¡MONITRAF!

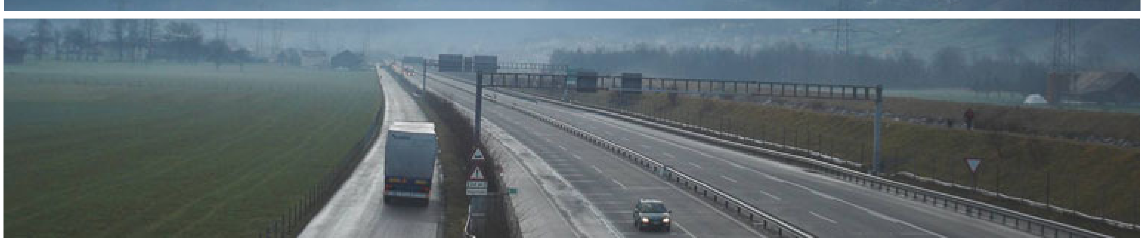
Pilot Study
Noise Modelling in the Tarvisio Corridor

ARPA Friuli Venezia Giulia

Udine

13/06/2012

Arturo Merlino, Valerio Cipriani, Luca Piani and Miro Salvagni



Alpine SPACE
EUROPEAN TERRITORIAL COOPERATION
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CONTENT

1 Introduction

In this document we will present the work done by the Agenzia Regionale per la Protezione dell'Ambiente del Friuli Venezia Giulia for the pilot study of the European Project "iMONITRAF!".

In this project it has been analyzed the impact on the territory and on the population of the noise pollution generated by the traffic that travels on the roads and rail in the Alpine Area of Tarvisio.

It has been created a three-dimensional scenario containing the geometry of the whole corridor in the proximity of the noise sources. Afterwards, acquired the traffic data of all the infrastructures, the simulation has been ran to define the noise level in the whole study area. Finally, using the demographic data of the resident population, it has been possible to estimate how many people are affected by each noise class.

Bearing in mind the propositions and the results of the European Project "Monitraf" aquired in the past years, it was possible to analyze the impact of the noise pollution on the inhabitants in the various traffic conditions, determining which conditions are the most desirable and which one would worse the state of the environment.

2 The iMONITRAF! Project

2.1 Project Description

iMONITRAF! Is an European Project whose objective is to define common strategies finalized to the development of the best politics of traffic management in the international corridors of the Alpine Space. It suggests new and innovative approaches based on the *Best Practice* which should help to attenuate the negative effects of the pollution generated by the road and rail traffic on the population, environment and economy.

iMONITRAF! Is an Alpine Space Project that lasted three years, from 2009 to 2012 and it is approved by the European Found of Regional Development (FESR) and by national founds.

The Project studies the effects of the road and rail traffic on five International corridor:

- Frejus
- Monte Bianco
- Gottardo
- Brennero
- Tarvisio

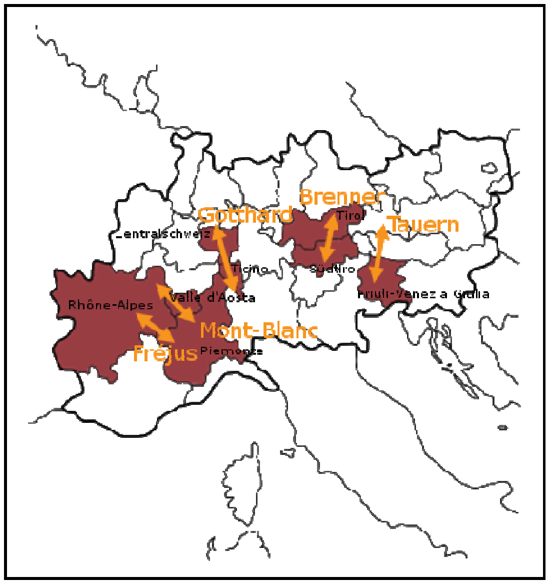

Figure 1: *iMONITRAF! Project Area*

The Pilot Study object of this document deals with the analysis of the noise pollution in the Tarvisio corridor.

2.2 Project Partners

The following partners participate to the project:

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Furthermore, the following are Project Observers:

- Permanent Secretary of the Alpine Convention
- Regione Autonoma Friuli Venezia Giulia
- Regione Liguria
- Ragion Provence-Alpes-Côte d'Azur
- Regione Piemonte
- Land Salzburg
- Slovenia
- Provincia Autonoma di Trento

2.3 The Alpine Area

In the Friuli Venezia Giulia corridor in the alpine space area are conducted the calculus of noise propagation and in which we want to study the impact of noise on the dwelling population.

It is important to consider that, for the particular characteristics of the alpine region, the problem of the noise generated from vehicular traffic has a critical importance.

In the alpine regions it is known that the pollution generated from the transit of a single heavy duty vehicles has the same effects of three vehicles of the same type in an urban area.

For this reason the alpine area is identified as a critical region and the studies that accounts for the decrease of the pollutants, the regulation of the traffic fluxes and the introduction of new technologies to improve the environmental quality are of extreme importance to ensure the sustainable growth of this area.

2.4 Pilot Study Description

The Pilot Project consists in the application of mathematical models to calculate the noise emissions generated from the roads and rails, the propagation of noise and the final impact on the inhabitants.

Using appropriate software it is possible, setting the parameters relatives to the sound sources, the three-dimensional geometry of the scenario and the position of the inhabitants to determinate the impact of the real situation existent on the roads on the population and considerate what effects would future traffic variations have on the existent condition.

Considering all the suggestions presented in the previous European Project "Monitraf" it is possible to analyze them from a noise pollution point of view and calculate what effects would they have, in order to determinate which one is the best one.

The pilot study object of this document has two main goals: we desire to model, using the noise propagation software, the existing situation of the alpine region of Friuli Venezia Giulia analyzing the state of the environment and the impact of noise on the inhabitants and then to conduct the same type of analysis on some possible future scenarios. In the “iMONITRAF!” Project, indeed, many propositions to modify the traffic fluxes and compositions have been advanced, such as for instance night driving ban for heavy duty vehicles, shifting the load from road to rail or using different toll fees for different “EURO” class vehicles.

In addition to analyze specific cases, we want to develop a methodology that permits, having the required information about the geometry, infrastructure and inhabitants of any alpine area, to set up simulations and noise pollution studies.

2.5 Noise Pollution

The noise pollution is defined, in Italy, in the second article of the 447/1995 law that states that it is considered noise pollution “the introduction of noise in inside or outside space that provokes disturb or annoyance to the human activities, health risk, degrade of ecosystems, of material goods, monuments, living environment or that interferes with their lawful fruition”. It represents, mostly in the urban areas, a very important environmental problem and, even if it is believed to be less risky to the human health than other pollution types, it is considered by the people affected by it one of the worst causes of worsening of living conditions.

To measure noise pollution a particular kind of instrument, known as the noise level meter, is used. The instrument measures the *equivalent noise level* in the environment, that represents the quantity of noise energy.

It is important to note that in the iMONITRAF! project it has been decided to use the European directive and regulations defined in 2002/49/CE and not those in use in Italy, defined by Legislative Decree 194/2005.

The noise levels are observed in three different periods during the day. The reference periods are defined as follows:

Reference Period	From	To
Day	7 am	7 pm
Evening	7 pm	11 pm
Night	11 pm	7 am of following day

Table 1: *Reference periods used for noise measurements and simulations.*

A model is a software tool that permits, without taking an actual measure, to estimate the noise level in a particular position of the environment after this has been defined geometrically. It is therefore constituted by algorithms. In a practical scenario models are used when it is necessary to evaluate how the noise levels would change when new infrastructures are built or when, having different possible scenarios, it is necessary to choose which one has the smallest impact on the population.

The main advantage of using the noise modelling software is that it is possible to estimate the noise levels of a situations using very little time and resources.

The parameters that a model has to consider are all those that influence the emission and the propagation of sound: the geometry of the environment, the climatic variables and the meteorological ones and the characterization of the noise sources.

A noise model considers how the sound waves that are generated from *noise sources* reach the *receptors*. In this context it is defined as *noise source* every object that emits sound and *receptor* a point with precisely defined space coordinates where we want to calculate the noise level.

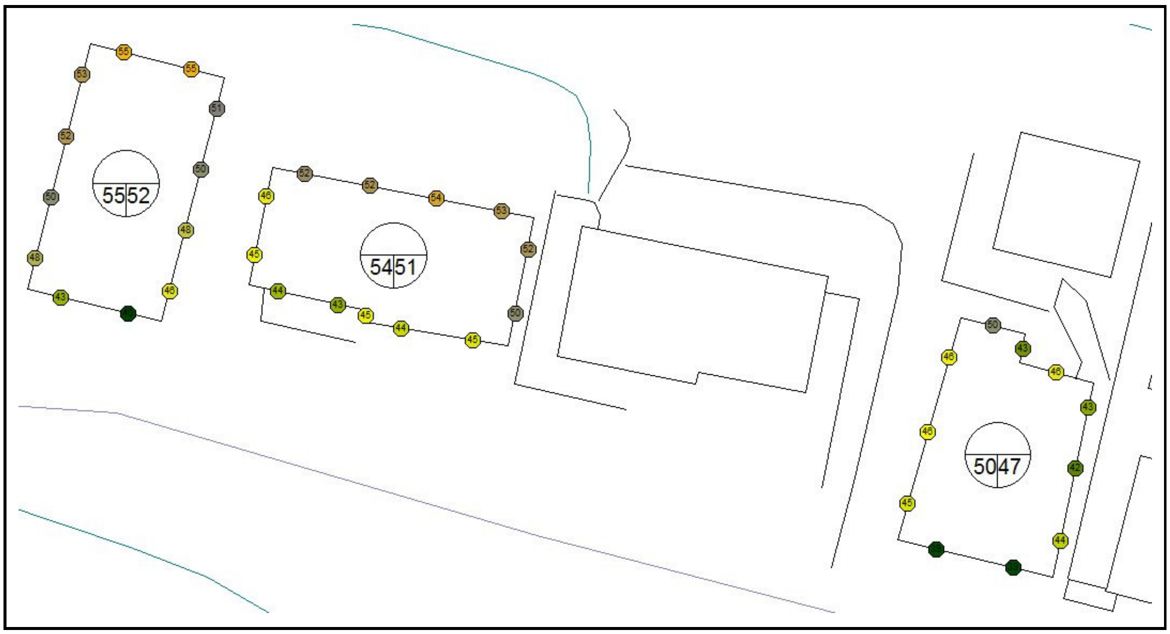


Figure 2: *Noise Simulation Software: noise level calculated for receptors. In the white circle it is possible to read the building mean noise levels calculated for day (left) and night (right)*

In addition to estimate the noise level in a particular point, a model is very useful to calculate the level within a *calculation area* that one wants to study: it is possible to calculate a *calculation grid*, that is a grid constructed by a number of nodes with a user defined spacing in which each node works as a receptor. Executing a noise simulation on a calculation grid it is possible to observe the noise levels in the area that is being analyzed and locate the isophonic surfaces on which the noise level is constant; from the geometrical study of those surfaces it is possible to understand how sound propagates in the environment described by the simulation.

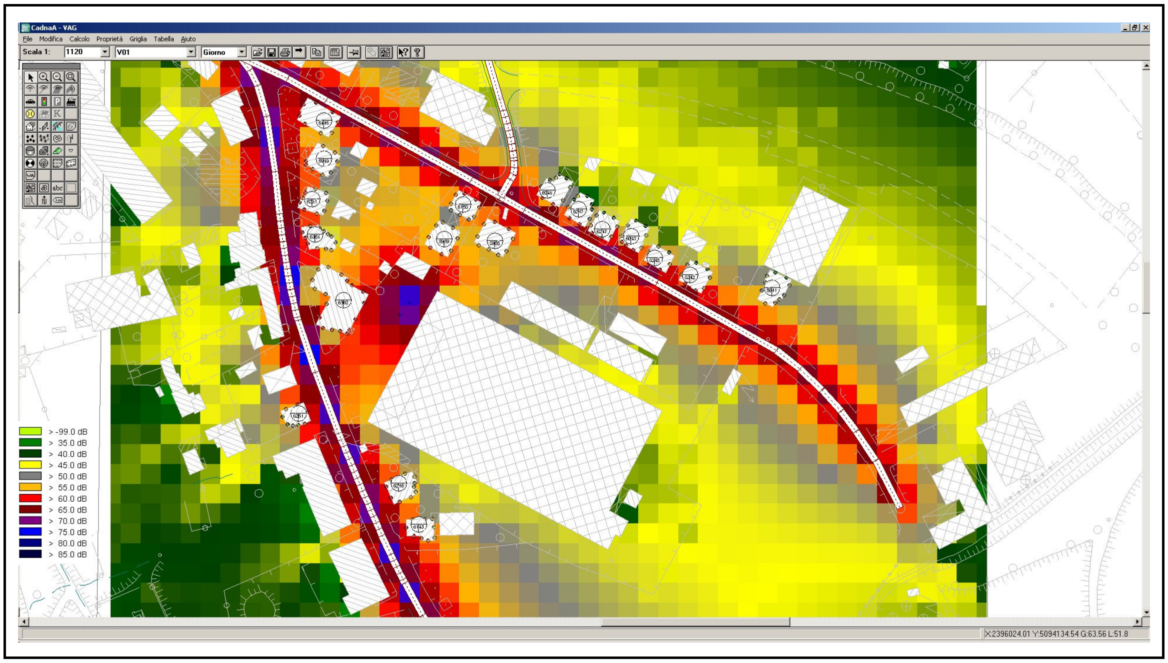


Figure 3: *Noise Simulation Software: noise level calculated in an urban area*

3 Modelling the scenario

3.1 The Simulation Software

There are many types of commercial software for who wants to use a numerical model to calculate sound levels.

The software types have different user interface, project management and cartography management but, since they implement the very same algorithms, they should theoretically provide the same results to a scenario. Studies have shown that in the majority of cases, differences in the obtained results are to be attributed to the impossibility that sometime arises to model a scenario in the same way in two different software packages.

A recent study of the *Istituto Superiore per la Protezione e la Ricerca Ambientale* has shown the which softwares are used in all the italian *Agenzia Regionale per la Protezione dell'Ambiente* agencies.

It has been observed that four software models are used the most:

- Immi, produced by Microbel
- Cadna, produced by Datakustik
- Soundplan, produced by Braunstein+Berndt GhbH
- INM produced by Federal Aviation Administration

In the following graph, it is shown how many italian agencies use each software:

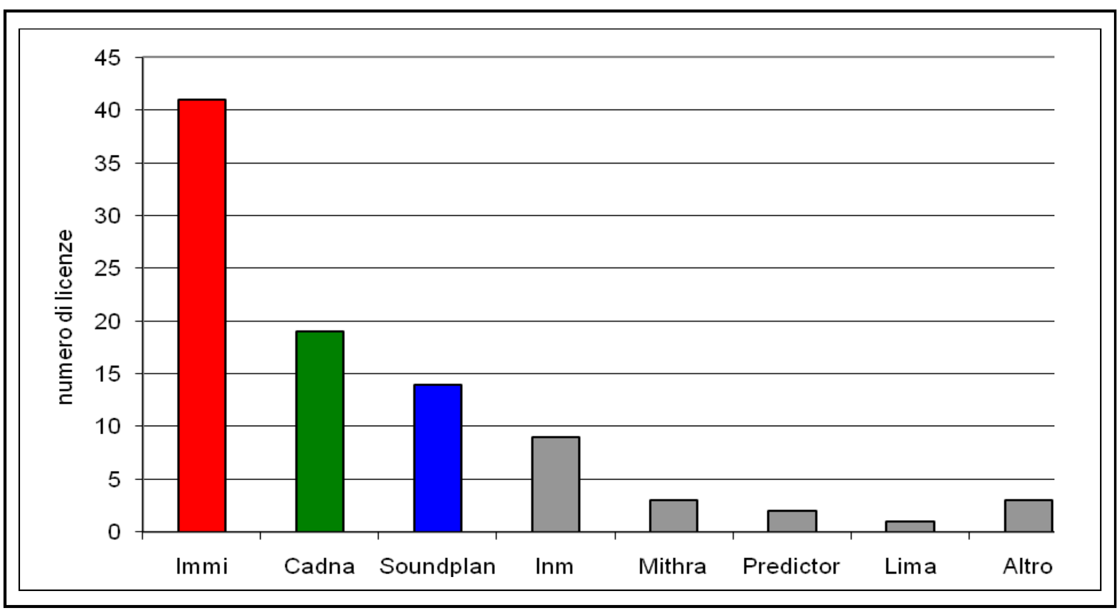


Figure 4: *Noise Simulation Software usage in Italian ARPA agencies*

Noting that the Inm software, that ranked fourth in the above graph, is used only to evaluate noise pollution generated by airplanes, we can clearly see that three software are used by quite the entirety of the agencies. It has been shown in the ISPRA study that the results calculated with any of these thee software packages are to be considered equivalent and that they are equally valid to model a general scenario.

The scenario object of this study has been set up using the software for noise propagation CadnaA, used in the Udine department of the *Agenzia Regionale per la Protezione dell'Ambiente* of the *Friuli Venezia Giulia*.

To support the analysis of the results and of the components of the scenario the software packages *ArcGIS* and *Google Earth* has been used.

Using the noise modelling software it is possible to define various types of noise sources such as point sources or linear ones. The scenario we want to model is constituted only by roads and rails, and there aren't any factories or any other point source.

It is therefore necessary, to obtain the results, to set up the geometry of the whole scenario, to set up the linear noise sources (that are roads and rail) and to define their characteristics and to define the area where to calculate the noise levels. In the simulations we want to run, in fact, we are interested in knowing the noise levels in all the territory near the roads and not only where people live.

Having chosen a software, it is now important to define what elements have to be imported in the scenario, how to import them and what is the precision that we want to use modelling the scenario.

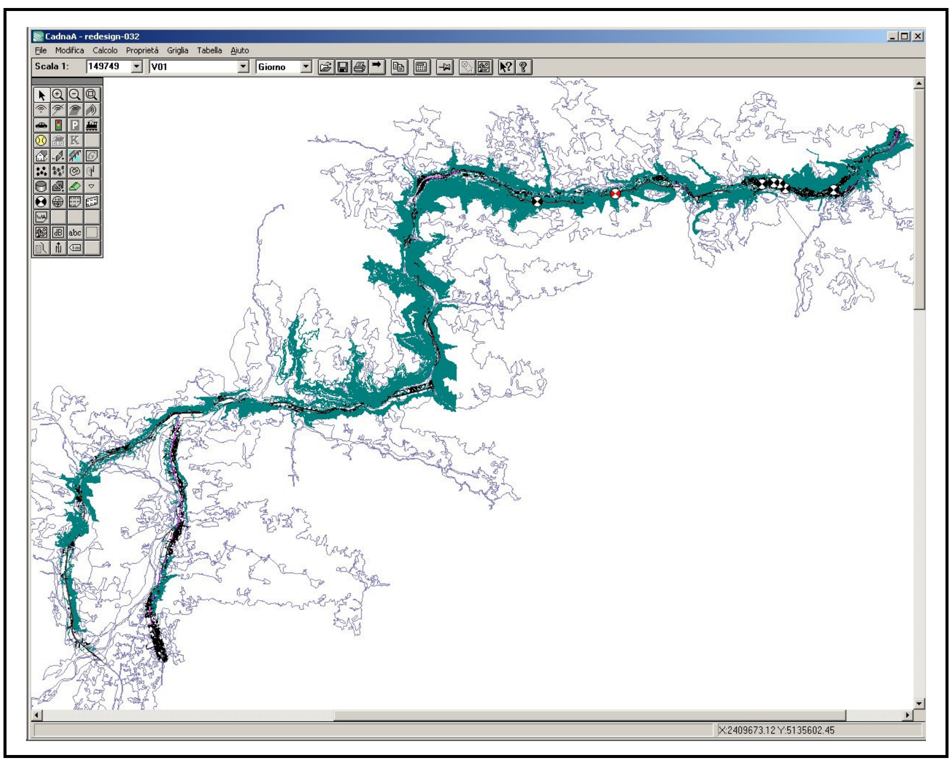


Figure 5: *The whole project as it appears in the Cadna A simulation software*

3.2 Model Parts

As stated, there are different part that constitute the model.

It is absolutely necessary to have a definition of the terrain, because the geometry of it influences how the sounds propagates in the environment, the roads and the rail tracks, that constitutes the totality of the noise sources and the inhabited buildings, because we ultimately want to calculate the impact of the noise on the dwelling population.

All the other parts that constitute the model are optional and, generally speaking, could be avoided at the cost of a lesser precision in the results. If a study similar to the one presented here were to be carried out for another area, it could very well be possible to define only the parts mentioned above and achieve a sufficient precision in the results.

The data of each parts have been obtained from different sources and have been provided by the national, regional and communal offices.

The parts that constitute the model we created to study the impact of the noise pollution on the populations were:

Model Part	Data Source
Buildings	Technical Regional map
Ground Absorption	CORINE Land Cover
Noise Barriers	Technical Regional map
Rails	Technical Regional map
Roads	Technical Regional map, regional road graph
Terrain	Technical Regional map
Study Area	GIS Elaborations on Technical Regional map
Inhabitants	Municipalities
Traffic fluxes: roads	Autostrade s.p.a.
Traffic fluxes: rails	RFI s.p.a.

Table 2: *Parts constituting the model.*

It is possible to download a lot of cartographical data about the Friuli Venezia Giulia region from the internet address:

http://www.regione.fvg.it/rafvg/cms/RAFVG/AT9/link/cartografia_e_fotogrammi_ricerca_geografica_webgis_new

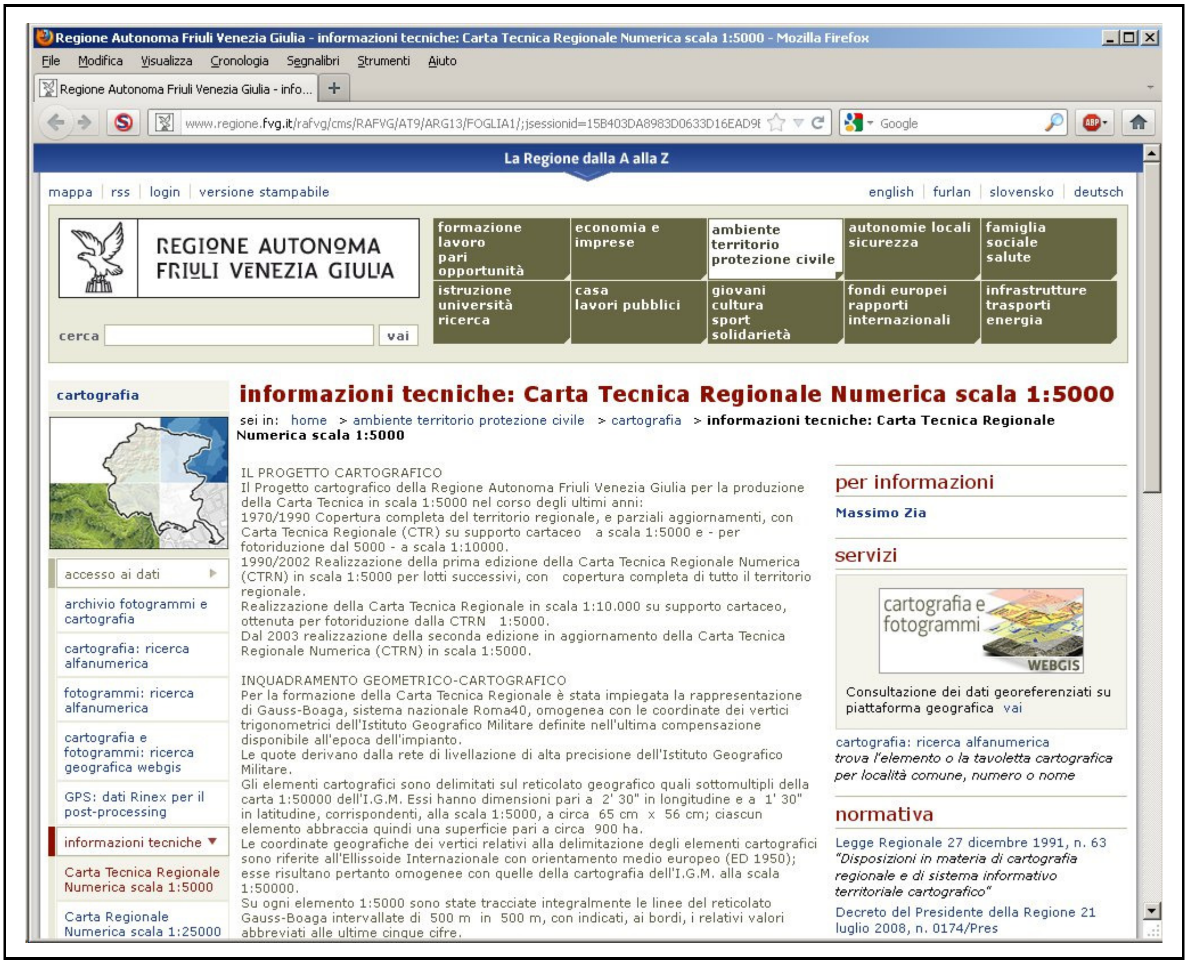


Figure 6: *Technical Regional map site*

During the pilot study it has been noted how, starting only from the technical regional map, it is possible to recreate very precisely the three-dimensional geometry of the scenario. Using this geometry, the traffic data that characterize the highways and the data on the dwelling population it is possible to create a very precise model of the actual Tarviso situation.

Moreover, it has been noted how it is possible to obtain the elements that constitute the whole scenario from different sources. As long as the elements have the required precision, it is therefore possible to use whatever data source one wants.

Note that the correct definition of the three-dimensional geometry of the whole scenario is needed to conduct the noise analysis but that the information on the noise sources and the dwelling population is also essential to obtain the results: it is therefore not enough to have only the geometrical data of the environment, to conduct a noise analysis of a large area it is absolutely needed to have traffic data, noise measurements in various spatial points and information about where the people lives.

3.3 Study Area

The first operation that has been conducted has been the definition of the calculus area in which the noise level are calculated.

In the iMONITRAF! Project the partners agreed to consider affected by noise pollution an area of 250 meters from the road and rails.

Using the ArcGIS software, in use at the ARPA Friuli Venezia Giulia, two strips were created, one centered on the road and one on the rail, both with width of 500 meters. Those two areas have been merged obtaining the final calculus area, presented in the next figure:

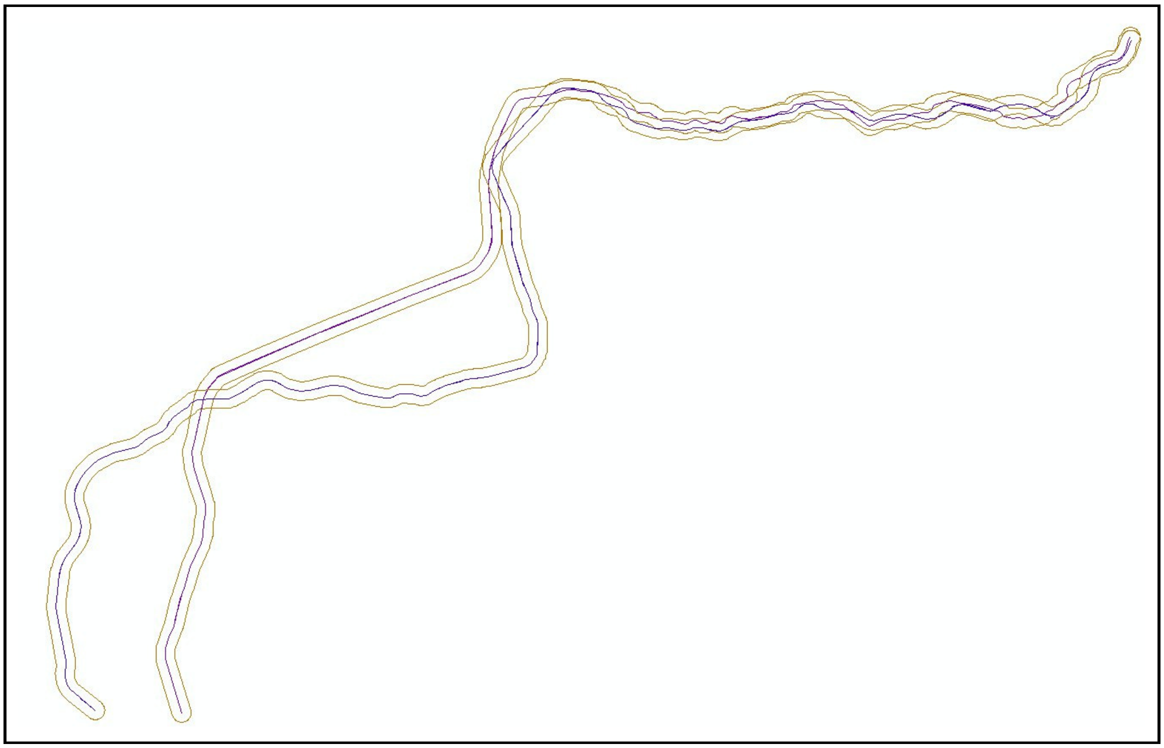


Figure 7: *The initial buffers for road and train*

This calculus area, obtained with the procedure described, is not the best to be used in a software for noise pollution modelling. It is, in fact, necessary to exclude from the analysis all those areas in which the roads or the rails pass through tunnels: in those areas the emitted noise is completely blocked from the terrain.

We proceeded to identify and delete all the segments of infrastructures in the tunnels, obtaining the calculus area in which the final simulations are run. The result is shown in the next figure.

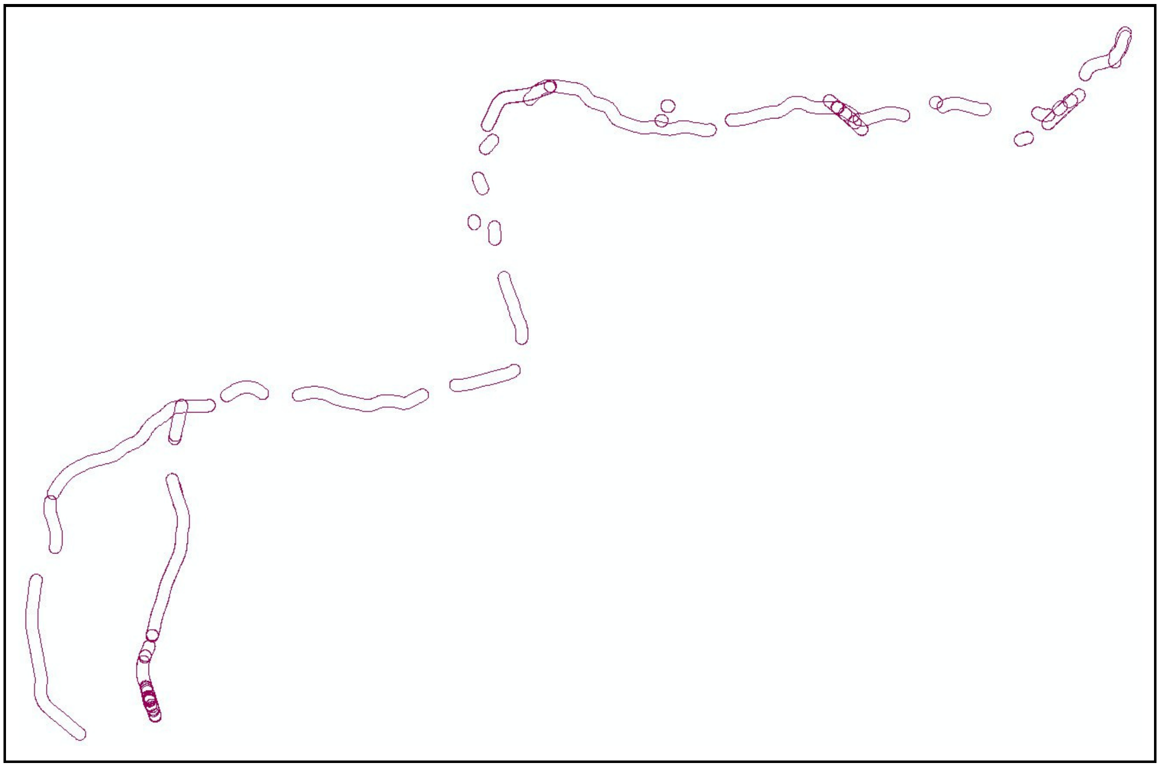


Figure 8: *The polygons that form the various buffers to be merged*

In addition to this buffer in which the simulations will be run It is important to have another one where it's easy to perform geometrical operations. This is very useful for some operations that will be presented in the next chapters, such as the determination of the number of inhabitants that live within 250 meters from the infrastructures (where those are not in tunnels).

From the last presented figure we can observe how the area that will be used for the simulation is divided in small pieces, for this reason it would be difficult to use it for the predisposition of the model.

A new area has been created, called *working area*. This is defined as the union of the individual small pieces that constitute the calculus area. In the following picture it is possible to observe the resulting shape.

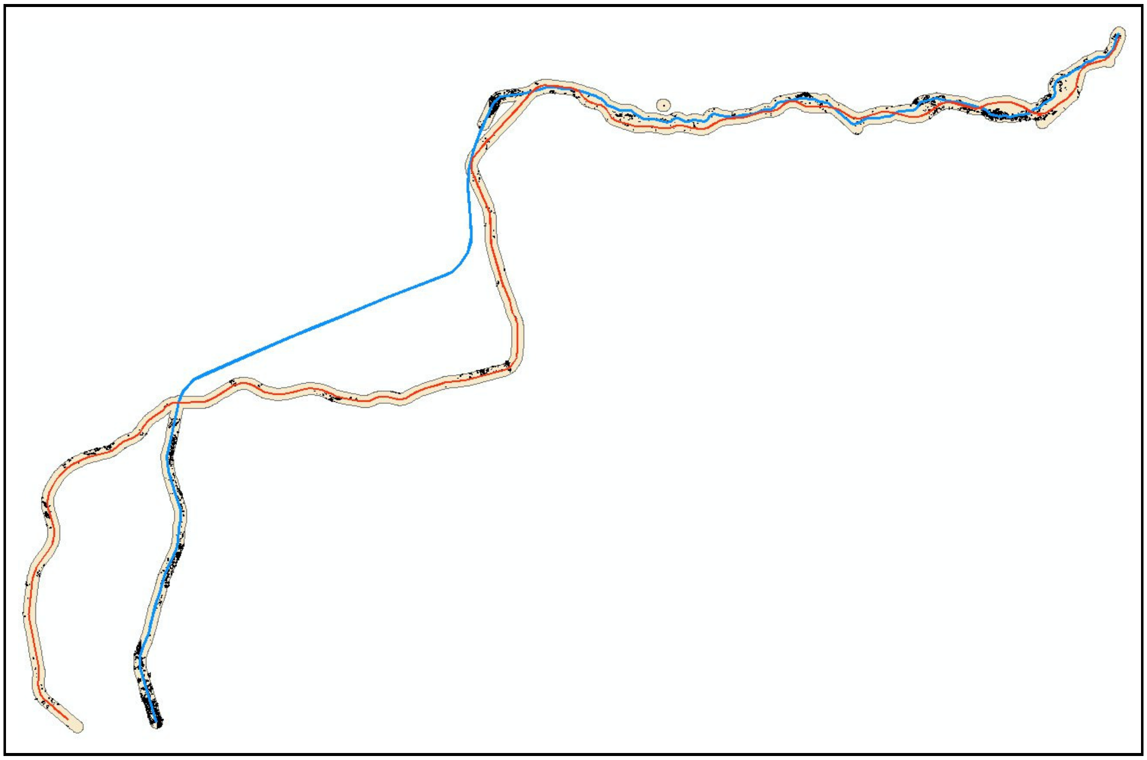


Figure 9: *The calculus area. In the image it is possible to see the road (in orange) and the rail tracks (in blue)*

We, therefore, have created two different areas:

- The *calculus area*, where the simulations will be run and the noise levels will be estimated.
- The *working area* that will be used to conduct some operations of predisposition of the model and, in general, every time we want to know if a given object is within the 250 meters buffer from the infrastructures.

3.4 The Digital Terrain Model

In the simulations model it is possible to use three types of representations of the terrain: in the first one the terrain is memorized as a set of height points having each a defined height, in the second one the terrain is constituted by iso-lines, lines with the same height; finally it is possible to use a three-dimensional mesh that holds precisely all the points of the terrain, view as a collection of polygons.

In our scenario the terrain is represented by a set of height lines. Each line contains height points (not necessary having all the same height).

The terrain data has been imported from the Technical Regional Map, provided by Intel S.p.a. and consist in a set of height lines that approximate the real height of the terrain with a precision of 5 meters. The same data are available, as height points, on the Technical Region Map.

The height-lines are expressed in the Technical Regional Map as dotted lines, therefore once they have been imported in the scenario it is necessary to join the segments that have the same height attribute in order to obtain a terrain representation suitable to run the simulations. Said segments have been joined using the *ArcGIS* software and the CadnaA procedures, the results is a set of height-lines that represent the full terrain of the corridor, in the whole calculus area, as shown in the next image:

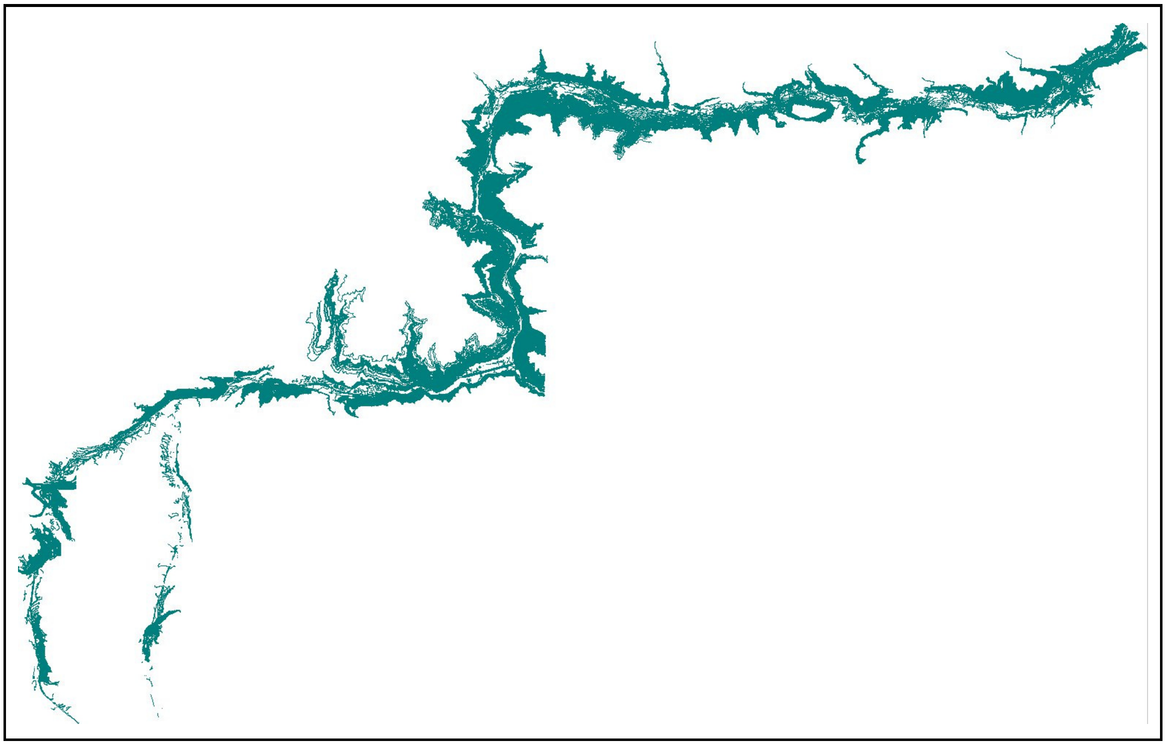


Figure 10: *Height lines used in the project*

It is important to note that the lines extends beyond the calculus area, this happens because once the original segments are merged the resulting lines are, usually, very long. It has been decided to keep the line as they are and not to cut them in the calculus area only, in order to have a terrain representation slightly larger than the area object of the study.

In the CadnaA software it is possible to observe the terrain in different 3D views, in the whole project these views have been used to check the correctness of the three-dimensional model in the whole project area, ensuring with field observation that the shapes modelled by the height lines are the same as they appear in reality.

In the next image it is possible to observe an example of the digital terrain model imported into the CadnaA modelling software as it appears in the 3D view.

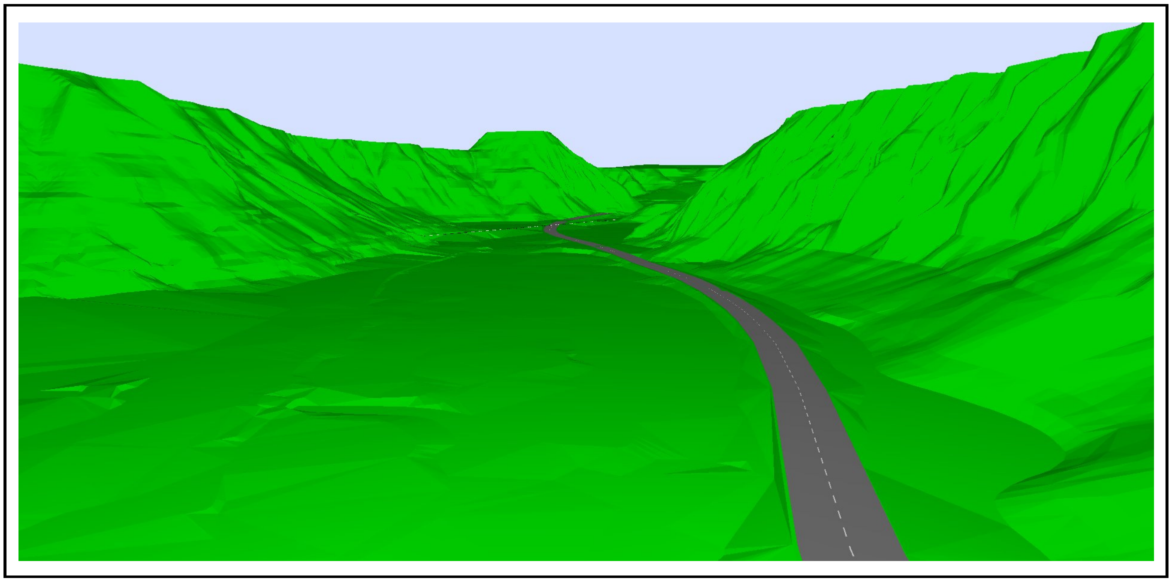


Figure 11: *Digital Terrain Model, example*

Having set up the terrain model, we proceeded to define all the other objects that compose the scenario.

3.5 Roads

Since the “iMONITRAF!” Project studies the International traffic we decided, in agreement with all the project partners, to consider only the highways as noise sources and to neglect the local roads.

For this reason we set up the A23 highway geometry and no other road.

The geometry of the roads has been recreated using two different data sources: the regional road graph, where it is possible to note the segments of road that travel in tunnels or on bridges and the Technical regional map, that has the information about the width of each road lane and the height above ground of each point that constitute the road.

To set up the geometry of the roads the following operations have been conducted:

- All the roads have been imported in the *working area*.
- All the roads but those constituting Highway A23 have been disabled or deleted.
- All the segments of the highway in tunnels have been identified and removed.

- All the segments of the highway on bridges have been identified. For those segment the “absolute height from ground” parameter has been set using the information contained in the Technical regional map.
  After this procedure, all the roads that act as noise sources were set up:

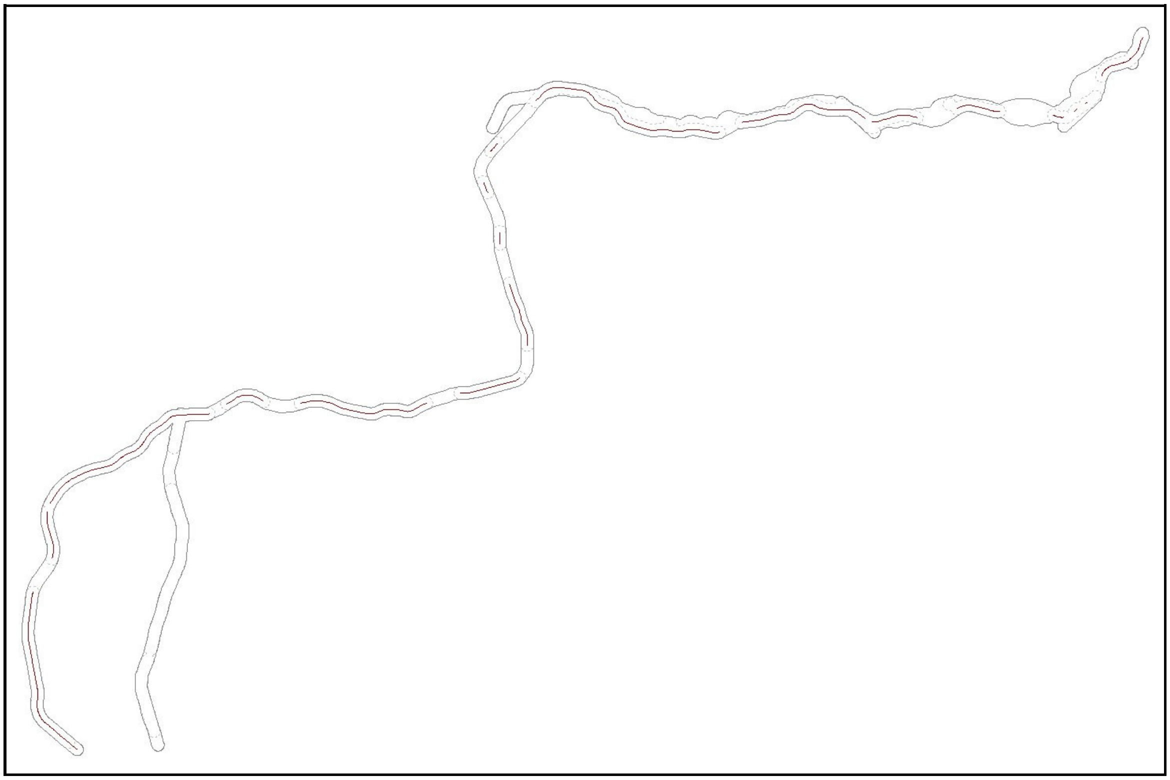


Figure 12: *The roads that form the model*

- Along the side of the road, two height lines were created parallel to the road having an height point for each point than defines the road, with the same height. An example of the results of this procedure is shown in the following picture:

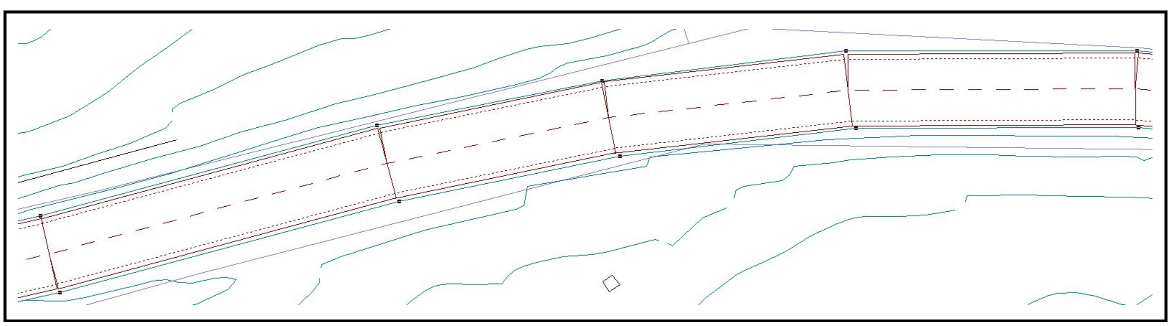


Figure 13: *artificial height lines set up at the road sides*

This step is very important: at the end of it the road is completely above the ground.

- Where the road enters a tunnel, a “tunnel entrance” has been modelled creating an height line seven meters higher than the terrain where the road lays. This feature has been modelled in the same way for all the tunnel entrances. The result is displayed in the following picture:

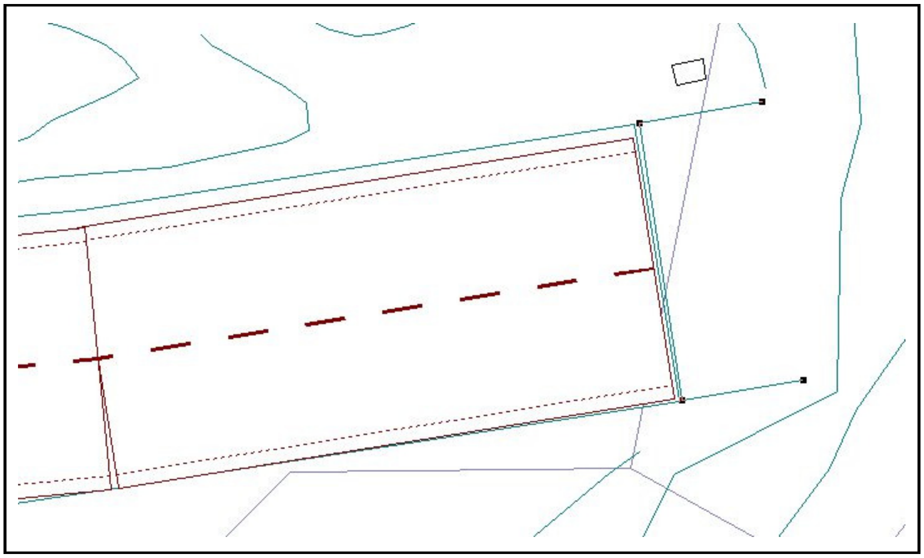


Figure 14: *Tunnel entrance, modelled with artificial height lines*

- Observing the cartographic information contained in the Technical regional map the width of the highway has been set up, in each point that constitute the road.
- Using the automatic tools of the simulation software, the road slope has been set up at each road point.
- After inspections, the type of asphalt has been set up for each segment of the high-way.
- Adjacent road segments having the same proprieties and asphalt type have been merged, forming h*omogeneous segments*. In the end the highway had 19 different segments.

After the described operations the three-dimensional representation of the road noise sources is completed.

All the non geometrical parameters were left not defined because they depend on the traffic typology that one wants to set up to simulate a particular situation on the corridor.

3.6 Rail Tracks

The other noise source in the scenario are the train tracks.

The rail tracks were found in the Technical Regional Map. The tracks were imported in the scenario using a procedure similar to the one used for the roads:

- All the rail tracks were imported in the scenario.
- All the tracks have been deleted but those that travel from Gemona to Tarvisio.
- All the segments of rail tracks in tunnels have been identified and removed.
- All the segments of the rail tracks on bridges have been identified. For those segment the "absolute height from ground" parameter has been set using the information contained in the Technical regional map.
- At the stations, where there typically are many rail tracks, we kept the most extern ones and deleted or disabled all the others. This is crucial, because every rail track will have a traffic flux associated and therefore having too many tracks would result in wrong, higher, noise levels.
  After this procedure, all the tracks that act as noise sources were set up:

Figure 15: *The rail tracks of the scenario*

- Along the side of the track, two height lines were created parallel to it having an height point for each point than defines the track, with the same height. An example of the results of this procedure is shown in the following picture:

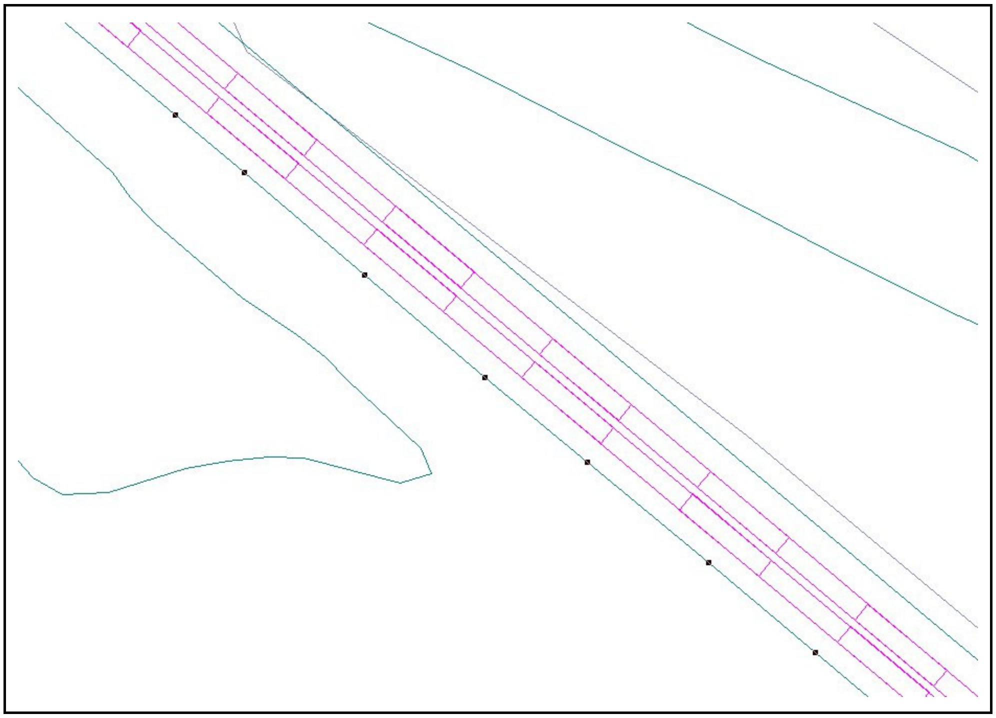


Figure 16: *Artificial height lines along the rail sides*

This step is very important: at the end of it the rail track is completely above the ground.

- Where the track enters a tunnel, a "tunnel entrance" has been modelled creating an height line seven meters higher than the terrain where the road lays. This feature has been modelled in the same way for all the tunnel entrances.

It is important to note that in the Friuli Venezia Giulia region, the rails run almost completely in tunnels.

There are 13 segments of rail that are not covered by tunnels, mainly in the proximities of the train stations of Pontebba, Gemona and Tarvisio.

The parameters regarding the train traffic were left undefined in this first phase, because those depend on the scenario one wants to model.

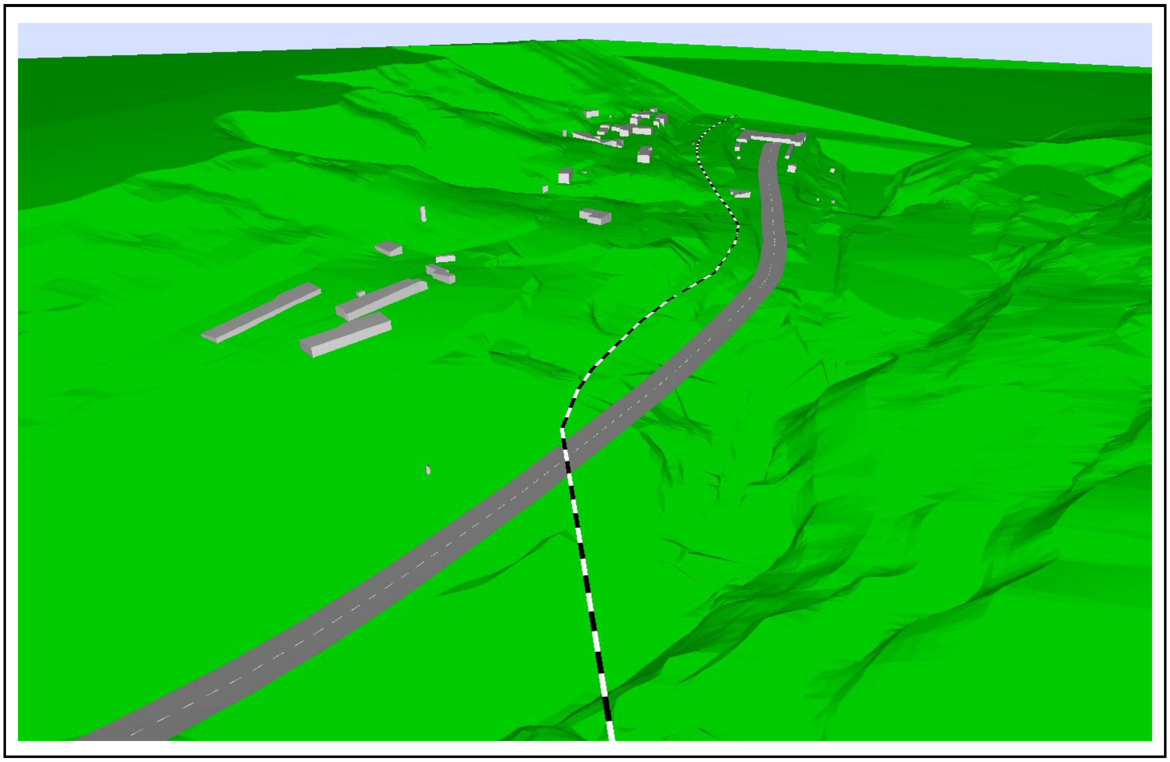


Figure 17: *Example of three dimensional view of the rail track*

3.7 Buildings

Insiel S.p.a. provided the information about the geometry and the position of all the buildings in the analyzed area.

From the Technical regional map it is possible to import into the simulation model the perimeter of each building. The same information is memorized into *shapefiles*.

In order to have a three-dimensional representation it has been received another shapefile that contains a database with, for each building, an height point that states the height of the base and the eaves of the building. Using the *ArcGIS* software it has been possible to unite all the information into an unique file that contains the geometry of the buildings, their base height and their eaves height. Importing this file into the modelling software we obtained a complete geometrical representation of the buildings in the calculus area.

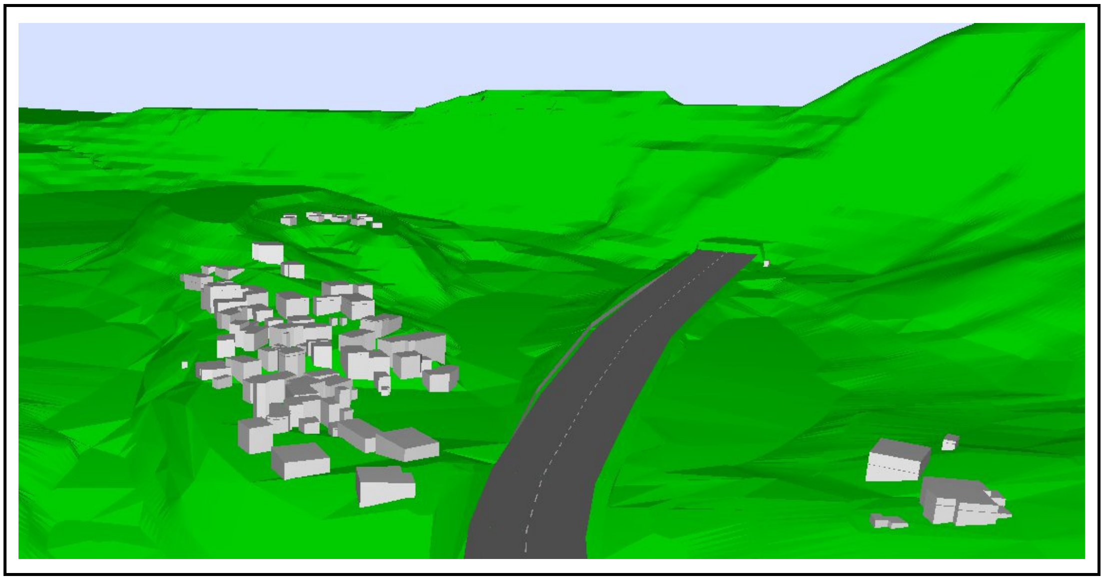


Figure 18: *Example of inhabitated area, as it appears in the Cadna 3D view*

After having set up the geometry, we proceeded to identify the street name and civic number and city name of each building. From Insiel S.p.a. we obtained information regarding the georeferenced positions of all the buildings in the alpine arc. Using the *ArcGIS* software it has been possible to unite this to the geometrical data, obtaining a model in which each building has an associated address.

After the buildings were set up, the data on the inhabitants were used.

Some of the towns had data about the position of each building and the number of inhabitants for every building, while others had only the number of inhabitants of the roads.

Municipality	**Data type**
Dogna	roads
Moggio Udinese	building
Resiutta	building
Trasaghis	building
Cavazzo Carnico	building
Amaro	roads
Chiusaforte	roads
Malborghetto Valbruna	building
Venzone	roads
Pontebba	building
Tarvisio	building

Table 3: *Type of inhabitants data received by different municipalities.*

The total number of buildings and inhabitants in the provided in each municipality is reported in the following table:

Municipality	Buildings	Inhabitants		Total number of inhabitants in municipality
Dogna	43	22		200
Moggio Udinese	71	1823		1842
Resiutta	87	314		320
Trasaghis	114	24		2337
Cavazzo Carnico	158	160		1102
Amaro	228	847		850
Chiusaforte	268	710		710
Malborghetto Valbruna	667	967		967
Venzone	824	2213		2223
Pontebba	846	1522		1535
Tarvisio	1570	2062		4683
	4876	10664		16769

Table 4: *Number of inhabitants and buildings in each municipality.*

Using the GIS software it was possible to import the inhabitants for the town that had the data for each building. For the others, we had to inspect the territory in order to note what buildings are inhabited and what are not. Having the inhabitants divided for street we split the total number of people that lives in a road into each building: considering only the buildings that we know to be inhabited we divided the total population accounting the area of each building.

After this procedure we set up the geometry, the name and address and the number of inhabitants for each building in the calculus area.

3.8 Barriers and Walls

To complete the scenario it is necessary to set up the information about the barriers and the obstacles that will block or reflect the noise.

The walls and barriers were imported from the technical regional map. In this map all the walls and obstacles made of concrete are present, even those with very small size. Since the number of elements was very high and screening the walls one by one would have been a very long task, and the results are pretty much the same with or without walls (defining wall everything that is not a noise barrier) we decided to keep all the walls into the model.

While creating the model we decided that, since it is impossible to analyze every single barrier present in the model, each wall or barrier is to be set with the same proprieties: the simulations will be run with barriers that do not reflect the sound and the noise absorption of the barriers is set to 20%.

Since in the technical regional map not all the noise barriers have the height information, it was necessary to inspect the barriers mounted at the sides of the highway in order to have a correct definition of those.

It is important to note that in the category there are two distinct object types: the noise barrier mounted at the road sides and the walls (made of concrete, walls, and various other materials) found in the city areas. The noise barriers have, as expected, a great impact on the propagation of noise while the simple walls have a quite unnoticeable impact; for these reasons we tried to model the noise barriers as well as we could, while the simple walls were merely imported into the scenario ensuring their geometry was correct.

A total of 3157 barriers is used in the whole simulation, of these less than 20 were noise barriers mounted at the road sides.

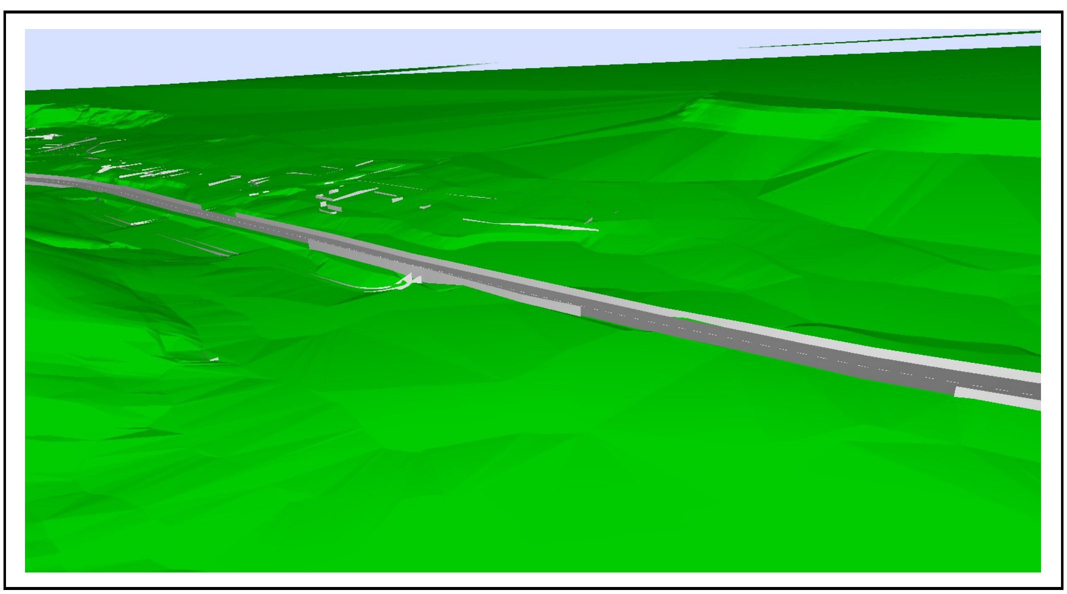


Figure 19: *Example of noise barriers along the road sides*

3.9 Ground Absorption

The ground absorption data was imported from CORINE Land Cover.

This parameter can assume three values in the map: 1.0 where the terrain is not used in human activities: such as completely covered by grass or woods. Using this value for the parameters means, in the model scenario, that the sound is completely absorbed (and not reflected) by the ground.

The value for the parameter for the areas where the terrain is considered to be used in human activities only marginally is 0.5.

Finally, the value for the roads, rails and the highly populated areas is 0.0.

The defined area are bigger than the calculus area, but since this doesn't affect much the calculus time it has been decided to leave them as they are. The ground absorption layer is therefore exactly defined by the data found from CORINE Land Cover.

A total of 449 different areas were used.

Figure 20: *Ground Absorption areas, from CORINE Land Cover*

3.10 Measurement Points

In order to calibrate the model, many measurements were conducted.

A few measurement points were chosen at different distances from the road. The nearest ones are useful to determinate the correct emission of the roads while the more distant ones are particularly interesting to study how the sound does propagate in the observed environment.

During the iMONITRAF! project ARPA FVG conducted one noise measurement per season in order to have the data to comply to the Project Indicator 6 guidelines. These measurements had a duration equal or greater to seven days.

Therefore, both long term measurements and short term ones were available to be used in the calibration process.

The long term measurements were conducted in Bagni di Lusnizza, and a few points in Tarvisio. The distance from road of these sites was in the order of 10-20meters.

The short term measurements were conducted at various distances from road, mostly in the proximities of the Tarviso city.

In the following picture it is possible to observe the position of all the measuring points.

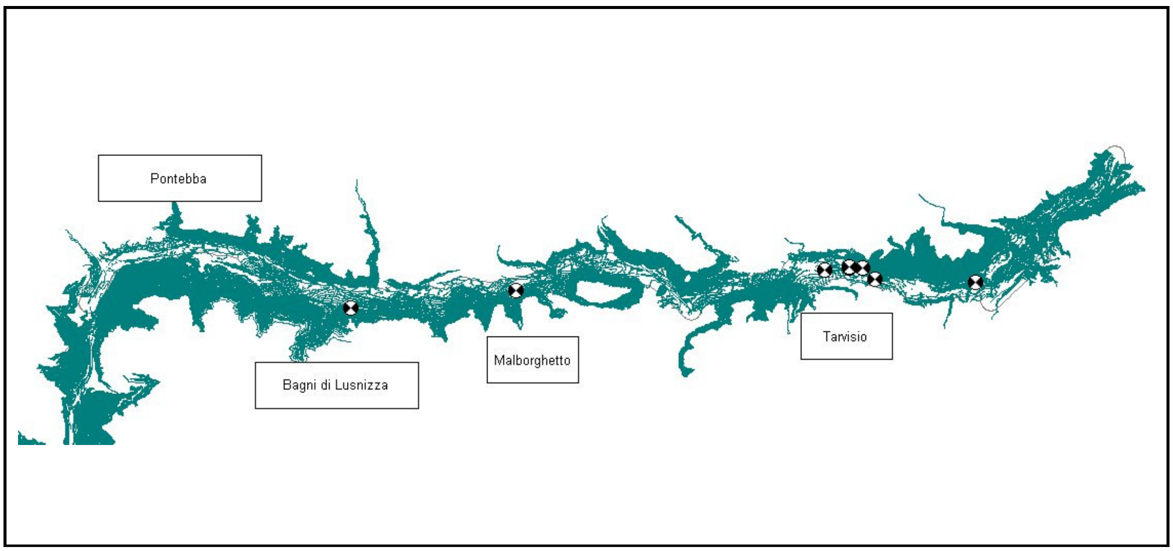


Figure 21: *The measurement points*

Starting from West, the first measurement points is Bagni di Lusnizza

Long and short term measurements were conducted in this site. The microphone was positioned at 10 meters from the road side, at about 2 meters height (the terrain were the microphone was located was lower than the one were the road ran). It has been observed that the measured levels were lowered by the simulated ones, this has been explained by the presence of a guardrail that blocks noise.

For the short term measurements conducted in this site, traffic data was gathered as well.

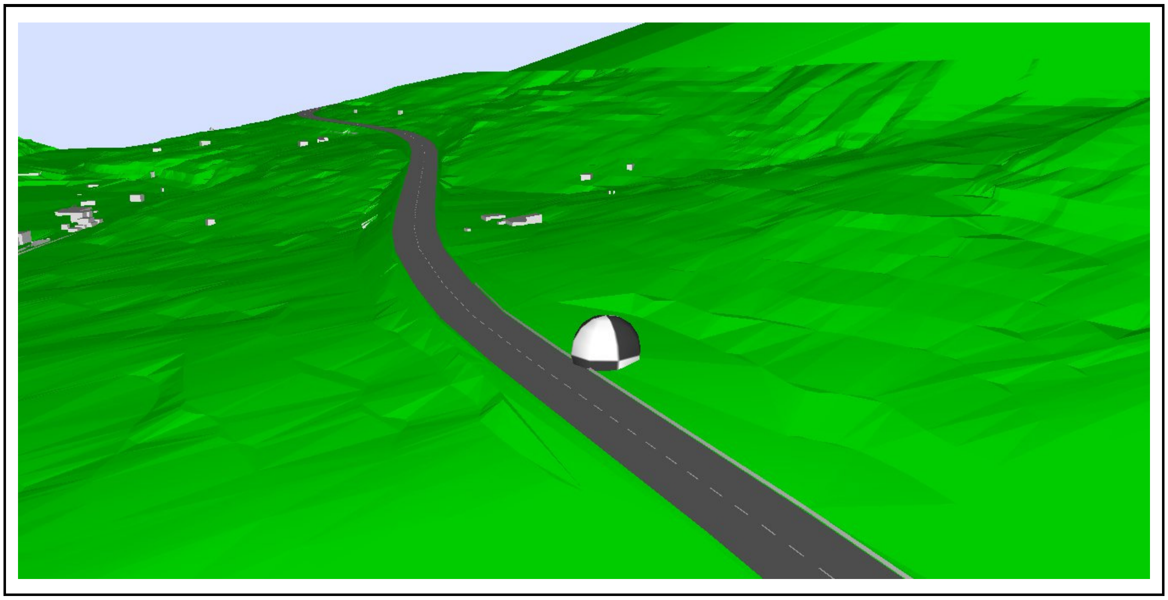


Figure 22: *Bagni di Lusnizza measurement point, in Cadna*

Figure 23: *Bagni di Lusnizza measurement point, in Google Street View*

A few kilometres to the east another measurement point was found. This site is located just outside the inhabited area of Malborghetto, to the South. The distance of the microphone from the road side was 10 meters, and the height 4 meters.

In this area short term measurements, with 1-3 hours duration, were conducted and the site was found to be very useful to calibrate the model presented in this study. Along with noise measurements, traffic counts were performed every time at this site.

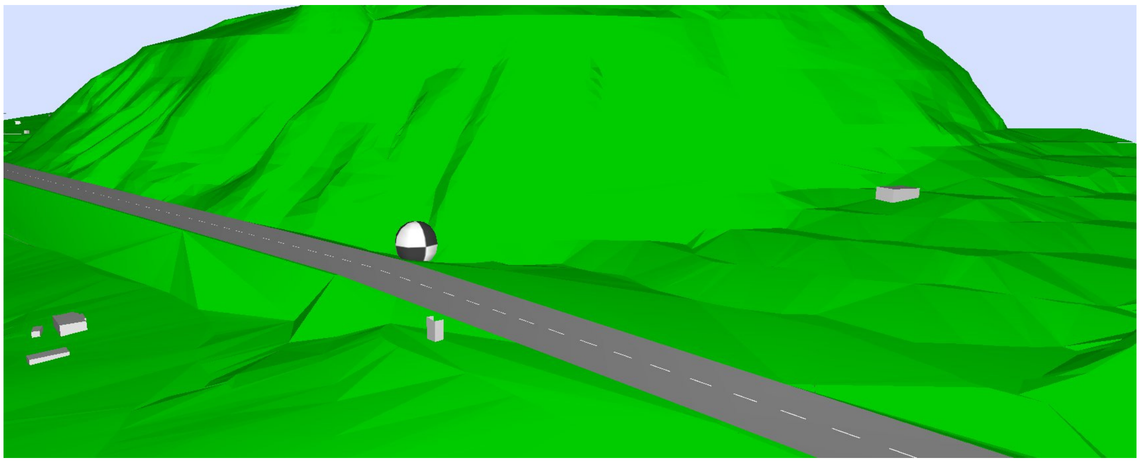


Figure 24: *Malborghetto measurement point, in Cadna*

Figure 25: *Malborghetto measurement point, in Google Maps*

Lastly, six different measurement points were located in the Tarvisio city:

- The first one, called “Dawit”, was located outside a road tunnel. Short term measurements were conducted in this site.
- Two different points were located at 20 and 30 meters from the road side in an area where the noise barrier is not present. Long term measurements were ran at 20 meters distance and short term ones at the other site.
- In Camporosso, we located a point at about 60 meters distance from road where long term measurements were conducted, before the start of the iMONITRAF! Project. These measured were not part of the indicator 6 document because they are well outside the maximum distance allowed.

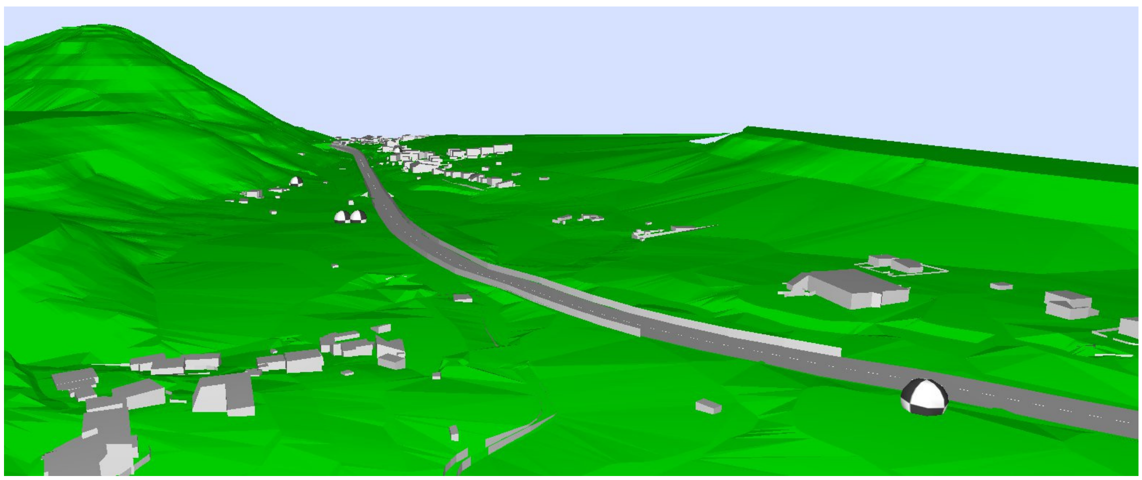


Figure 26: *Tarvisio measurement points, in Cadna*

- Inside the Tarvisio City, a measurement points was located at about 50 meters distance and 10 height. This site was used in years previous to the project start to analyze the noise generated by the highway. This measurement point is located in a zone where noise barriers are installed, but the sound level meter was very high above the road level, therefore the effect of the barriers on the observed level was limited. For its distance, this point was not part of the indicator 6 results, but the values measured here have been used during the calibration process.

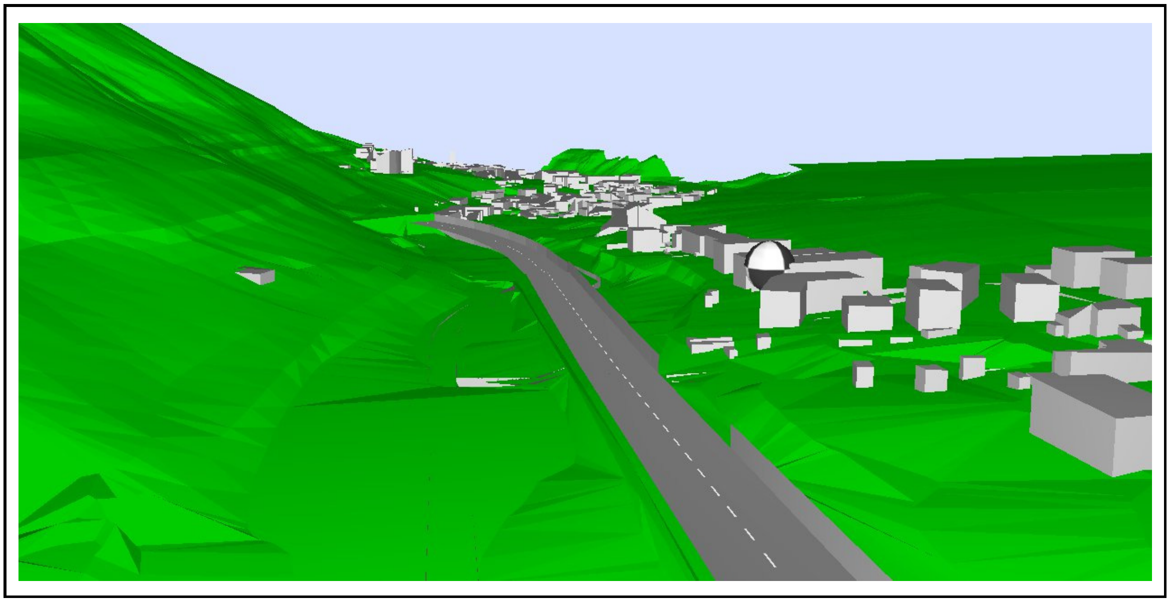


Figure 27: *Tarvisio, Via Diaz measurement point, in Cadna*

Figure 28: *Tarvisio measurement points, in Google Maps*

- The last measuring point was located at approximately 20 meters distance and 10 meters below the road. Noise barriers should be present in the proximities of the site but, in the first year of the project, they were not completely present due to maintenance works on them. Since the noise levels greatly varied with and without barriers, this point was marginally used in the calibration process.

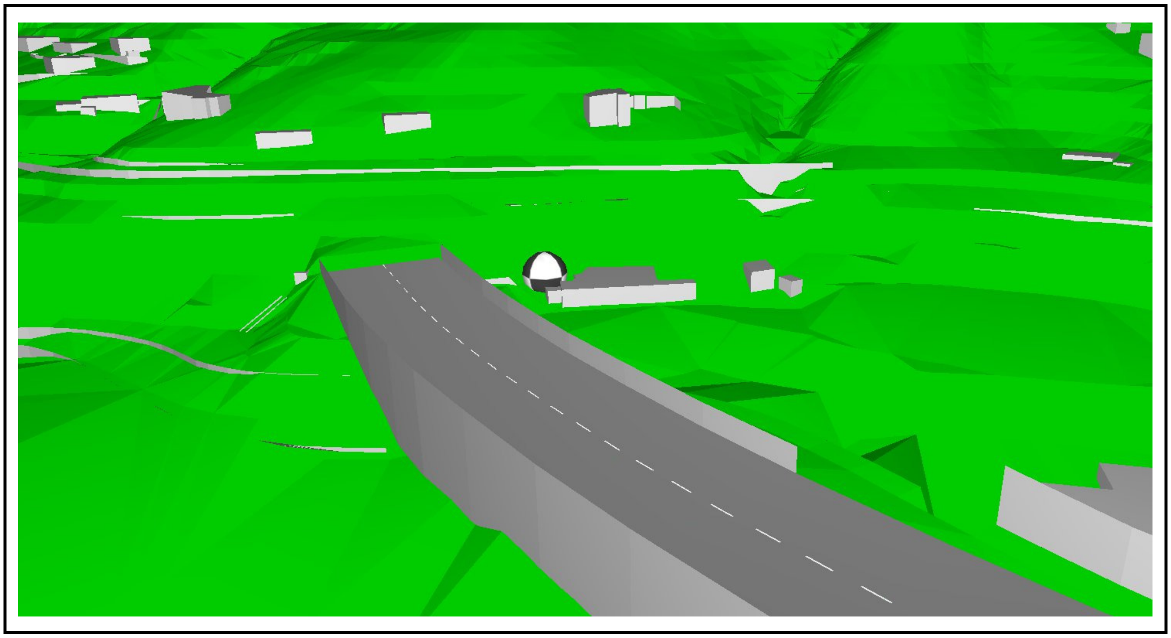


Figure 29: *Tarviso, Borgo Angelo measurement points, in Cadna*

Figure 30: *Tarviso, Borgo Angelo measurement points, in Google Maps*

To conclude, the measuring points used in the project were:

ID	Location	Measurement type
1	Tarvisio, Via Diaz	Long term
2	Tarvisio, Borgo Angelo	Long term
3	Rue di Camporosso, 200m	Long term
4	Malborghetto municipality	Short Term
5	Tarvisio, Dawit	Short Term
6	Tarvisio-Camporosso, 30m from A23	Short Term
7	Bagni di Lusnizza	Long and short term
8	Tarvisio – Rutte di Camporosso, 20m from A23	Long and short term

Table 5: *Measurement points for the Tarvisio corridor in the iMONITRAF! Project*

The noise levels measured in every site are reported in the Appendix A of this document.

4 Noise Source Data

After the setup of the geometry of the scenario it is necessary to define the variables that characterize the noise sources.

As shown in the previous chapter there are two types of noise sources to be considered in the project: the highway and the train tracks.

The raw traffic data have been obtained from the infrastructure administrators and, after some considerations and calculations, permitted to define the noise emissions in the environment and run the simulations.

4.1 Highways traffic data

The highway that travels from Gemona to the national border there are four points where it is possible, for the vehicles, to enter or exit the corridor; therefore, there are four different highway segments, each with a different traffic flows. The entrances/exits are, from South to North:

- Gemona-Osoppo
- Carnia-Tolmezzo
- Pontebba
- Ugovizza barrier

Every vehicle must pass through the Ugovizza barrier, thus the vehicle count taken at that place accounts for all the vehicles that travel on that highway segment. From the Ugovizza barrier to the national border there is one more exit and it has been observed that the majority of the vehicles doesn't exit the highway at that point and proceed to Austria.

In the iMONITRAF! Project it was recorded for each year the traffic value, divided in light and heavy duty vehicles, of the four highway segments. The trend of the four segments is, as expected, the same, therefore we present the data measured at the Ugovizza barrier, that accounts for quite all the traffic that travel across the national border.

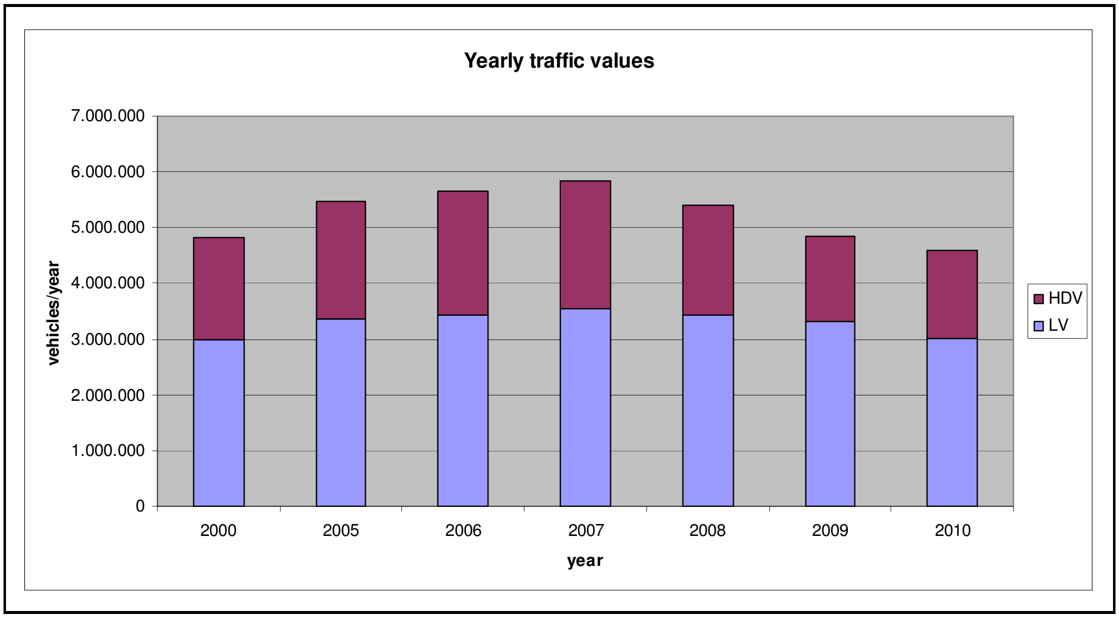


Figure 31: *Yearly traffic values for light and heavy duty vehicles at the A23 Ugovizza barrier*

In the graph it is clearly visible the effect that the economical crisis had on the transport sector, causing a decrease on the number both of the light and heavy duty vehicles.

The data used for the reports of the iMONITRAF! Projects are not sufficient to characterize the noise sources of the scenario: to setup a noise simulation is necessary to have at least the number of light and heavy duty vehicles that travel in the three reference periods (day, evening and night, as stated in the previous chapters); to achieve even better results, it would be best to have the hourly traffic values. The traffic data is present, but the aggregation used make the data useless for the objectives of the noise study.

During the project we conducted seven traffic counts on the A23 highway. Each count had a duration between one and two hours. These kind of measurements are used together with noise measurements to understand how the propagation of noise works within the model and can not be used to characterize the noise sources.

In order to obtain the necessary data to characterize the highway noise, it has been necessary to obtain more data from the highway administrators; the data had the following characteristics:

- Separated counts for light and heavy duty vehicles
- Separated mean speeds for light and heavy duty vehicles
- Separated in two distinct flows: one for each direction
- one count per hour, for a whole day; therefore composing a complete day profile of the traffic travelling on the highway.
- Since the data has to represent a mean day, the day in which the data was gathered has not to be into a weekend.

Autostrade per l'Italia provided the requested data, complying the above points. Two whole day profiles were selected, one for Wednesday 14th of September 2011 and one for Sunday 22nd of May 2011. The provided data came from coil traffic counters sited

Since into the Cadna modelling software the traffic is not divided by direction, we aggregated the two traffic direction into a *total traffic* flow.

Autostrade per l'Italia divided the vehicles into classes using the measured vehicle length; the length classes are:

Class	Vehicle length [meters]
Class 1	Between 0 and 5
Class 2	Between 5 and 10
Class 3	Between 10 and 12,5
Class 4	Between 12,5 and 16,5
Class 5	Between 16.5 and 19
Class 6	Above 19

Table 6: *Vehicle classes as defined by Autostrade per l'Italia*

The noise modelling software used for this study divides the traffic into just the two categories heavy duty and light vehicles, it was therefore necessary to chose what classes had to be used for those two. Vehicles such as buses and light trucks were categorized in class two from the above table, since the noise emission of those vehicles is much more closer to the one of the trucks it has been decided to use class 1 for light vehicles and all other classes for heavy duty ones.

The total number of vehicles travelling on the different segments of the A23 highway is:

Segment		LV	HDV	TOTAL	HDV%
GEMONA OSOPPO - CARNIA		13.164	6.145	19.309	31,8%
CARNIA - PONTEBBA		6.786	4.780	11.567	41,3%
PONTEBBA - UGOVIZZA TARV.		6.458	5.042	11.500	43,8%

Table 7: *Traffic on the segments of the A23 highway*

Having decided the classification of the vehicles and aggregated the traffic data taking into account the direction of the flows, we obtained the hourly day profiles of the light and heavy duty traffic on the highway, for a typical day and for a weekend day.

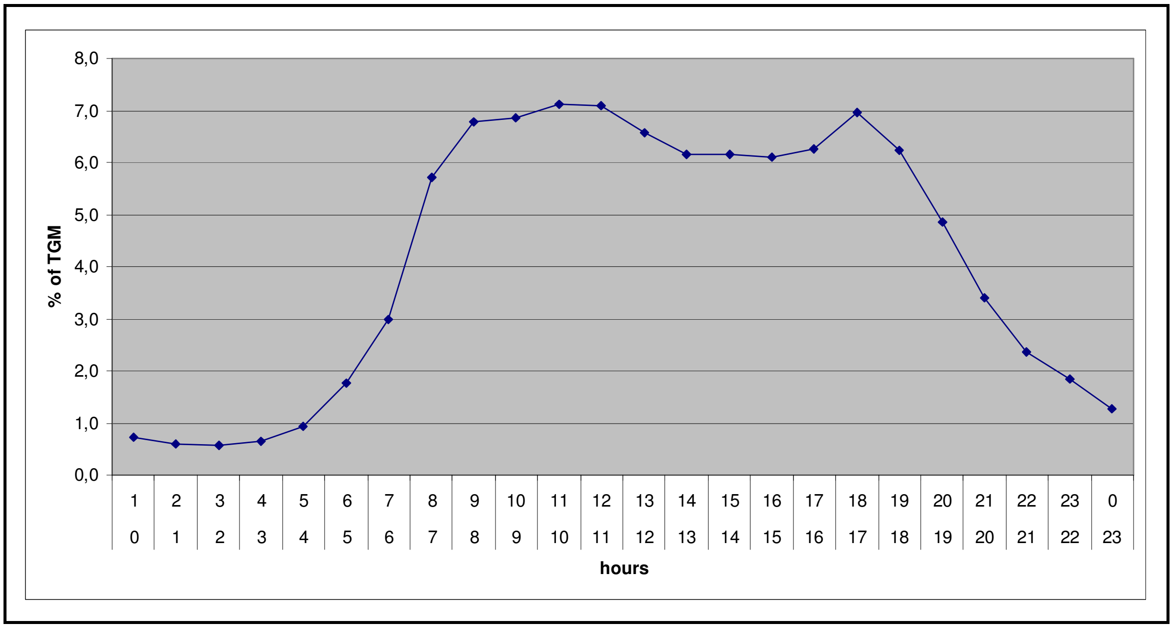


Figure 32: *Light vehicle traffic in the hours of a typical day*

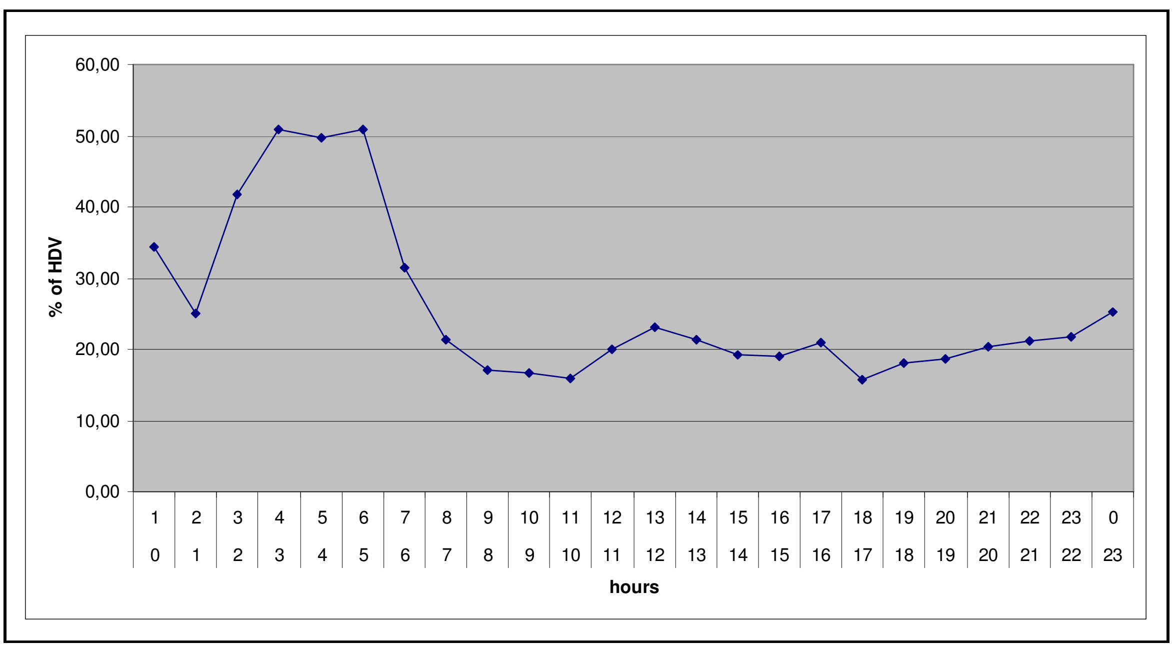


Figure 33: *Heavy duty vehicle traffic in the hours of a typical day*

As shown in the above graph, the light vehicle traffic has two peaks in the morning and in the evening, this is a known fact in the literature on the traffic subject. The heavy duty traffic has maximum values during the night hours.

The same analysis was performed on the weekend day:

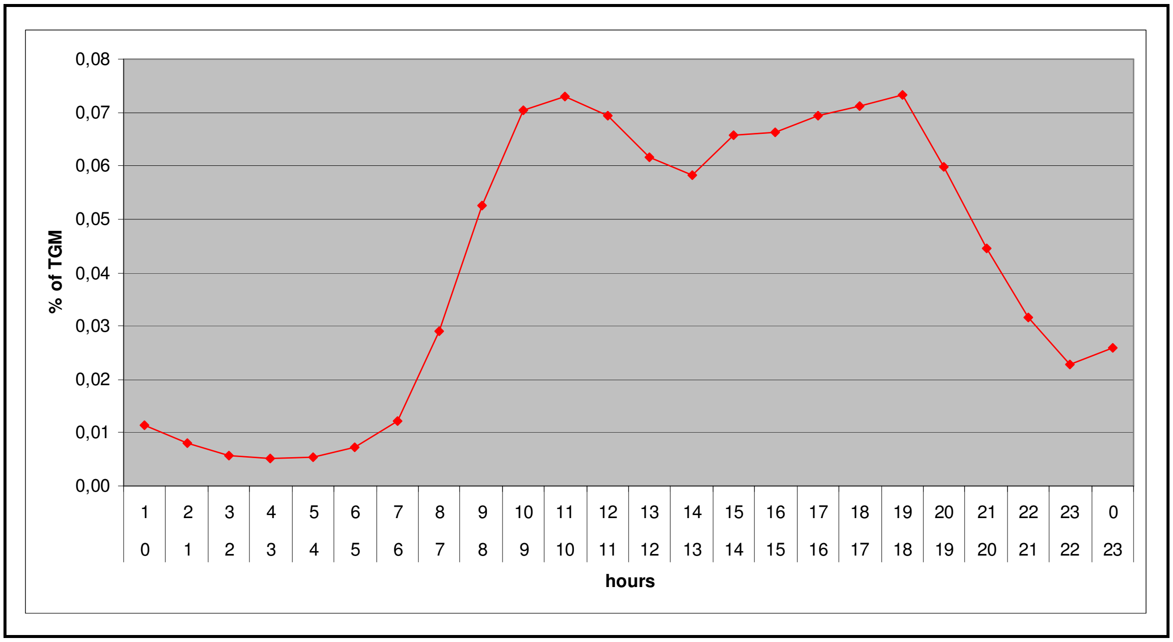


Figure 34: *Light vehicle traffic in the hours of a typical weekend day*

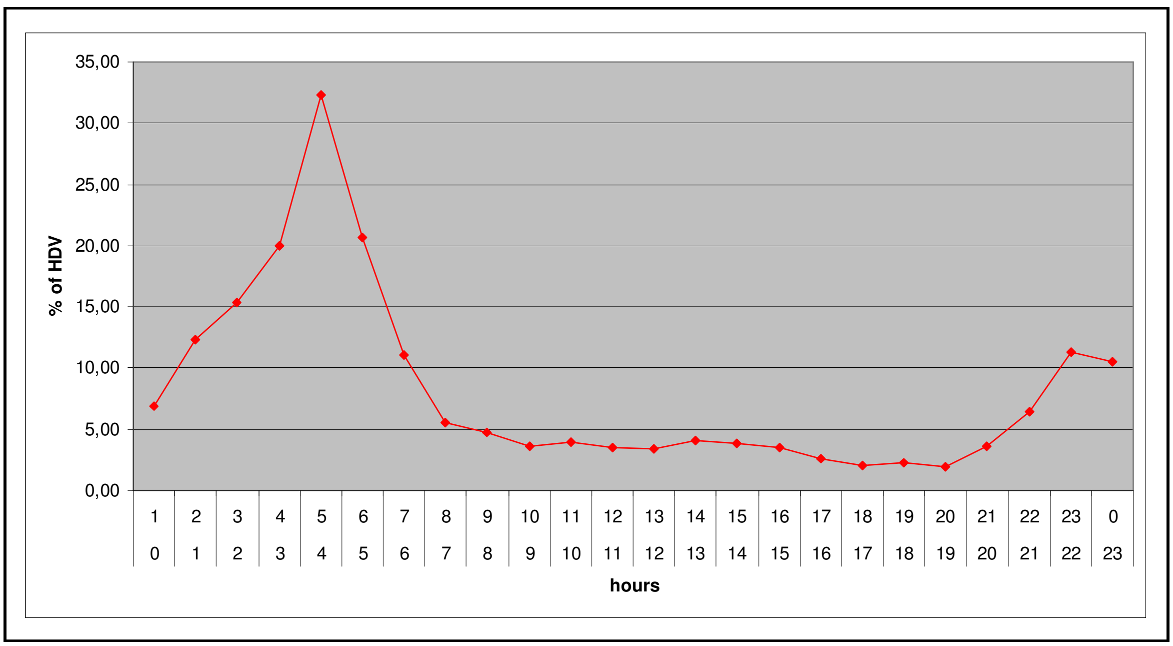


Figure 35: *Heavy duty vehicle traffic in the hours of a typical weekend day*

We can observe that, during the weekend, the light vehicles traffic has a trend similar to the one of a typical day but that the maximum values are found for slightly late hours. The heavy traffic during the weekend is, instead, much lower.

The noise simulations will take into account the typical days and not the weekend one, since the traffic in those days is much lower and therefore the noise levels less dangerous and annoying to the population.

The final traffic data used into the simulation to characterize the highway noise sources are reassumed in the following tables.

Hour from	Hour to	Number of Light vehicles	Number of Heavy duty vehicles	Total number of vehicles	Percentage of heavy duty vehicles
0	1	86	45	131	34,35
1	2	81	27	108	25,00
2	3	60	43	103	41,75
3	4	58	60	118	50,85
4	5	85	84	169	49,70
5	6	156	162	318	50,94
6	7	367	168	535	31,40
7	8	809	219	1.028	21,30
8	9	1.011	207	1.218	17,00
9	10	1.026	207	1.233	16,79
10	11	1.076	205	1.281	16,00
11	12	1.019	256	1.275	20,08
12	13	908	272	1.180	23,05
13	14	870	236	1.106	21,34
14	15	894	213	1.107	19,24
15	16	887	209	1.096	19,07
16	17	888	235	1.123	20,93
17	18	1.052	197	1.249	15,77
18	19	916	203	1.119	18,14
19	20	712	163	875	18,63
20	21	486	125	611	20,46
21	22	334	90	424	21,23
22	23	259	72	331	21,75
23	0	172	58	230	25,22
TOTAL		14.212	3.756	17.968	

Table 8: *Typical day traffic on the A23 Highway: hourly profile*

It is important to note that the hourly profile of the highway traffic, meaning the total number of travelling vehicles and the heavy duty percentage, are the same for the four segments of the highway; the segments will have a different total number of travelling vehicles (meaning TGM values) that will determine different noise emissions.

4.2 Rail traffic data

On the Tarvisio corridor the train tracks run for most part in galleries. There are four different segments named after the train station where each segment ends, from south to north: Gemona, Carnia, Pontebba and Tarvisio.

The analysis of the train traffic highlighted the presence of different train classes on the tracks, different categories have different characteristics.

All the freight trains are equipped with blocks brakes, and their traffic is divided in weight and length subclasses. The subclasses have been then simplified observing that the majority of the freight trains have length 400 or 500 meters. We decided to approximate all the trains to these two lengths. The speed of freight trains is 100 Km/h.

The passenger trains are equipped with disc brakes, on the corridor there are five sub-classes for these train typology:

Name	length [meters]	weight [tons]	Speed [km/h]
Ale 501	52	125	160
Ale 801	108	254	140
E464 Nav	174	329	160
EuroNight	300	500	180
EuroNight	350	700	160

Table 9: *Characteristics of each passenger train subclass*

Trenitalia and *Rete Ferroviaria Italiana S.p.A.* provided the train traffic data for all the sub-classes for all the days of the week in the three reference periods (*day*, *evening*, *night*).

From the weekday traffic data the mean midweek day was calculated, obtaining the number of trains in each subclass that travel in the four segments in the three reference periods. The results are shown in the following table (for passenger trains: red is for day value, purple for evening and blue for night):

	Length = 400 m			Length = 500 m		
	day	evening	night	day	evening	night
Gemona	1	2	2	14	6	6
Carnia	1	2	2	14	5	7
Pontebba	1	2	2	14	5	7
Tarvisio	1	2	2	14	5	7

Table 10: *Number of freight trains, in each reference period, for all the segments of the scenario*

	Ale 501	Ale 801	E 464 Nav	EuroNight	EuroNight
Length	52	108	174	300	350
Speed	160	140	160	180	160
Gemona	11	4			
Gemona	2	1	1		
Gemona	1	1	1	2	2
Carnia	11	4			
Carnia	2	1	1		
Carnia	1	1	1	2	2
Pontebba	1	2			
Pontebba	1		1		
Pontebba			1	2	2
Tarvisio	1	2			
Tarvisio	1		1		
Tarvisio			1	2	2

Table 11: *Number of passenger trains, in each reference period, for all the segments of the scenario*

From the numbers presented in the table it appears clear that the majority of the noise emissions of the trains comes from the freight trains and that the contribution of the passenger ones is very limited.

As with the motorway traffic data, the simulation software does not differ the direction of the traffic. In all the points where there are two different tracks (one for each direction) the traffic was split in half and assigned to both tracks.

4.3 Noise measurements used

To ensure the model is correctly calibrated, noise measures were taken In the points described in the previous chapter.

Measures of 7 days duration were used to ensure the correctness of the long term levels (in the three reference periods). In accordance with the WP5 noise guidelines, developed during the project, the long term measurements were taken at distance of no less than 5 meters from the road sides and no more than 20 meters; the height of the microphone from the ground level is 4 meters.

The instruments used were Larson Davis 831 and Larson Davis 820; both are class 1 instruments capable of measuring the noise levels with 0.5 dB(A) maximum error in accordance to Italian laws and regulations.

The measurement uncertainty for all the noise campaigns is, as defined by UNI/TR 11326/2009 0.41 dB. It is important to note that the uncertainty coming from the reflection from ground, the distance between the noise sources and the measurement point and the height from ground is in the order of 1 dB. It is extremely important to note that the effects of measurement uncertainty were in the end not considered in the calibration process and that the raw data was used for it.

Furthermore, measurements of 1 hour were used in correspondence of traffic count to ensure the emission of the road was set up correctly. During these measurements an instrument capable of counting the number of light and heavy duty vehicles of each lane and the mean speed of each defined vehicle class was used. As said, since in the simulation software it is not possible to differ the direction of the traffic a few aggregation (sum for the count and mean for the speed) operation have been performed to make the raw measured data usable with the software.

For all the measurements, meteorological data was gathered as well, to ensure that the atmospherical conditions did not invalidate the measured levels. All the noise levels obtained in correspondence of wind speeds greater than 5 m/s or in presence of rain have been considered invalid and were not taken into account when calculating the mean sound levels for the calibration process.

In the two years of the project a total of twenty measurements were taken, six of those were short term noise monitoring measurements conducted with the traffic counter.

The results of the campaigns are included in this document in Appendix A.

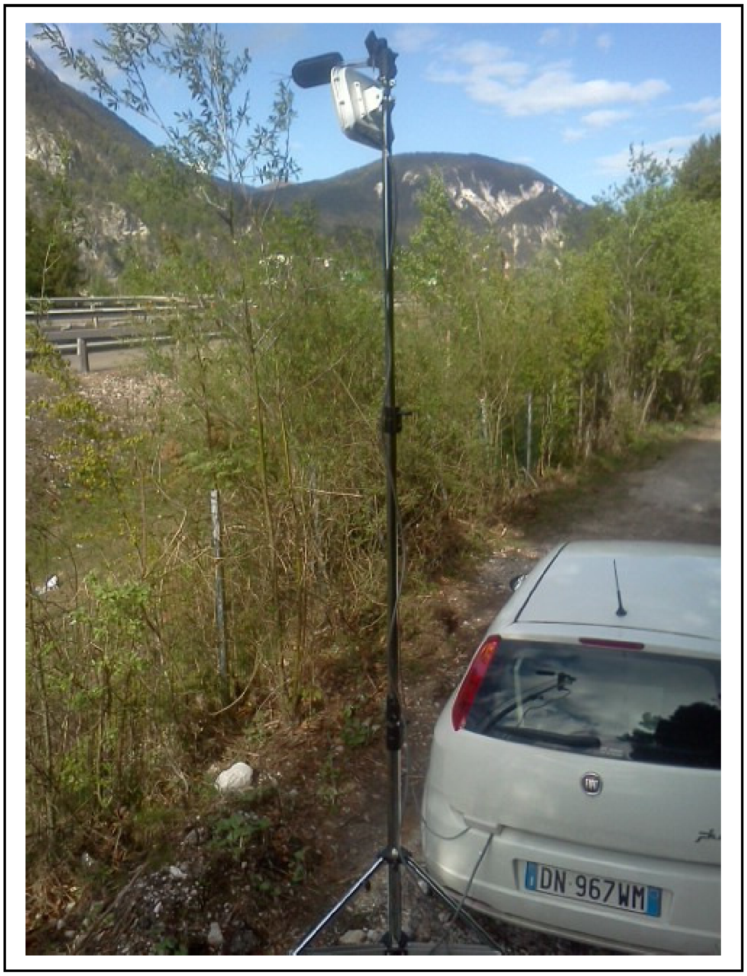


Figure 36: *Short term measurement performed with a noise level meter and a traffic counter*

It is important to note that the traffic counts performed during the short term noise measurements were in very good accordance with the traffic data provided by *Autostrade per l'Italia*, this was a good index of the quality of the data that determine the noise emission on the analyzed area.

Of all the measurement point presented it was decided to not use the values coming from Bagni di Lusnizza because in the site a guardrail is present as an obstacle to noise propagation and it was not possible to achieve a sufficient precision with the simulated noise level in that location.

The calibration procedure was done In accordance to UNI 11143-2 that states that the simulated level must not differ for more than 0.5dB(A) from the measured one. When a higher difference is found the emission and geometry of the scenario has to be modified and the calibration is to be redone. In the analyzed case this has been done mainly selecting the road surfaces and the rail tracks characteristics, in order to achieve the desired precision.

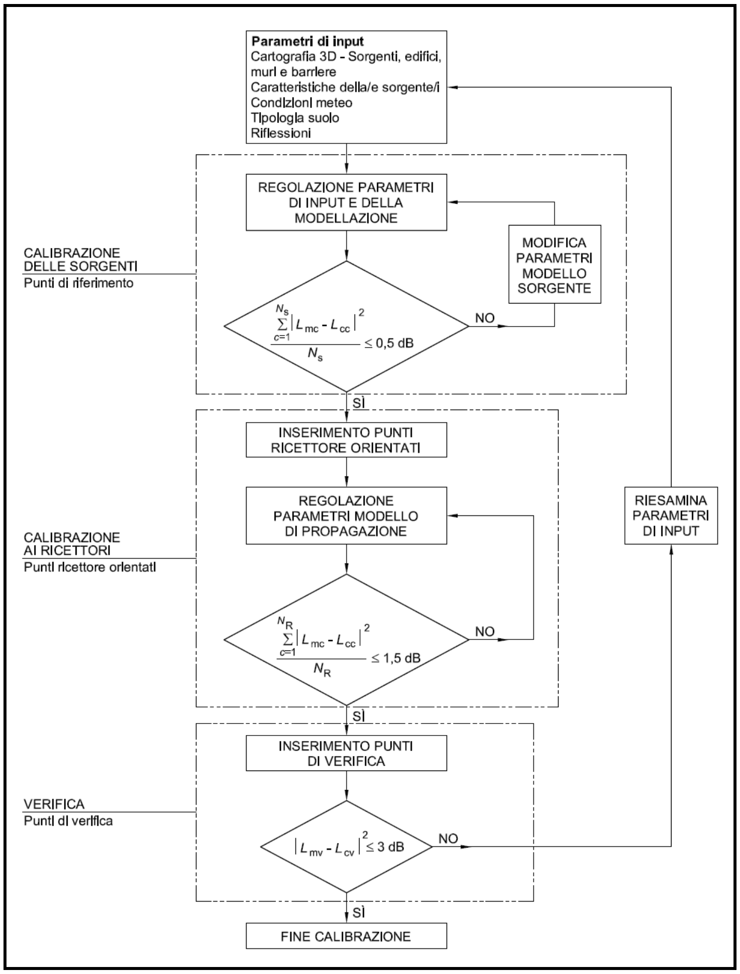


Figure 37: *ISO 11143 Calibration procedure*

To calibrate the model we used the traffic data obtained during the short term measurements along with their correspondent noise levels.

Measuring point	Date	Start	End	Light vehicles	Heavy duty Vehicles	Light vehicles speed	Heavy duty vehicles speed	Measured Level	Calculated Level	Δ
	dd/mm/yyyy	hh:mm	hh:mm	count	count	km/h	km/h	dB(A)	dB(A)	dB
4	03/05/2011	16:20	17:20	580	249	117	95	70,1	70,5	0,4
4	24/08/2011	15:02	16:02	853	152	120	100	69,1	69,3	0,2
5	03/05/2011	14:38	15:38	325	158	113	96	68,6	68,1	0,5
6	03/05/2011	10:41	11:41	410	131	113	103	60,1	60,5	0,4
7	24/08/2011	11:35	12:35	1224	189	115	97	67,9	70,2	2,3
8	03/05/2011	12:00	13:00	380	140	114	101	59,7	60,0	0,3

Table 12: *Calibration: number of counted vehicles, measured level ones and differences.*

After the calibration phase, the long term measurements were used to verify the results. UNI 11143-2 states that the maximum acceptable difference between the simulated levels and the measured ones in this phase of the work is 1.5 dB(A).

Measuring point	Measured Lday	Measured Levening	Measured Lnight	Calculated Lday	Calculated Levening	Calculated Lnight	rms	max error
	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB	dB
1	55,7	53,2	52,3	54,8	52,3	51,2	1,7	1,1
2	60,7	58,3	57,5	59,3	56,8	56,1	2,5	1,5
3	54,6	56,3	51,2	55,9	54,9	51,2	1,9	1,4
7	68,4	63,8	63,8	70,8	67,8	64,8	4,8	4,0
8	67,6	64,5	62,8	66,6	63,6	62,0	1,6	1,0

***Table 13**: Verification points, long term measured levels and calculated ones.*

5 Results

In this chapter we will present the simulation results obtained for the actual 2012 Tarvisio situation.

Two simulation were ran, the first to obtain the noise level map of the whole study area, and the second to evaluate the noise levels of the buildings façades. It is important to note that from the analysis of the results coming from the fist simulation gives information about the general physical propagation of the noise in the study area while the second results are used to evaluate the impact of the noise on the inhabitants. For this reason the noise level map is used mainly to find critical situations and to check the correctness of the geometry and the simulation setup while the façade maps will actually be used to conduct our analysis.

5.1 Running the Simulations

In the study area a grid was set up, containing point with spacing 10 meters.

The grid height is 4 meters from ground. Since this height is the same as the one used in the real measurements it is possible to compare the simulated noise levels with the real measured ones.

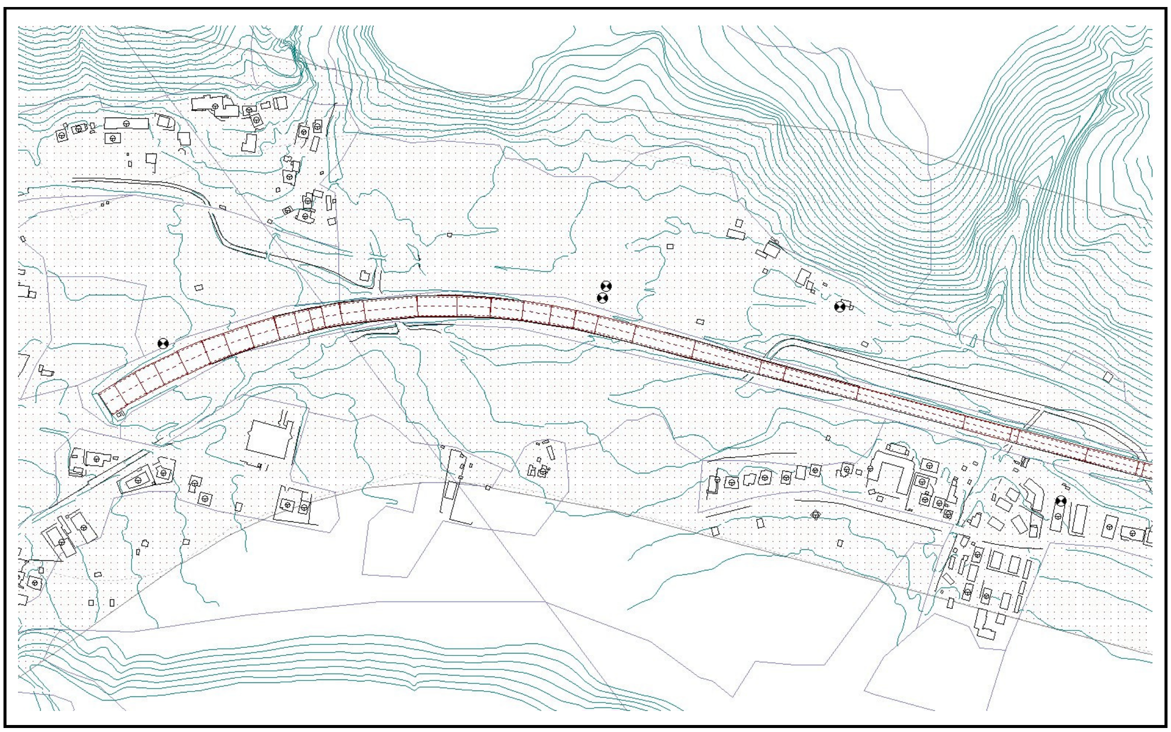


Figure 38: *Grid points where the noise levels are calculated.*

Another analysis with a grid height at 1.5 meters, height correspondent to he one of the ears of a typical person, has been run; since the results coming from this analysis are extremely close to the ones obtained at 4 meters height we choose not to present these.

Having set up the geometry of the whole scenario, the emission factors of the noise sources and the grid where the levels are calculated the simulation has been run. The required time to obtain the results for the noise map was of about 48 hours.

To calculate the noise levels on the façade of the inhabited buildings, a few more parameters to define the geometry of the houses have been set up: the ground floor height was set to 2.50 meters and the height of all the others floor to 2.80 meters.

The calculus of the noise level in the correspondence of the buildings façades took about 10 hours.

It is important to note that, in order to evaluate the impact of the WP6 scenario that will be presented in the next chapter, only this last simulation had to be re-launched while we didn't recalculate the noise map, since the calculus time is much greater and, as said, its use is limited to considerations about the noise propagation.

The models used for the calculations were NMPB-Routes-96 for the road noise and Schall03 for the rail noise. The maximum propagation distance, used in the simulations, was of 2Km and the maximum reflection order was set to 1.

The meteorological data were analyzed in order to choose appropriate conditions to run the simulations. In accordance with NMPB-Routes-96 the simulation software permits the definition, in percentage, of how much favourable the propagation of sound is in the environment. It has been observed a great variability in the meteorological data, we therefore decided, since the simulation must provide results for the typical day, to use a 50% favourable condition during the Day reference period. Since noise pollution has a greater effect on population during the night hours we decided to set the conditions to 75% favourable during Evening and 100% during Night, in order to obtain results for the worst case scenario during those periods.

5.2 Noise Map

Since the noise map is very large we split it in the various municipalities in order to present it in this document. Only the area where buildings are located will be presented.

The noise maps will be presented from south to north, following the A23 highway direction from Gemona to the national border located north of Tarvisio.

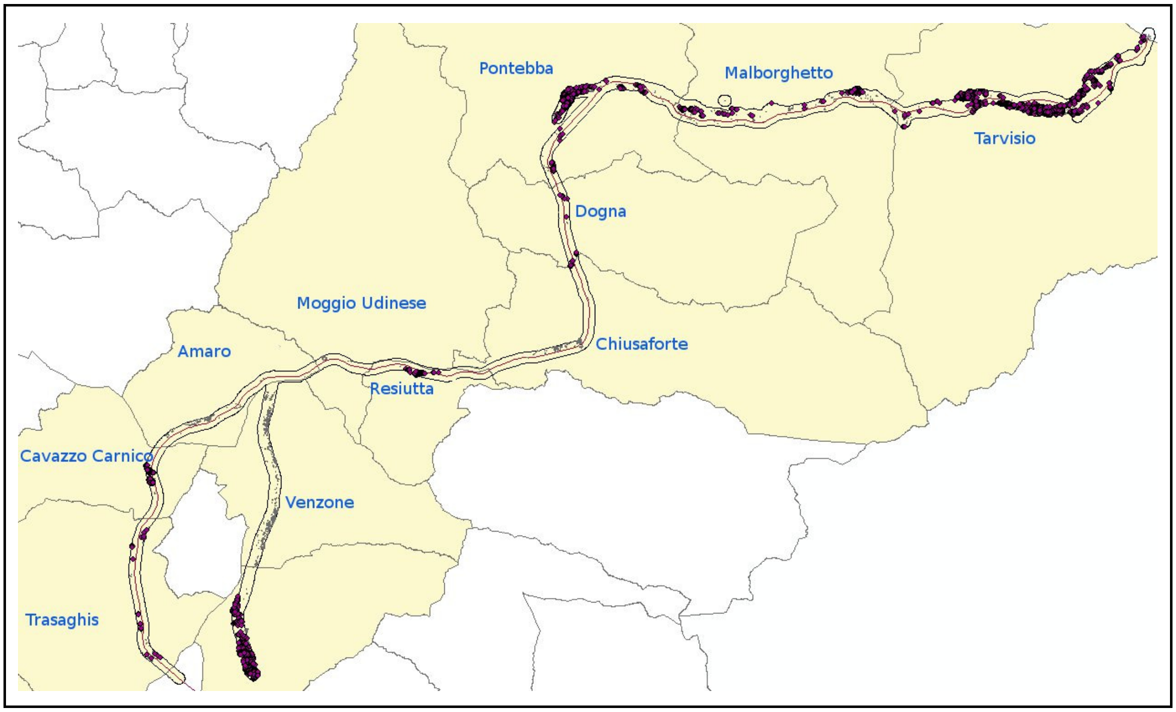


Figure 39: *Municipalities located in the study area.*

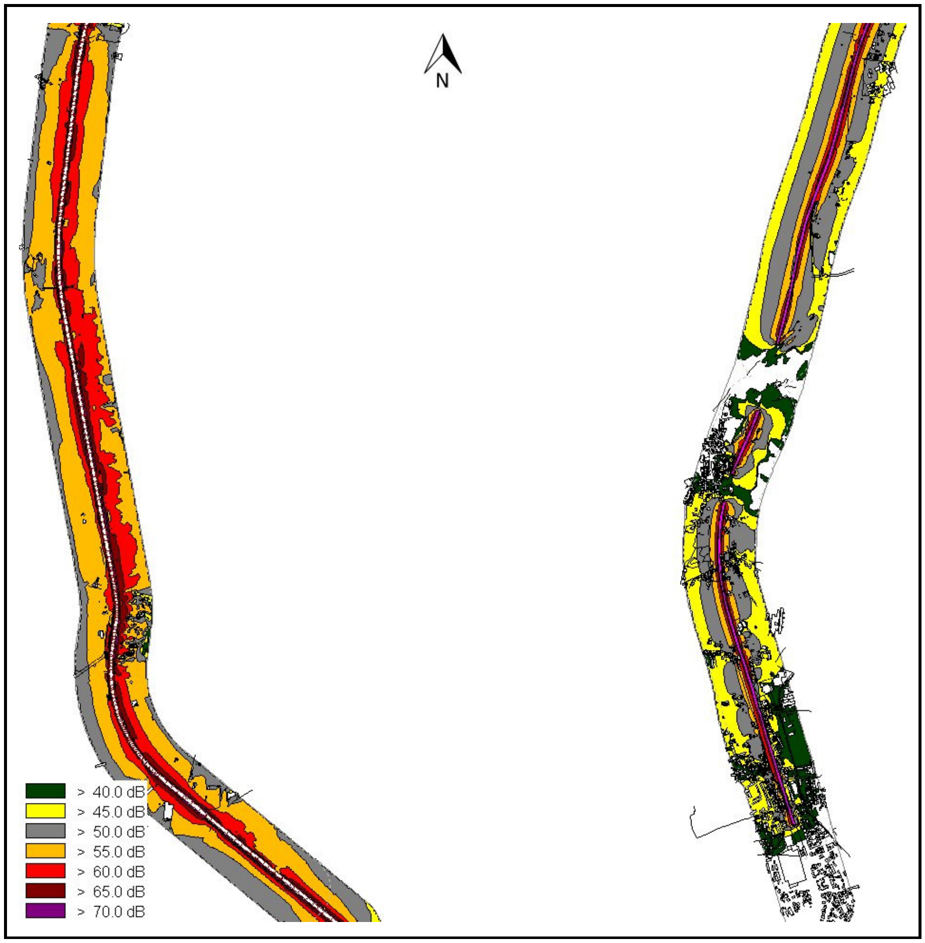


Figure 40: *Noise Map: Trasaghis (west) and Gemona (east). Scale 1:25000*

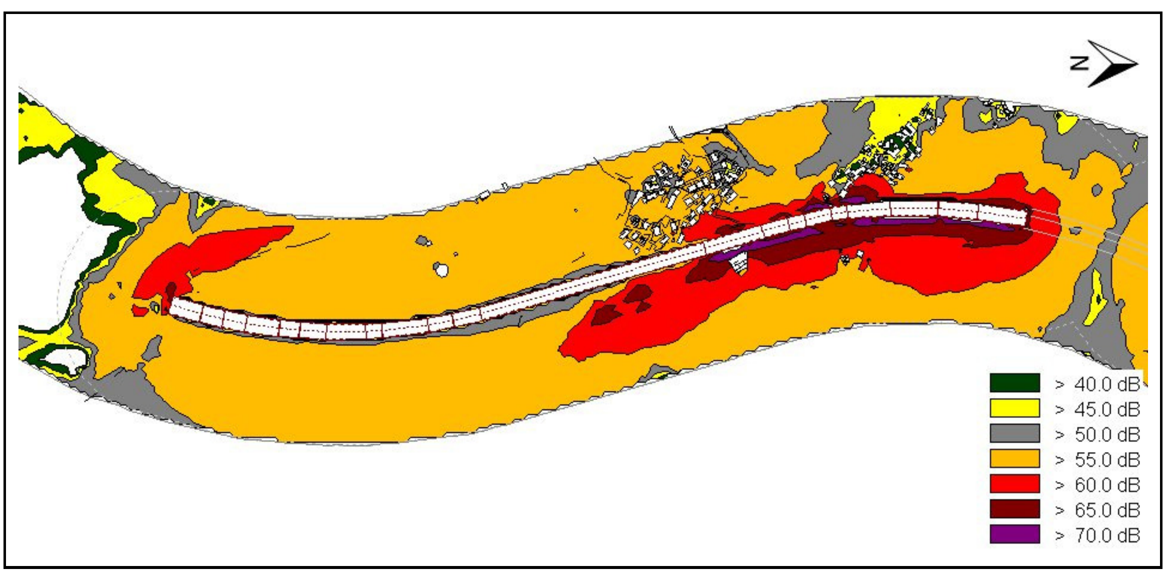


Figure 41: *Noise Map: Cavazzo Carnico. Scale 1:10000.*

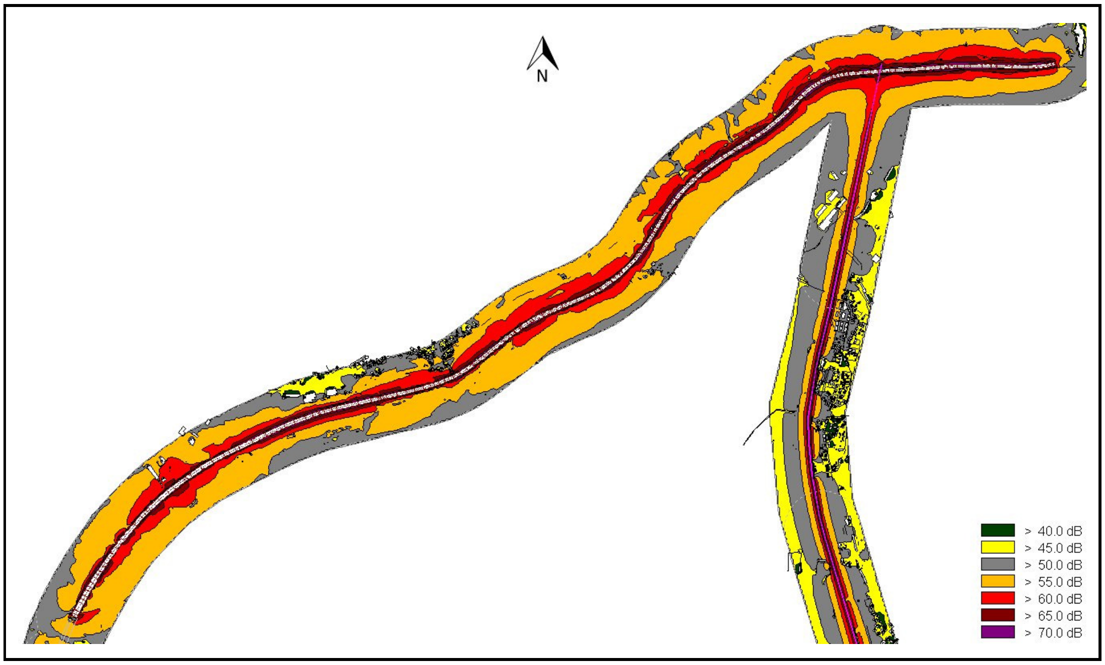


Figure 42: *Noise Map: Amaro (west) and Venzone (east). Scale 1:20000.*

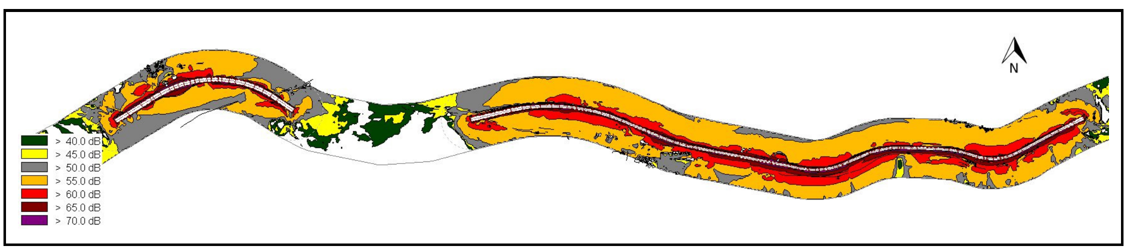


Figure 43: *Noise Map: Moggio and Resiutta. Scale 1:20000.*

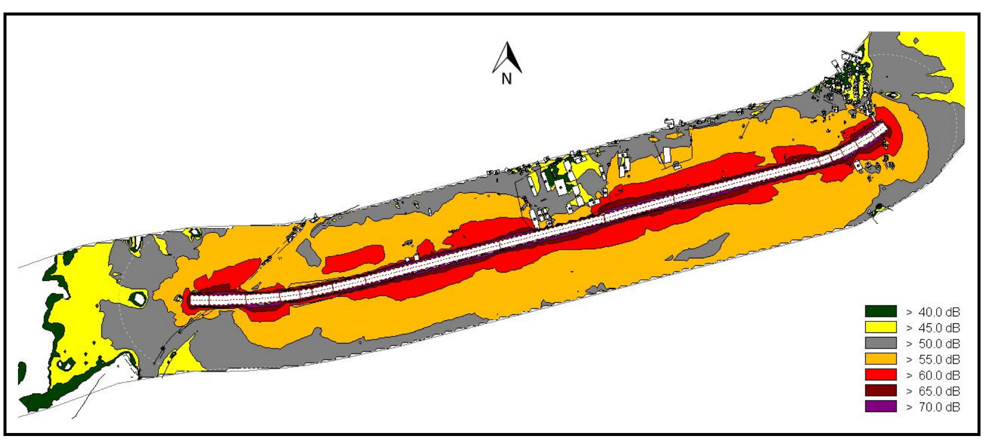


Figure 44: *Noise Map: Cavazzo Carnico. Scale 1:10000.*

As seen in the Map obtained for Cavazzo Carnico, there are a few buildings very near to the motorway, determining critical situations for the inhabitants that live there. In the whole corridor these are the inhabited buildings with the highest noise levels.

In the segments located in the Dogna municipalities there are very few inhabitants and the road is mostly in tunnels, therefore we will not present those maps in this document.

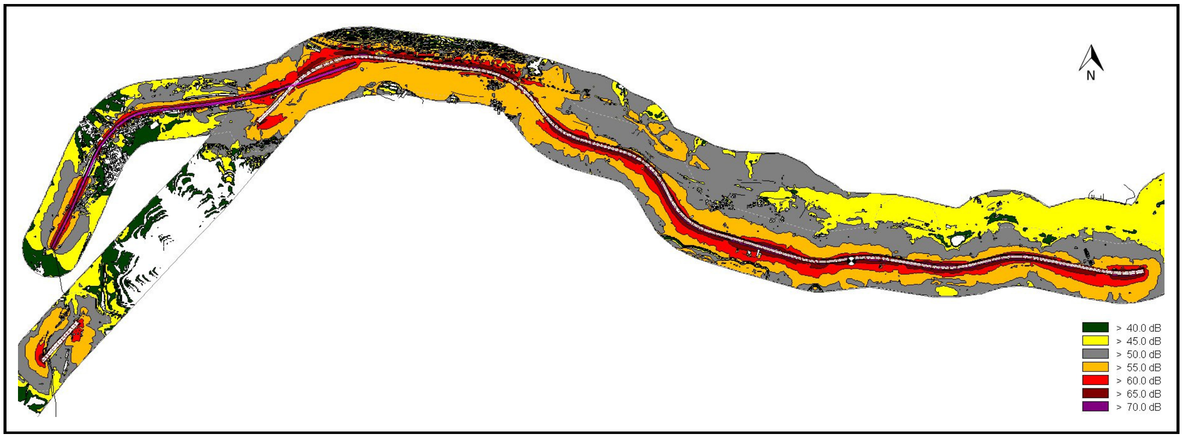


Figure 45: *Noise Map: Pontebba. Scale 1:20000.*

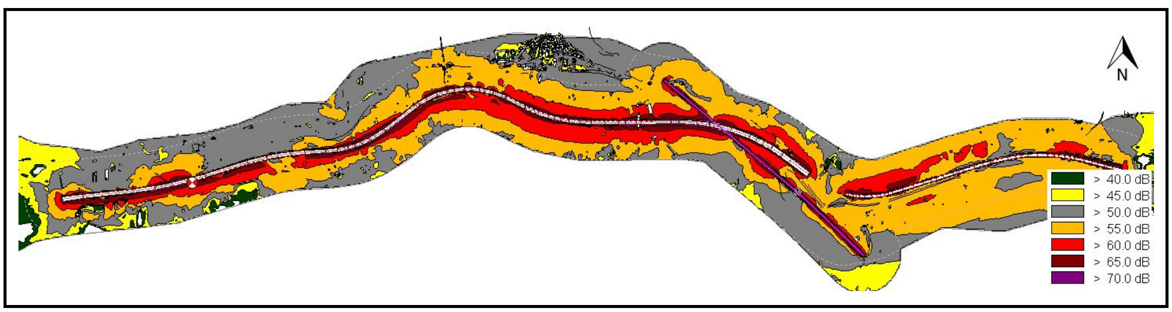


Figure 46: *Noise Map: Malborghetto-Valbruna. Scale 1:20000.*

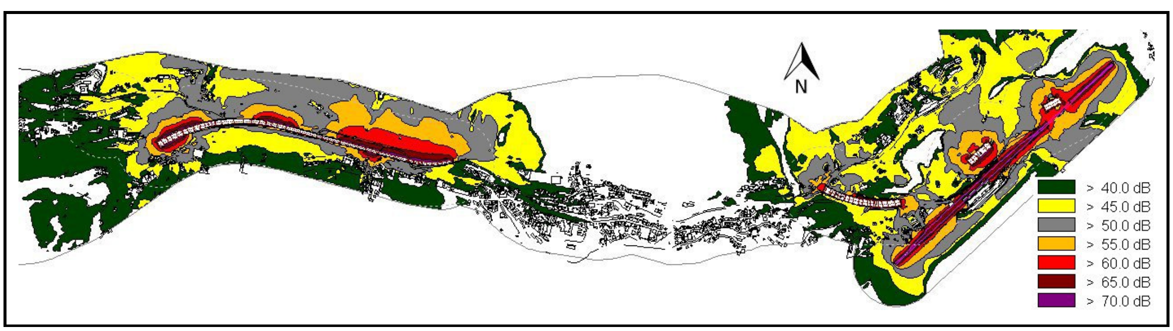


Figure 47: *Noise Map: Tarvisio. Scale 1:20000.*

Using the simulation software it is possible to have a three-dimensional view of all the noise map presented above. Using this kind of view it is easier to identify the critical situations that can arise when the buildings are very near to the a noise source and the noise is not blocked by barriers or walls.

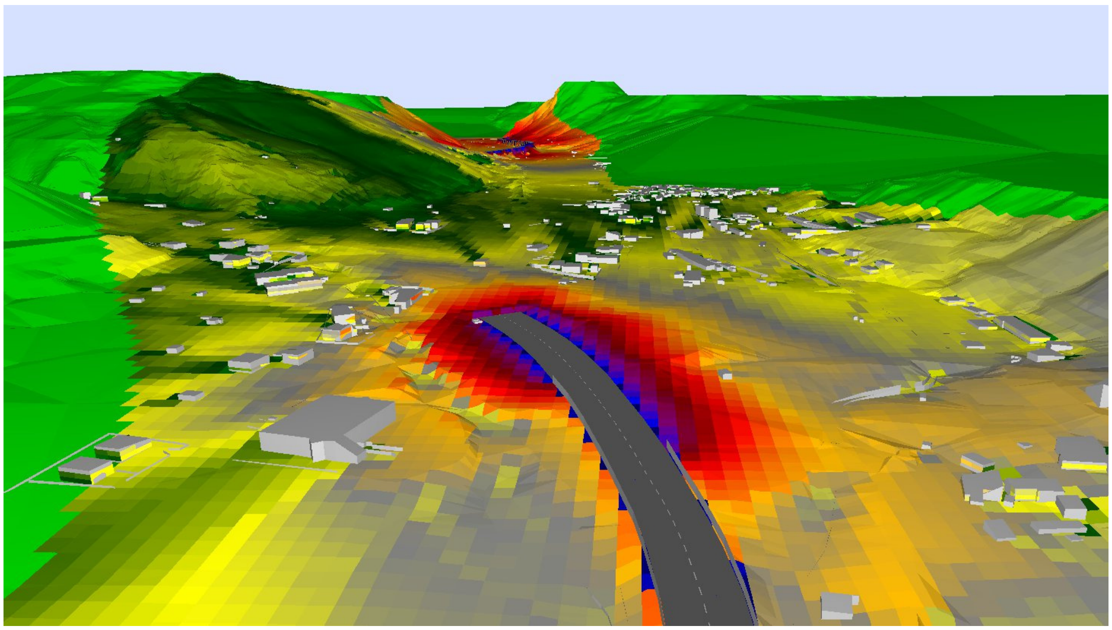


Figure 48: *3D representation of the noise levels calculated in the scenario, example of a zone just outside Tarvisio city.*

5.3 Noise Classes

After the calculus of the noise levels on the building façades, it was possible to calculate, using the inhabitants data provided by the various municipalities, the number of inhabitants exposed to the noise levels.

In order to complete the analysis noise classes have to be defined: we choose to use the classes defined in 2002/49/CE Environmental Noise Directive considering the total inhabitants for noise class and the buildings with and without the most silent façade. Since the total population isn't very high, we will not round the numbers to the hundreds digits.

In addition to this classification of the noise classes we used a custom one (that will be called in the results *simple*) that defines, without accounting the silent façade of the buildings, 7 classes of 5 dB(A) starting from the minimum level of 45 dB(A). This class is used to confront the results of the simulations with the *WP6 Buffer Methodology to estimate the impact of noise pollution on inhabitants* that uses a very similar classification.

Since the ultimate goal of the analysis on the population affected by noise level is the comparison between the WP6 scenarios, in this document we will present the division in classes for all the calculated levels (being those L_D, L_E, L_N, L_{DEN}) and the comparison will be done on all those levels.

5.4 Impact of Noise Pollution on the inhabitants

Performing the object-scan on the building façade, the following number of inhabitants have been found for the noise classes defined in the previous paragraph.

As defined in 2002/49/CE, the total number of inhabitants for the noise classes are:

Interval [dB(A)]		Value					Value			
min	max	L_D	L_E	L_N	L_{DEN}		L_D	L_E	L_N	L_{DEN}
	50	3298	4358	3586	2444		63%	84%	69%	47%
50	55	951	627	1042	795		18%	12%	20%	15%
55	60	651	189	321	1171		13%	4%	6%	23%
60	65	187	27	93	464		4%	1%	2%	9%
65	70	107	0	142	167		2%	0%	3%	3%
70	75	7	0	17	124		0%	0%	0%	2%
75		0	0	0	36		0%	0%	0%	1%

Table 14: *Total number of inhabitants that live in the noise classes defined by 2002/49/CE*

As defined in 2002/49/CE, the total number of inhabitants living in a building without a silent façade is:

Interval [dB(A)]		Value					Percentages			
min	max	L_D	L_E	L_N	L_{DEN}		L_D	L_E	L_N	L_{DEN}
	50	3106	3534	3091	2332		72%	87%	78%	56%
50	55	768	408	722	617		18%	10%	18%	15%
55	60	360	124	154	861		8%	3%	4%	21%
60	65	60	15	12	287		1%	0%	0%	7%
65	70	8	0	0	36		0%	0%	0%	1%
70	75	0	0	0	0		0%	0%	0%	0%
75		0	0	0	0		0%	0%	0%	0%

Table 15: *Number of inhabitants that live in the noise classes, without silent façade, defined by 2002/49/CE*

As defined in 2002/49/CE, the total number of inhabitants living in a building with a silent façade is:

Interval [dB(A)]		Value					Percentages			
min	max	L_D	L_E	L_N	L_{DEN}		L_D	L_E	L_N	L_{DEN}
	50	163	821	495	112		18%	73%	41%	10%
50	55	179	184	320	178		20%	16%	26%	17%
55	60	253	103	167	310		28%	9%	14%	29%
60	65	149	12	81	177		16%	1%	7%	17%
65	70	133	0	142	131		15%	0%	12%	12%
70	75	37	0	17	124		4%	0%	1%	12%
75		0	0	0	36		0%	0%	0%	3%

Table 16: *Number of inhabitants that live in the noise classes, with silent façade, defined by 2002/49/CE*

For the simple class defined in the paragraph 5.3, the number of inhabitants living in areas affected by each noise class is:

Interval [dB(A)]		Value					Percentages			
min	max	L_D	L_E	L_N	L_{DEN}		L_D	L_E	L_N	L_{DEN}
	45	2409	3985	2769	1697		46%	77%	53%	33%
45	50	889	373	817	747		17%	7%	16%	14%
50	55	951	627	1042	795		18%	12%	20%	15%
55	60	651	189	321	1171		13%	4%	6%	23%
60	65	187	27	93	464		4%	1%	2%	9%
65	70	107	0	142	167		2%	0%	3%	3%
70	75	7	0	17	124		0%	0%	0%	2%
75		0	0	0	36		0%	0%	0%	1%

Table 17: *Total number of inhabitants that live in areas affected by "simple" noise classes.*

Defining therefore the number of people that live in a zone where the level (in the three reference period) is above or below 66 dB(A):

Interval [dB(A)]		Value					Percentages			
min	max	L_D	L_E	L_N	L_{DEN}		L_D	L_E	L_N	L_{DEN}
0	66	4193	3515	5094	4944		99%	100%	98%	95%
66		61	0	99	249		1%	0%	2%	5%

Table 18: *Number of inhabitants that live in areas where the noise level, in the selected reference period, is higher than 66 dB(A).*

5.5 Impact of Noise Pollution on the inhabitants for municipality

In this paragraph are presented the resulting total number of inhabitants affected by the noise classes defined in 2002/49/CE, for each municipality:

Interval [dB(A)]		Value					Percentages			
min	max	L_D	L_E	L_N	L_{DEN}		L_D	L_E	L_N	L_{DEN}
	50	44	57	107	27		20%	26%	48%	12%
50	55	64	122	99	30		29%	55%	45%	14%
55	60	93	36	13	117		42%	16%	6%	53%
60	65	18	6	2	41		8%	3%	1%	19%
65	70	2	0	0	6		1%	0%	0%	3%
70	75	0	0	0	0		0%	0%	0%	0%
75		0	0	0	0		0%	0%	0%	0%

Table 19: *Total number of inhabitants that live in the noise classes defined by 2002/49/CE for Amaro.*

Interval [dB(A)]		Value					Percentages			
min	max	L_D	L_E	L_N	L_{DEN}		L_D	L_E	L_N	L_{DEN}
	50	13	17	28	11		26%	34%	56%	22%
50	55	15	18	14	6		30%	36%	28%	12%
55	60	14	10	8	18		28%	20%	16%	36%
60	65	6	5	0	10		12%	10%	0%	20%
65	70	2	0	0	5		4%	0%	0%	10%
70	75	0	0	0	0		0%	0%	0%	0%
75		0	0	0	0		0%	0%	0%	0%

Table 20: *Total number of inhabitants that live in the noise classes defined by 2002/49/CE for Cavazzo Carnico.*

Interval [dB(A)]		Value					Percentages			
min	max	L_D	L_E	L_N	L_{DEN}		L_D	L_E	L_N	L_{DEN}
	50	97	123	162	79		31%	40%	53%	26%
50	55	71	134	126	40		23%	44%	41%	13%
55	60	120	40	15	130		39%	13%	5%	42%
60	65	11	11	5	48		4%	4%	2%	16%
65	70	9	0	0	11		3%	0%	0%	4%
70	75	0	0	0	0		0%	0%	0%	0%
75		0	0	0	0		0%	0%	0%	0%

Table 21: *Total number of inhabitants that live in the noise classes defined by 2002/49/CE for Chiusaforte.*

For the Dogna municipality there aren't reported inhabitants that live within 250 meters from the A23 highway.

Interval [dB(A)]		Value					Percentages			
min	max	L_D	L_E	L_N	L_{DEN}		L_D	L_E	L_N	L_{DEN}
	50	333	461	310	242		72%	100%	67%	52%
50	55	87	0	69	65		19%	0%	15%	14%
55	60	38	0	79	72		8%	0%	17%	16%
60	65	2	0	0	79		0%	0%	0%	17%
65	70	1	0	3	0		0%	0%	1%	0%
70	75	0	0	0	3		0%	0%	0%	1%
75		0	0	0	0		0%	0%	0%	0%

Table 22: *Total number of inhabitants that live in the noise classes defined by 2002/49/CE for Gemona.*

Interval [dB(A)]		Value					Percentages			
min	max	L_D	L_E	L_N	L_{DEN}		L_D	L_E	L_N	L_{DEN}
	50	54	90	167	21		30%	49%	91%	11%
50	55	113	92	16	64		62%	50%	9%	35%
55	60	16	1	0	97		9%	1%	0%	53%
60	65	0	0	0	1		0%	0%	0%	1%
65	70	0	0	0	0		0%	0%	0%	0%
70	75	0	0	0	0		0%	0%	0%	0%
75		0	0	0	0		0%	0%	0%	0%

Table 23: *Total number of inhabitants that live in the noise classes defined by 2002/49/CE for Malborghetto-Valbruna.*

Interval [dB(A)]		Value					Percentages			
min	max	L_D	L_E	L_N	L_{DEN}		L_D	L_E	L_N	L_{DEN}
	50	6	7	13	6		27%	32%	59%	27%
50	55	8	12	9	1		36%	55%	41%	5%
55	60	7	3	0	12		32%	14%	0%	55%
60	65	1	0	0	3		5%	0%	0%	14%
65	70	0	0	0	0		0%	0%	0%	0%
70	75	0	0	0	0		0%	0%	0%	0%
75		0	0	0	0		0%	0%	0%	0%

Table 24: *Total number of inhabitants that live in the noise classes defined by 2002/49/CE for Moggio Udinese.*

Interval [dB(A)]		Value					Percentages			
min	max	L_D	L_E	L_N	L_{DEN}		L_D	L_E	L_N	L_{DEN}
	50	291	825	255	92		31%	89%	27%	10%
50	55	250	44	342	142		27%	5%	37%	15%
55	60	183	60	114	296		20%	6%	12%	32%
60	65	107	0	63	125		12%	0%	7%	13%
65	70	91	0	138	119		10%	0%	15%	13%
70	75	7	0	17	119		1%	0%	2%	13%
75		0	0	0	36		0%	0%	0%	4%

Table 25: *Total number of inhabitants that live in the noise classes defined by 2002/49/CE for Pontebba.*

Interval [dB(A)]		Value					Percentages			
min	max	L_D	L_E	L_N	L_{DEN}		L_D	L_E	L_N	L_{DEN}
	50	11	11	22	11		15%	15%	31%	15%
50	55	12	36	34	0		17%	50%	47%	0%
55	60	29	20	15	36		40%	28%	21%	50%
60	65	19	5	1	20		26%	7%	1%	28%
65	70	1	0	0	5		1%	0%	0%	7%
70	75	0	0	0	0		0%	0%	0%	0%
75		0	0	0	0		0%	0%	0%	0%

Table 26: *Total number of inhabitants that live in the noise classes defined by 2002/49/CE for Resiutta.*

Interval [dB(A)]		Value					Percentages			
min	max	L_D	L_E	L_N	L_{DEN}		L_D	L_E	L_N	L_{DEN}
	50	1819	1893	1935	1481		88%	92%	94%	72%
50	55	149	163	117	371		7%	8%	6%	18%
55	60	88	8	7	170		4%	0%	0%	8%
60	65	8	0	5	37		0%	0%	0%	2%
65	70	0	0	0	5		0%	0%	0%	0%
70	75	0	0	0	0		0%	0%	0%	0%
75		0	0	0	0		0%	0%	0%	0%

Table 27: *Total number of inhabitants that live in the noise classes defined by 2002/49/CE for Tarvisio.*

Interval [dB(A)]		Value					Percentages			
min	max	L_D	L_E	L_N	L_{DEN}		L_D	L_E	L_N	L_{DEN}
	50	1	3	4	1		5%	15%	20%	5%
50	55	3	6	16	2		15%	30%	80%	10%
55	60	11	11	0	6		55%	55%	0%	30%
60	65	5	0	0	11		25%	0%	0%	55%
65	70	0	0	0	0		0%	0%	0%	0%
70	75	0	0	0	0		0%	0%	0%	0%
75		0	0	0	0		0%	0%	0%	0%

Table 28: *Total number of inhabitants that live in the noise classes defined by 2002/49/CE for Trasaghis.*

Interval [dB(A)]		Value					Percentages			
min	max	L_D	L_E	L_N	L_{DEN}		L_D	L_E	L_N	L_{DEN}
	50	629	871	583	473		72%	100%	67%	54%
50	55	179	0	200	74		21%	0%	23%	8%
55	60	52	0	70	217		6%	0%	8%	25%
60	65	10	0	17	89		1%	0%	2%	10%
65	70	1	0	1	16		0%	0%	0%	2%
70	75	0	0	0	2		0%	0%	0%	0%
75		0	0	0	0		0%	0%	0%	0%

Table 29: *Total number of inhabitants that live in the noise classes defined by 2002/49/CE for Venzone.*

6 Future Scenarios

6.1 WP6 Scenarios

In the WP6 of the iMONITRAF! Project, five different scenarios were hypnotized for the year 2020:

- The BAU/BAT (Business as usual, best available technology) scenario extends the traffic trend of the last year to the next ones. With this scenario the heavy duty vehicle number is expected to increase in the future.
- The ACE (Alpine Cross Exchange) scenario is based on the introduction of an slot-base market system to regulate the traffic on the Alpine Area similar to the one actually implemented in Switzerland. With this scenario it is expected a modal shift from road to rail caused by the increased of the passage costs on the highways.

In all the scenarios the number of light vehicles and the one of the passenger trains remains the same in the following year, therefore the only traffic parameters that change the emissions of the noise sources are the number of heavy duty vehicles (that will result in a variation of the total number of vehicles and in the fraction of heavy duty vehicles on the whole traffic) and the one of freight trains (that in the model is treated directly).

For the various corridors, the expected variation in the heavy duty vehicle traffic are, for the various scenarios:

		BAU/BAT	ACE	AETS-10	AETS-20	AETS-30
France	Frejus	128%	90%	117%	106%	96%
	Mont Blanc	128%	102%	120%	111%	103%
Suisse	Gotthard	119%	52%	109%	100%	91%
Autriche	Brenner	128%	90%	108%	89%	74%
Italy	Tarvisio	128%	93%	112%	96%	83%

Table 30: *Heavy duty vehicle traffic variations in the WP6 scenarios.*

The number of freight trains is expected to change in accordance to the following table:

		BAU/BAT	ACE	AETS-10	AETS-20	AETS-30
France	Frejus	100%	147%	115%	131%	150%
	Mont Blanc	100%	147%	100%	100%	100%
Suisse	Gotthard	100%	147%	109%	117%	127%
Autriche	Brenner	100%	147%	116%	132%	153%
Italy	Tarvisio	100%	198%	112%	125%	140%

Table 31: *Number of freight trains, variations in the WP6 scenarios.*

These variation cause a different number of total vehicles and a different composition of vehicles on the highways, for each scenario it is therefore necessary to calculate the new total traffic values for all the segments and the new traffic profile during the hours of the day.

6.2 BAU/BAT

The new total traffic data for this scenario are calculated from the percentages presented in the paragraph 6.1 and the table representing the actual traffic on the highway reported in paragraph 4.1. The traffic data for the scenario result:

Segment		LV	HDV	TOTAL	HDV%
GEMONA OSOPPO - CARNIA		13.164	7.743	20.907	37,0%
CARNIA - PONTEBBA		6.786	6.023	12.810	47,0%
PONTEBBA - UGOVIZZA TARV.		6.458	6.353	12.811	49,6%

Table 32: *Total traffic on the A23 highway segments for the BAU/BAT scenario*

Since in the simulation software the propagation is defined from the total number of vehicles that travel on the roads and the percentage of heavy duty traffic for all the hours of the day, it is necessary to recalculate the hourly profile of the traffic during the day with these values.

The resulting profile is:

Hour from	Hour to	Number of Light vehicles	Number of Heavy duty vehicles	Total number of vehicles	Percentage of heavy duty vehicles
0	1	86	58	144	40,11
1	2	81	35	116	29,91
2	3	60	55	115	47,84
3	4	58	77	135	56,97
4	5	85	108	193	55,85
5	6	156	207	363	57,07
6	7	367	215	582	36,95
7	8	809	280	1.089	25,73
8	9	1.011	265	1.276	20,77
9	10	1.026	265	1.291	20,52
10	11	1.076	262	1.338	19,61
11	12	1.019	328	1.347	24,33
12	13	908	348	1.256	27,72
13	14	870	302	1.172	25,77
14	15	894	273	1.167	23,37
15	16	887	268	1.155	23,17
16	17	888	301	1.189	25,30
17	18	1.052	252	1.304	19,34
18	19	916	260	1.176	22,10
19	20	712	209	921	22,66
20	21	486	160	646	24,77
21	22	334	115	449	25,65
22	23	259	92	351	26,24
23	0	172	74	246	30,15
TOTAL		14.212	4.808	19.020	

Table 33: *Hourly traffic profile on the A23 highway for the BAU/BAT scenario*

The number of trains doesn’t change from the actual scenario, therefore it is not necessary to change any parameters of the rail tracks and rail traffic.

Having set up the new emission parameters, the simulation has been ran and the number of inhabitants that live in areas affected by noise levels defined by each noise class calculated.

As defined in 2002/49/CE, the total number of inhabitants for the noise classes are:

Interval [dB(A)]		Value					Percentages			
min	max	L_D	L_E	L_N	L_{DEN}		L_D	L_E	L_N	L_{DEN}
	50	3232	4322	3486	2371		62%	83%	67%	46%
50	55	963	568	1105	825		19%	11%	21%	16%
55	60	682	270	352	1112		13%	5%	7%	21%
60	65	206	41	99	552		4%	1%	2%	11%
65	70	111	0	142	181		2%	0%	3%	3%
70	75	7	0	17	124		0%	0%	0%	2%
75		0	0	0	36		0%	0%	0%	1%

Table 34: *Total number of inhabitants that live in the noise classes defined by 2002/49/CE*

As defined in 2002/49/CE, the total number of inhabitants living in a building without a silent façade is:

Interval [dB(A)]		Value					Percentages			
min	max	L_D	L_E	L_N	L_{DEN}		L_D	L_E	L_N	L_{DEN}
	50	3046	3501	3015	2276		71%	86%	76%	55%
50	55	775	390	781	633		18%	10%	20%	15%
55	60	397	169	179	850		9%	4%	4%	21%
60	65	75	21	16	335		2%	1%	0%	8%
65	70	9	0	0	42		0%	0%	0%	1%
70	75	0	0	0	0		0%	0%	0%	0%
75		0	0	0	0		0%	0%	0%	0%

Table 35: *Number of inhabitants that live in the noise classes, without silent façade, defined by 2002/49/CE*

As defined in 2002/49/CE, the total number of inhabitants living in a building with a silent façade is:

Interval [dB(A)]		Value					Percentages			
min	max	L_D	L_E	L_N	L_{DEN}		L_D	L_E	L_N	L_{DEN}
	50	186	821	471	95		21%	73%	39%	9%
50	55	188	178	324	192		21%	16%	27%	18%
55	60	285	101	173	262		32%	9%	14%	25%
60	65	131	20	83	217		15%	2%	7%	20%
65	70	102	0	142	139		11%	0%	12%	13%
70	75	7	0	17	124		1%	0%	1%	12%
75		0	0	0	36		0%	0%	0%	3%

Table 36: *Number of inhabitants that live in the noise classes, with silent façade, defined by 2002/49/CE*

For the simple class defined in the paragraph 5.3, the number of inhabitants living in areas affected by each noise class is:

Interval [dB(A)]		Value					Percentages			
min	max	L_D	L_E	L_N	L_{DEN}		L_D	L_E	L_N	L_{DEN}
	45	2304	3897	2654	1641		44%	75%	51%	32%
45	50	928	425	832	730		18%	8%	16%	14%
50	55	963	568	1105	825		19%	11%	21%	16%
55	60	682	270	352	1112		13%	5%	7%	21%
60	65	206	41	99	552		4%	1%	2%	11%
65	70	111	0	142	181		2%	0%	3%	3%
70	75	7	0	17	124		0%	0%	0%	2%
75		0	0	0	36		0%	0%	0%	1%

Table 37: *Total number of inhabitants that live in areas affected by "simple" noise classes.*

Defining therefore the number of people that live in a zone where the level (in the three reference period) is above or below 66 dB(A):

Interval [dB(A)]		Value					Percentages			
min	max	L_D	L_E	L_N	L_{DEN}		L_D	L_E	L_N	L_{DEN}
0	66	4182	3515	5094	4939		98%	100%	98%	95%
66		72	0	99	254		2%	0%	2%	5%

Table 38: *Number of inhabitants that live in areas where the noise level is higher than 66 dB(A).*

As expected, the number of inhabitants affected by noise is increased as a cause to the increase of heavy traffic.

6.3 ACE

The new total traffic data for this scenario are calculated from the percentages presented in the paragraph 6.1 and the table representing the actual traffic on the highway reported in paragraph 4.1. The traffic data for the scenario result:

Segment		LV	HDV	TOTAL	HDV%
GEMONA OSOPPO - CARNIA		13.164	7.436	20.599	36,1%
CARNIA - PONTEBBA		6.786	5.784	12.571	46,0%
PONTEBBA - UGOVIZZA TARV.		6.458	6.101	12.559	48,6%

Table 39: *Total traffic on the A23 highway segments for the ACE scenario*

Since in the simulation software the propagation is defined from the total number of vehicles that travel on the roads and the percentage of heavy duty traffic for all the hours of the day, it is necessary to recalculate the hourly profile of the traffic during the day with these values. The resulting profile is:

Hour from	Hour to	Number of Light vehicles	Number of Heavy duty vehicles	Total number of vehicles	Percentage of heavy duty vehicles
0	1	86	42	128	32,73
1	2	81	25	106	23,66
2	3	60	40	100	39,99
3	4	58	56	114	49,03
4	5	85	78	163	47,89
5	6	156	151	307	49,13
6	7	367	156	523	29,86
7	8	809	204	1.013	20,11
8	9	1.011	193	1.204	16,00
9	10	1.026	193	1.219	15,80
10	11	1.076	191	1.267	15,05
11	12	1.019	238	1.257	18,94
12	13	908	253	1.161	21,79
13	14	870	219	1.089	20,15
14	15	894	198	1.092	18,14
15	16	887	194	1.081	17,97
16	17	888	219	1.107	19,75
17	18	1.052	183	1.235	14,83
18	19	916	189	1.105	17,09
19	20	712	152	864	17,55
20	21	486	116	602	19,30
21	22	334	84	418	20,04
22	23	259	67	326	20,54
23	0	172	54	226	23,87
TOTAL		14.212	3.493	17.705	

Table 40: *Hourly traffic profile on the A23 highway for the ACE scenario*

For this scenario it is defined a new number of train traffic. The new values of freight traffic have been set up, in accordance to the percentage defined in the scenario table, as follows:

	Length = 400 m			Length = 500 m		
	day	evening	night	day	evening	night
Gemona	2	3	5	28	11	12
Carnia	2	3	5	28	10	13
Pontebba	2	3	5	27	10	13
Tarvisio	2	3	5	27	10	13

Table 41: *Number of freight trains in each reference period, for all the segments, for the ACE scenario*

Having set up the new emission parameters, the simulation has been ran and the number of inhabitants that live in areas affected by noise levels defined by each noise class calculated.

As defined in 2002/49/CE, the total number of inhabitants for the noise classes are:

Interval [dB(A)]		Value					Percentages			
min	max	L_D	L_E	L_N	L_{DEN}		L_D	L_E	L_N	L_{DEN}
	50	3024	4388	3402	2306		58%	84%	65%	44%
50	55	1029	609	993	765		20%	12%	19%	15%
55	60	752	179	440	1090		14%	3%	8%	21%
60	65	222	25	196	619		4%	0%	4%	12%
65	70	116	0	112	248		2%	0%	2%	5%
70	75	58	0	58	115		1%	0%	1%	2%
75		0	0	0	58		0%	0%	0%	1%

Table 42: *Total number of inhabitants that live in the noise classes defined by 2002/49/CE*

As defined in 2002/49/CE, the total number of inhabitants living in a building without a silent façade is:

Interval [dB(A)]		Value					Percentages			
min	max	L_D	L_E	L_N	L_{DEN}		L_D	L_E	L_N	L_{DEN}
	50	2871	3558	2912	2192		67%	87%	73%	53%
50	55	842	391	732	614		20%	10%	18%	15%
55	60	498	117	280	820		12%	3%	7%	20%
60	65	64	15	41	424		1%	0%	1%	10%
65	70	7	0	0	66		0%	0%	0%	2%
70	75	0	0	0	1		0%	0%	0%	0%
75		0	0	0	0		0%	0%	0%	0%

Table 43: *Number of inhabitants that live in the noise classes, without silent façade, defined by 2002/49/CE*

As defined in 2002/49/CE, the total number of inhabitants living in a building with a silent façade is:

Interval [dB(A)]		Value					Percentages			
min	max	L_D	L_E	L_N	L_{DEN}		L_D	L_E	L_N	L_{DEN}
	50	153	830	490	114		17%	74%	40%	11%
50	55	187	218	261	151		20%	19%	21%	14%
55	60	254	62	160	270		28%	6%	13%	25%
60	65	158	10	155	195		17%	1%	13%	18%
65	70	109	0	112	182		12%	0%	9%	17%
70	75	58	0	58	114		6%	0%	5%	11%
75		0	0	0	58		0%	0%	0%	5%

Table 44: *Number of inhabitants that live in the noise classes, with silent façade, defined by 2002/49/CE*

For the simple class defined in the paragraph 5.3, the number of inhabitants living in areas affected by each noise class is:

Interval [dB(A)]		Value					Percentages			
min	max	L_D	L_E	L_N	L_{DEN}		L_D	L_E	L_N	L_{DEN}
	45	2267	4025	2489	1693		44%	77%	48%	33%
45	50	757	363	913	613		15%	7%	18%	12%
50	55	1029	609	993	765		20%	12%	19%	15%
55	60	752	179	440	1090		14%	3%	8%	21%
60	65	222	25	196	619		4%	0%	4%	12%
65	70	116	0	112	248		2%	0%	2%	5%
70	75	58	0	58	115		1%	0%	1%	2%
75		0	0	0	0		0%	0%	0%	0%

Table 45: *Total number of inhabitants that live in areas affected by "simple" noise classes.*

Defining therefore the number of people that live in a zone where the level (in the three reference period) is above or below 66 dB(A):

Interval [dB(A)]		Value					Percentages			
min	max	L_D	L_E	L_N	L_{DEN}		L_D	L_E	L_N	L_{DEN}
0	66	5039	5201	5041	4833		97%	100%	97%	93%
66		162	0	160	368		3%	0%	3%	7%

Table 46: *Number of inhabitants that live in areas where the noise level, in the selected reference period, is higher than 66 dB(A).*

For this scenario the road traffic is slightly decreased, but since the freight traffic is about doubled the population is exposed to higher levels of noise.

Due to the high increase in the freight trains number, there are a few very critical situations, as observable there are 58 people living in areas affected by L_{DEN} greater than 75 dB(A).

7 Conclusions

In this work we modelled the geometry of the Tarvisio Corridor scenario from the data provided by Insiel and those found in the Technical Regional Map. We set up the emission of the noise sources with the data representing the actual traffic of the A23 highway (provided by *Autostrade per l'Italia)* and the number train that travel on the rail tracks (provided by *RFI* and *Trenitalia*). The data of the dwelling population was provided by the municipalities of the area.

Having set up the model, we proceeded to simulate the noise levels for the actual 2012 situation and calculate the number of inhabitants affected by the noise pollution.

The World Health Organization defines an important noise limit for the night reference period, all the inhabitants that live in areas where the nightly noise level is higher than 55 dB(A) are at serious health risk [18], [20]. Furthermore, the World Health Organization defines L_{DEN} = 66 dB(A) as the noise limit of the whole day.

For the actual 2012 situation, according to our results, there are 249 inhabitants (1.5% of total population) living in areas where L_{DEN} is equal or higher than 66 dB(A). The number of inhabitants affected by L_N higher than 55 dB(A) is 573, 3.4 % of the total population.

After the study of the present situation, we conducted other simulations to predict the variation of the noise levels in the future 2020 WP6 scenarios BAU/BAT and ACE. For both scenarios we found higher noise levels and observed that the number of inhabitants affected by noise increased.

For the BAU/BAT Scenario, there are 254 inhabitants (1.5%) living in areas where L_{DEN} is higher than the limit value and 640 (3.6%) affected by noise higher than the limit value during night. The variation expected from the actual situation is therefore minimal.

For the ACE Scenario, the results show 368 (2.2%) inhabitants living in areas where L_{DEN} is higher than the limit value and 806 (4.8%) affected by noise higher than the limit value during night. Due to the increase of train traffic and the fact that a high fraction of trains travel during the night the results for this scenario are much worse than the actual situation and the BAU/BAT scenario.

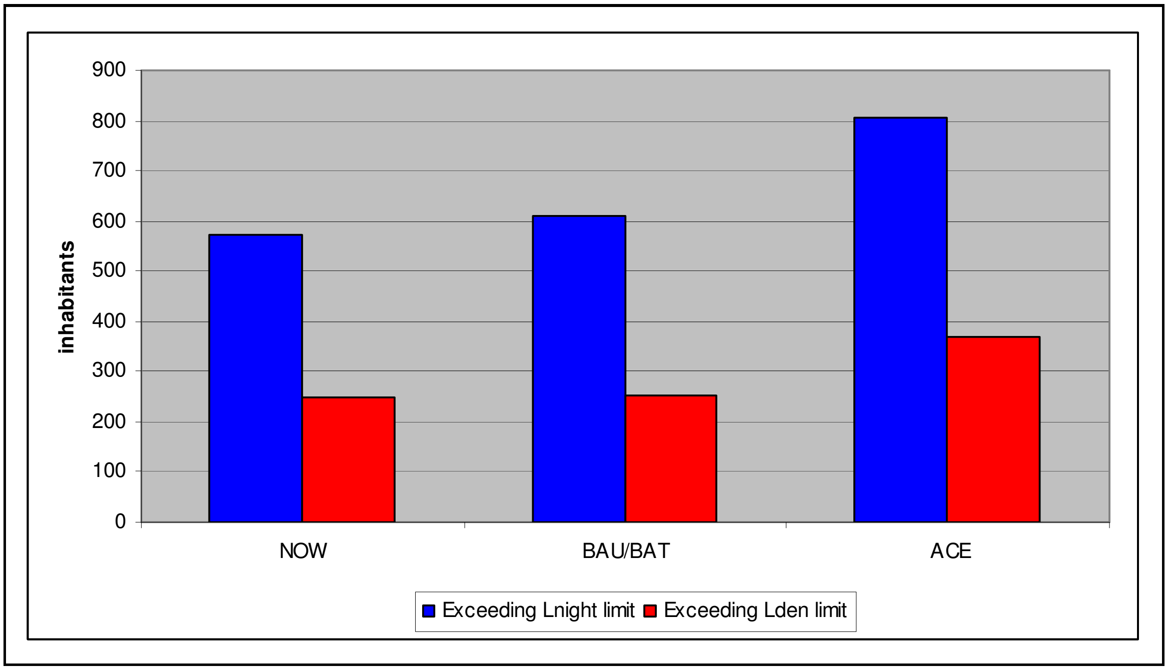


Figure 49: *Inhabitants living in areas where the noise limit is exceeded for the present situation and the future scenarios*

From the analysis of the scenarios we can conclude that the situation of noise pollution on the Tarvisio corridor is expected to get worse in the next years. Therefore, it would be advisable to monitor the corridor in the future, in order to identify critical situations and be able to take corrective actions, such as installing new noise barriers were needed, quickly

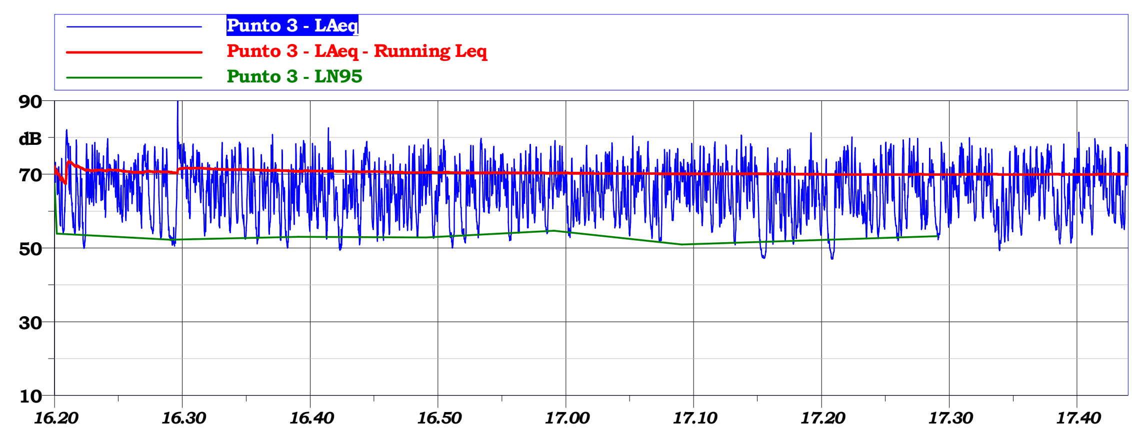
8 Appendix A: Noise Campaigns results

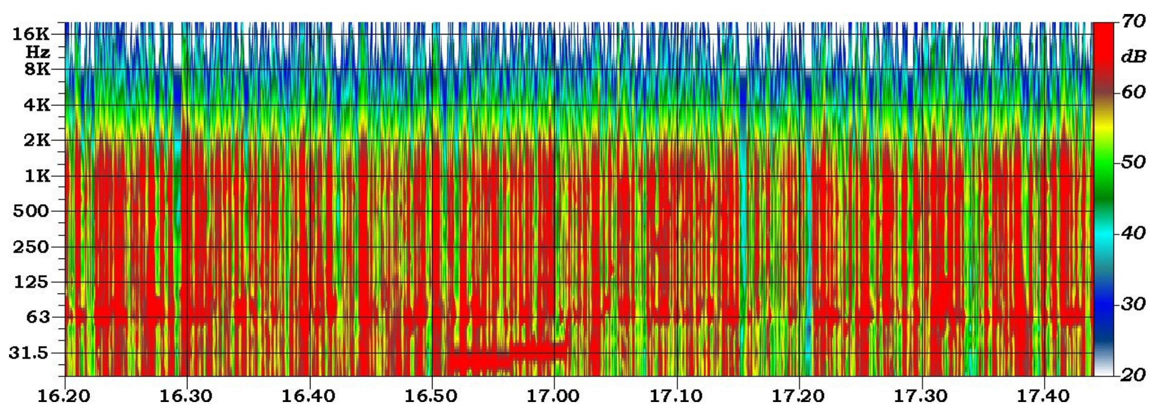
In this appendix we present the results of the most important measurements performed on the Tarvisio Corridor. As said in the document the short term measurements are used to calibrate the model and the long term ones to verify the results calculated by the noise modelling software.

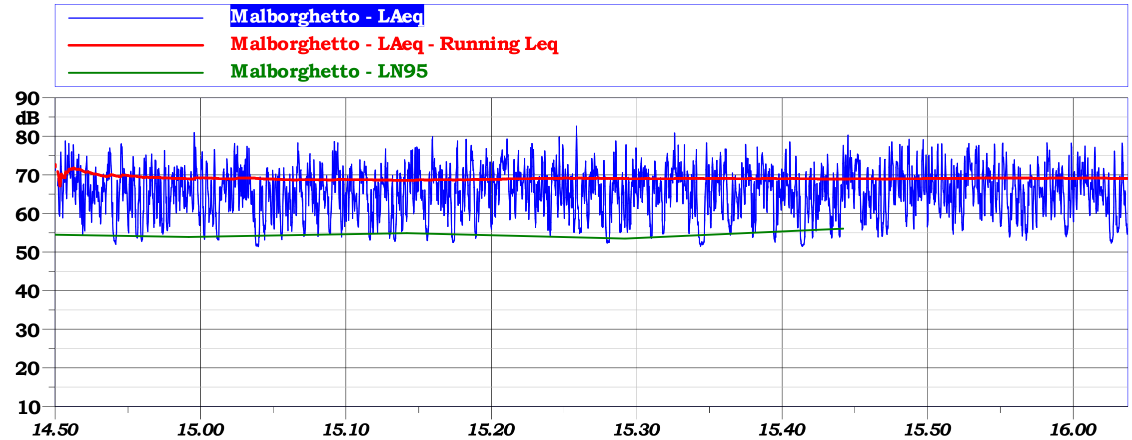
8.1 Short Term Measurements

Malborghetto

Measuring point	Date	Start	End	Light vehicles	Heavy duty Vehicles	Light vehicles speed	Heavy duty vehicles speed	Measured Level	Calculated Level	Δ
	dd/mm/yyyy	hh:mm	hh:mm	count	count	km/h	km/h	dB(A)	dB(A)	dB
4	03/05/2011	16:20	17:20	580	249	117	95	70,1	70,5	0,4
4	24/08/2011	15:02	16:02	853	152	120	100	69,1	69,3	0,2







Malborghetto - LAeq
Malborghetto - LAeq - Running Leq
Malborghetto - LN95
90
dB
80
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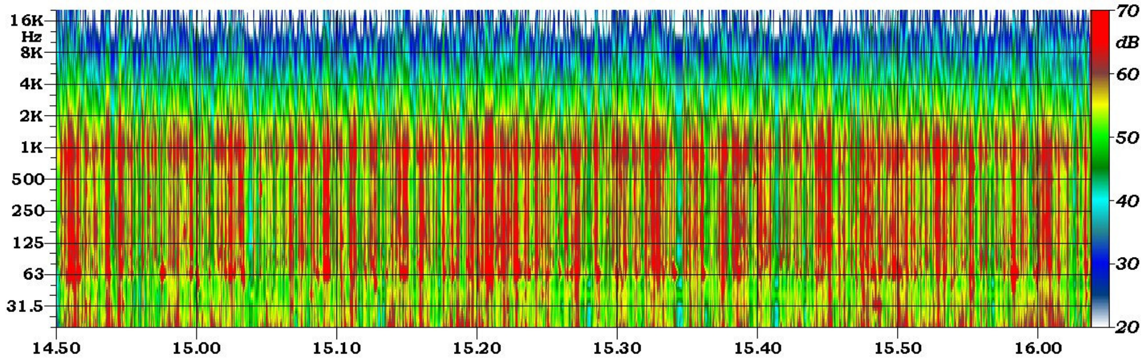
16.00



16K
Hz
8K
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1K
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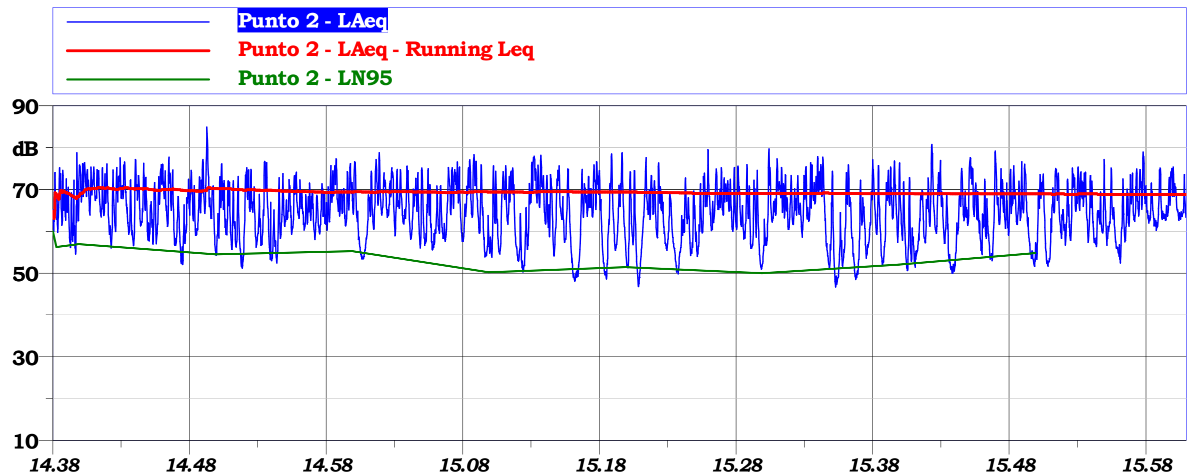
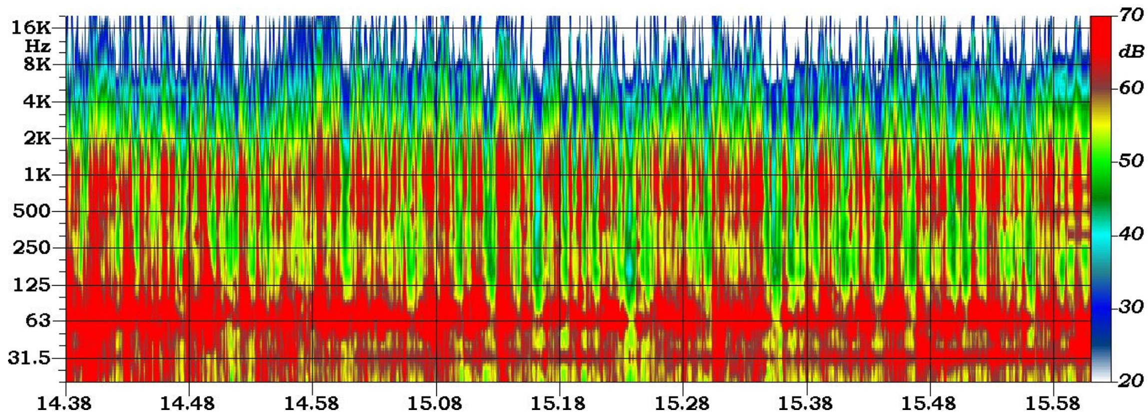
250
125
63
31.5
70
dB
60
50
40
30
20
14.50
15.00
15.10
15.20
15.30
15.40
15.50
16.00

Tarvisio - Dawit

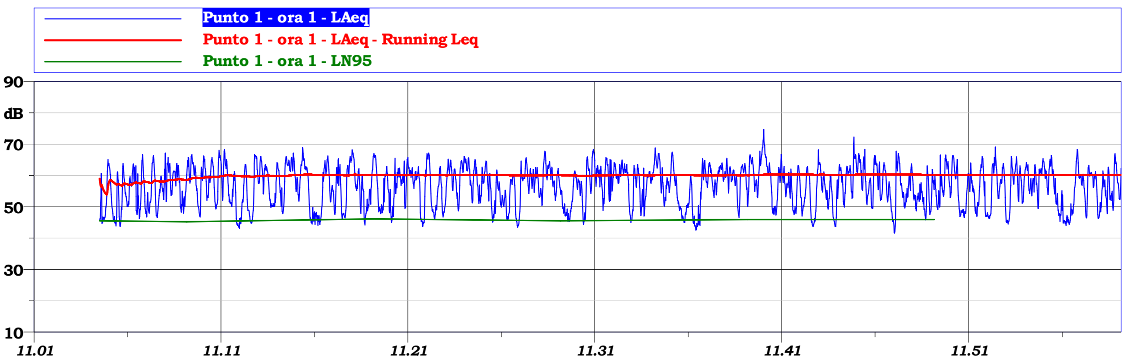
Measuring point	Date	Start	End	Light vehicles	Heavy duty Vehicles	Light vehicles speed	Heavy duty vehicles speed	Measured Level	Calculated Level	Δ
	dd/mm/yyyy	hh:mm	hh:mm	count	count	km/h	km/h	dB(A)	dB(A)	dB
5	03/05/2011	14:38	15:38	325	158	113	96	68,6	68,1	0,5

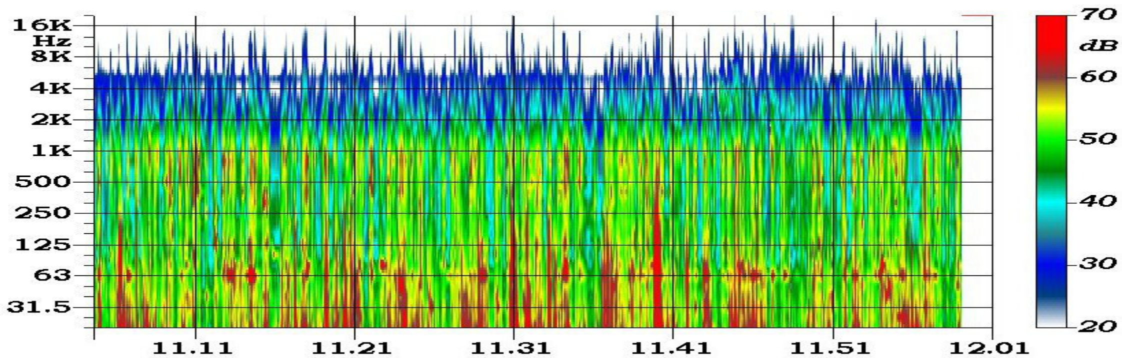




Tarvisio-Camporosso, 30m from A23

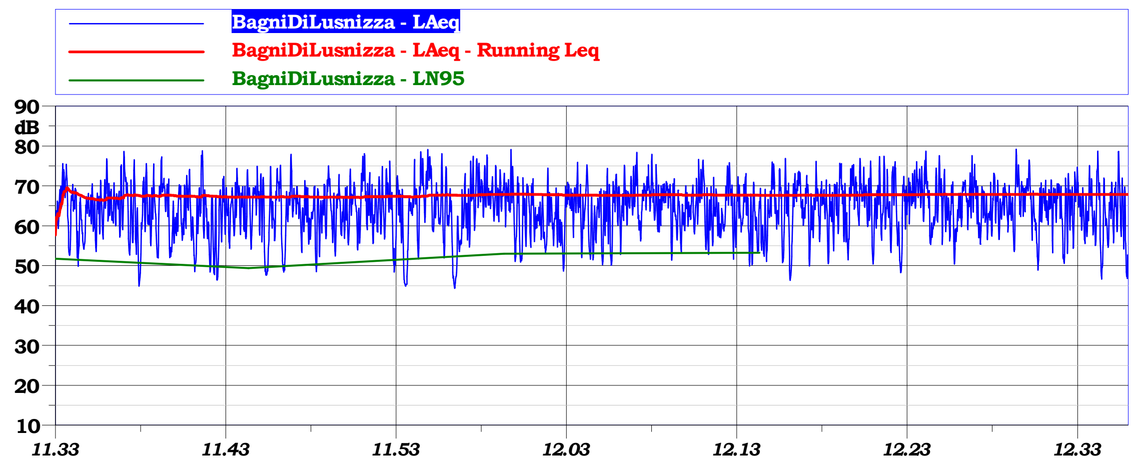
Measuring point	Date	Start	End	Light vehicles	Heavy duty Vehicles	Light vehicles speed	Heavy duty vehicles speed	Measured Level	Calculated Level	Δ
	dd/mm/yyyy	hh:mm	hh:mm	count	count	km/h	km/h	dB(A)	dB(A)	dB
6	03/05/2011	10:41	11:41	410	131	113	103	60,1	60,5	0,4

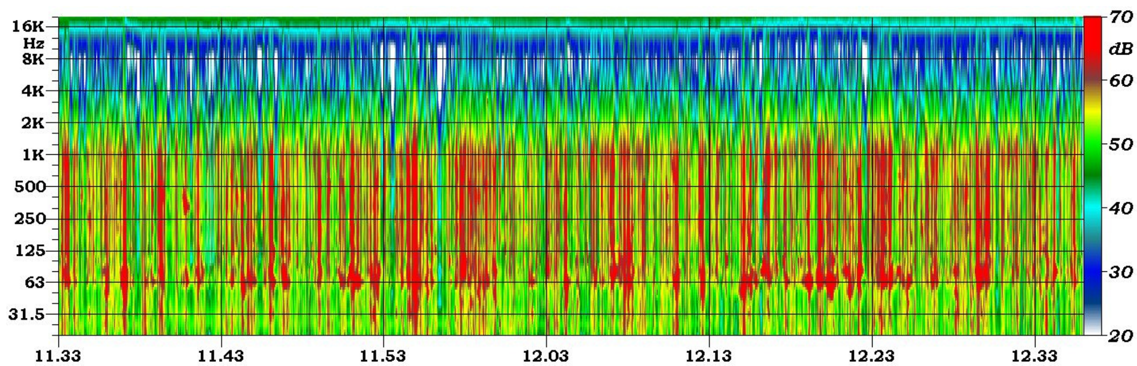




Bagni di Lusnizza

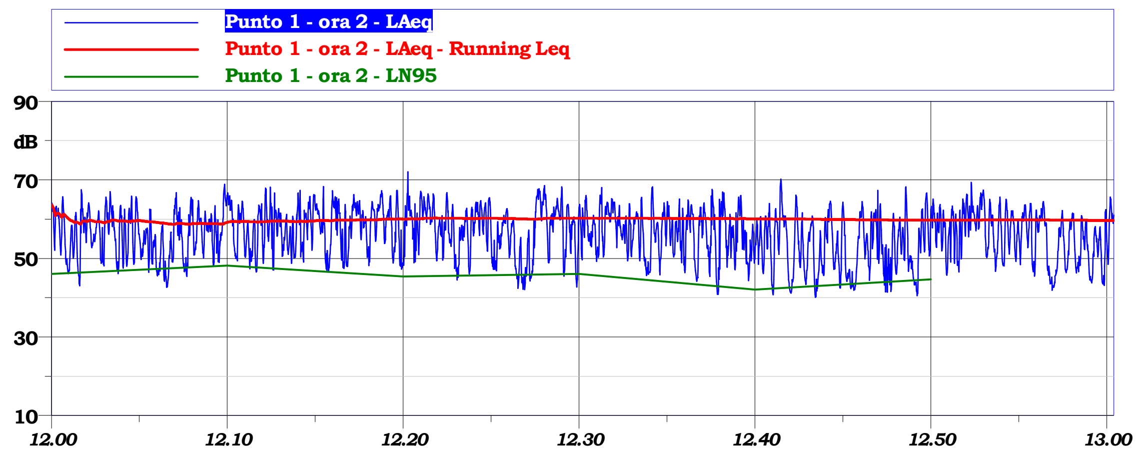
Measuring point	Date	Start	End	Light vehicles	Heavy duty Vehicles	Light vehicles speed	Heavy duty vehicles speed	Measured Level	Calculated Level	Δ
	dd/mm/yyyy	hh:mm	hh:mm	count	count	km/h	km/h	dB(A)	dB(A)	dB
7	24/08/2011	11:35	12:35	1224	189	115	97	67,9	70,2	2,3

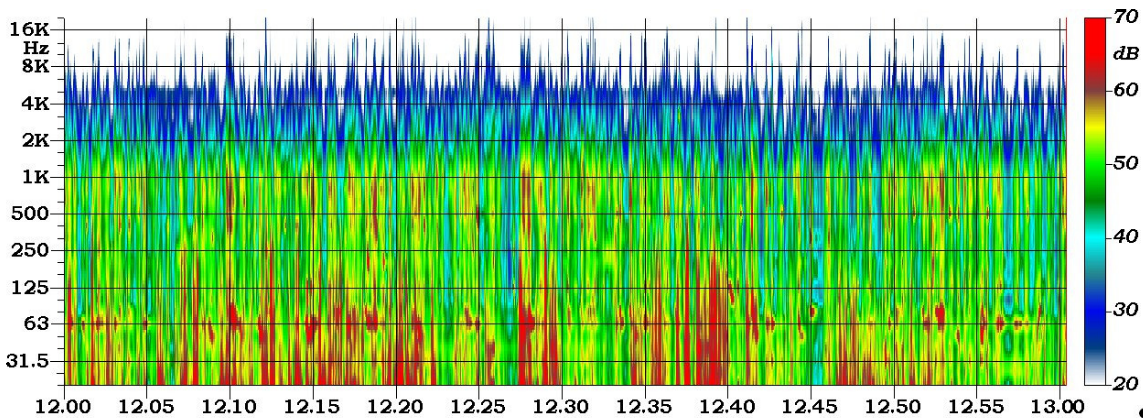




Tarvisio – Rutte di Camporosso, 20m from A23

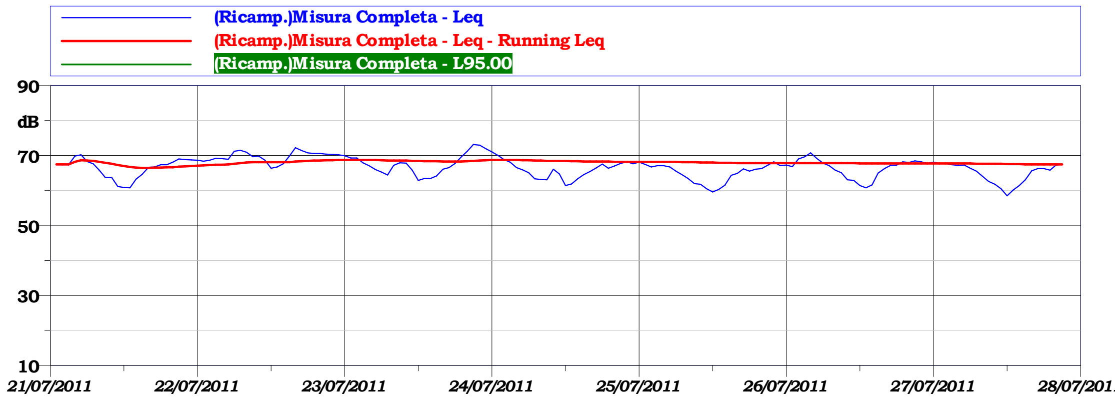
Measuring point	Date	Start	End	Light vehicles	Heavy duty Vehicles	Light vehicles speed	Heavy duty vehicles speed	Measured Level	Calculated Level	Δ
	dd/mm/yyyy	hh:mm	hh:mm	count	count	km/h	km/h	dB(A)	dB(A)	dB
8	03/05/2011	12:00	13:00	380	140	114	101	59,7	60,0	0,3

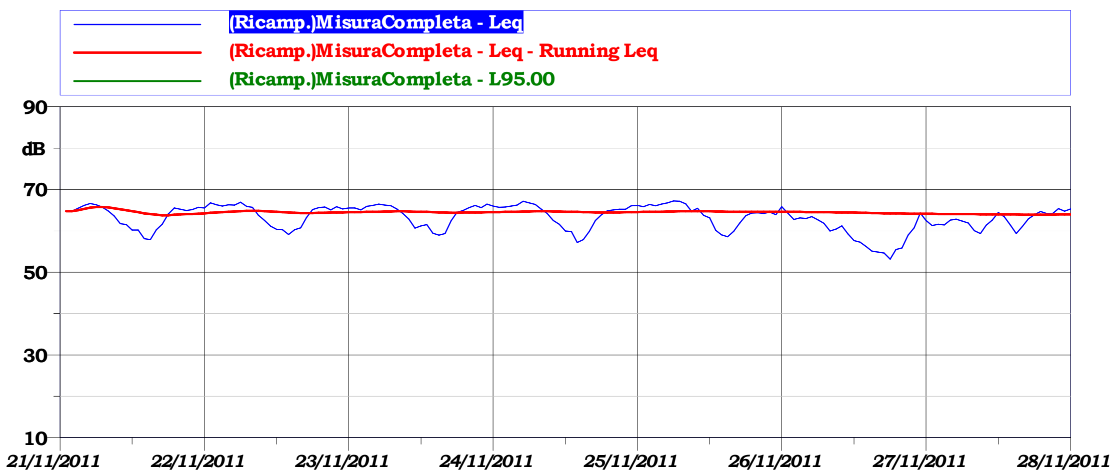




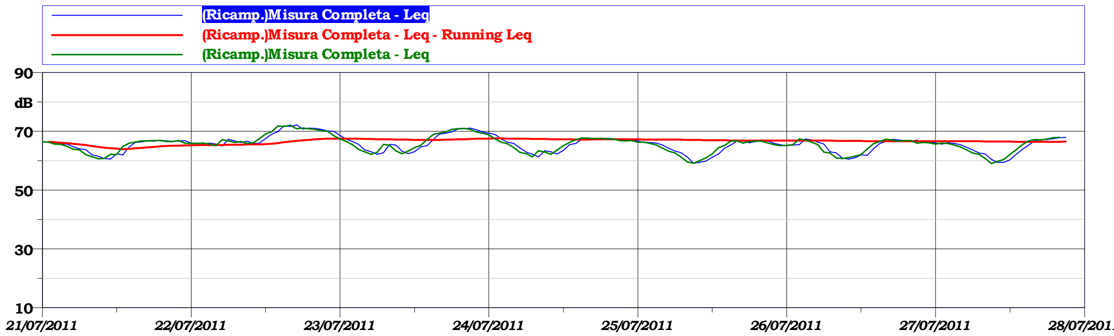
8.2 Long Term Measurements

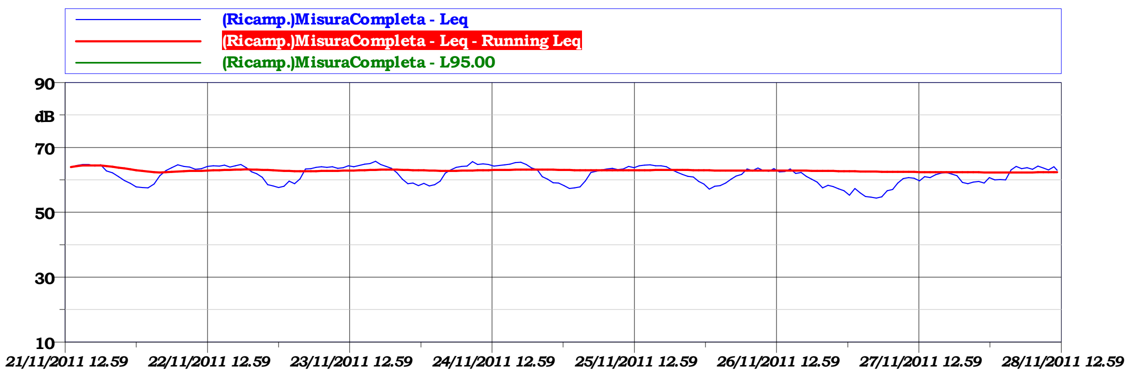
BagniDiLusnizza



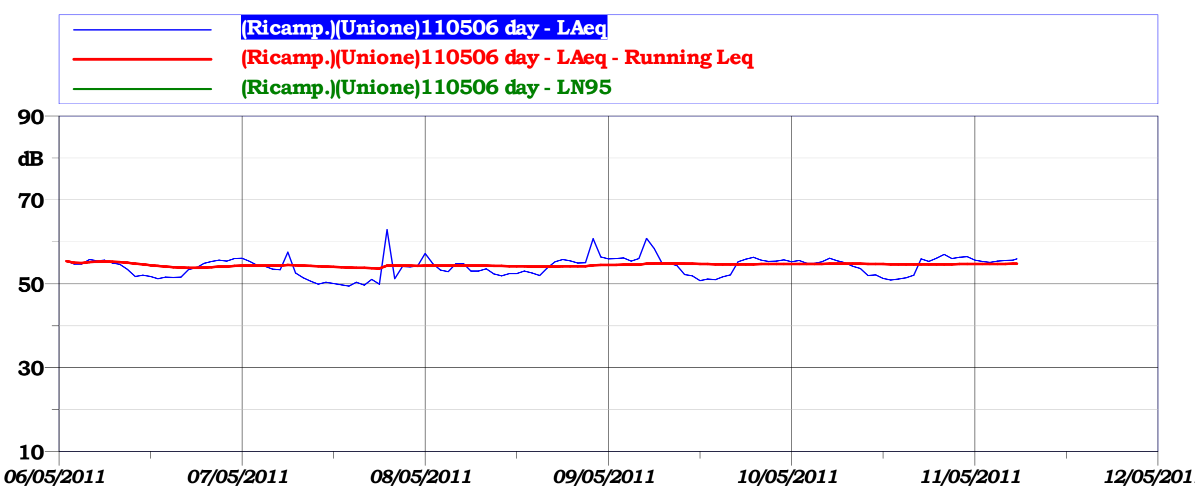


Rue di Camporosso

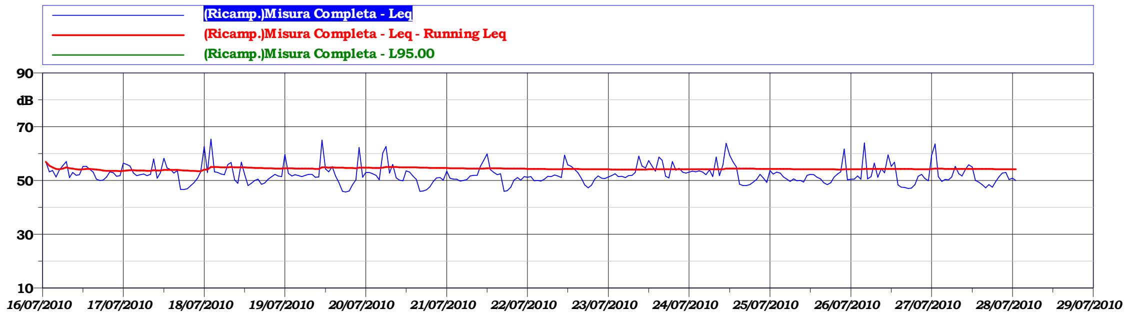




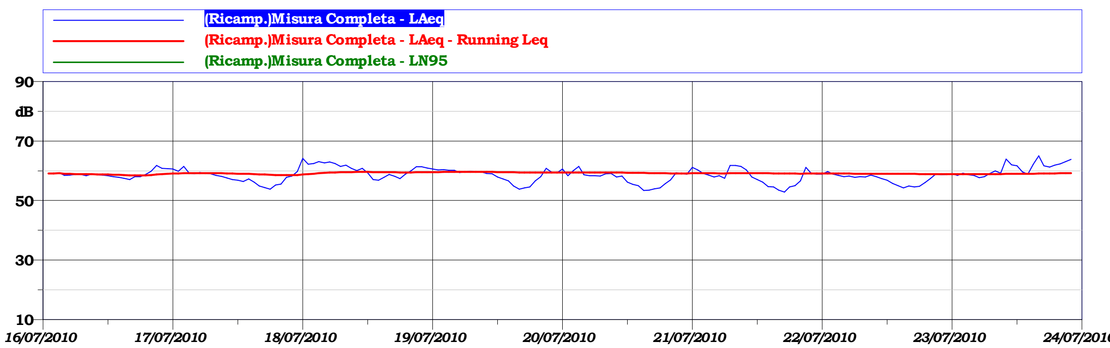
Borgo Angelo

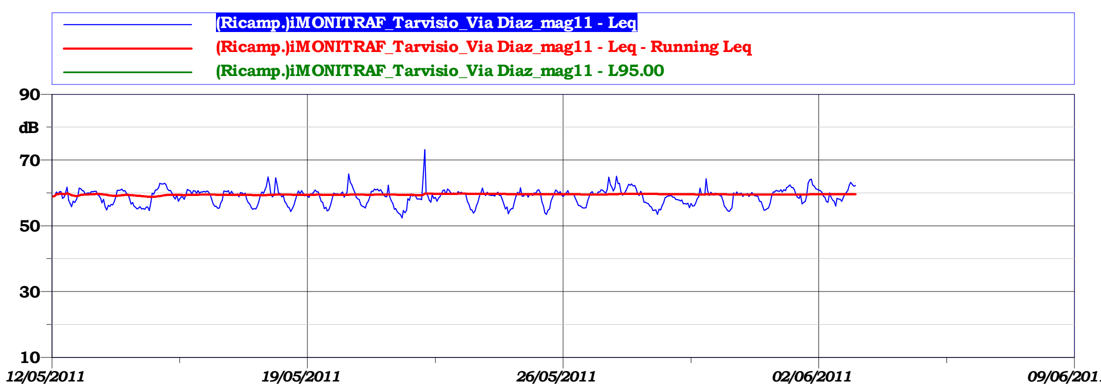


Camporosso



Tarvisio, Via Diaz





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