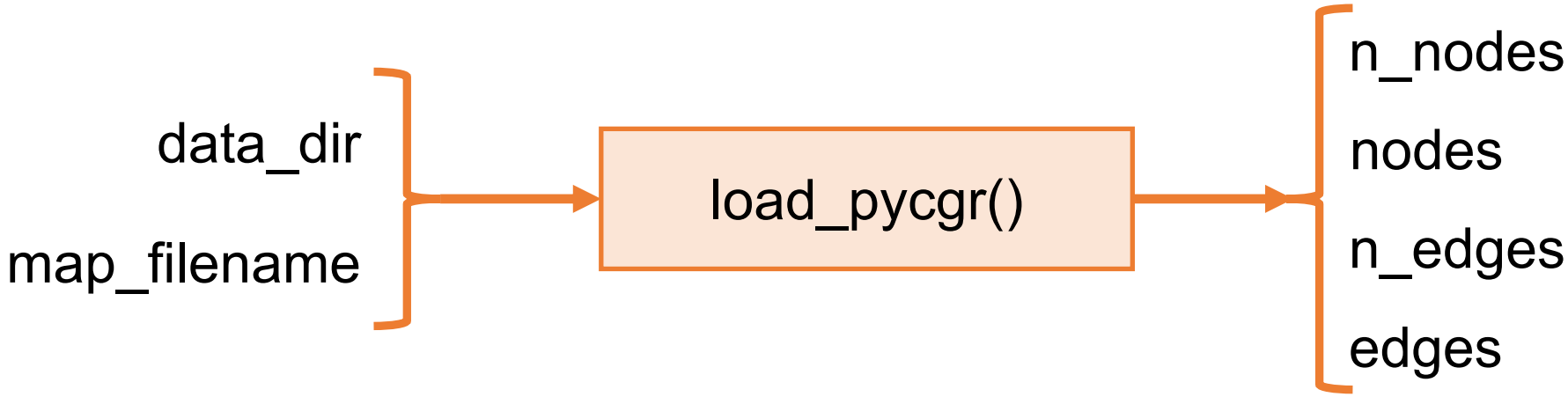
Calle Altagracia
Calle Altagracia
Calle Altagracia
Calle Altagracia
Calle Altagracia
Calle Altagracia
Calle Don Quijote
Calle Don Quijote
Calle Don Quijote
Calle Don Quijote
Calle Don Quijote
Calle Carlos López Bustos
Avenida de los Descubrimientos

Template for Hito1.m

```
%% Variable definition
data_dir = 'data/'; % Relative path to the data
map_filename = 'ESI'; % Values: ESI, RondaCiudadReal, CiudadReal

% Set the bounds for the map (do not change)
switch map_filename
    case 'ESI'
        bounds = [-3.9272, -3.9140; 38.9871, 38.9940];
    case 'RondaCiudadReal'
        bounds = [-3.9388, -3.9136; 38.9795, 38.9965];
    case 'CiudadReal'
        bounds = [-3.9568, -3.8964; 38.9670, 39.0038];
    otherwise
        error("Wrong value for variable `map_filename`");
end


%% Load graph data



%% Construct the graph
% Undirected graph for visualization


% Actual digraph
% Add reverse direction to bidirectional roads (from target to source)



%% Plot the graph
```

Load the pycgr file




```
nodes =

  struct with fields:

     id: [409×1 int32]
    lat: [409×1 double]
    lon: [409×1 double]
```

```
edges =

  struct with fields:

         source: [550×1 int32]
         target: [550×1 int32]
         length: [550×1 double]
           type: {550×1 cell}
       maxspeed: [550×1 single]
  bidirectional: [550×1 int32]
           name: [550×1 string]
```

Construct the graph

1. Construct an **undirected graph** for visualization

2. Construct the actual **digraph** for the navigation system

But first:

1. Add reverse direction to bidirectional roads (edges.bidirectional == 1)

2. Append those edges at the end of the *edges* structure

Plot the graph

1. Create a figure

```
fig = figure();
```

2. Create a axes object

```
ax = axes('Parent', fig);
```

3. Draw the background image

```
show_map(ax, bounds, ‘A title for the map’,
data_dir, map_filename)
```

4. Plot the graph on top

! Remember to set the X and Y coordinates for the nodes

Graph of ‘ESI’

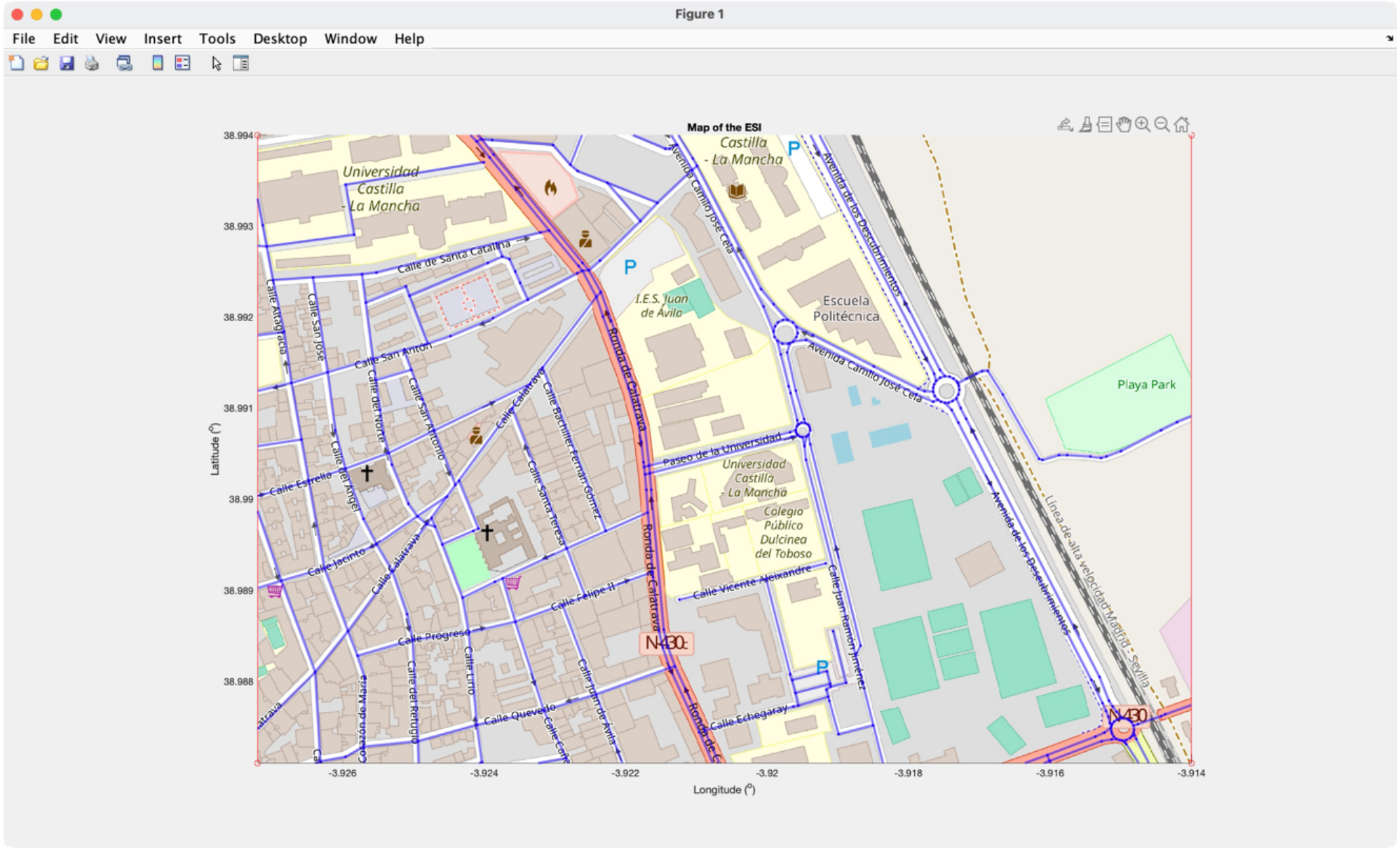
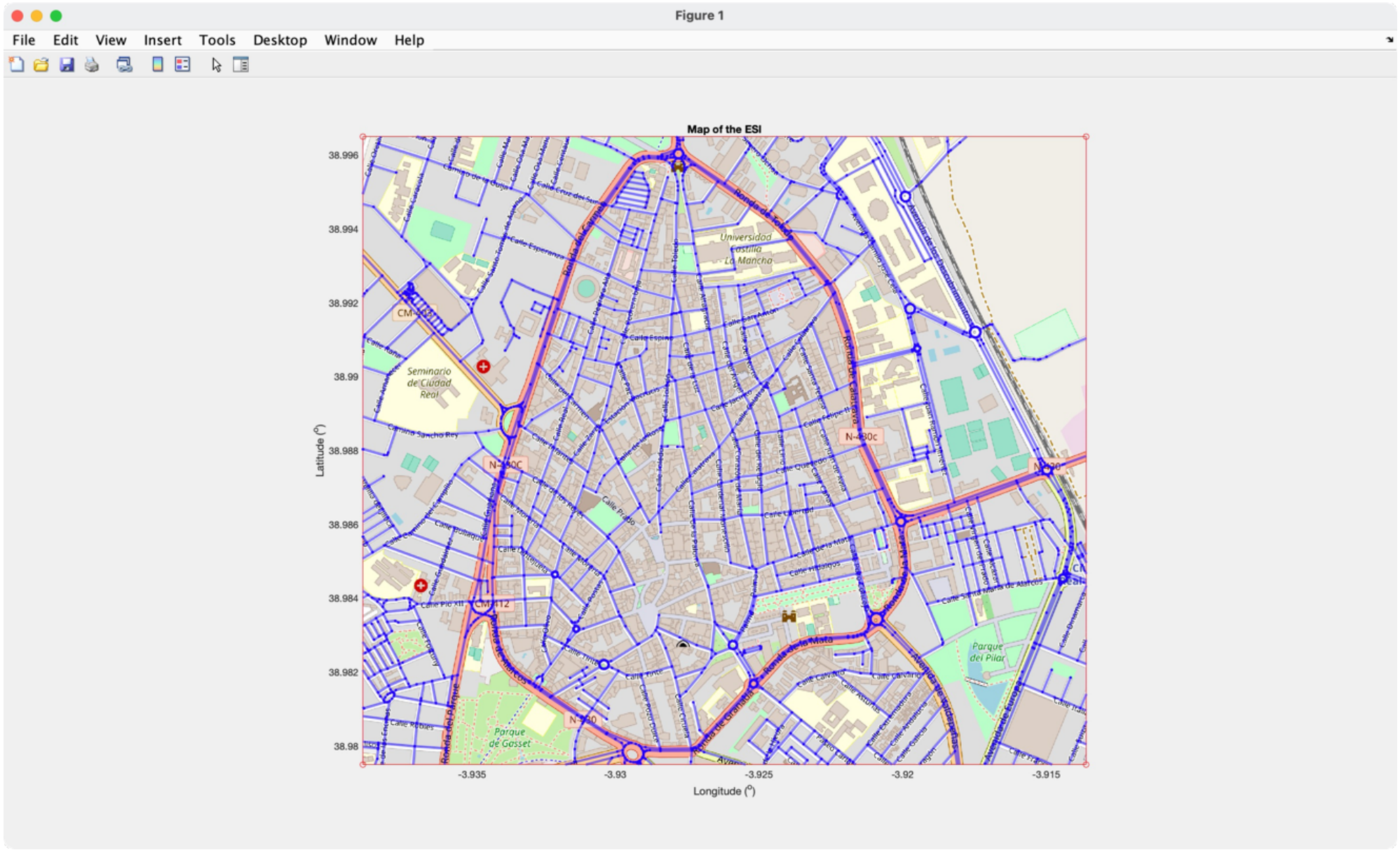
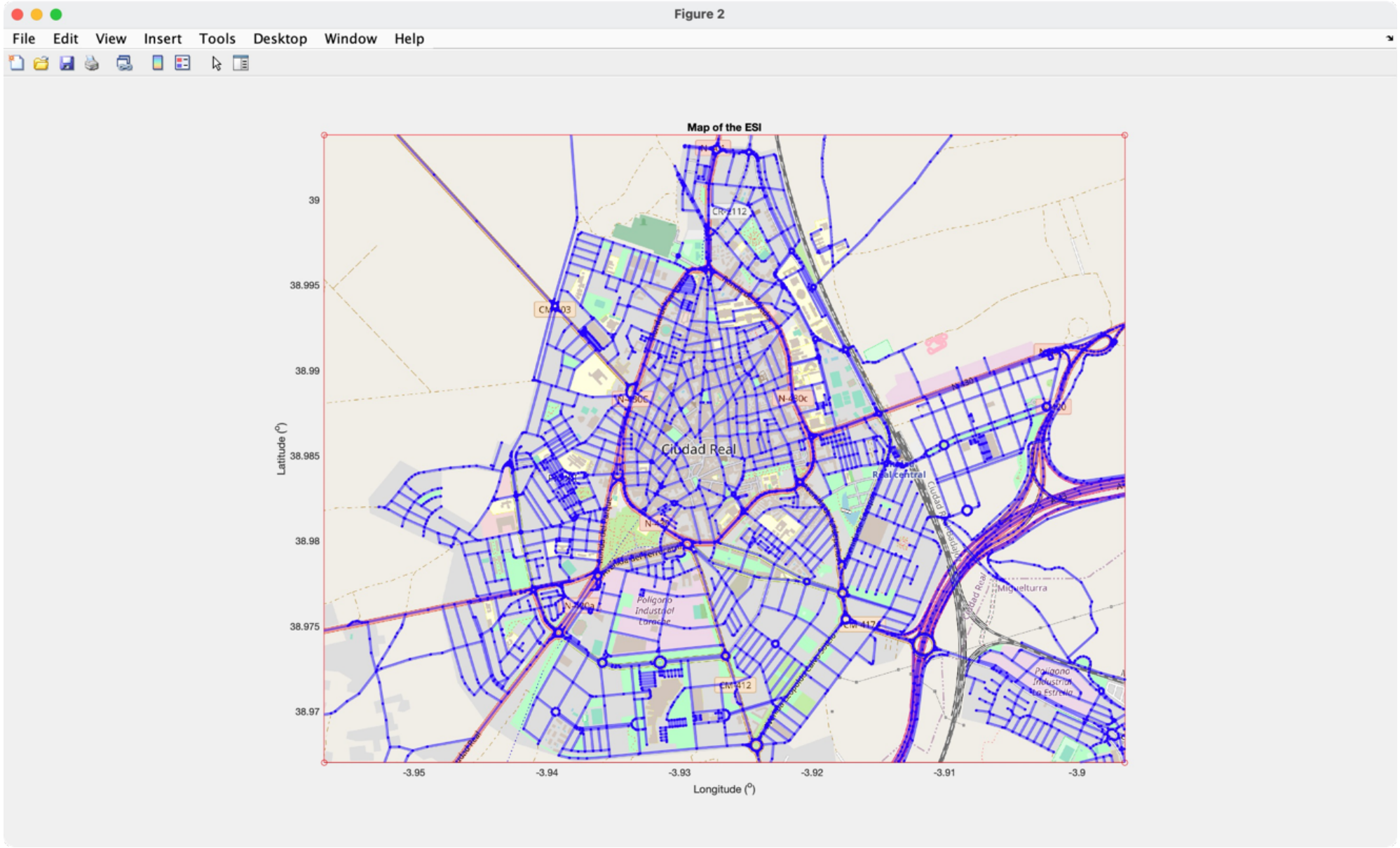


Figure 1
File Edit View Insert Tools Desktop Window Help
Map of the ESI
Universidad Castilla - La Mancha
Castilla - La Mancha
I.E.S. Juan de Ávila
Escuela Politécnica
Playa Park
Universidad Castilla - La Mancha
Colegio Público Dulcinea del Toboso
Avenida Camilo José Cela
Avenida de los Descubrimientos
Ronda de Calatrava
Paseo de la Universidad
Calle de Santa Catalina
Calle San Antón
Calle Calatrava
Calle Bachiller Fernán Gómez
Calle Santa Teresa
Calle Felipe II
Calle Progreso
Calle Quevedo
Calle Echegaray
Calle Vicente Meixandre
Calle Juan Ramón Jiménez
Línea de alta velocidad Madrid - Sevilla
N-430
Latitude (°)
38.994
38.993
38.992
38.991
38.99
38.989
38.988
Longitude (°)
-3.926
-3.924
-3.922
-3.92
-3.918
-3.916
-3.914

Graph of ‘RondaCiudadReal’



Graph of ‘CiudadReal’



Hito 2

Designing a simple GPS – Weighted digraph

```
edges =
```

1 struct with fields:

```
          source: [550×1 int32]
          target: [550×1 int32]
          length: [550×1 double]
            type: {550×1 cell}
        maxspeed: [550×1 single]
   bidirectional: [550×1 int32]
            name: [550×1 string]
```

travel_time: $\frac{length}{0.9\,maxspeed} \cdot \frac{60}{1000}$ (min)

(m)

(Km/h)

2 Construct a new digraph
(using travel_time as the weights)

```
>> G.Edges

ans =

  550×5 table
```

	EndNodes		Weight
1		368	0.015987
2		133	0.034467
2		241	0.0228
3		184	0.069453
4		29	0.049533
5		76	0.194
5		135	0.6279
5		313	0.026733
6		136	0.060367
6		363	0.015667
7		14	0.21427
8		371	0.18501

Designing a simple GPS – Weighted digraph

3

```
>> G.Edges

ans =

  550×5 table
```

EndNodes		Weight	length	maxspeed	name
1	368	0.015987	11.99	50	"Ronda de Calatrava"
2	133	0.034467	25.85	50	"Ronda de Calatrava"
2	241	0.0228	6.84	20	"Calle Quevedo"
3	184	0.069453	52.09	50	"Ronda de Calatrava"
4	29	0.049533	37.15	50	"Ronda de Calatrava"
5	76	0.194	58.2	20	"Calle Carlos López Bustos"
5	135	0.6279	188.37	20	"Avenida Camilo José Cela"
5	313	0.026733	8.02	20	"Calle Carlos López Bustos"
6	136	0.060367	18.11	20	"Calle Carlos López Bustos"
6	363	0.015667	11.75	50	"Ronda de Toledo"
7	14	0.21427	64.28	20	"Calle Calatrava"
8	371	0.18501	138.76	50	"Avenida de los Descubrimientos"

Designing a simple GPS – Weighted digraph

```
>> [edges.source, edges.target]

ans =

  550×2 int32 matrix

    14    56
    56    55
    55   203
   203    58
    58    23
    23   227
   227   380
   380    15
    15   375
```

≠

```
>> G.Edges

ans =

  550×5 table
```

EndNodes		Weight
1	368	0.015987
2	133	0.034467
2	241	0.0228
3	184	0.069453
4	29	0.049533
5	76	0.194
5	135	0.6279
5	313	0.026733
6	136	0.060367
6	363	0.015667
7	14	0.21427
8	371	0.18501

Be careful. The order of the edges structure and the Graph.Edges table is different, because MATLAB change the order of edges when creating the digraph.

Solution: Use `findedge(G, source, target)`

Obtaining the minimum path

4

Get the shortest path (in time) using Dijkstra on the digraph

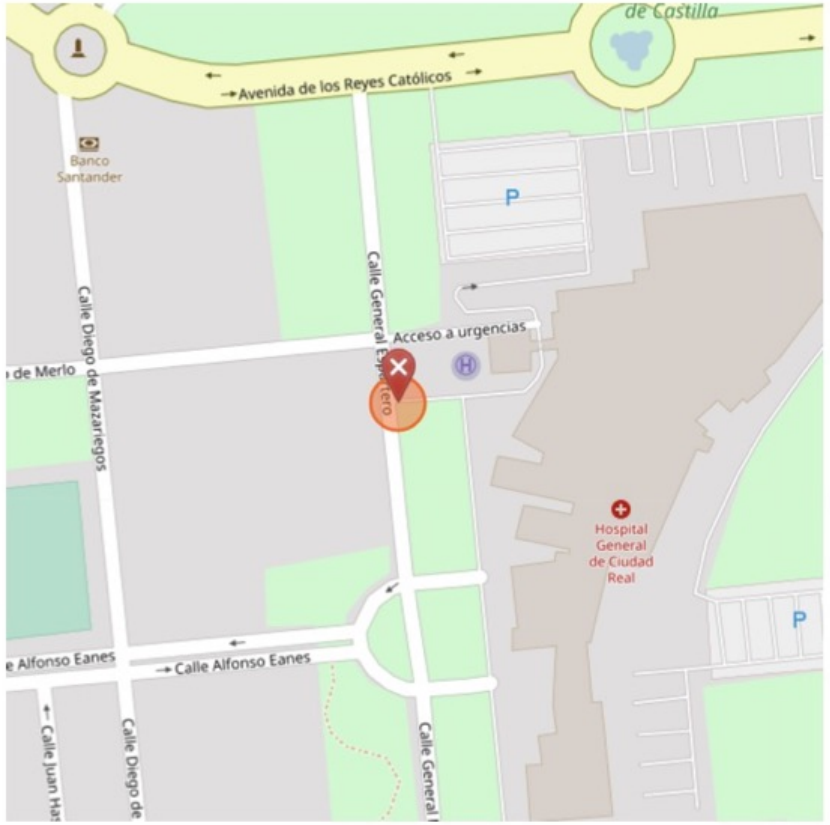
Remember the MATLAB notebook 3

5

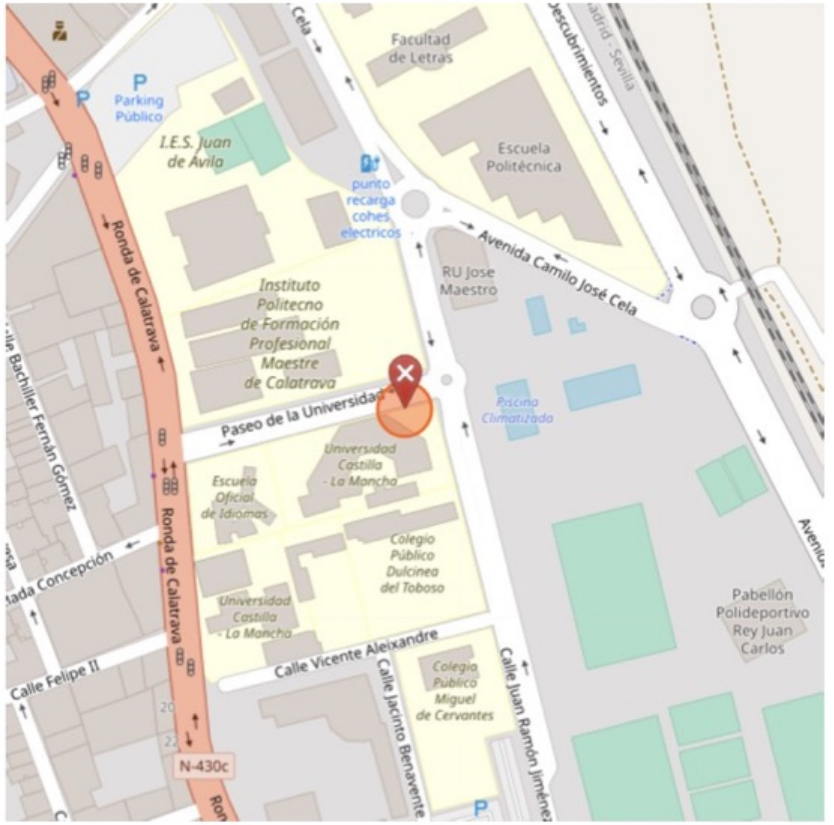
Represent the shortest path using the undirected graph

Remember the highlight function from the MATLAB notebook 3

Hito 2: Optimal route 1

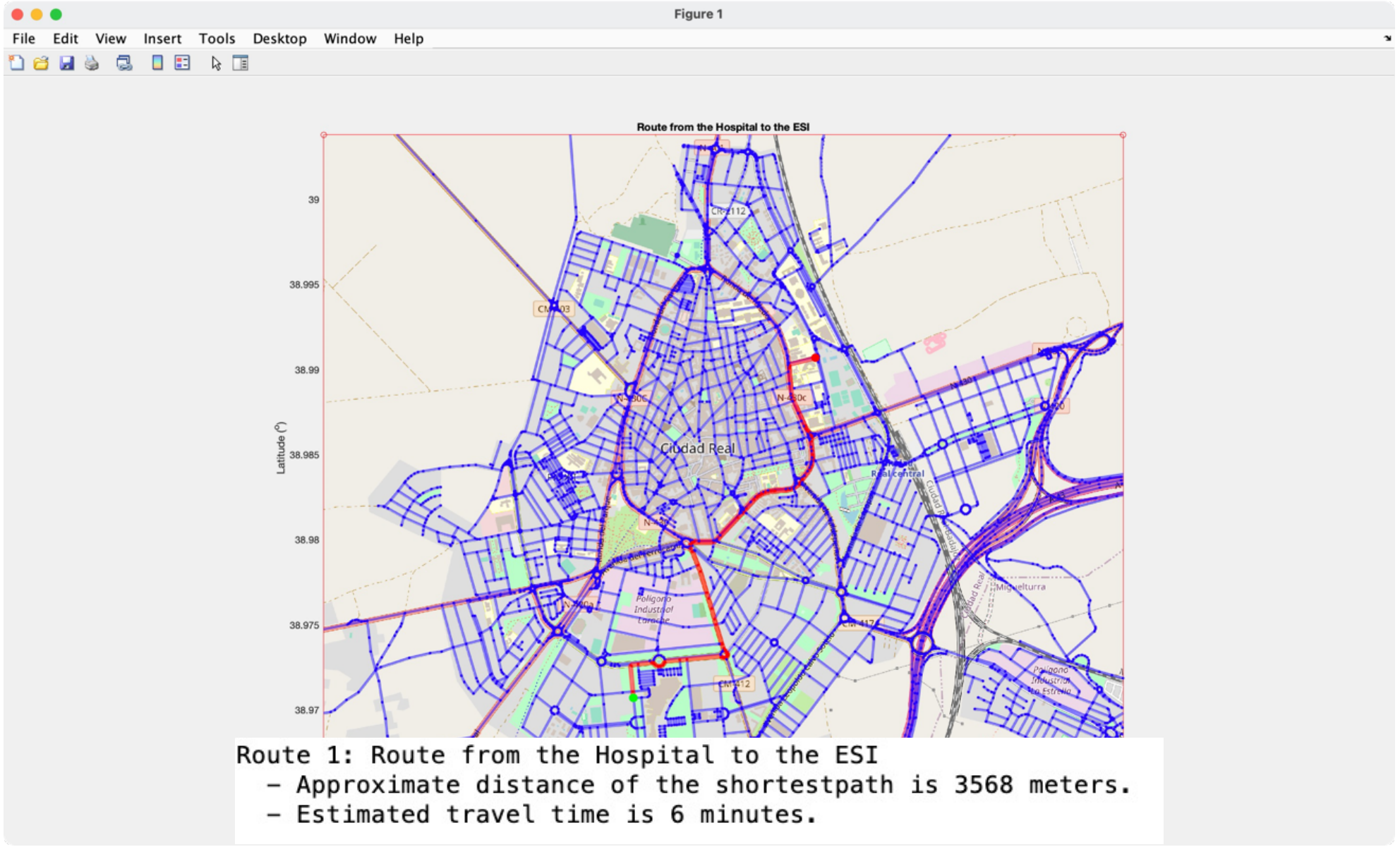


(a) Emergency door of the Hospital

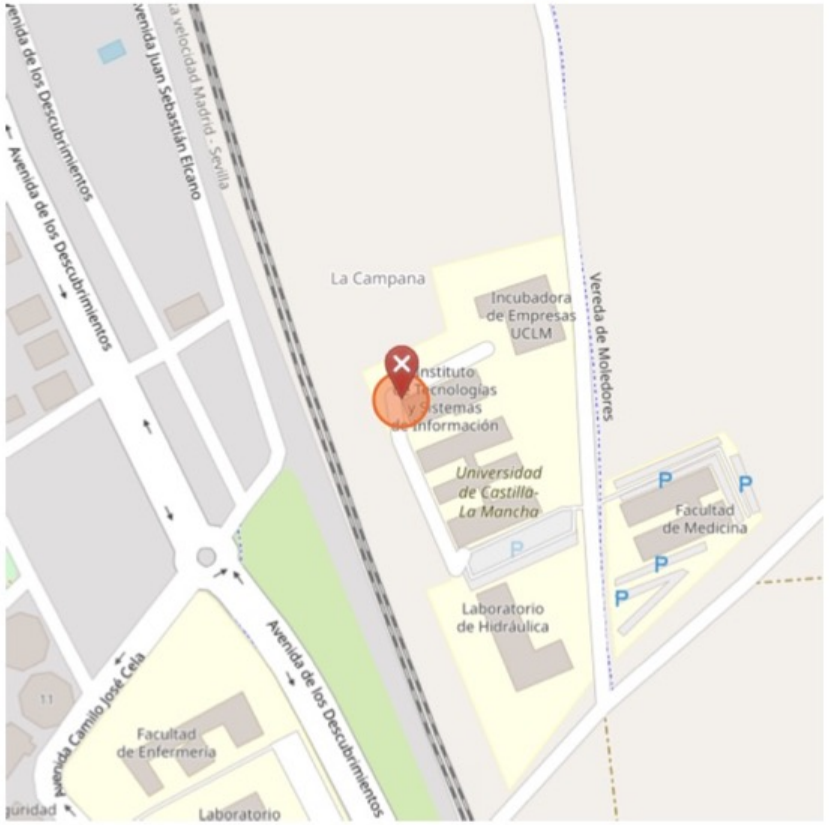


(b) ESI

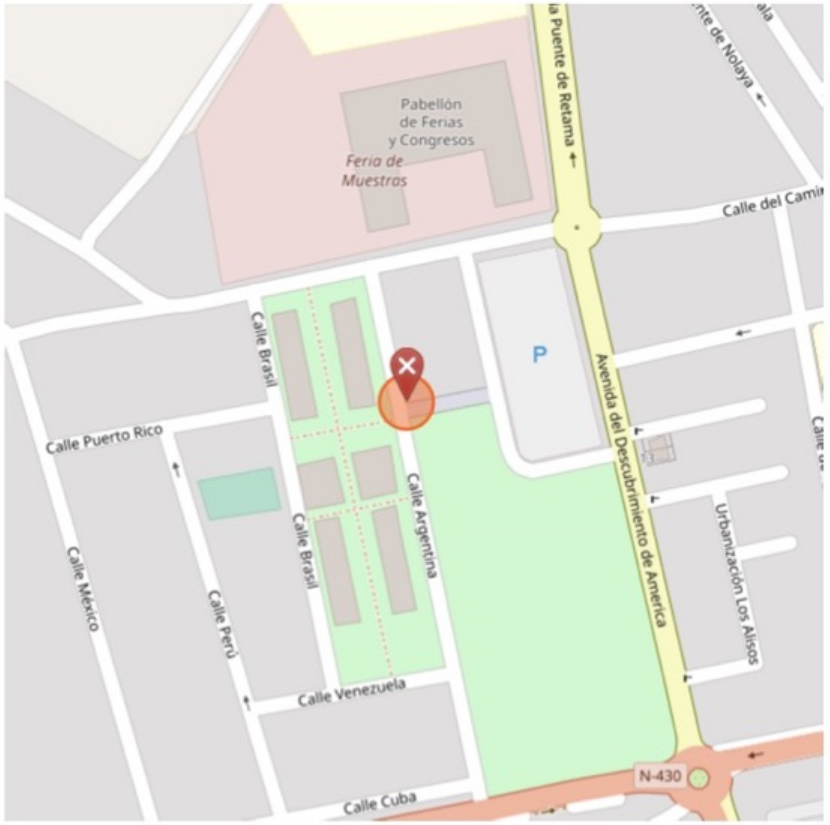
Hito 2: Optimal route 1 (Solution)



Hito 2: Optimal route 2

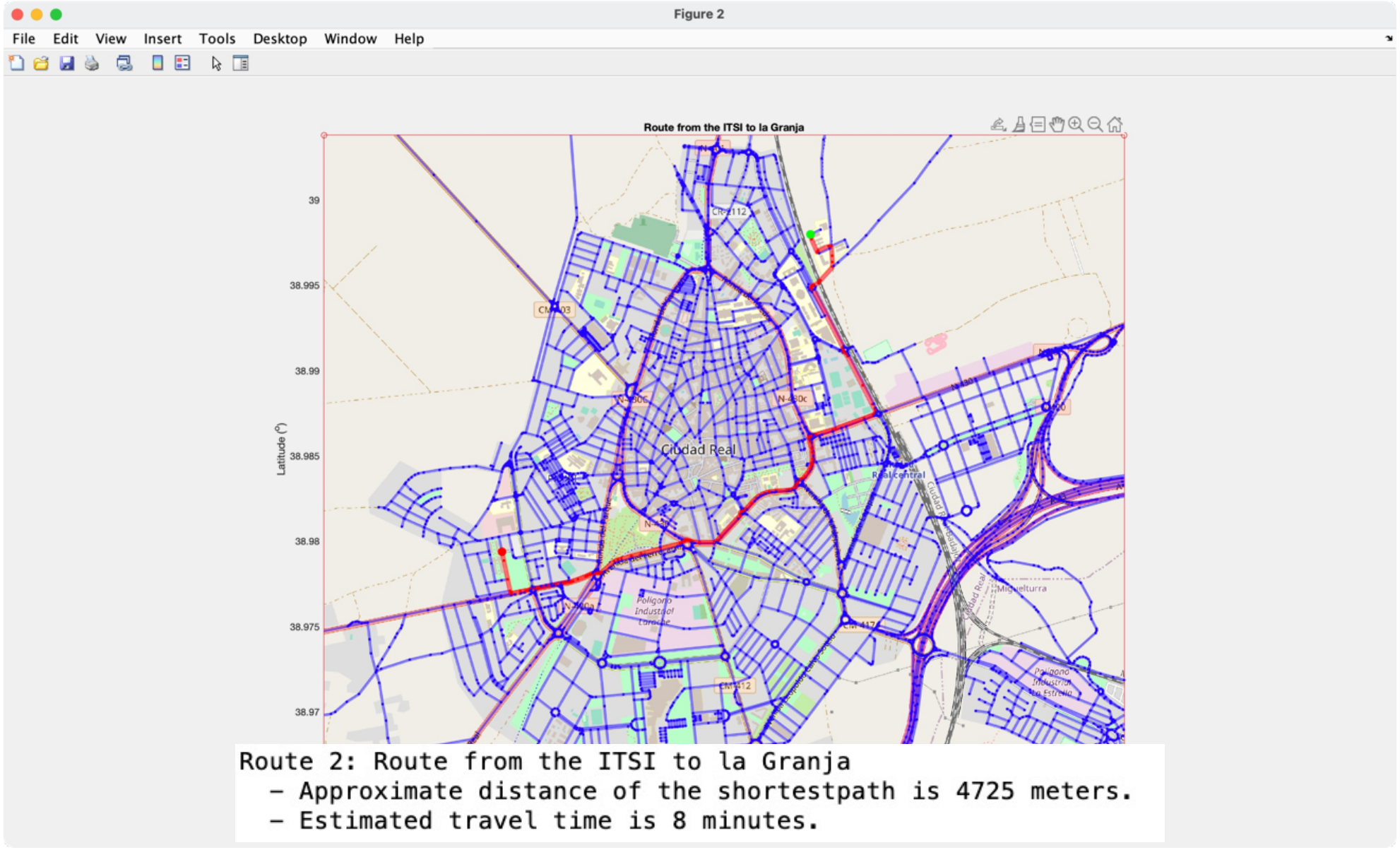


(a) ITSI

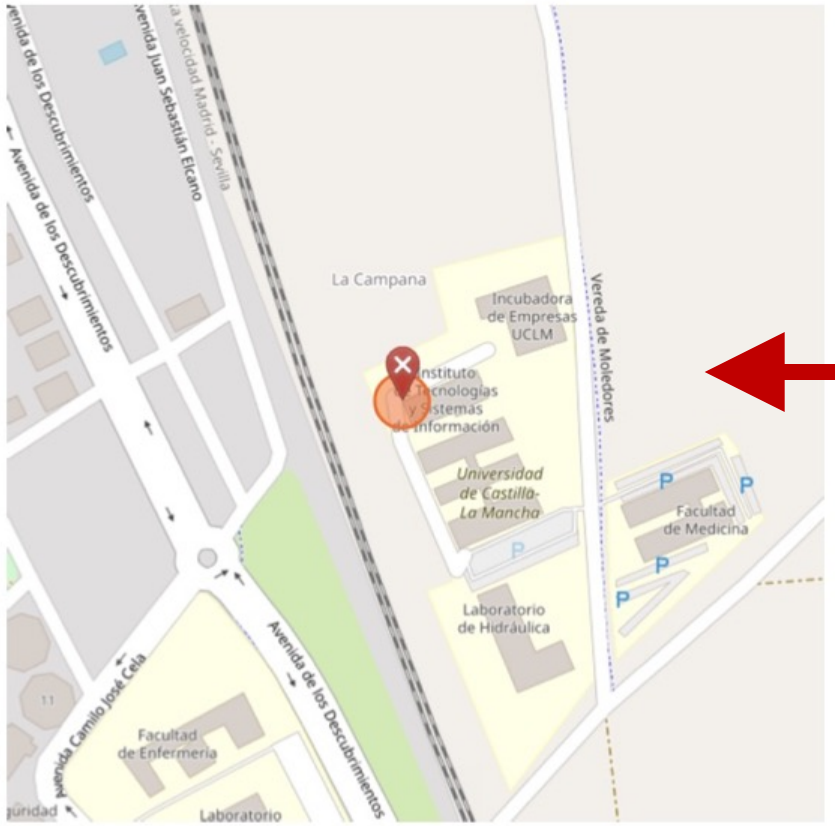


(b) Auditorio de la Granja

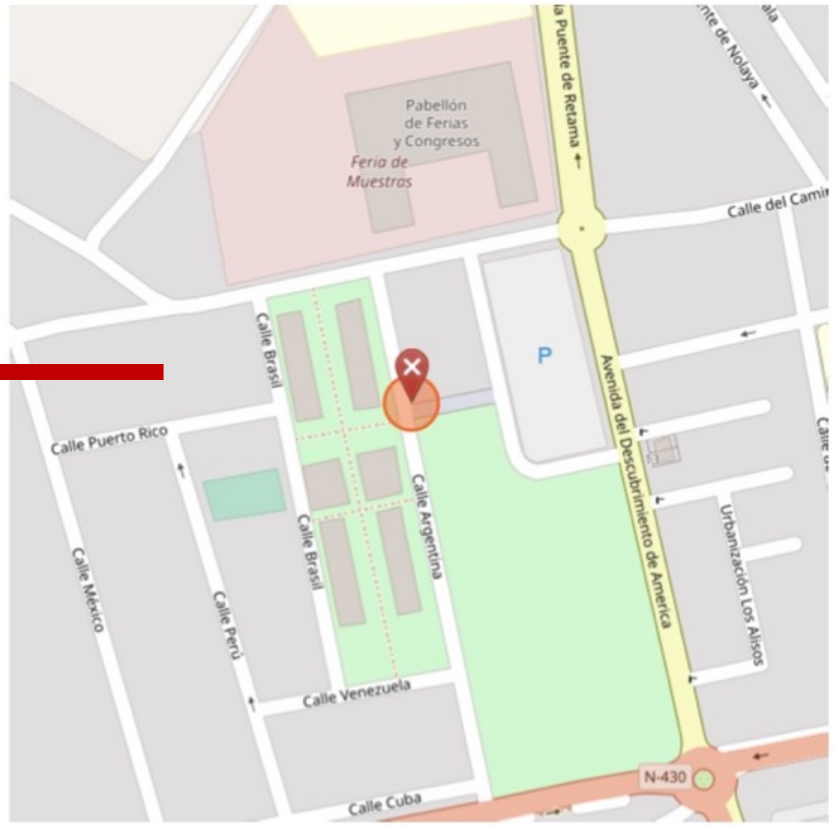
Hito 2: Optimal route 2 (Solution)



Hito 2: Optimal route 3

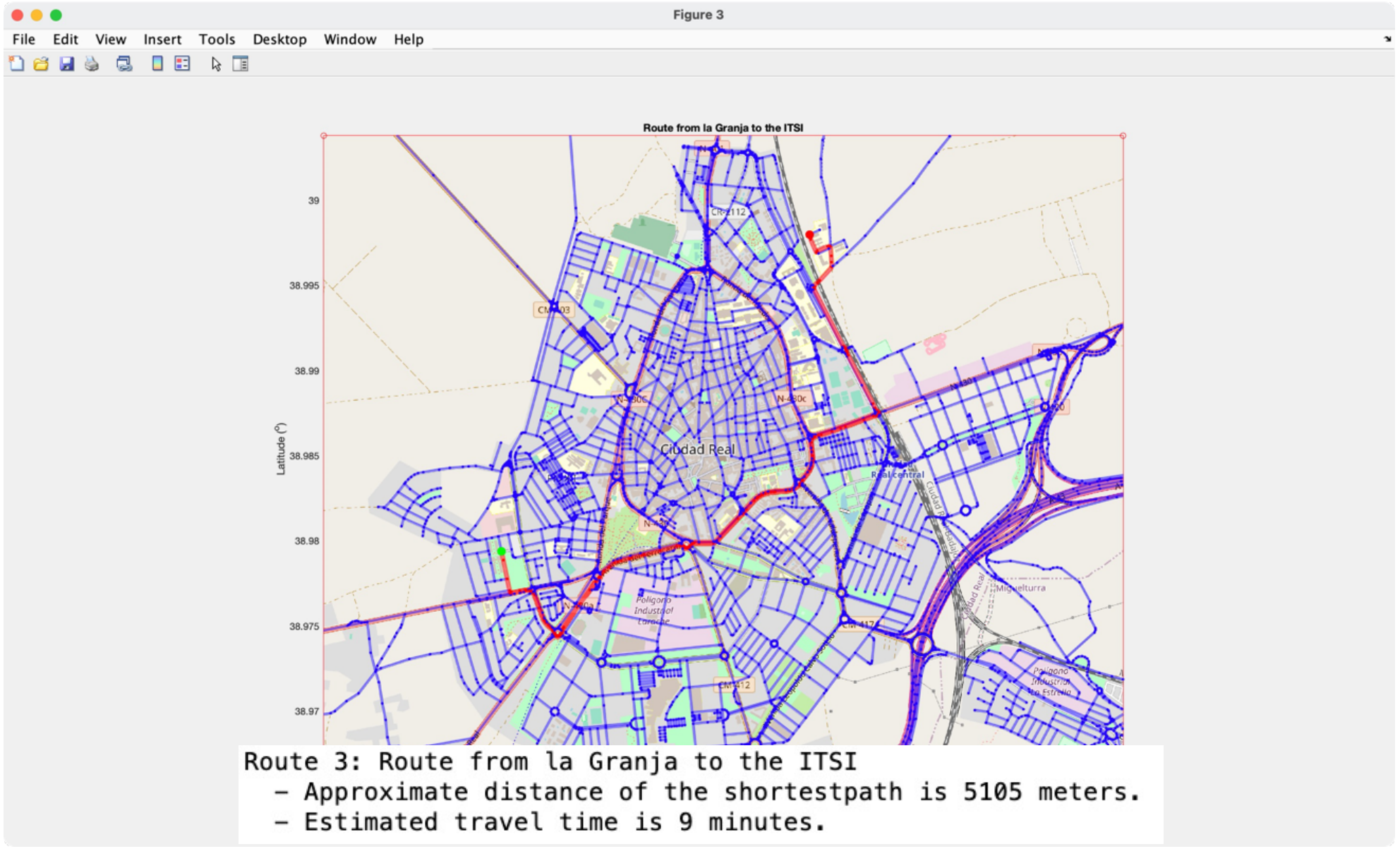


(a) ITSI



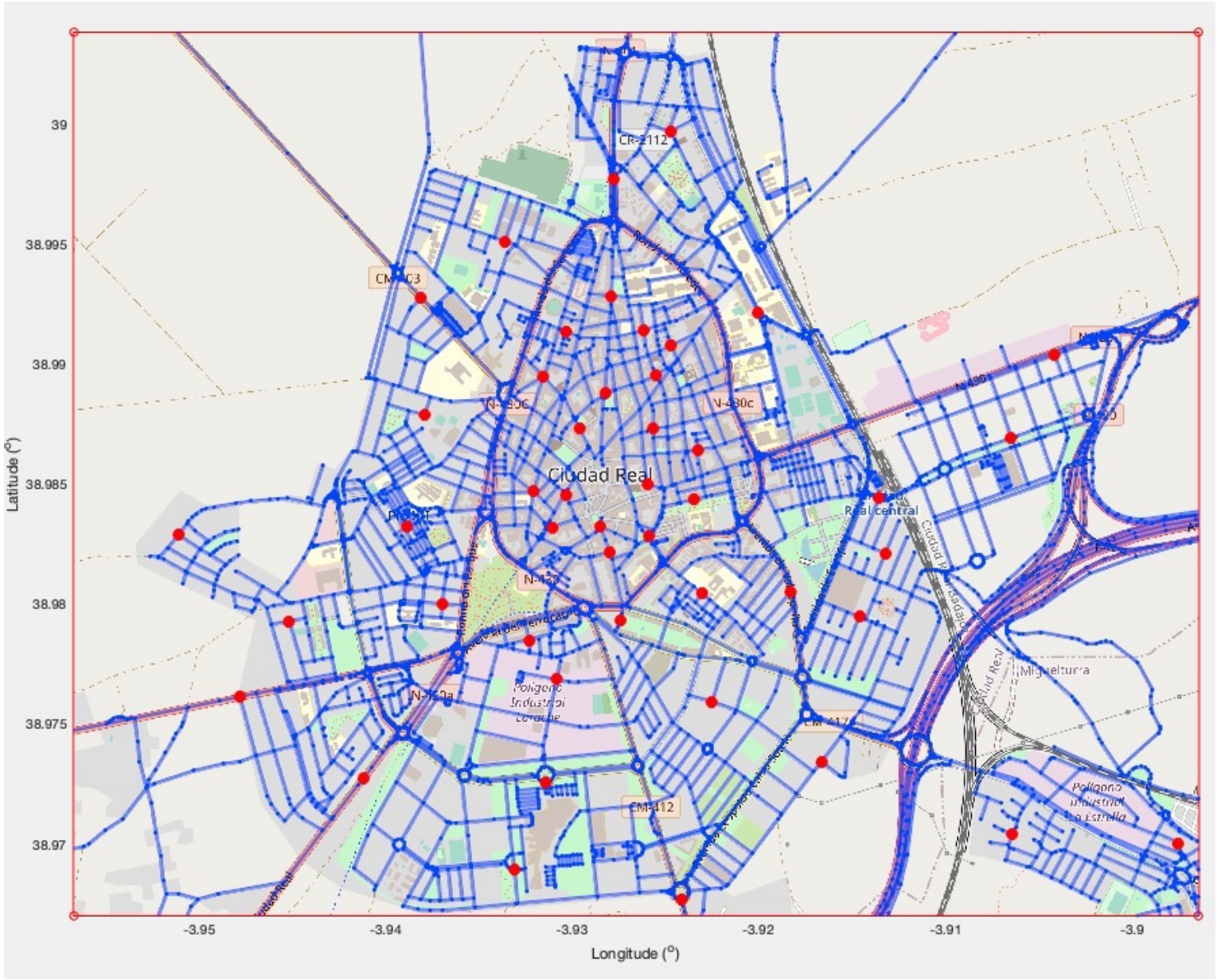
(b) Auditorio de la Granja

Hito 2: Optimal route 3 (Solution)




Hito 3

Simulating city traffic



Simulating city traffic

```
xlsread('data/Odmatrix.xlsx')
```

```
>> ODmatrixdata
```

ID centroid	Trips attracted (A)	Trips generated (G)
1736	1000	250
1757	150	50
1561	200	0
2024	30	250
341	150	50
1865	50	150
1557	50	200
1204	150	150
843	100	250
1164	300	50
880	50	240

Simulating city traffic

1 For each pair (i, j) of the O-D matrix, compute: $d_{ij} = \frac{G_i A_j}{D}$ con $i \neq j$

d_{ij} is the demand from zone i to zone j

G_i is the number of trips generated in zone i

A_j is the number of trips attracted by zone j

D is the total demand, i.e. $D = \sum_i G_i$

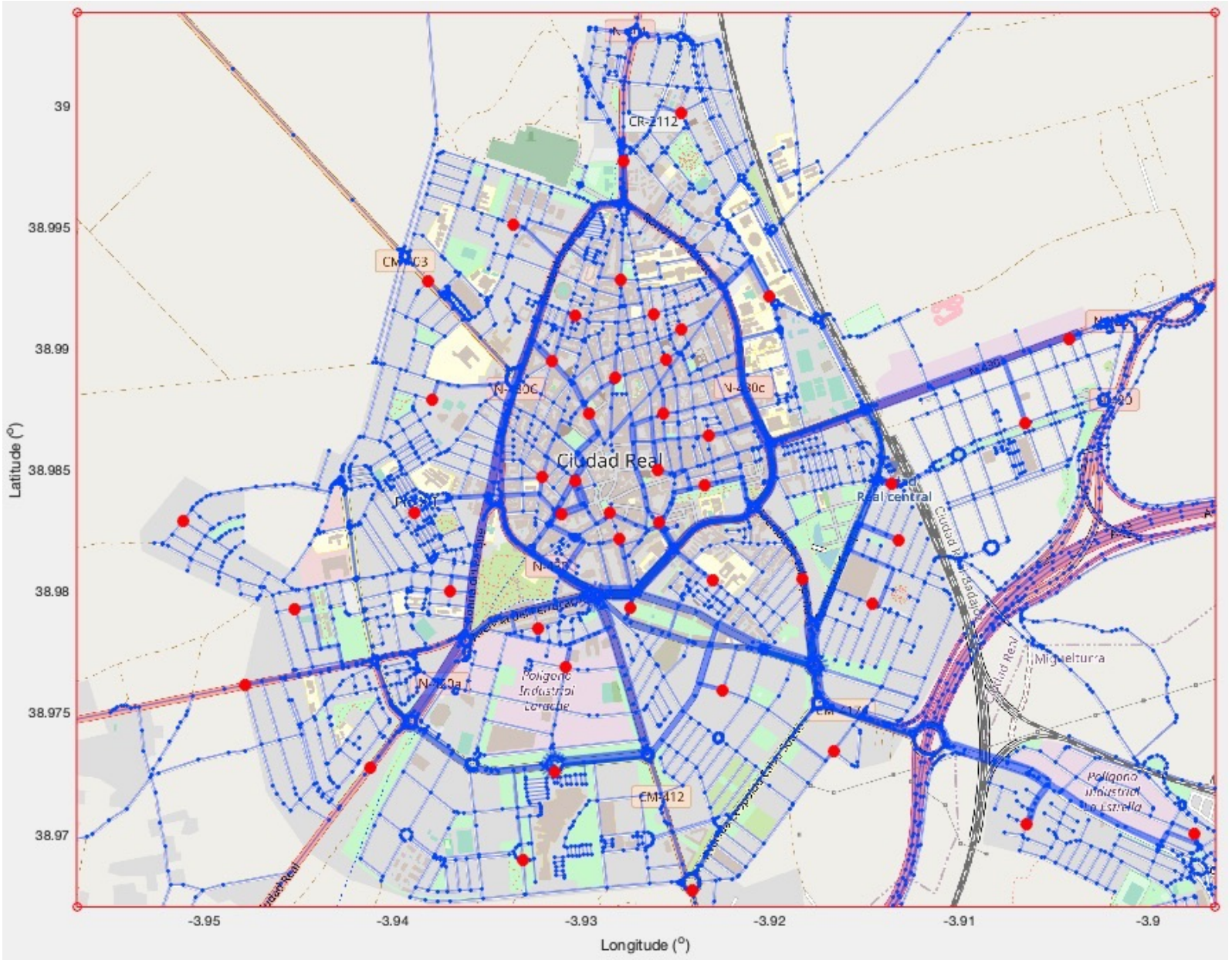
Be careful. The trips from i to i must not be computed.

2 Obtain the minimum path for each pair (i, j) of the O-D matrix.

3 Compute the traffic flow on edge a: $f_a = \sum_{(i,j)} \delta_{a,p_{ij}} d_{ij}$ for all edge a

$$\delta_{a,p_{ij}} = \begin{cases} 1 & \text{if the edge } a \text{ is in the path } p_{ij} \\ 0 & \text{the opposite case} \end{cases}$$

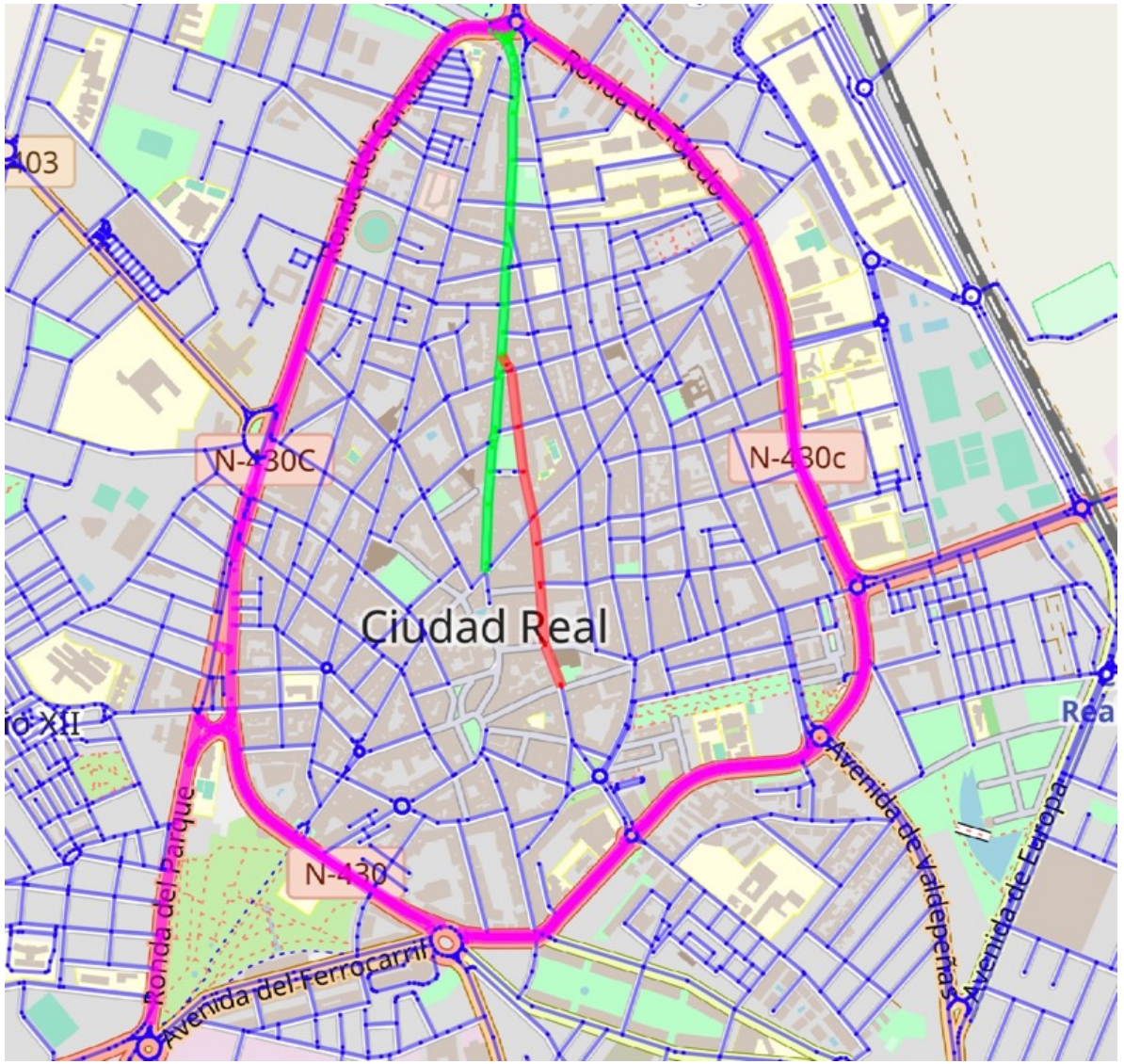
Simulating city traffic




Hito 4

Network intervention analysis

- Pedestrianise the streets “Calle Elisa Cendreros” and “Calle de la Paloma”.
- Reduce the maximum speed of the entire “Ronda” to 30 Km/h.
- Change the traffic direction on the street “Calle Toledo”.



Network intervention analysis – Total travel time

$$T = \sum_a f_a t_a$$

t_a is the time to cross the edge a (travelling at 90% of maximum speed)

f_a is the traffic flow on the edge a

Scenario	T
"Initial situation"	"?"
"Scenario 1"	"?"
"Scenario 2"	"?"
"Scenario 3"	"?"

Hito 5


SWEDEN
FINLAND
NORWAY
Stockholm
Moscow
Warsaw
UKRAINE
Istanbul
TURKEY
LIBYA
EGYPT
SAUDI

Designing an improved GPS

1. Modify the travel time obtained in Milestone 2 to consider congested edges

$$t_a(f_a) = t_a^0 * \left(1 + 0.2 * \left(\frac{f_a}{k_a}\right)^4\right)$$

f_a is the flow of the edge a

t_a^0 is the travel time when edge has no congestion

k_a is the capacity of the edge $k_a = 500$ vehicles/hour.

2. Replicate Milestone 2 but considering these new travel times

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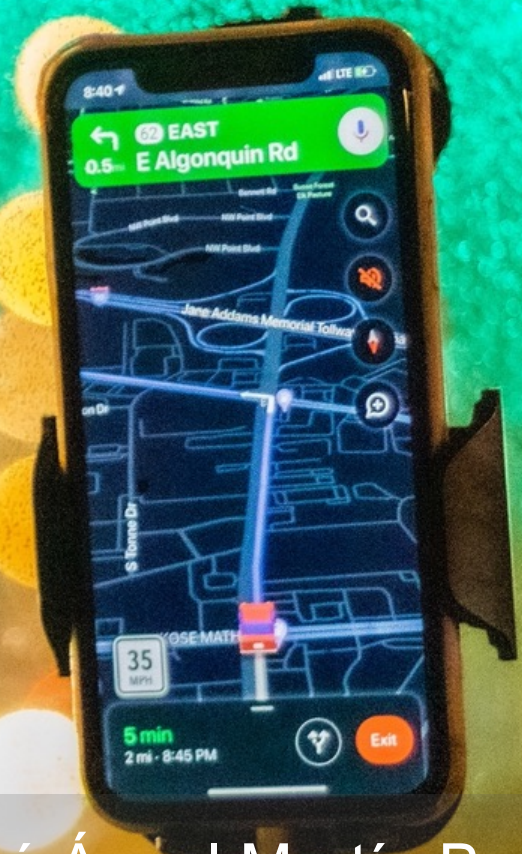

2021/2022

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