

IMT modules advances: traffic, energy, noise and tailpipe emissions modules. Platform structure and integration

Session II: IMT and simulation of low carbon mobility solutions

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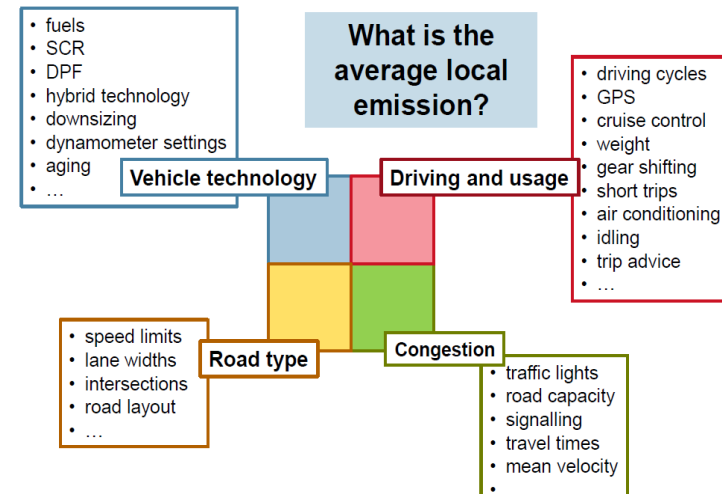
[1] USE

Implementation of the Integrated Modelling Tool (IMT)

Customized modelling tool to evaluate the transport, energy and environmental-related performance of low-carbon actions to be implemented.

- At local street level
- Focused on selected streets/condominiums
- Validated in selected roads participant regions (Treviso)
- Structure based on FIWARE platform
- Includes models from energy, tailpipe emissions, dispersion models,

GETTING THE COMPLETE PICTURE



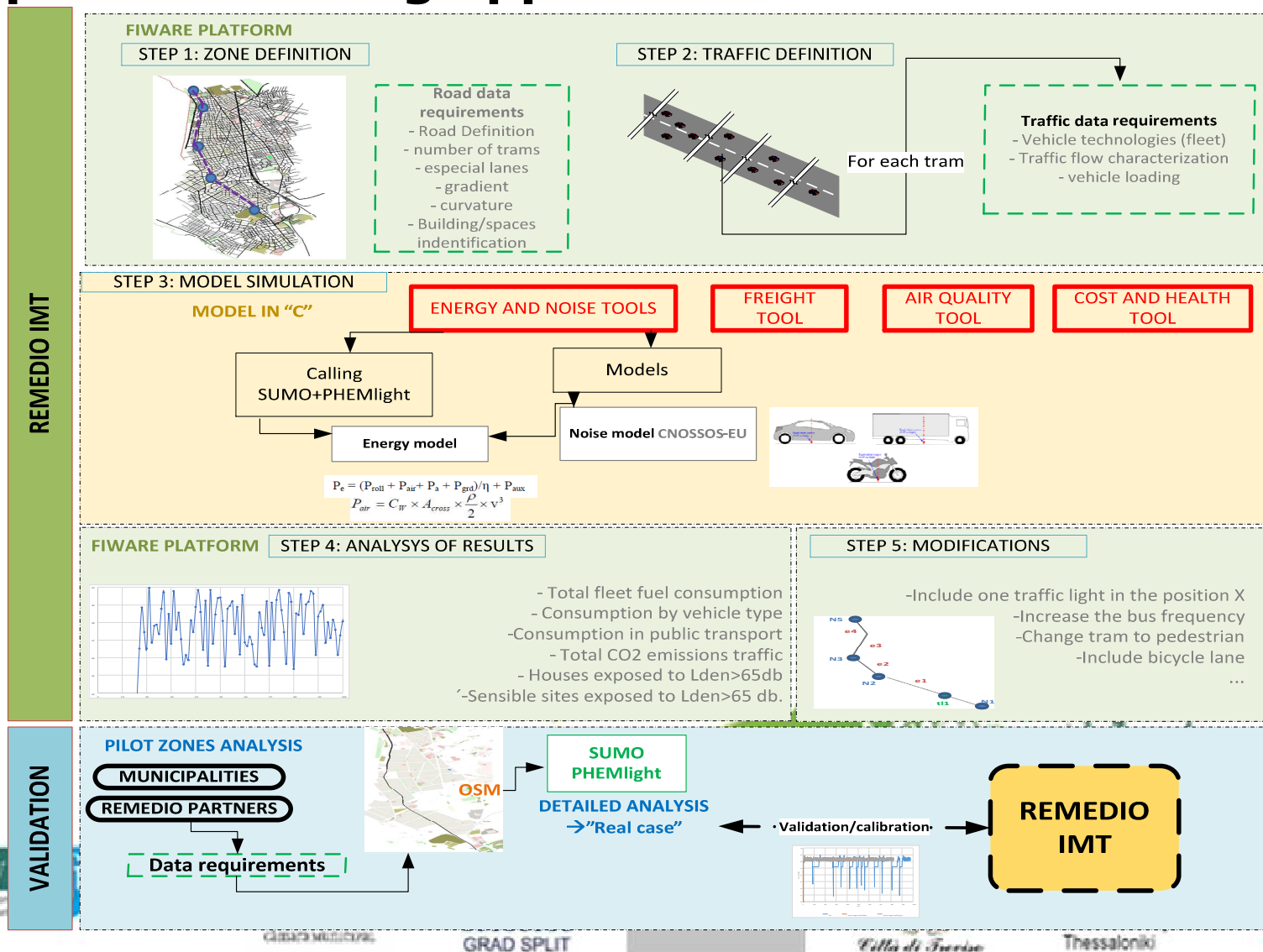
Implementation of the Integrated Modelling Tool (IMT)

ACTIVITIES				DELIVERABLES				FORESEEN RESULTS
Id	Activity Leader	Title	Description	Number	Title	Description	Planned value	Delivery date (month from 1 to 31)
3.3	ARPAV	Fine-tuning of the integrated modelling tool and validation in the test city of Treviso	Scientific partners joint implement a common model, integrating state-of-the-art modules for the analysis of urban low carbon mobility settings. USE is in charge of the overall system architecture (device and sensor integration, standard & protocol for in/out interfaces) customized to public authorities' specific needs by the involvement of the Municipality technicians. USE is also in charge of the transport energy efficiency module & the noise one. AUTH is in charge of the atmospheric pollution emission & carbon footprint modules. IST of the air pollution dispersion & freight streamlining modules. ARPAV is in charge of the cost & health modules. The tool is tested and validated on the Treviso study-area, fine tuning its capability to detect soft mobility actions.	L3.3.1	Integrated modelling tool for low carbon mobility solutions	The tool integrates various modules with algorithms to calculate energy transport efficiency, air pollution, carbon footprint, health and noise impact, freight streamlining and other performance indexes for urban road connectivity.	1	18
<div>06/17</div> <ul style="list-style-type: none"> - First draft of the integration structure of modules of tool and within Fiware - First draft of the traffic/modules integration - First draft of the Energy Module - First draft of the Noise module - First draft of the Emission Module 								

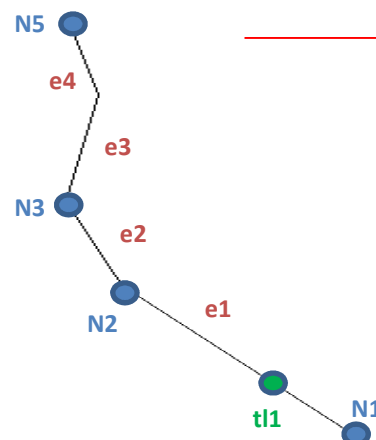
Agreements KOM session for IMT

- First internal deliverable must be in **May 2017**
- The IMT deliverable (L3.3.1) to be ready: end of **October 2017**
- Conclusion of fine-tuning of the integrated modelling tool with Test and validation in the pilot area of Treviso (end of **April 2018**)

Conceptual modelling approach



Step 1: zone definition



project_name.nod.xml

```
<nodes>
<node id="N1" x="2000" y="0"
/>
<node id="N2" x="1400"
y="200" />
<node id="tl1" x="1600"
y="100" />
.
.
.
.
</nodes>
```

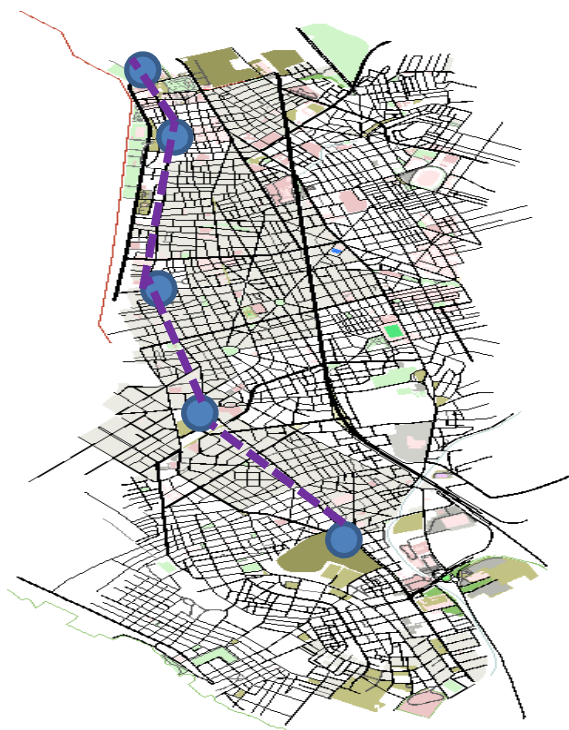
IMT MODULES INPUT FILE

Step 1: zone definition



edge id	Gradient user	Gradient model	lanes
e1	flat	0%	2
e2	slightly uphill	2%	1
...			...

Step 2: traffic definition



Traffic characterization in the pilot area		
Maximum number of vehicles (at peak-hour)	3037	
Average number of cars per day	Average number (cars)	Average speed (km/h)
00:00-01:00	731	40
01:00-02:00	474	41
02:00-03:00	277	44
03:00-04:00	226	41
04:00-05:00	224	47
05:00-06:00	455	48
06:00-07:00	1171	43
07:00-08:00	2361	37
08:00-09:00	2772	31
09:00-10:00	2655	29
10:00-11:00	2699	29
11:00-12:00	2479	29
12:00-13:00	2408	27
13:00-14:00	2229	30
14:00-15:00	2161	29
15:00-16:00	2406	31
16:00-17:00	2356	32
17:00-18:00	2420	33
18:00-19:00	2418	29
19:00-20:00	2291	31
20:00-21:00	2314	28
21:00-22:00	1939	28
22:00-23:00	1339	35
23:00-24:00	1035	36
vehicle occupancy (average persons/car)		
Number of bikes per day		NA
Number of motobikes per day		NA
Number of trucks per day		NA

Step 2: traffic definition



Cars	65%
Motorbikes	20%
Trucks	1%
Bus	4%
bikes	10%

Vehicle emission type

country

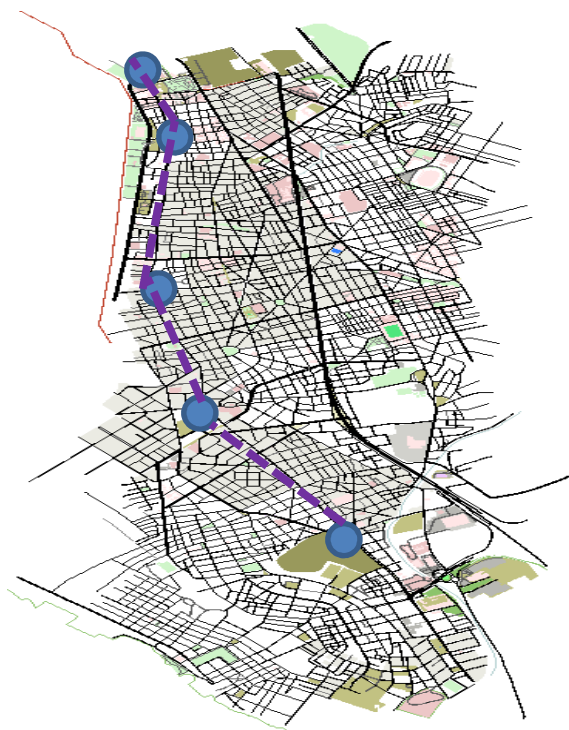
Database

Cars

75% /EU5

25% /EU6

Step 2: traffic definition

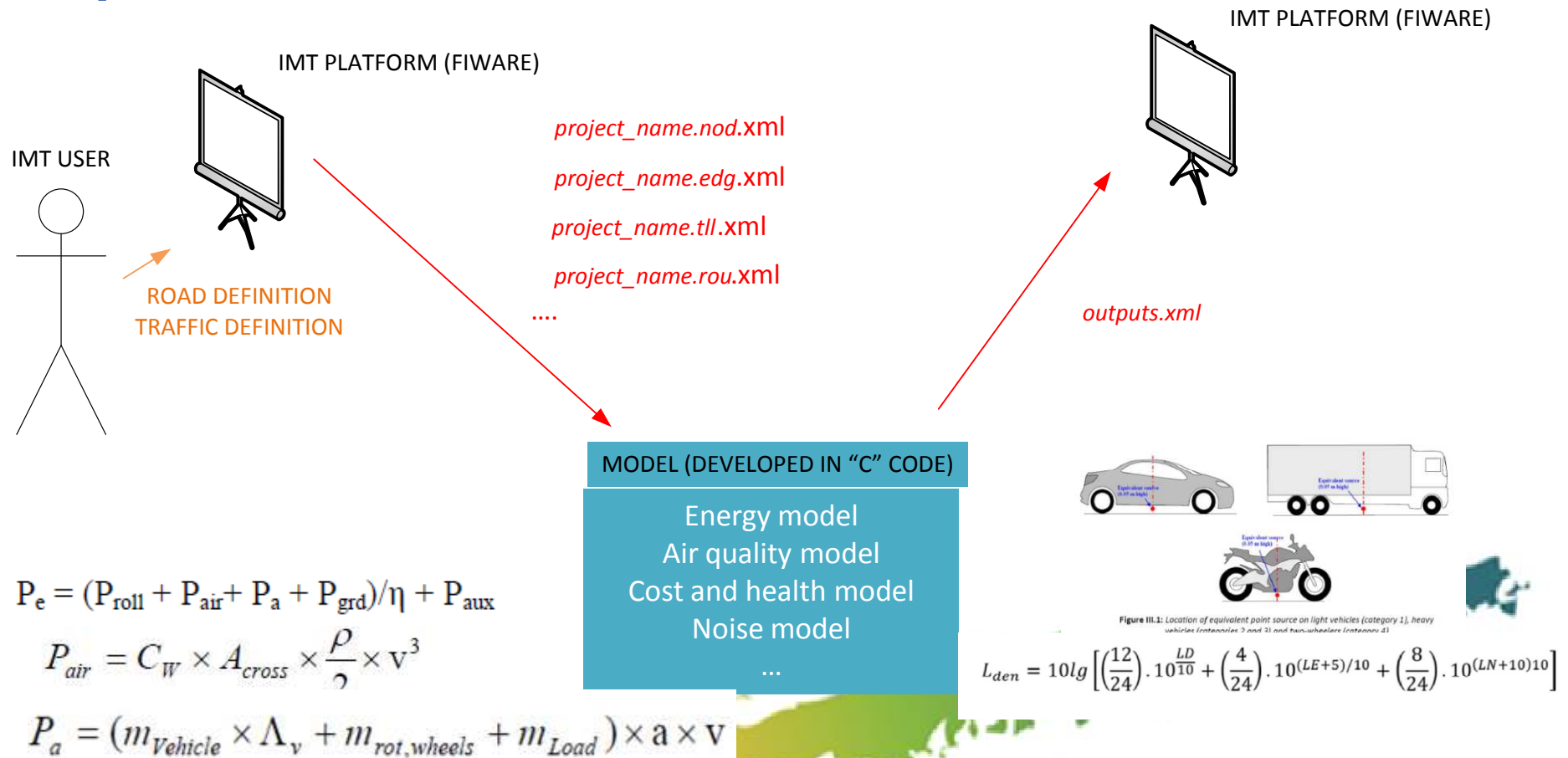


project_name.rou.xml

```
<routes>
  <vType accel="1.0" decel="5.0" id="Car" maxSpeed="10.0" />
  <route id="route1" edges="e1 e2 e3 e4"/>
  <vehicle depart="0" id="veh0" route="route1" type="Car" />
</routes>
```

IMT MODULES INPUT FILE

Step 3: simulation



Remarks for module developers!

.xml files (inputs for module)

```
<nodes>
  <node id="1" x="2812.72" y="1518.45" />
  <node id="2" x="1709.09" y="3230.12" type="traffic_light" />
  <node id="3" x="1689.28" y="3569.51" type="traffic_light"/>
  <node id="4" x="1390.85" y="4468.06" type="traffic_light"/>
  <node id="5" x="1520.87" y="5852.46" type="traffic_light" />
  <node id="6" x="1367.44" y="6516.96" />
</nodes>
```

```
<routes>

<vType id="car" vClass="passenger" maxSpeed="7"/>
<vType id="bus" vClass="bus" maxSpeed="5"/>

<route id="1" edges="ed1 ed2 ed3 ed4 ed5"/>

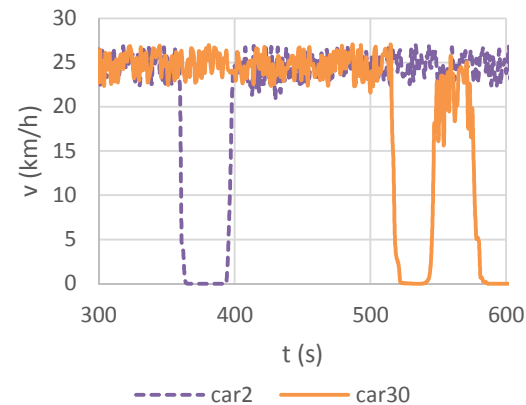
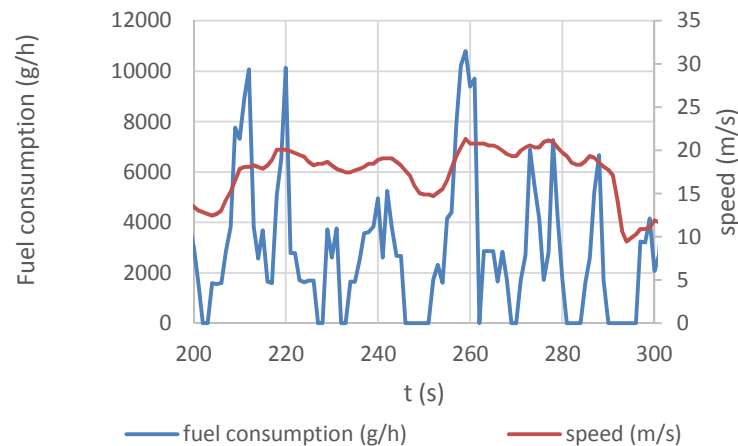
<flow id="car1" route="1" type="car" begin="0" vehsPerHour="400" departSpeed="max" departLane="0"/>
<flow id="car2" route="1" type="car" begin="5" vehsPerHour="400" departSpeed="max" departLane="1"/>
<flow id="car3" route="1" type="car" begin="10" vehsPerHour="400" departSpeed="max" departLane="2"/>

<flow id="line_3" route="1" type="bus" begin="10" period="480">
  <stop busStop="1" duration="30"/>
  <stop busStop="2" duration="30"/>
  <stop busStop="3" duration="30"/>
</flow>
</routes>
```

```
<edges>
  <edge from="1" id="ed1" to="2" numLanes="3" />
  <edge from="2" id="ed2" to="3" numLanes="2"/>
  <edge from="3" id="ed3" to="4" numLanes="1"/>
  <edge from="4" id="ed4" to="5" numLanes="2"/>
  <edge from="5" id="ed5" to="6" numLanes="3"/>
</edges>
```

- Each module must be able to generate its own output file
- **Outputs/model results in .xml files**
- Recommended language for modelling **"C code"**
- **Each module should be a compiled file ready to execute**

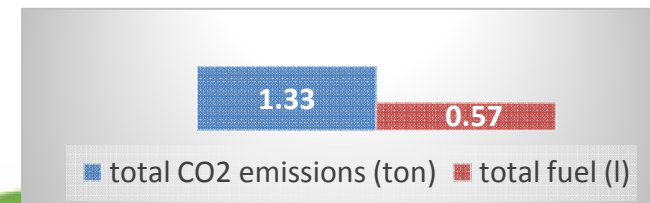
Step 4: Analysis of results



Other results:

- noise
- Vehicle position as a function of time
- CO₂, CO, HC, NO_x, PM_x emissions

indicators



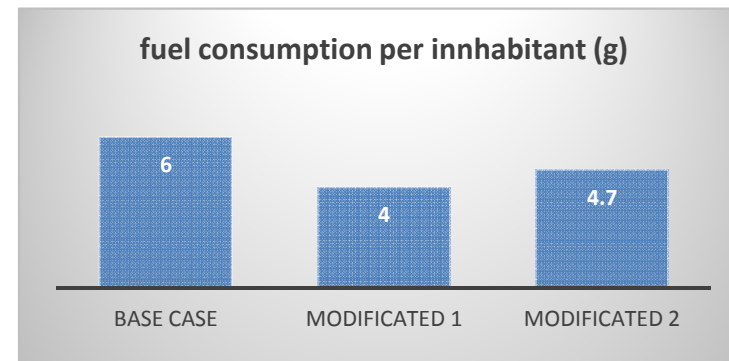
id ▼ eclass ▼ CO₂ ▼ CO ▼ HC ▼ NO_x ▼ PM_x ▼ fuel ▼ electricity ▼ noise ▼ route ▼ type ▼ waiting ▼ lane ▼ pos ▼ speed ▼ angle ▼ x ▼ y ▼

Step 5: Modifications

- Include one traffic light in the position X
- Increase the bus frequency
- Change tram to pedestrian
- Include bicycle lane

**Mobility actions to be
evaluated by IMT**

→ Modeling process again!

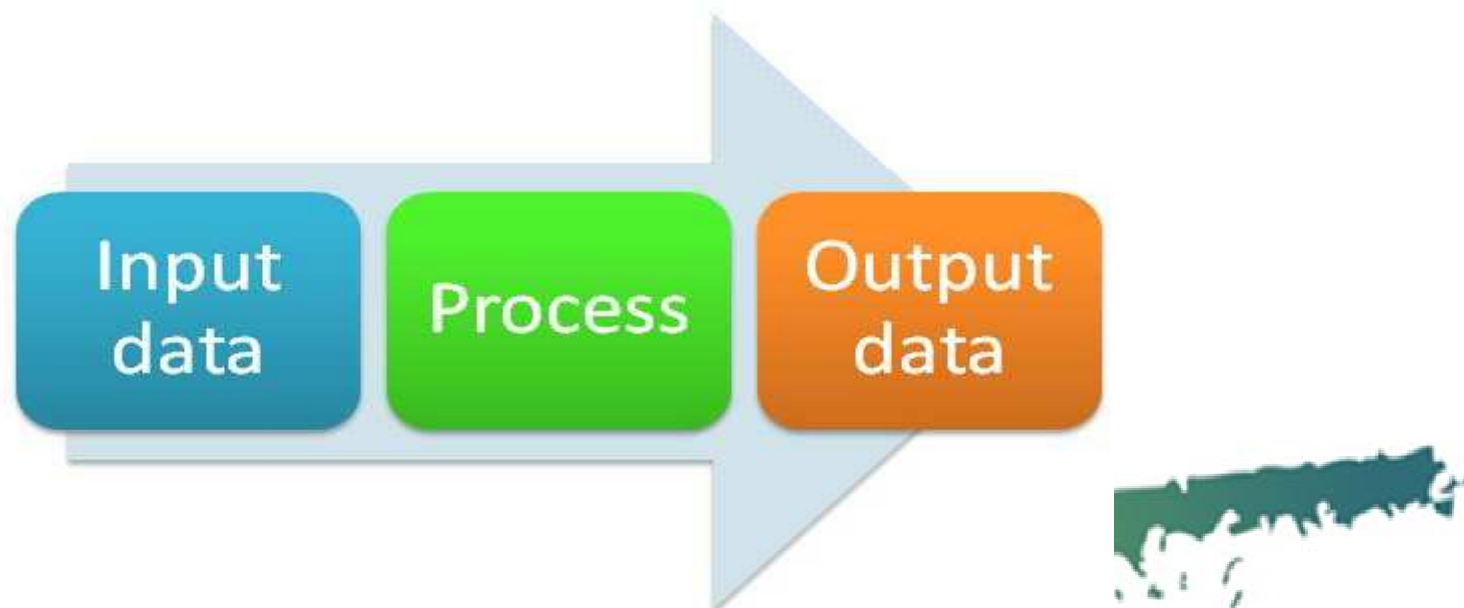


FIWARE Platform

- Powerfull and easy service integration
- Multiple and heterogeneous systems
- Collaborative and scalable
- Open and free
- Available wherever and whenever



FIWARE Platform



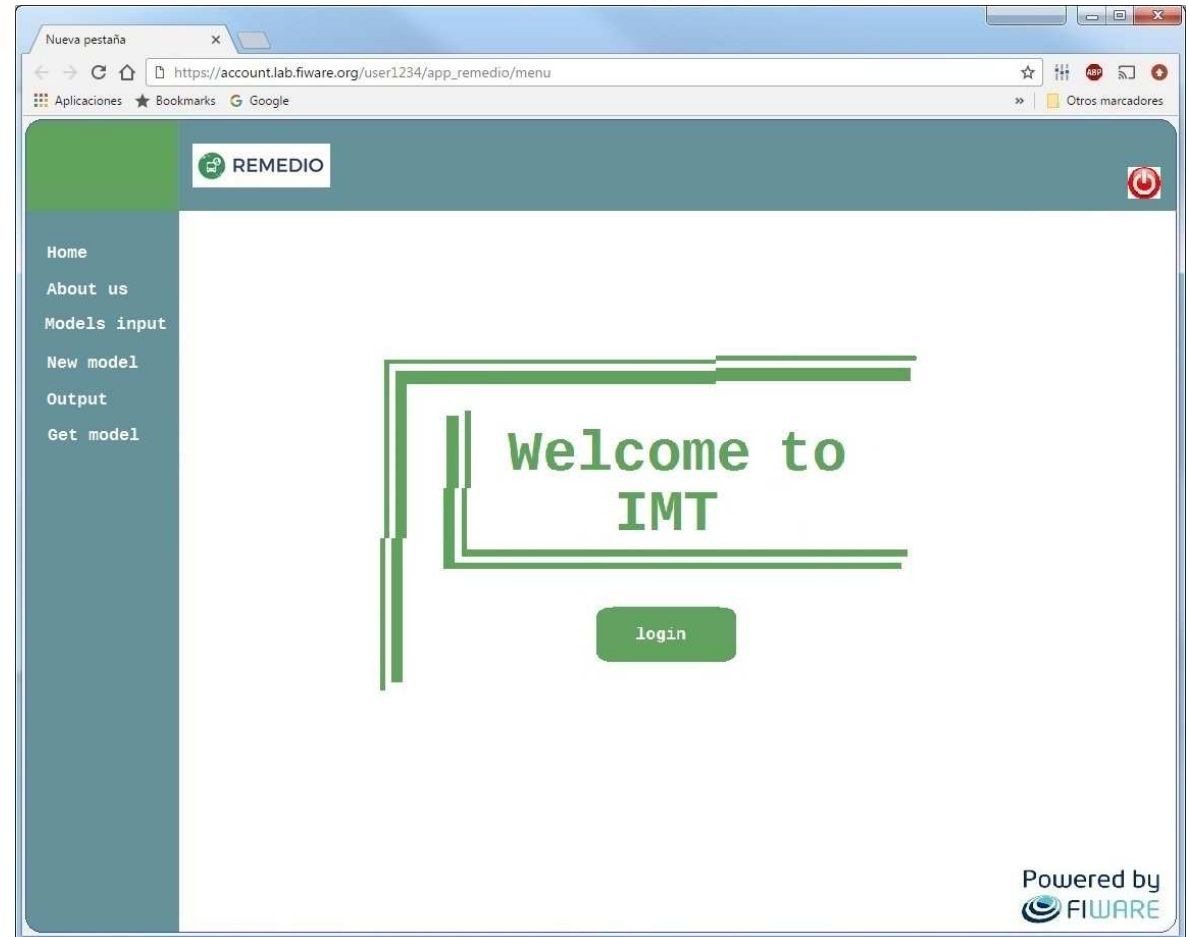
FIWARE Platform

Conceptual design

Allow visualize and understand
the platform better

Platform interface

- Simple and easy to use
- Secure
- Powerfull
- Versatile



FIWARE Platform

Select Input Files

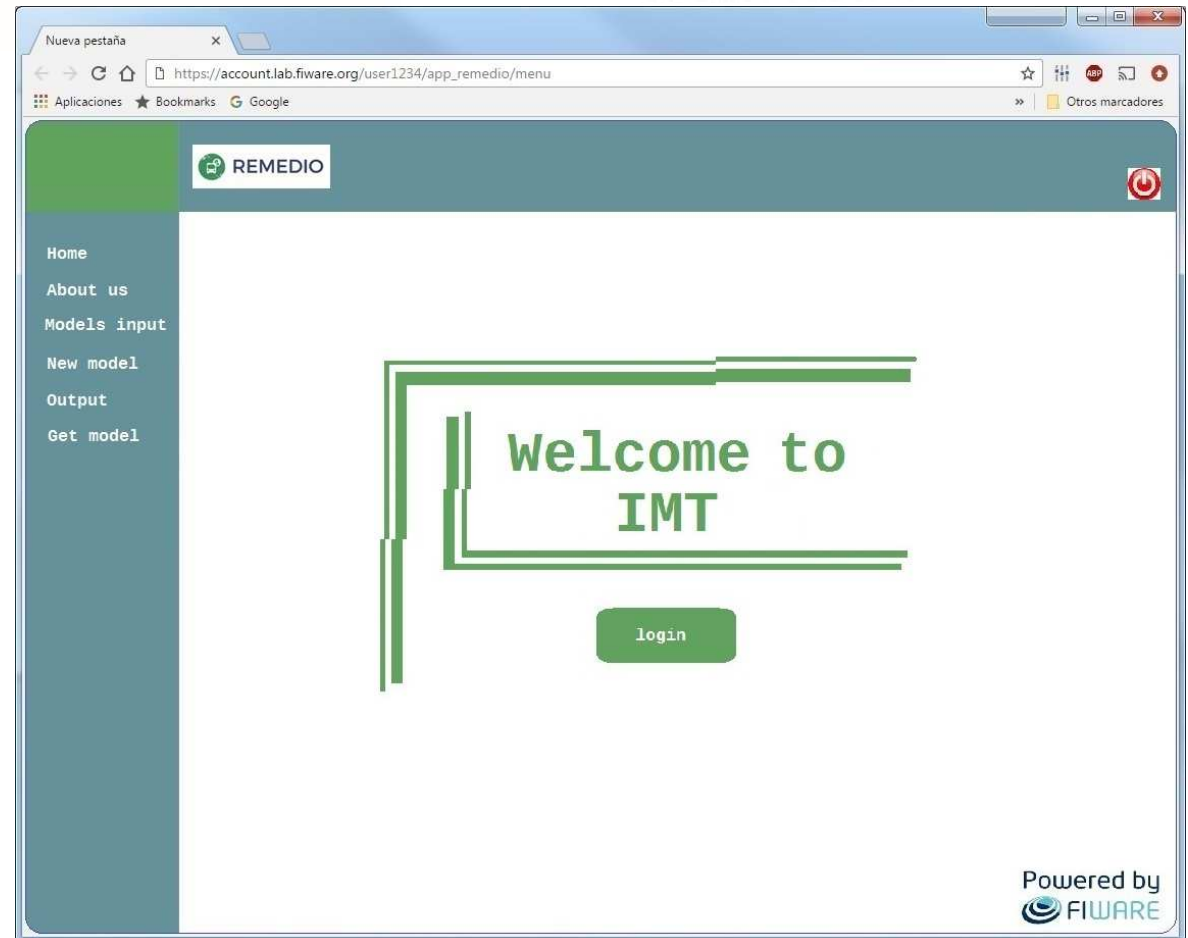
- Reuse uploaded
- Create new
- Add & modify info
- Others

Run Processing

- Tool Selection
- Apply algorithm
- Others

Use Output files

- Check output
- Compare outputs
- Select export format
- Graphic view
- Others

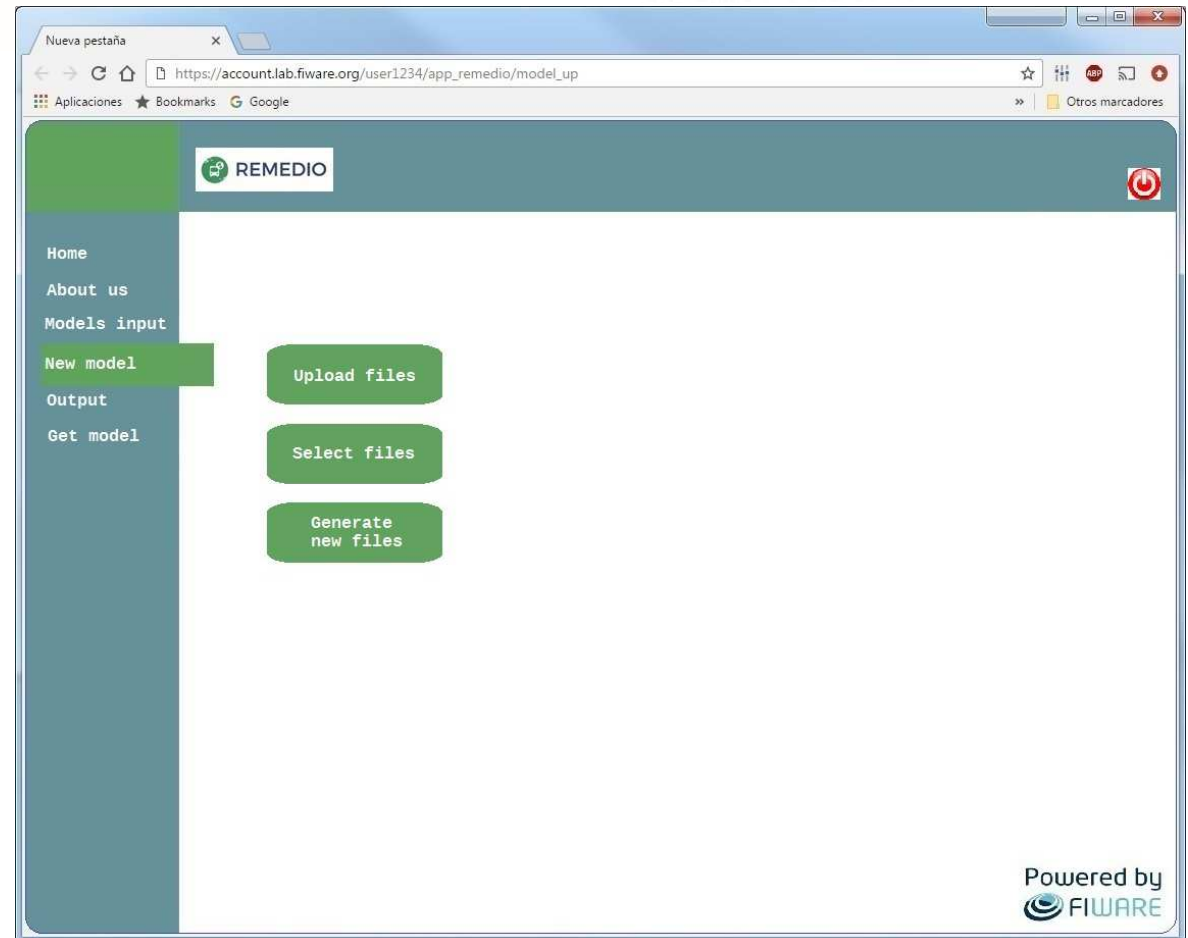


FIWARE Platform

Run a new simulation

New model menu

- Create new files
- Modify files

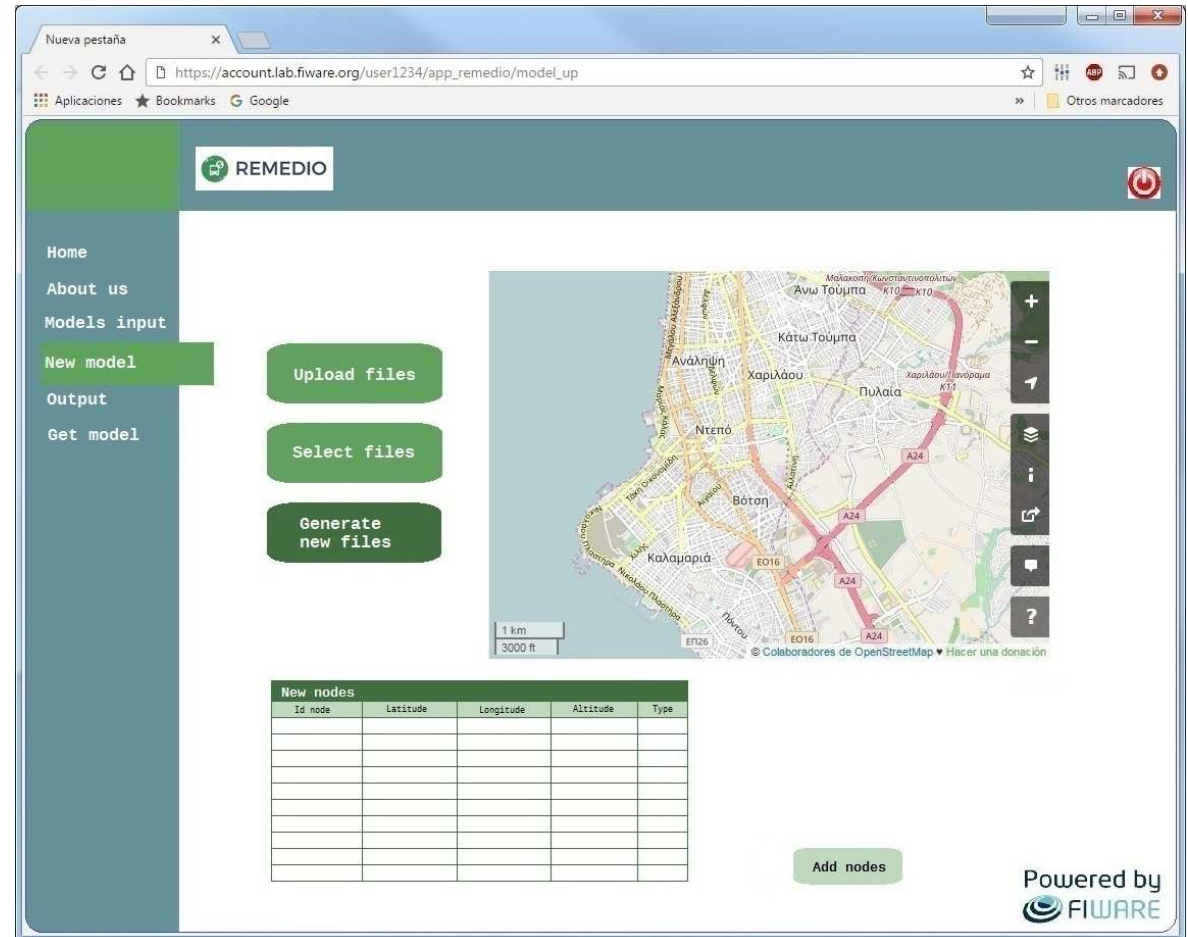


FIWARE Platform

*Generate a new file is
selected*

Model any route of any city
in the world

- Add more information easily
- Modify file information
- Add info by graphic interface
- Edit and complete information
- Select model to apply

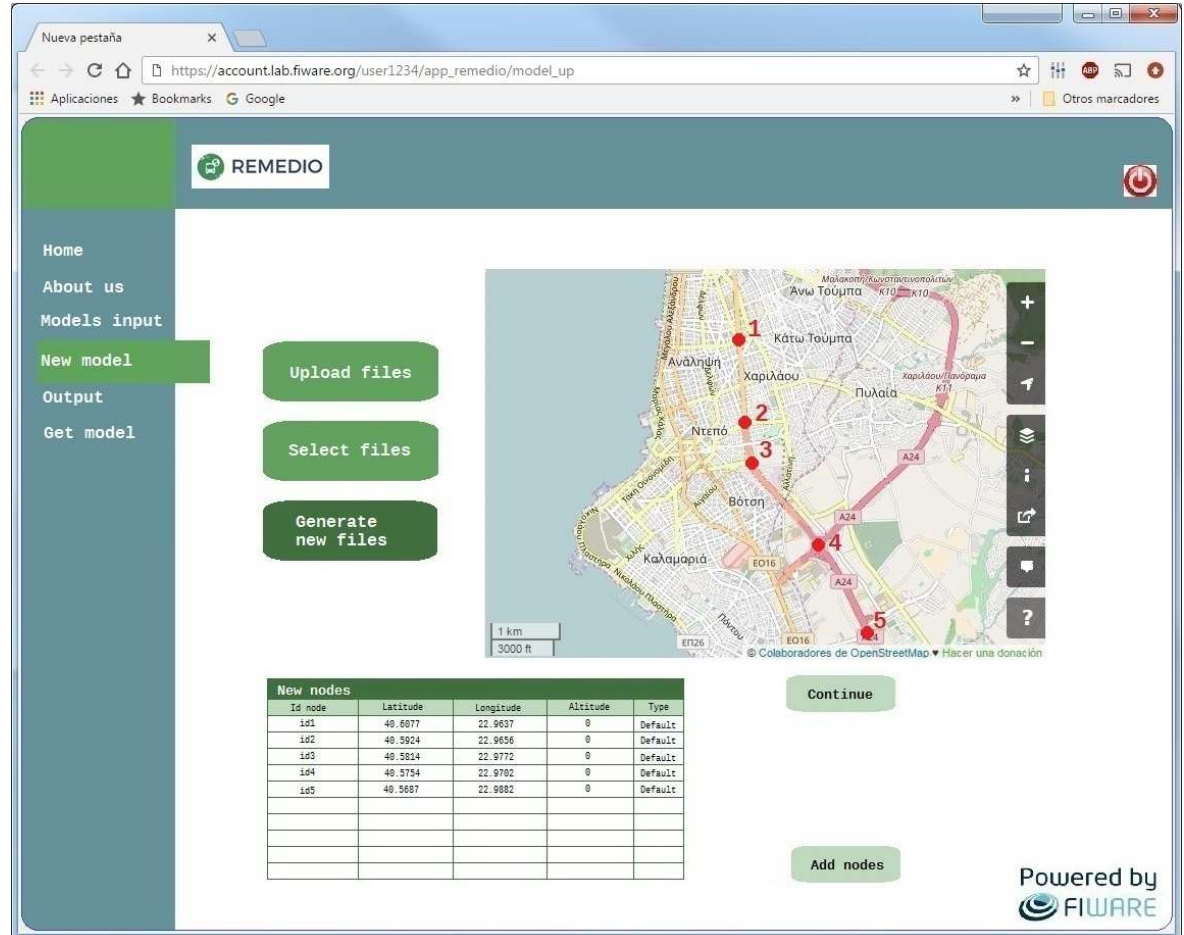


FIWARE Platform

Generate a new file is selected

View node selected and their features

Edit info



Nueva pestaña x
 https://account.lab.fiware.org/user1234/app_remedio/model_up
 Aplicaciones ★ Bookmarks G Google

REMEDIO

Home
 About us
 Models input
New model
 Output
 Get model

Upload files
 Select files
 Generate new files

Continue

Add nodes

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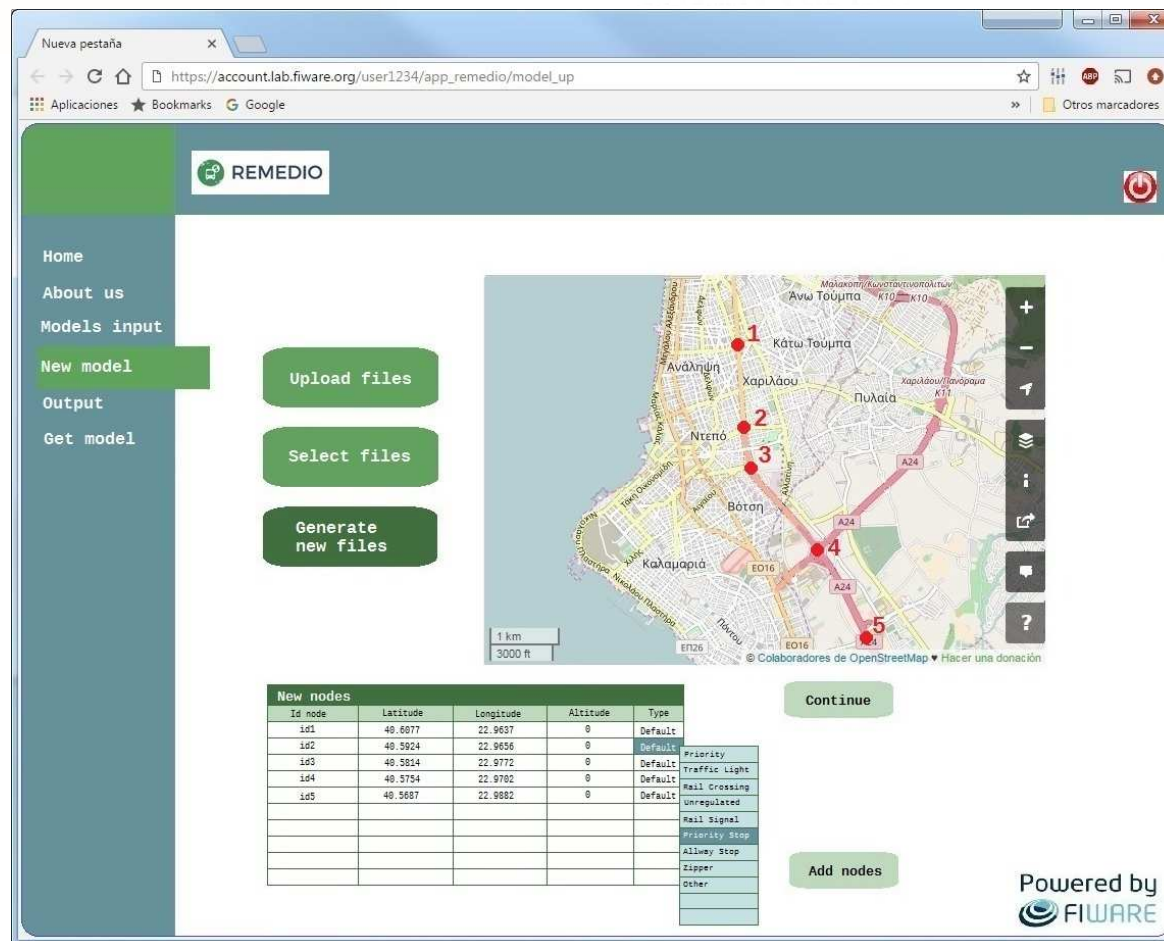
New nodes				
Id node	Latitude	Longitude	Altitude	Type
101	40.6077	22.9637	0	Default
102	40.5924	22.9656	0	Default
103	40.5824	22.9772	0	Default
104	40.5794	22.9702	0	Default
105	40.5687	22.9882	0	Default

FIWARE Platform

Generate a new file is selected

View node selected

Edit info



[New pestaña](#) x
https://account.lab.fiware.org/user1234/app_remedio/model_up
 Aplicaciones ★ Bookmarks Google

REMEDIO

Home
 About us
 Models input
New model
 Output
 Get model

Upload files
 Select files
 Generate new files

1 km
 3000 ft

© Colaboradores de OpenStreetMap ♥ Hacer una donación

New nodes				
Id node	Latitude	Longitude	Altitude	Type
101	40.6077	22.9637	0	Default
102	40.5924	22.9656	0	Default
103	40.5814	22.9772	0	Default
104	40.5754	22.9702	0	Default
105	40.5687	22.9882	0	Default
				Priority
				Traffic Light
				Rail Crossing
				Unregulated
				Rail Signal
				Priority Stop
				Alley Stop
				Zipper
				Other

Continue

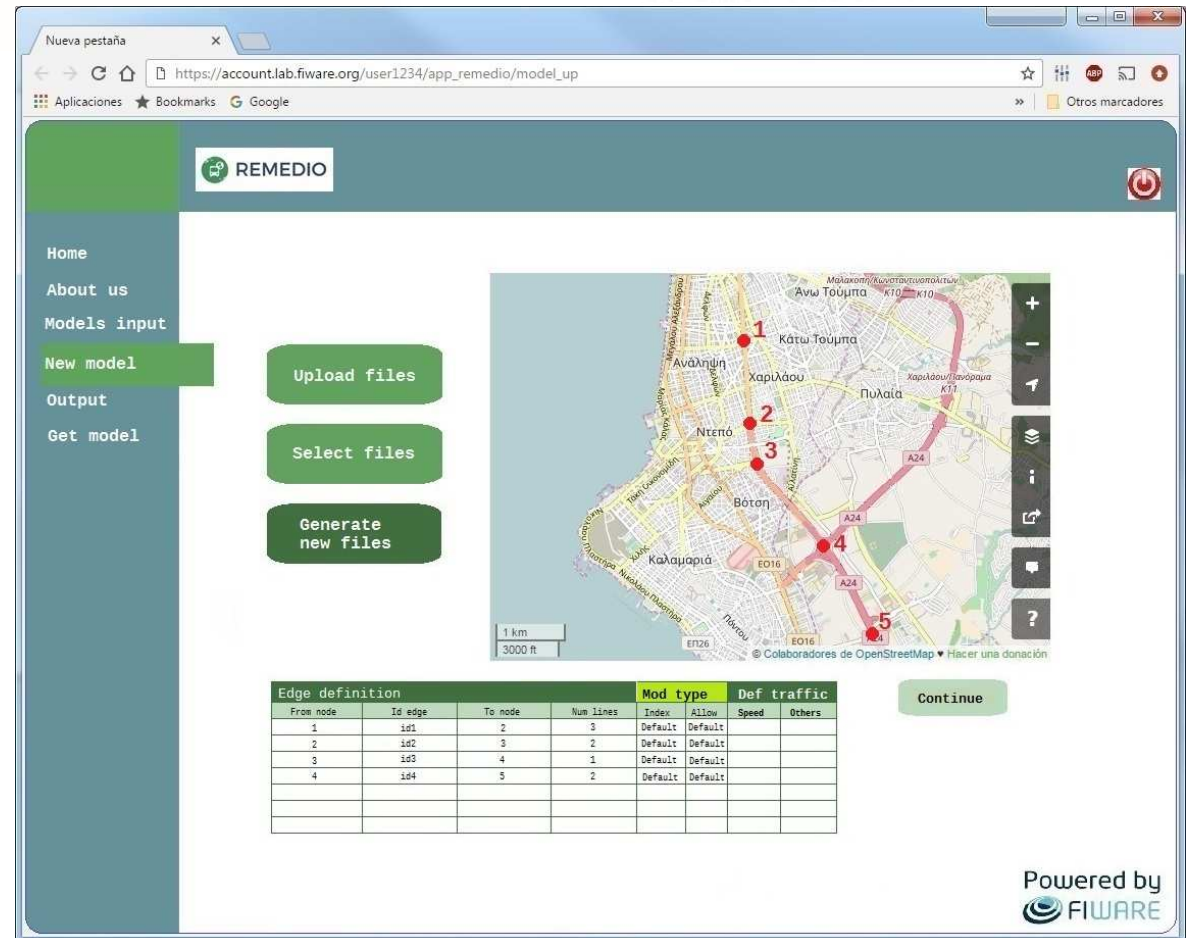
Add nodes

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FIWARE Platform

Generate a new file is
selected

- Add and modify edge info



REMEDIO

Home
About us
Models input
New model
Output
Get model

Upload files
Select files
Generate new files

Edge definition

From node	Id edge	To node	Num lines	Mod type	Def traffic	Speed	Others
1	101	2	3	Default	Default		
2	102	3	2	Default	Default		
3	103	4	1	Default	Default		
4	104	5	2	Default	Default		

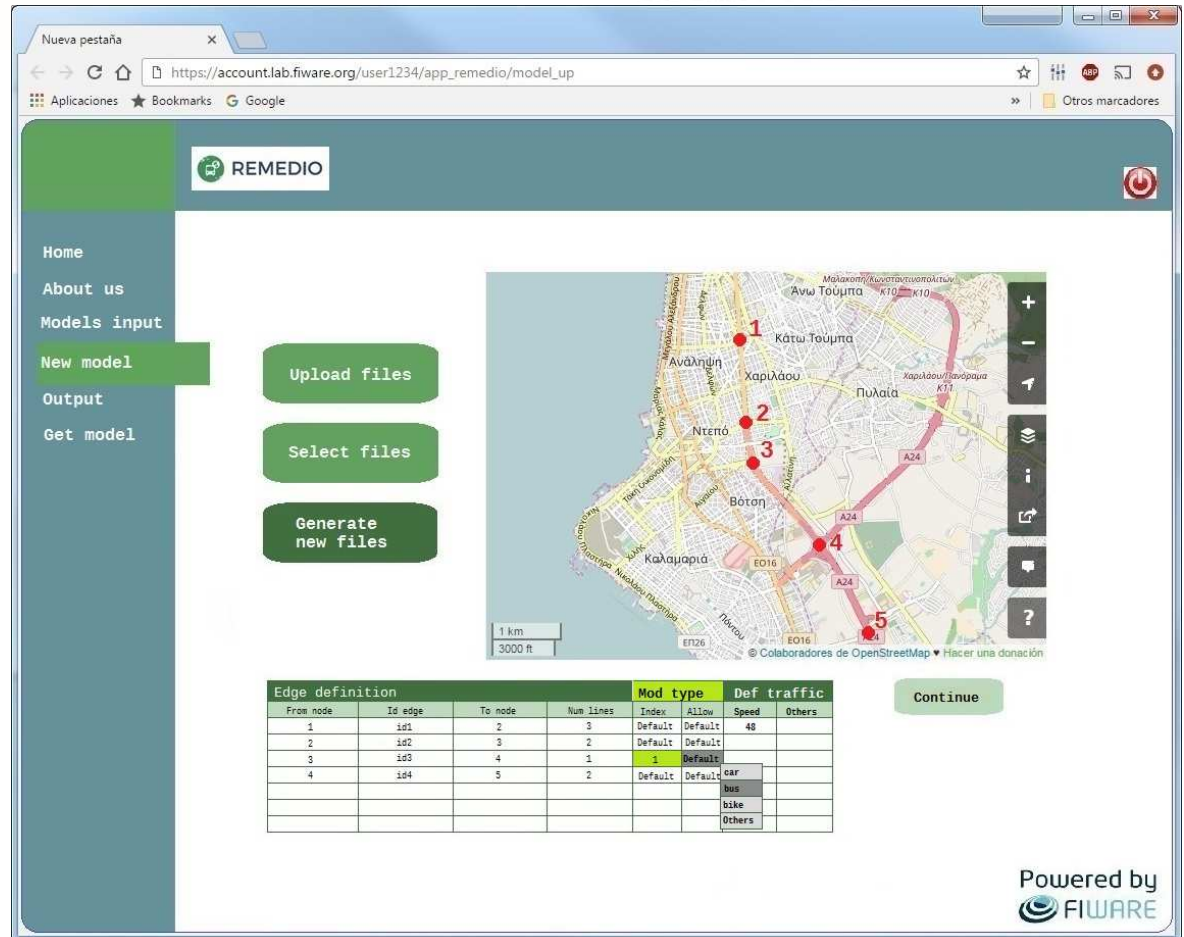
Continue

Powered by
FIWARE

FIWARE Platform

Generate a new file is
selected

- Add and modify edge info



Edge definition

From node	Id edge	To node	Num lines	Mod type	Def traffic	Speed	Others
1	101	2	3	Default	Default	40	
2	102	3	2	Default	Default		
3	103	4	1	1	Default		
4	104	5	2	Default	Default	car	

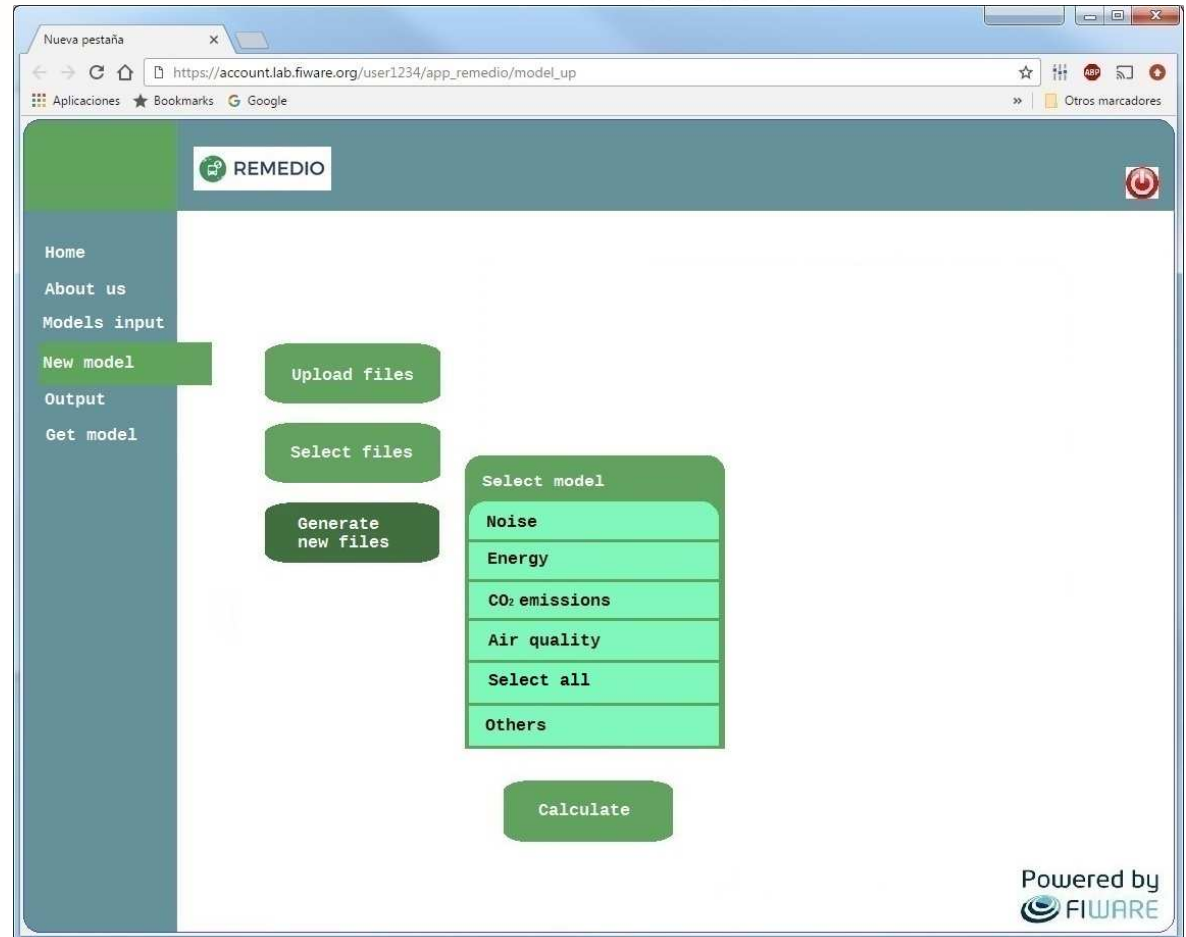
Continue

Powered by
FIWARE

FIWARE Platform

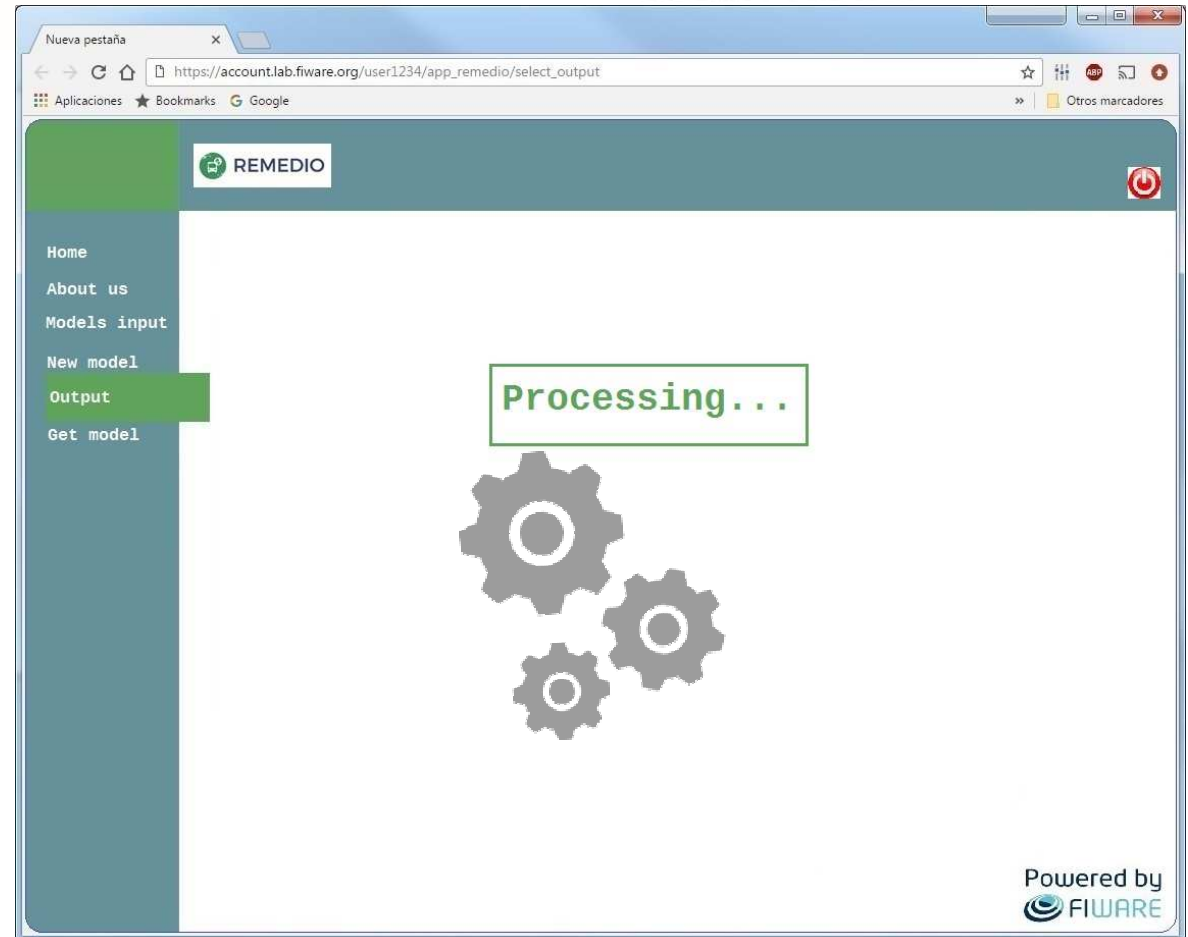
Calculate outputs

- Select model to apply



FIWARE Platform

Processing data with
algorithm selected

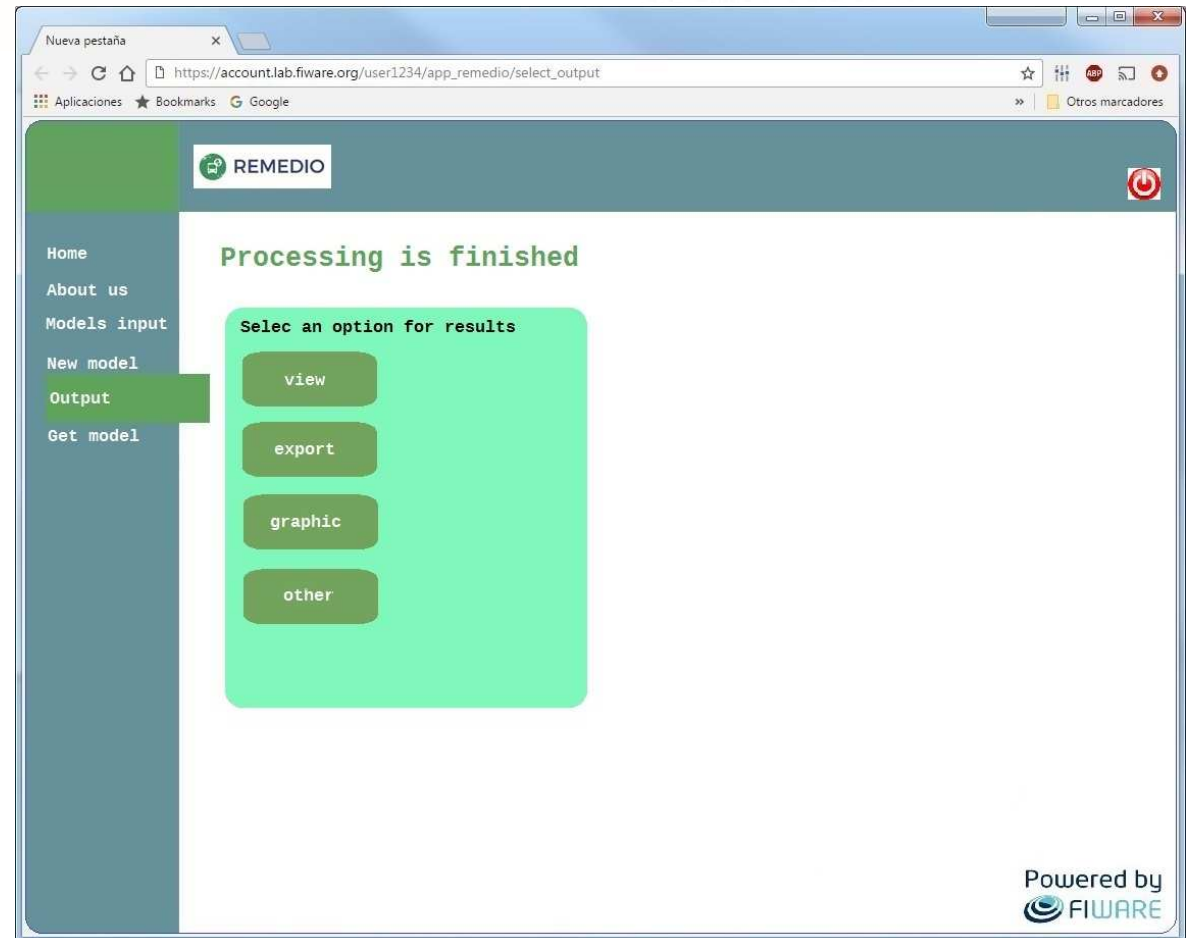


FIWARE Platform

Processing is finished

Output menu

- View output file
- Select export format
- View a graphic representation



FIWARE Platform

Use example: *code view*

- Check the file
- Add or modify information
- Save the changes

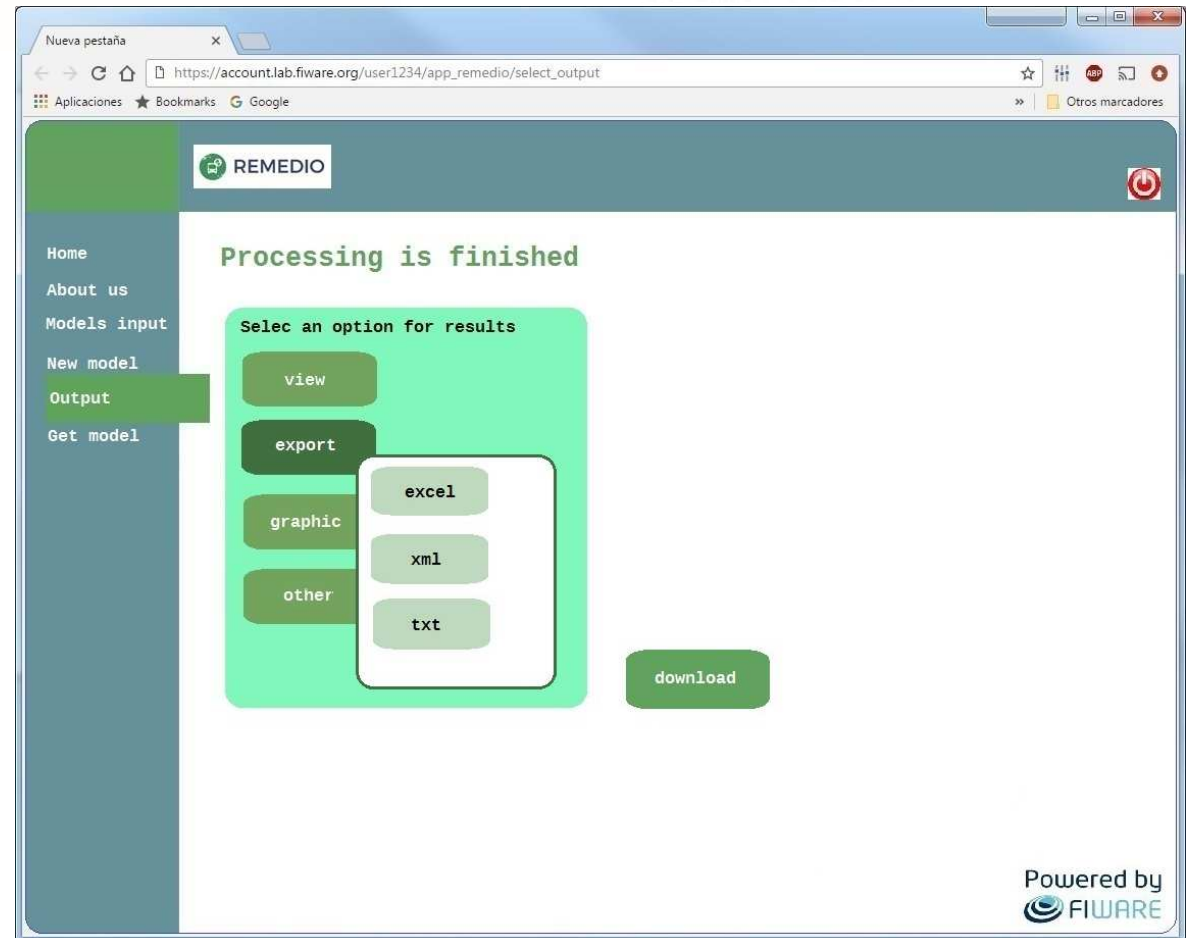
The screenshot shows a web browser window with the URL `https://account.lab.fiware.org/user1234/app_remedio/select_output`. The application interface includes a sidebar with navigation links: Home, About us, Models input, New model, Output (highlighted), and Get model. The main content area displays the message "Processing is finished" and a "Select an option for results" menu with buttons for view, export, graphic, other, and save. The "view" button is selected, showing a XML snippet of a SUMO network configuration. The XML includes details about the network version, location, edges, and junctions.

```
<?xml version="1.0" encoding="UTF-8"?>
<!-- generated on 03/27/17 19:18:25 by SUMO netconvert Version 0.29.0 -->
<!--
  <!-- net version="0.27" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:noNamespaceSchemaLocation="http://sumo.dlr.de/xsd/net_file.xsd">
    <!-- location netOffset="-956.00,-1240.52" convBoundary="0.00,0.00,1978.06,7483.48" origBoundary="956.00,1240.52,2934.06,8724.00" projParameter="" />
    <!-- edge id="2_0" function="internal">
      <!-- lane id="2_0_0" index="0" speed="13.90" length="0.46" shape="389.66,2700.91 389.59,2701.03 389.55,2701.11 389.52,2701.20 389.49,2701.34"/>
    <!-- edge id="3_0" function="internal">
      <!-- lane id="3_0_0" index="0" speed="13.90" length="0.57" shape="1.74,4269.31 1.70,4269.47 1.69,4269.59 1.69,4269.70 1.71,4269.87"/>
    <!-- edge id="4_0" function="internal">
      <!-- lane id="4_0_0" index="0" speed="13.90" length="0.43" shape="223.64,6185.30 223.65,6185.42 223.66,6185.51 223.65,6185.60 223.63,6185.72"/>
    <!-- edge id="ed1" from="1" to="2" priority="1">
      <!-- lane id="ed1_0" index="0" speed="13.90" length="3133.35" shape="1979.48,0.04 389.66,2700.91"/>
    <!-- edge id="ed2" from="2" to="3" priority="1">
      <!-- lane id="ed2_0" index="0" speed="13.90" length="1615.20" shape="389.49,2701.34 1.74,4269.31"/>
    <!-- edge id="ed3" from="3" to="4" priority="1">
      <!-- lane id="ed3_0" index="0" speed="13.90" length="1928.24" shape="1.71,4269.87 223.64,6185.30"/>
    <!-- edge id="ed4" from="4" to="5" priority="1">
      <!-- lane id="ed4_0" index="0" speed="13.90" length="1313.32" shape="223.63,6185.72 23.63,7483.73"/>
    <!-- junction id="1" type="unregulated" x="1978.06" y="0.00" incLanes="" intLanes="" shape="1978.10,0.03 1980.86,1.65"/>
    <!-- junction id="2" type="priority" x="388.00" y="2700.48" incLanes="ed1_0" intLanes="2_0_0" shape="391.04,2701.72 388.28,2700.10 387.93,2700.95"/>
    <!-- junction id="3" type="priority" x="0.00" y="4269.48" incLanes="ed2_0" intLanes="3_0_0" shape="0.12,4270.06 3.30,4269.69 0.19,4268.92"/>
    <!-- request index="0" response="0" foes="0" cont="0"/>
  <!--
-->
```

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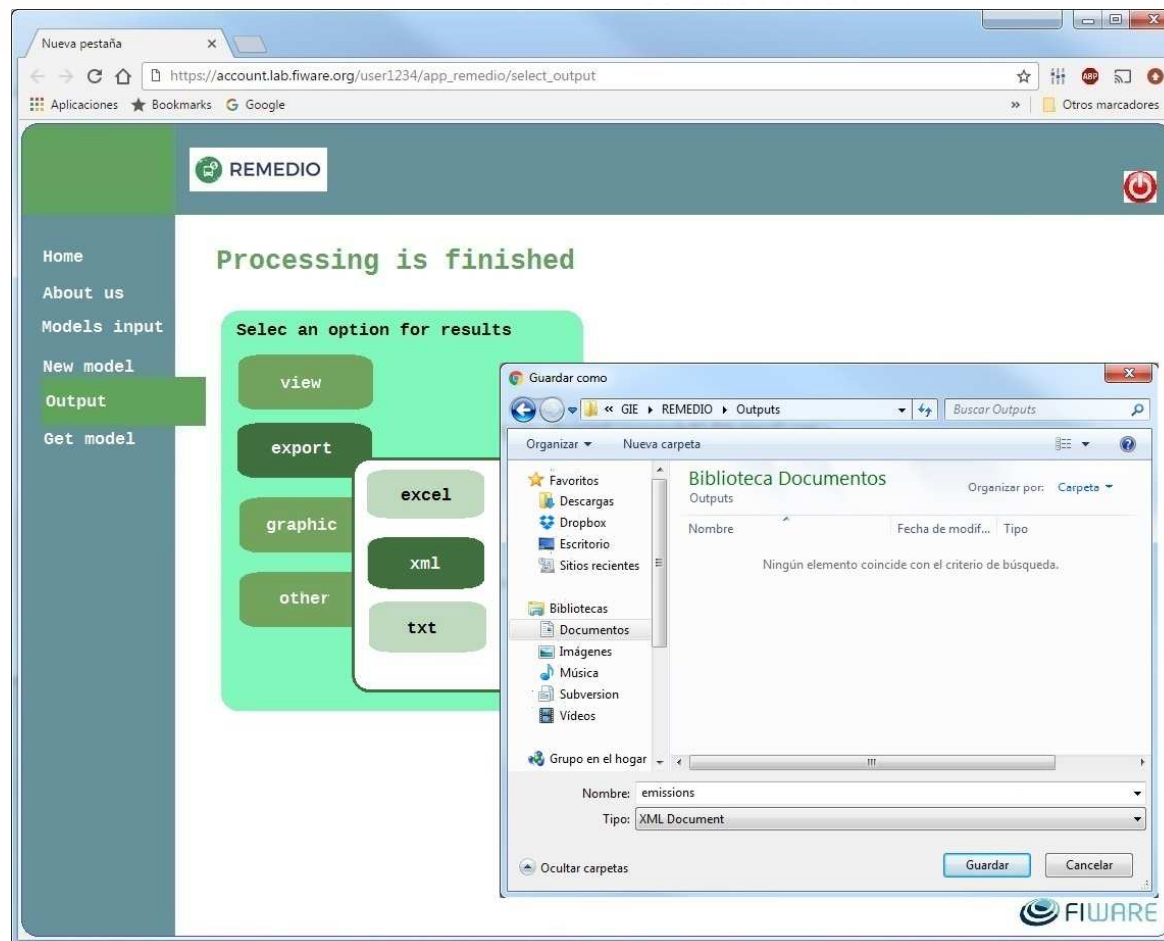
FIWARE Platform

Use example: *Select format*



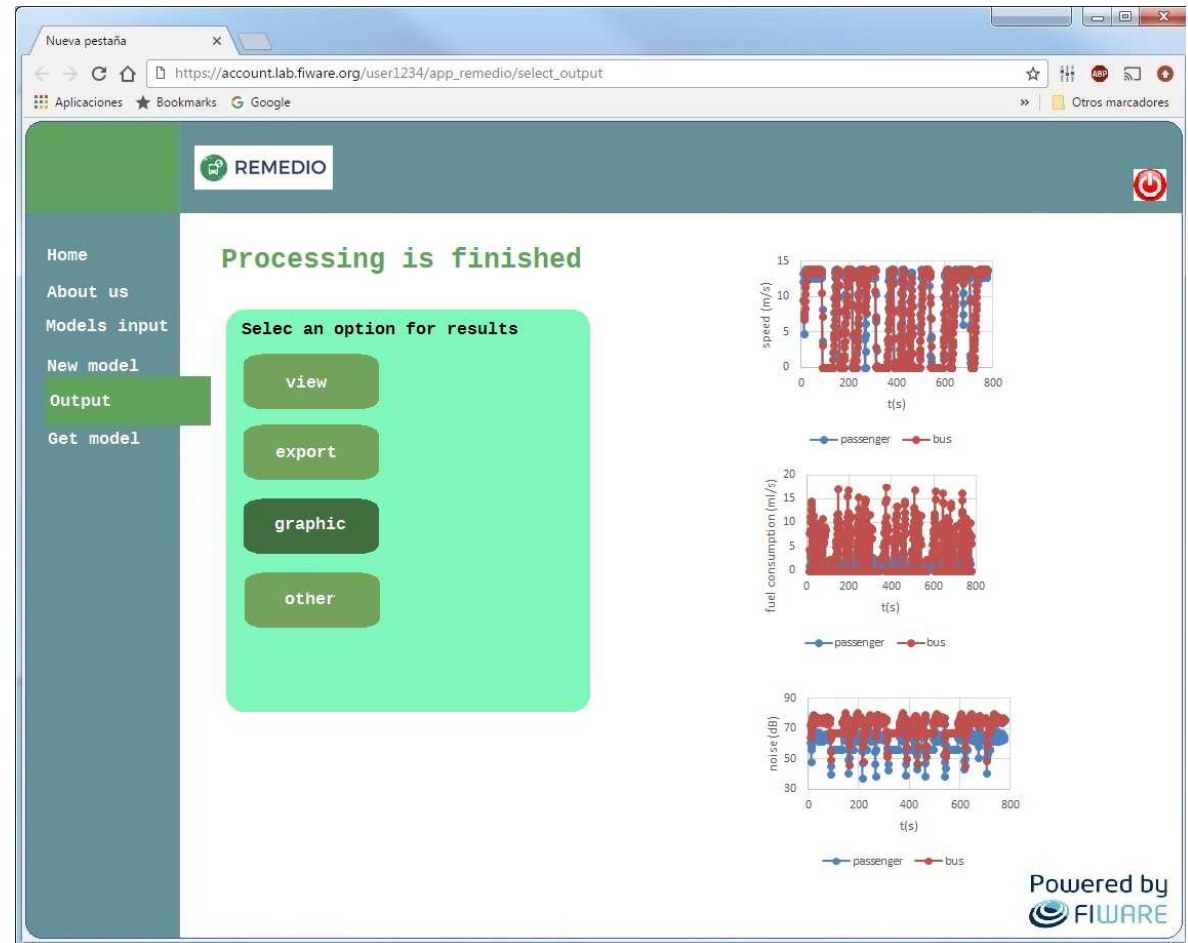
FIWARE Platform

Use example: *Select format*



FIWARE Platform

Use example: *Graphic view*



FIWARE Platform

Query outputs in a date range

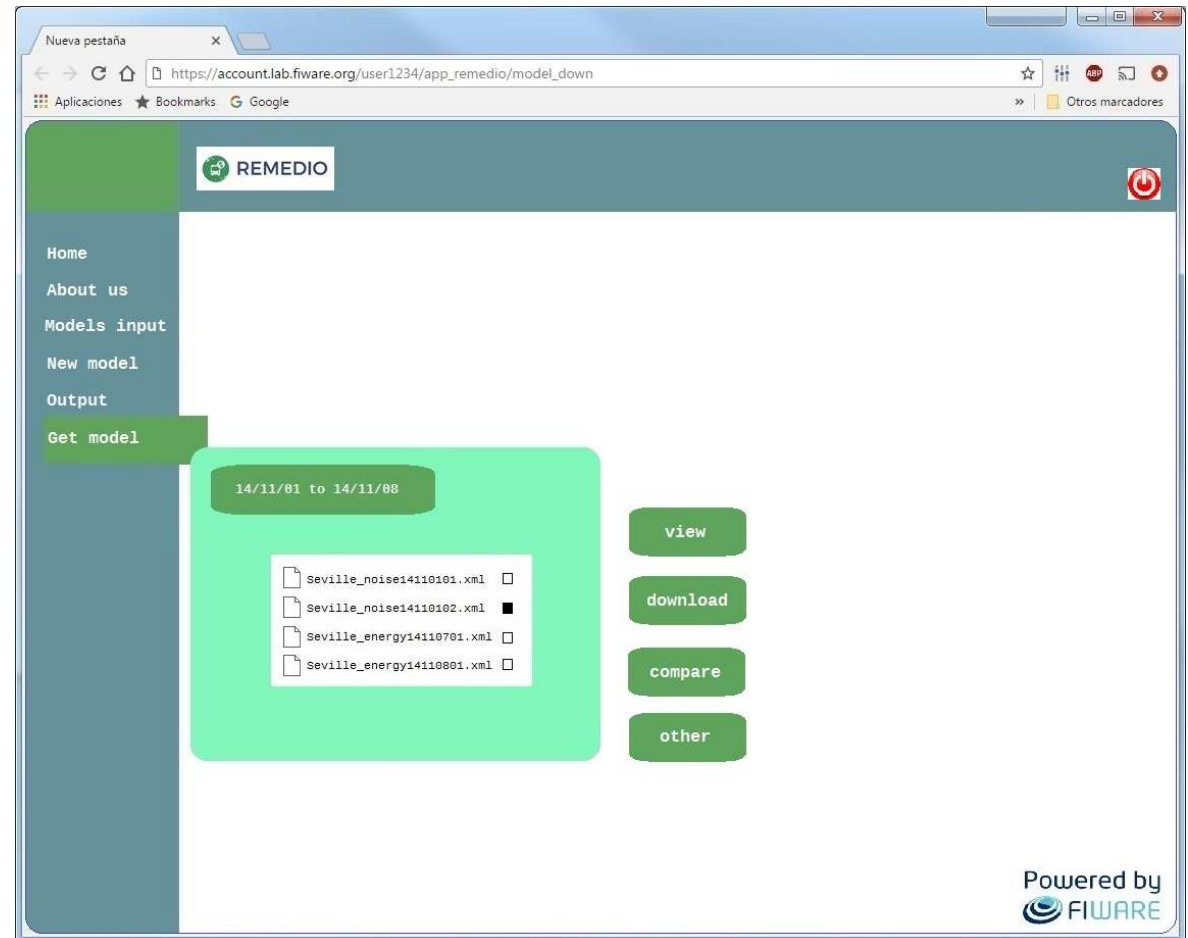
- View
- Download
- Compare
- Others

The screenshot shows a web browser window with the URL https://account.lab.fiware.org/user1234/app_remedio/model_down. The page features a sidebar with navigation links: Home, About us, Models input, New model, Output, and Get model (highlighted). The main content area is titled "REMEDIO" and displays a "Select a date range" section. This section includes two calendar pickers for "Start date" and "End date", both set to "Nov 2014". The "Start date" calendar shows the 1st of November selected. To the right of the calendars are buttons for "Last 7 Days", "Last 28 Days", and a dropdown menu currently showing "November 2014". Below these are buttons for "Query" and "November 2014". The bottom right corner of the page states "Powered by FIWARE".

FIWARE Platform

Query outputs in a data range

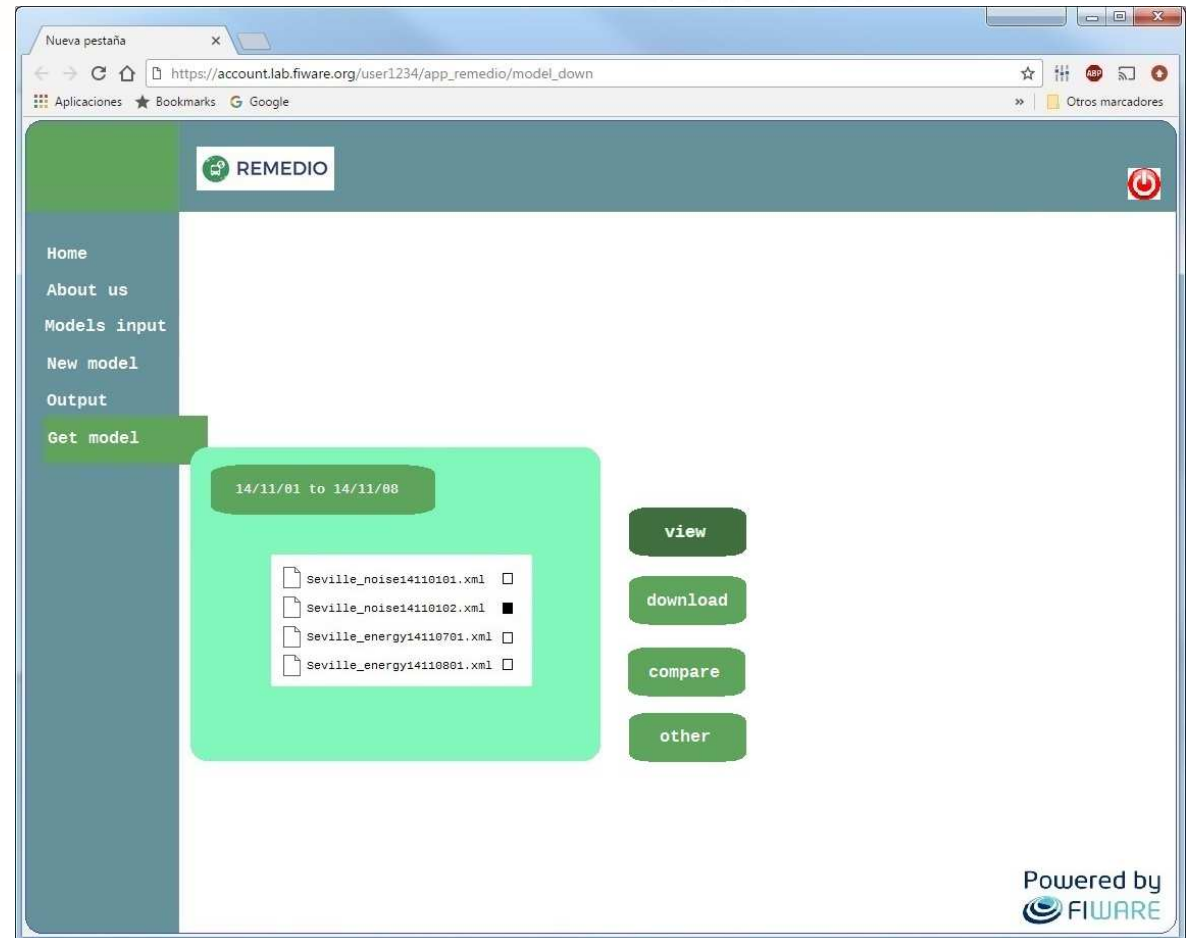
- **View**
- Download
- Compare
- Others



FIWARE Platform

Query outputs in a data range

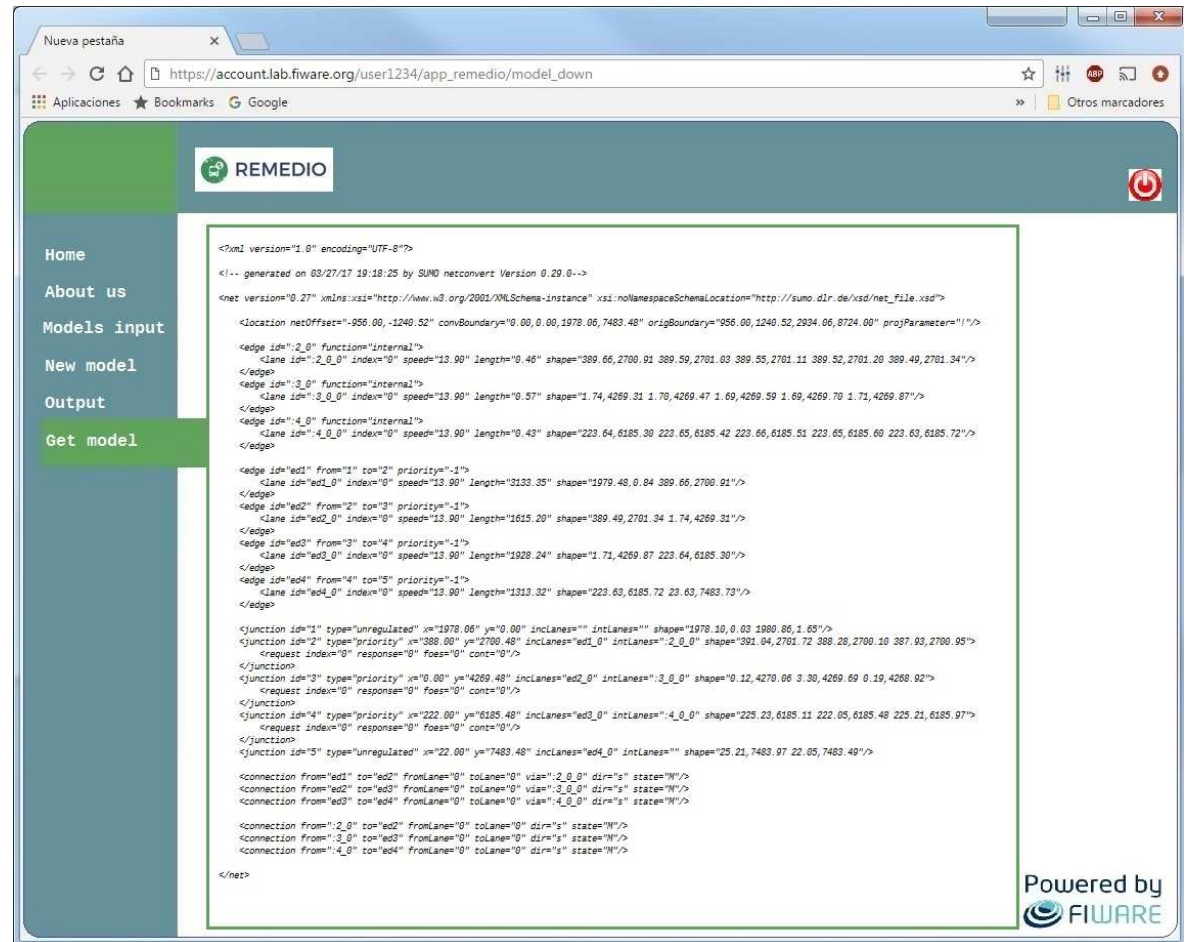
- **View**
- Download
- Compare
- Others



FIWARE Platform

Query outputs in a data
range

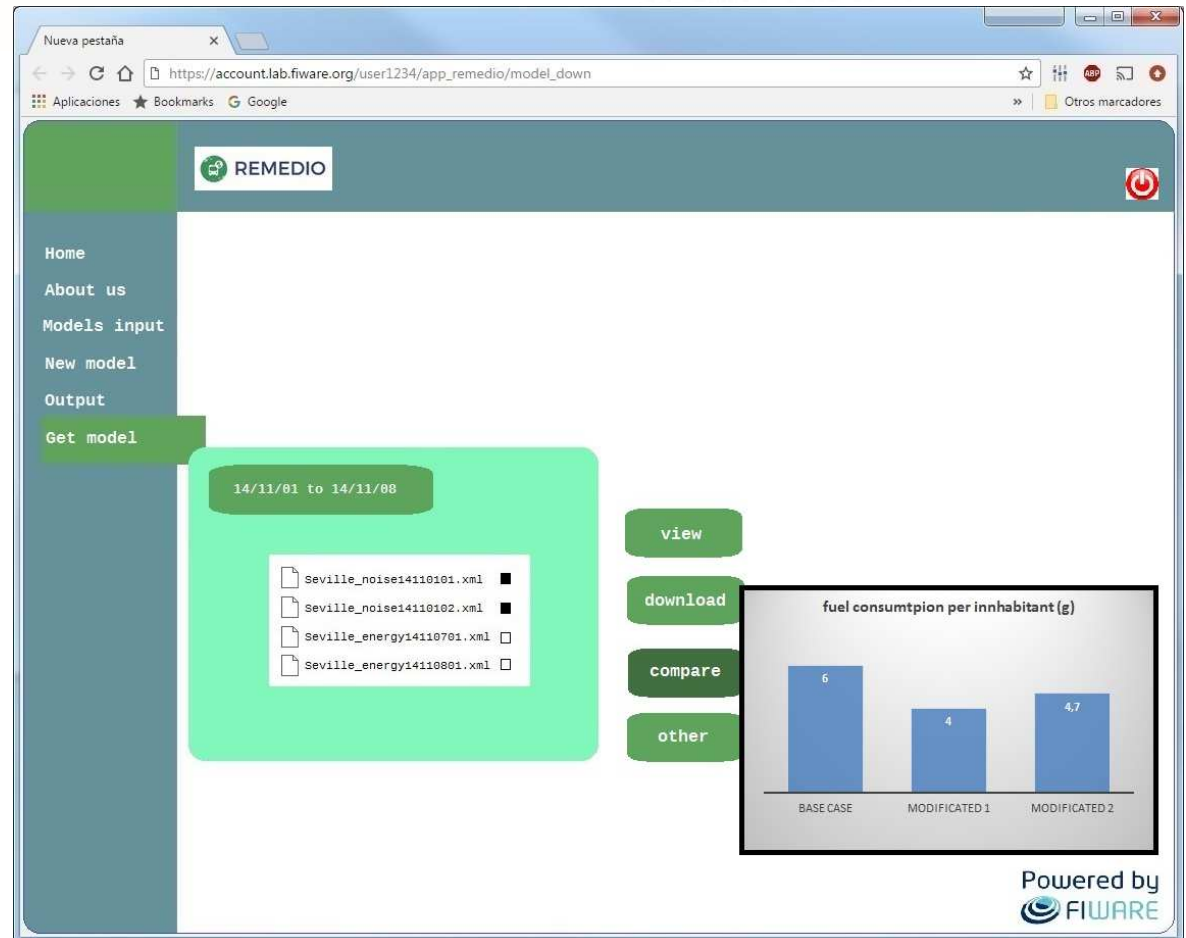
- View
- Download
- Compare
- Others



FIWARE Platform

Query outputs in a data
range

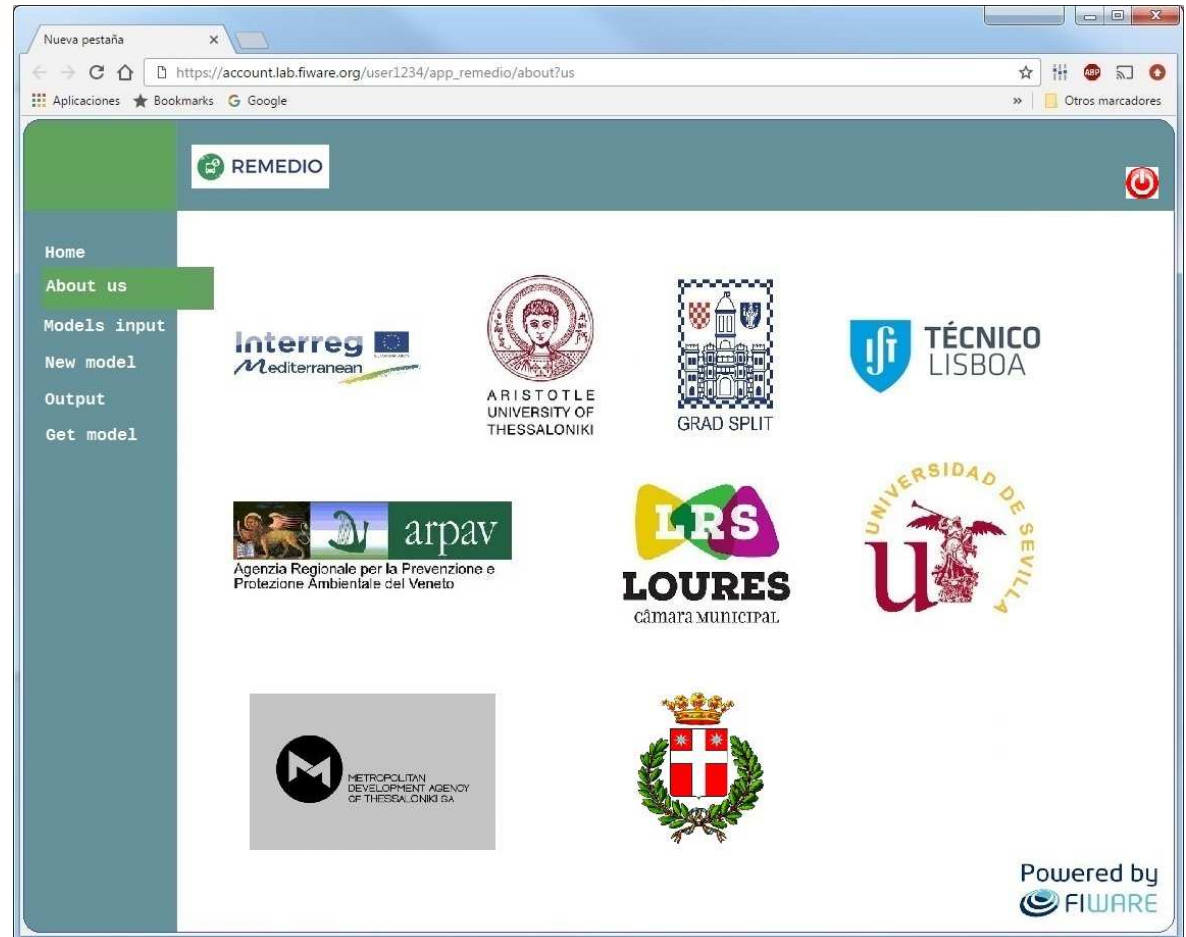
- View
- Download
- **Compare**
- Others



FIWARE Platform

Corporate information

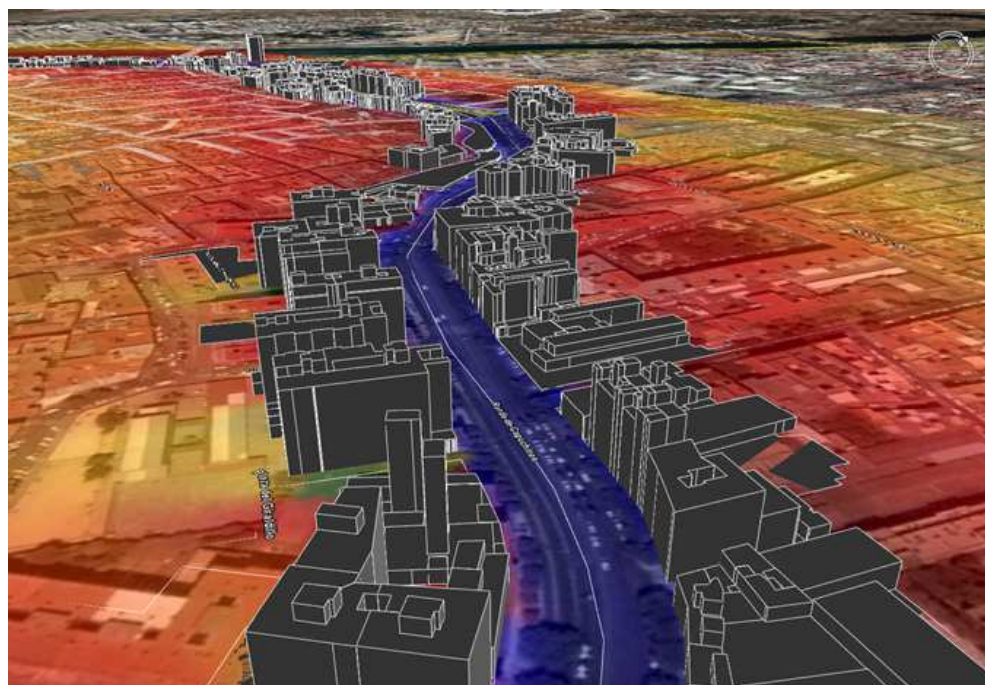
- Contact
- Location
- Projects
- Website
- Others



FIWARE Platform

Future enhancements

- Extend the IMT application range
- Integrated use of sensor

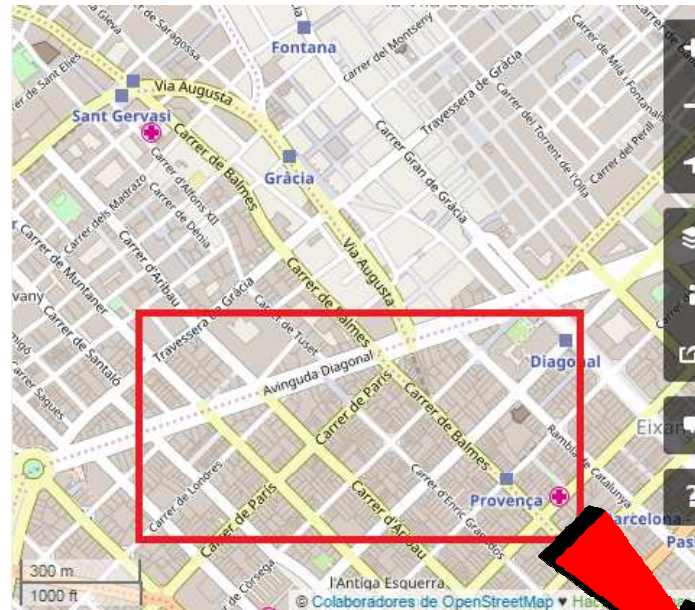


FIWARE Platform

Future enhancements

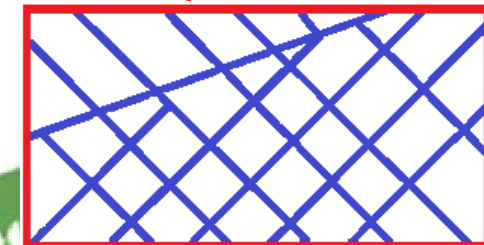
Extend the IMT application
range

- Select target zone by graphic interface
- Automatic generation of a simplified model with interconnected ways
- Edit this model
- Instant generation of input files



Target zone

Simplified model

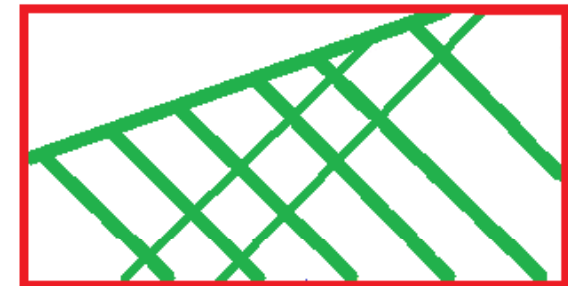
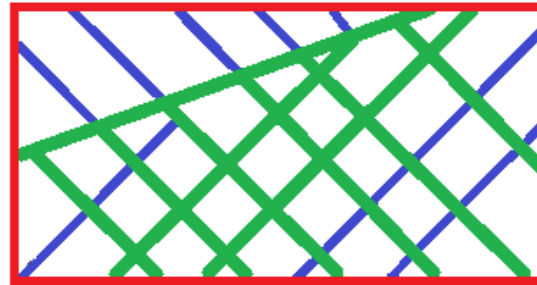


FIWARE Platform

Future enhancements

Extend the IMT application range

- Select target zone by graphic interface
- Automatic generation of a simplified model with interconnected ways
- Edit this model
- Instant generation of input files



```

5
6 <nodes>
7   <node id="1" x="2934.06" y="1240.52" />
8   <node id="2" x="1344" y="3941" />
9   <node id="3" x="956" y="5510" type="traffic_light"/>
10  <node id="4" x="1178" y="7426" />
11  <node id="5" x="978" y="8724" />
12  <node id="6" x="2934.06" y="1240.52" />
13  <node id="7" x="1344" y="3941" />
14  <node id="8" x="956" y="5510" type="traffic_light"/>
15  <node id="9" x="1178" y="7426" type="traffic_lig
16  <node id="10" x="978" y="8724" />
17  <node id="11" x="2934.06" y="1240.52" />
18  <node id="12" x="1344" y="3941" />
19  <node id="13" x="956" y="5510" type="rail_signa
20  <node id="14" x="1178" y="7426" />
21  <node id="15" x="978" y="8724" />
22  <node id="16" x="2934.06" y="1240.52" type="zip
23  <node id="17" x="1344" y="3941" />
24 </nodes>

```

```

4 <edges>
5   <edge from="1" id="ed1" to="2" numLanes="3"/>
6   <edge from="2" id="ed2" to="3" numLanes="3"/>
7   <edge from="3" id="ed3" to="4" numLanes="3"/>
8   <edge from="4" id="ed4" to="5" numLanes="3"/>
9   <edge from="5" id="ed5" to="6" numLanes="3"/>
10  <edge from="6" id="ed6" to="7" numLanes="3"/>
11  <edge from="7" id="ed7" to="8" numLanes="3"/>
12  <edge from="8" id="ed8" to="9" numLanes="3"/>
13  <edge from="9" id="ed9" to="10" numLanes="3"/>
14  <edge from="10" id="ed10" to="11" numLanes="3"/>
15  <edge from="11" id="ed11" to="12" numLanes="3"/>
16  <edge from="12" id="ed12" to="13" numLanes="3"/>
17  <edge from="13" id="ed13" to="14" numLanes="3"/>
18  <edge from="14" id="ed14" to="15" numLanes="3"/>
19  <edge from="15" id="ed15" to="16" numLanes="3"/>
20  <edge from="16" id="ed16" to="17" numLanes="3"/>
21  <edge from="17" id="ed17" to="1" numLanes="3"/>
22 </edges>

```



FIWARE Platform

Future enhancements

Integrated use of sensor
for:

- Add info to complete the input files
- Use FIWARE for storage and query sensor data
- Validate and complete IMT result
- Use with IMT result to act

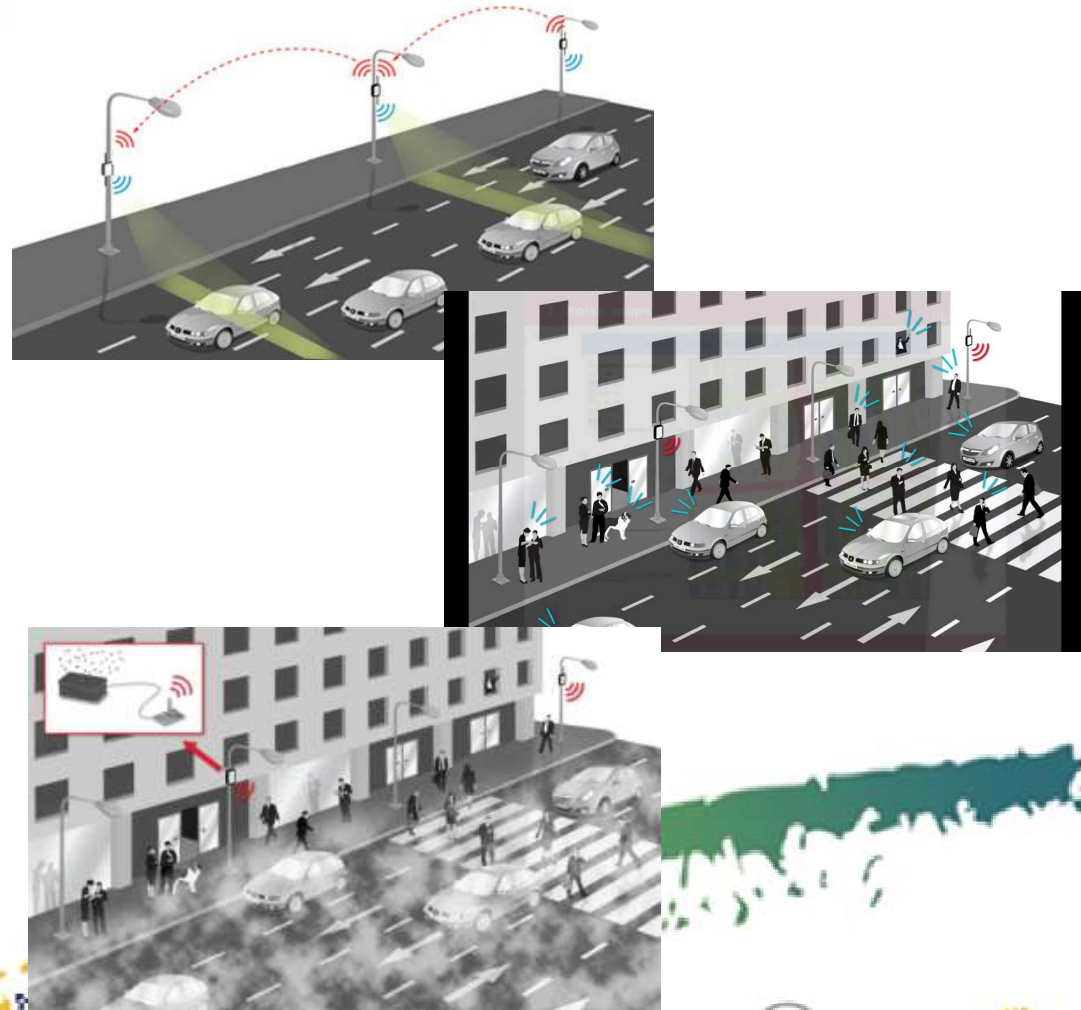


FIWARE Platform

Future enhancements

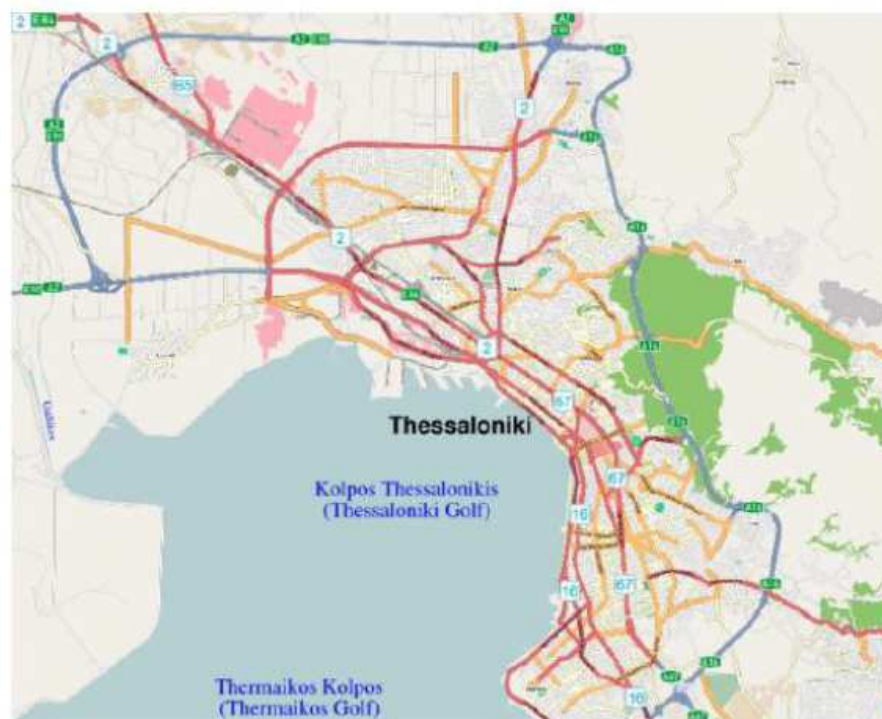
Integrated use of sensors

- Tree network
- Low power consumption
- Scalable
- Periodic data
- Alarms/Events
- Send commands
- FIWARE integrated



Using the REMEDIO IMT

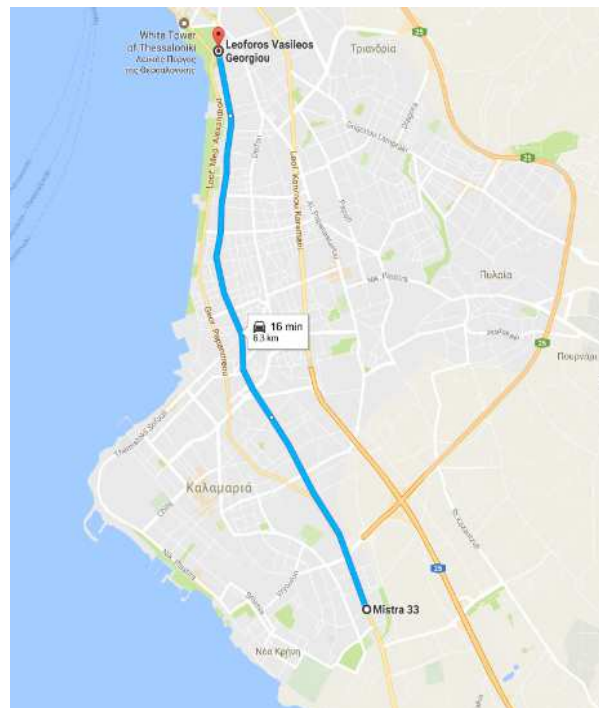
Case example: Thessaloniki



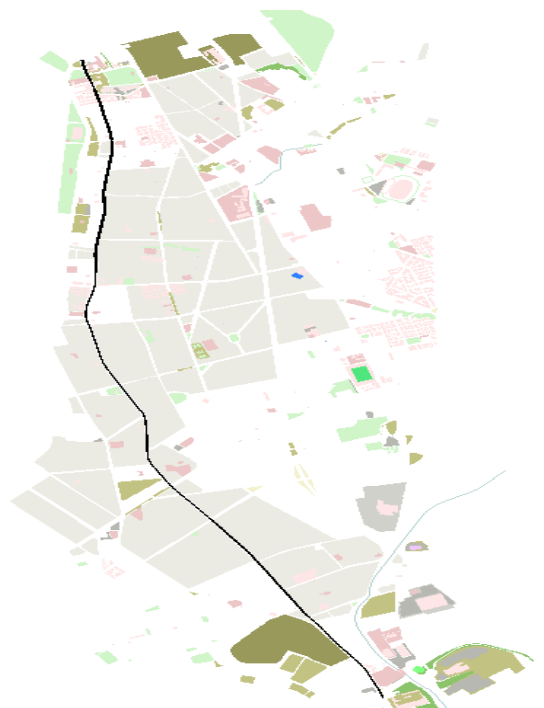
Using the REMEDIO IMT

Case example: Thessaloniki

Real



IMT



Thessaloniki- input data

Pilot area definition		
Road name (to find it in OSM)	Lenght (km)	Traffic lights /signals/others position (GPS coordinates)
Εθνικής Αντιστάσεως - Ethnikis Antistaseos	1.8	1 (40.57637, 22.96995)
		2 (40.58203, 22.96575)
		3 (40.58327, 22.96481)
		4 (40.58405, 22.96424)
		5 (40.58626, 22.96262)
		6 (40.58748, 22.96169)
		7 (40.58937, 22.95994)
Βασιλίσσης Όλγας -	3.3	8 (40.59120, 22.95814)
		9 (40.59175, 22.95771)
		10 (40.59235, 22.95718)
		11 (40.59345, 22.95646)
		12 (40.59419, 22.95616)
		13 (40.59585, 22.95619)
		14 (40.59712, 22.95605)
		15 (40.59792, 22.95554)
		16 (40.59944, 22.95461)
		17 (40.60103, 22.95367)
		18 (40.60207, 22.95339)
		19 (40.60406, 22.95282)
		20 (40.60680, 22.95325)
		21 (40.60933, 22.95340)
		22 (40.61041, 22.95353)
		23 (40.61210, 22.95398)
		24 (40.61426, 22.95410)
		25 (40.61553, 22.95443)
		26 (40.61635, 22.95457)
		27 (40.61779, 22.95468)
Βασιλέως Γεωργίου -	0.7	28 (40.61969, 22.95418)
		29 (40.62119, 22.95387)
		30 (40.62264, 22.95334)
		31 (40.62372, 22.95300)
Μανώλη Ανδρόνικου -	0.3	32 (40.62603, 22.95283)
TOTAL	6.1	

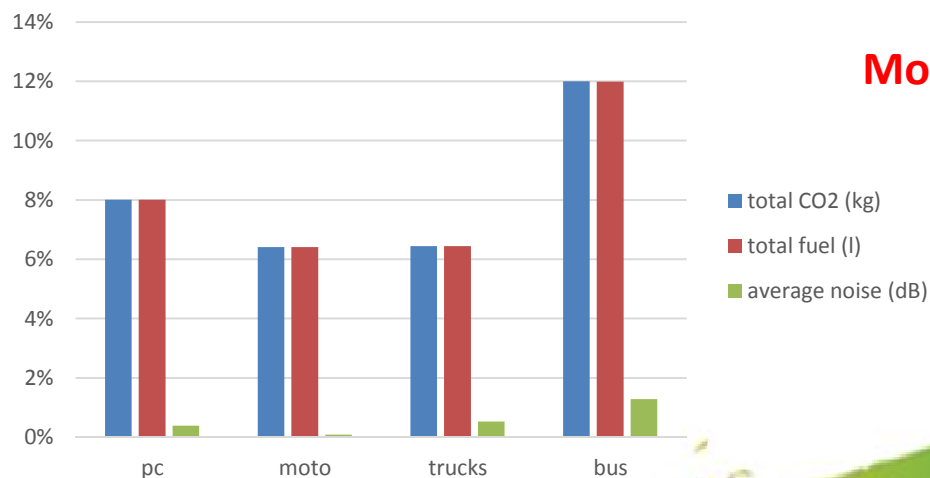
Traffic characterization in the pilot area		
Maximum number of vehicles (at peak-hour)	3037	
Average number of cars per day	Average number (cars)	Average speed (km/h)
00:00-01:00	731	40
01:00-02:00	474	41
02:00-03:00	277	44
03:00-04:00	226	41
04:00-05:00	224	47
05:00-06:00	455	48
06:00-07:00	1171	43
07:00-08:00	2361	37
08:00-09:00	2772	31
09:00-10:00	2655	29
10:00-11:00	2699	29
11:00-12:00	2479	29
12:00-13:00	2408	27
13:00-14:00	2229	30
14:00-15:00	2161	29
15:00-16:00	2406	31
16:00-17:00	2356	32
17:00-18:00	2420	33
18:00-19:00	2418	29
19:00-20:00	2291	31
20:00-21:00	2314	28
21:00-22:00	1939	28
22:00-23:00	1339	35
23:00-24:00	1035	36
vehicle occupancy (average persons/car)	1.4	
Number of bikes per day	NA	
Number of motobikes per day	NA	
Number of trucks per day	NA	

Thessaloniki- preliminary results

IMT (4 edges + traffic lights)			
	total CO2 (kg)	total fuel (l)	average noise (dB)
pc	884.8	380.5	60.2
moto	195.3	84.0	60.4
trucks	783.0	332.0	71.6
bus	135.9	57.9	72.7

Real (Open Street Map)			
	total CO2 (kg)	total fuel (l)	average noise (dB)
pc	961.7	413.7	60.0
moto	208.6	89.8	60.4
trucks	836.9	354.8	71.2
bus	154.4	65.8	71.8

differences between real and IMT cases

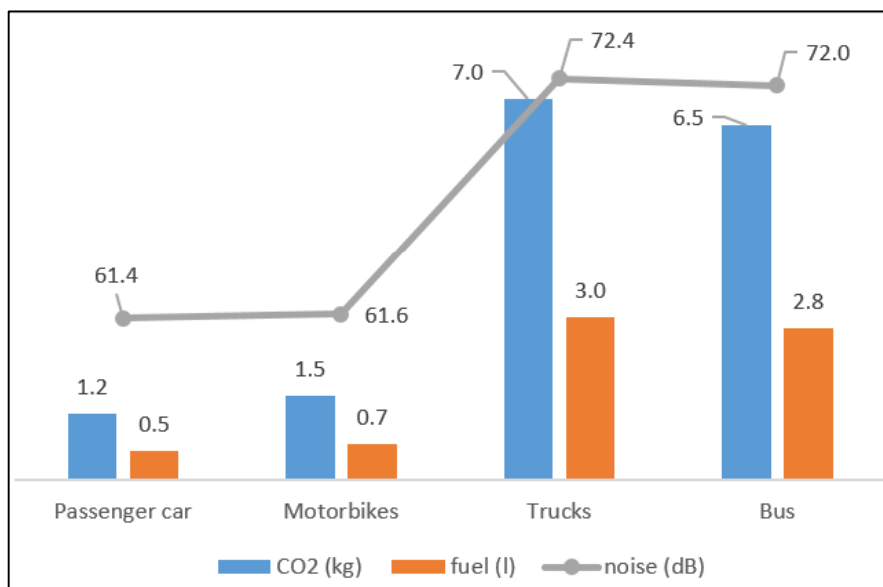


More data (higher number of road stretch)

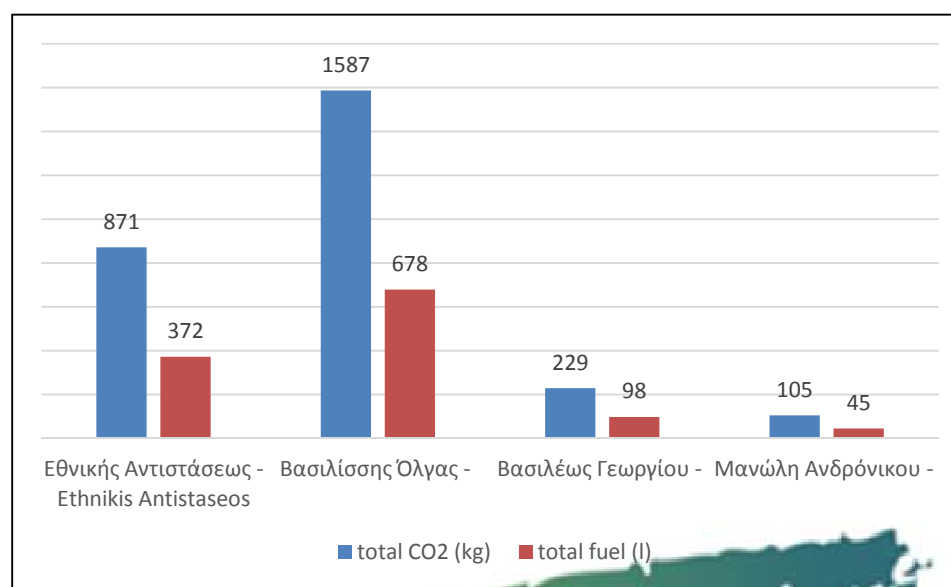
More realistic results

Thessaloniki- preliminary results

Average fuel consumption-noise and
CO2 by vehicle type

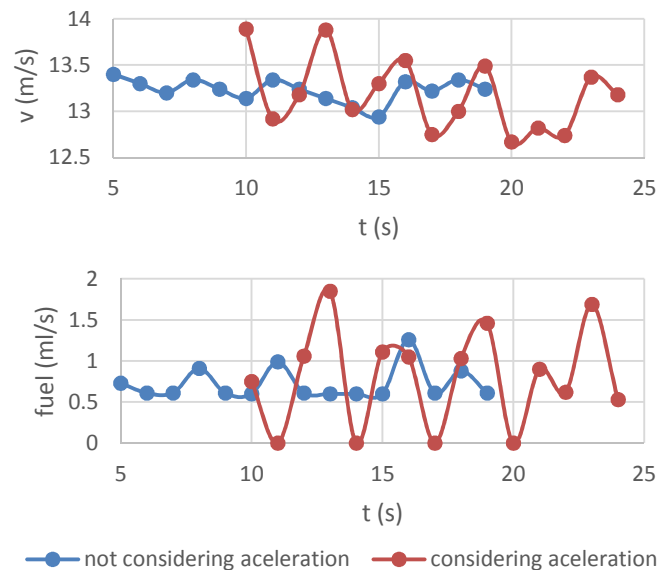


Fuel consumption and CO2 emissions by road
stretch

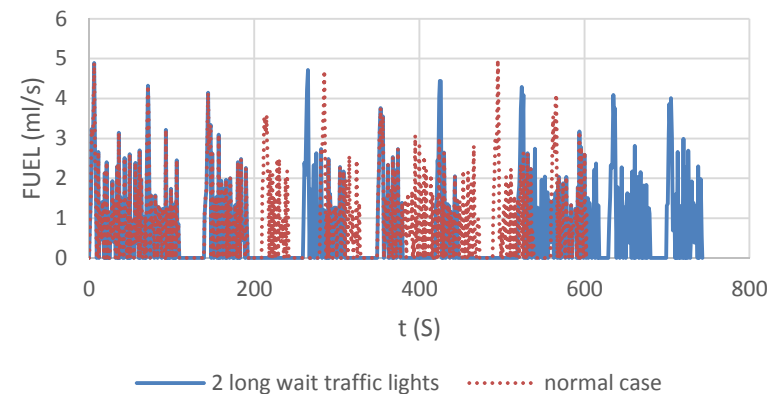


Proposed model → level of detail: Examples

constant velocity (without stops)
and considering accelerations



Analyzing the effect of increase the
traffic light time



	Fuel consumption (l)
normal case	0.504
2 long wait traffic lights	0.521

	average velocity (m/s)	fuel consumption (ml)
no acceleration case	13.2	10.83
acceleration case	13.2	12.05

THANKS FOR YOUR ATTENTION!