

DELIVERABLE 4

“Noise reduction Action Plans”



LIFE 09 ENV/IT/102

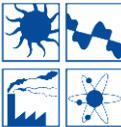
NADIA

*Noise Abatement
Demonstrative and
Innovative Actions
and information to
the public*

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1 Introduction

The European Directive 2002/49/EC [1], implemented in Italy by the Legislative Decree n°194/2005 [2], imposes the realization of Noise Action Plans on the managing authorities of high traffic roads, railways, airports and urban agglomerations with more than 100.000 inhabitants. Action 4 of NADIA Project focuses on the realization of Noise Action Plans for 5 roads managed by the Provinces of Genova and Savona (Table 1), and for selected parts of the agglomerations of Prato and Vicenza.

Table 1 List of the roads managed by the Provinces of Genoa and Savona and analysed within NADIA Project

Managing authority	Road	Managing authority	Road
Province of Genova (PROVGE)	SP 33	Province of Savona (PROVSV)	SP 28 bis
	SP 35		SP 29
	SP 225		SP334
	SP 333		-
	SP 523		-

The Noise Action Plans were prepared using the data collected in the Action 2 of the project and the noise maps done in the Action 3 (Table 2). The results of these activities are reported respectively in Deliverable 1 and 3 of the project, both available on the NADIA website [3].

The realization of the Noise Action Plans was made in compliance with the Italian Technical report UNI/TR 11327:2009 [4].

Table 2: Organization of NADIA Project

N°Action	Description	N° Action	Description
1	Project Management	6	Dissemination
2	Surveys	7	Monitoring
3	Noise Mapping	8	After LIFE communication plan
4	Action plans definition	9	Audit
5	Demostrative action for noise reduction		

1.1 Italian legal context

1.1.1 Law n.447/1995

The Italian Law n°447 of 26/10/1995, “*Legge quadro sull'inquinamento acustico*” (trad: “*Framework law on noise pollution*”) [5], defines the basic principles for the environmental protection from noise. The law specifies the duties of the State, Regions, Provinces and Municipalities and states the basic contents of the Noise abatement plan of a Municipality:

- a) *Identification of noise sources and of their effects;*
- b) *Individuation of authorities responsible for noise abatement measures;*
- c) *Definition of the priorities, modalities and time needed for noise abatement measures;*
- d) *Cost estimation of each one of the noise abatement measure foreseen by the Plan.*

The noise abatement plans should be coordinated with the Urban Traffic Plan and with other city plans foreseen by the legislation.

1.1.2 D.P.C.M 14/11/1997

The decree [6] defines the characteristics of six classes of acoustic areas that the territory of a Municipality must be divided in (Table 3); each area has two noise limits, one for the daytime (06:00-22:00) and one for the night-time period (22:00-06:00) (Table 4).

Table 3: Definition of the six noise classes by D.P.C.M. [6]

CLASS I Areas to be protected In these areas quiet is fundamental for their use, such as hospitals, schools, parks, etc.
CLASS II: Residential areas Urban areas characterized by local traffic, low population density, limited presence of commercial activities and absence of factories.
CLASS III: Mixed areas Urban areas with medium population density, presence of commercial activities and without industrial activities. The road traffic is not intensive.
CLASS IV: Areas of intense human activity Urban areas with intensive road traffic, high population density and high density of commercial activities. Areas close to high business zones, major roads and rail traffic infrastructures are included in this class.
CLASS V: Mainly industrial areas Urban areas mainly occupied by industrial activities. Low density of population.
CLASSE VI: Exclusively industrial areas Areas occupied exclusively by industrial activities.

Table 4: Absolute noise limits for the six classes [6]

Class	Noise Limits [dB(A)]	
	Daytime (6:00- 22:00)	Night-time (22:00 - 6:00)
CLASS I Areas to be protected	50	40
CLASS II: Residential areas	55	45
CLASS III: Mixed areas	60	50
CLASS IV: Areas of intense human activity	65	55
CLASS V: Mainly industrial areas	70	60
CLASSE VI: Exclusively industrial areas	70	70

1.1.3 D.M. 29/11/2000

The decree [7] defines the criteria for the elaboration of the noise abatement plans of transport infrastructure. The decree defines the legislative obligations and determines a rating system for the noise abatement activities.

A rate P is assigned to each area to be rehabilitated:

$$P = \sum R_i (L_i - L_{*i}) \quad (1.1)$$

where:

- R_i is the product between the population living inside an area or a building and the coefficient "a". The value of the coefficient "a" is 3 for schools, 4 for hospitals and 1 for other buildings;
- L_i is the sound pressure level evaluated on the façade of the most critical building [dB(A)];
- L_{*i} is the limit value [dB(A)] established by the Italian law for the considered area/building. If L_{*i} is larger than L_i then $(L_i - L_{*i})$ is set equal to 0.

1.1.4 D.P.R. 30/03/2004 n. 142

The decree [8] introduces acoustic buffer zones for roads: in these zones the noise level emitted by the road must be lower than the limits reported in Table 5. These areas have to be designed through an offset operation of each road considered. The extension of the buffer zones and the corresponding noise limits depend on the road typology, which is defined by [9].

Table 5: Noise limits inside the acoustic buffer zones of roads

Road Typology [11]	Sub-typology	Buffer extension [m]	Noise limit [dB(A)]			
			Schools, Hospitals, Retirement homes		Residential Buildings	
			Daytime (6:00- 22:00)	Night-time (22:00 - 6:00)	Daytime (6:00- 22:00)	Night-time (22:00 - 6:00)
A (highway)		100 (A)	50	40	70	60
		150 (B)	50	40	65	55
B (Main extra-urban road)		100 (A)	50	40	70	60
		150 (B)	50	40	65	55
C (Secondary extra-urban road)	Ca	100 (A)	50	40	70	60
		150 (B)	50	40	65	55
	Cb	100 (A)	50	40	70	60
		50 (B)	50	40	65	55
D (Urban highway)	Da	100	50	40	70	60
	Db	100	50	40	65	55
E (Urban road)		30	Defined by the municipality in compliance with [6]			
F (Local road)		30				

(A) First and (B) second acoustic buffer zone. The extension of (B) is referred to the distance between its boundaries and the one of (A).

1.1.5 European Directive 2002/49/EC and the Italian implementation D. Lgs. 194/2005

The European Directive 2002/49/EC [1], implemented in Italy by the D. Lgs. 194/05 [2] introduces the concept of Noise Action Plans defined as "*Plans designed to manage noise issues and effects, including noise reduction if necessary*". The minimum requirements of Noise Action Plans are defined in Annex V of the Directive:

- *description of the agglomeration or of the major roads taken into account;*
- *authority responsible for the plan;*
- *legal context;*
- *any limit values;*
- *summary of the noise mapping activities;*
- *estimation of people exposed to noise;*
- *record of public consultations;*
- *noise-reduction measures already planned or in force;*
- *financial information, if available, including cost-benefit analysis;*
- *long-time strategy.*

Noise reduction actions may also include:

- *traffic planning;*
- *land-use planning;*
- *technical measures at noise sources;*
- *selection of less noisy sources;*
- *reduction of sound transmission;*
- *regulatory or economic measures or incentives.*

Moreover the reduction of the number of persons affected by noise thanks to the realization of noise abatement measures must be calculated. The European Directive and the Italian implementation shall not apply to noise generated by the exposed person himself and by military activities in military areas.

1.1.6 UNI/TR 11327/2009

UNI/TR 11327/2009 [4] is a technical report issued by the Italian Standardization Organization (UNI) that gives useful criteria to draw up noise action plans. The standard identifies two typologies of approach for Noise Action Plans:

- a) *Strategic*: the noise reduction measures are defined from a strategic point of view;
- b) *Design*: the noise reduction action are defined in detail and designed.

The first one is related to the definition of guidelines of Noise Action Plans specifying the general criteria for noise reduction actions planning and design.

A Noise Action Plan defined using the second approach brings to the design of each noise abatement measure and its feasibility and efficiency is evaluated through detailed cost/benefit analysis.

Generally an approach mixing the two aforementioned ones should be preferred.

The standard suggests to follow a flowchart in the elaboration of Noise Action Plans (Figure 1).

The *Strategic* approach for Noise Action Plans is focused on the phase 1 of the flowchart while in the *Design* approach phases 2, 3 and 4 are carried out in detail.

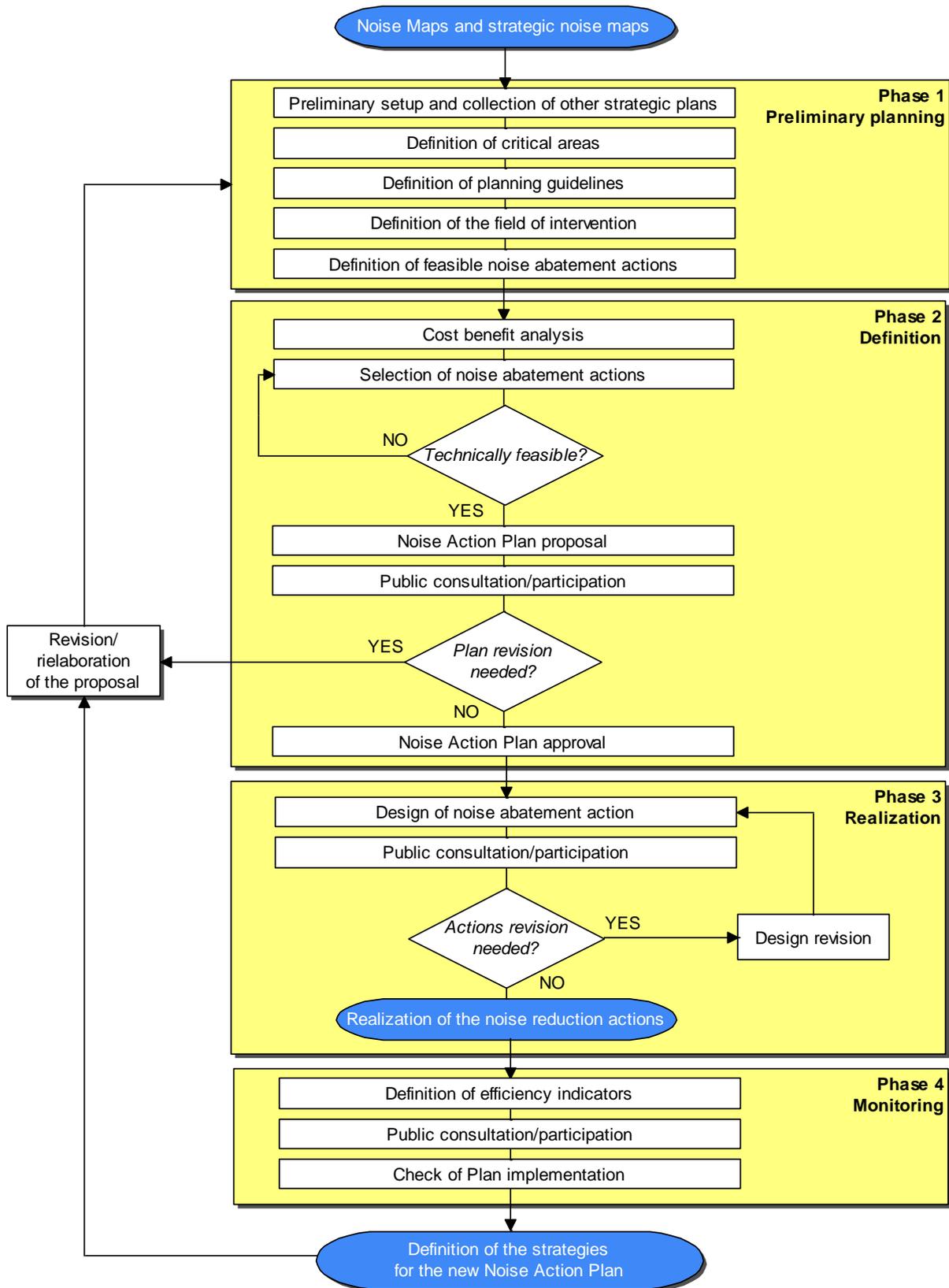


Figure 1: Flowchart for the elaboration of Noise Action Plans given by UNI/TR 11327

2 Description of the roads and of the agglomerates analysed within NADIA Project

The NADIA project considers five roads managed by the Province of Genova (S.P. 33, 35, 225, 333, 523), three roads in Province of Savona (S.P. 28bis, 29, 334) and wide parts of the agglomerates of Vicenza and Prato. The following sections report a brief description of each case study.

The maps containing the road axis and the acoustic zoning of the adjacent areas for each road and agglomerate analyzed in the NADIA project are reported in Annex 1. The acoustic classes are taken from the acoustic zoning plan of each municipality in which the road are located, in compliance with the requirements of [5], [6] and [8].

2.1 Roads managed by the Province of Genova

Figure 2 reports an overview of the five roads analysed in the project. A brief description of the roads is reported in the following paragraphs.

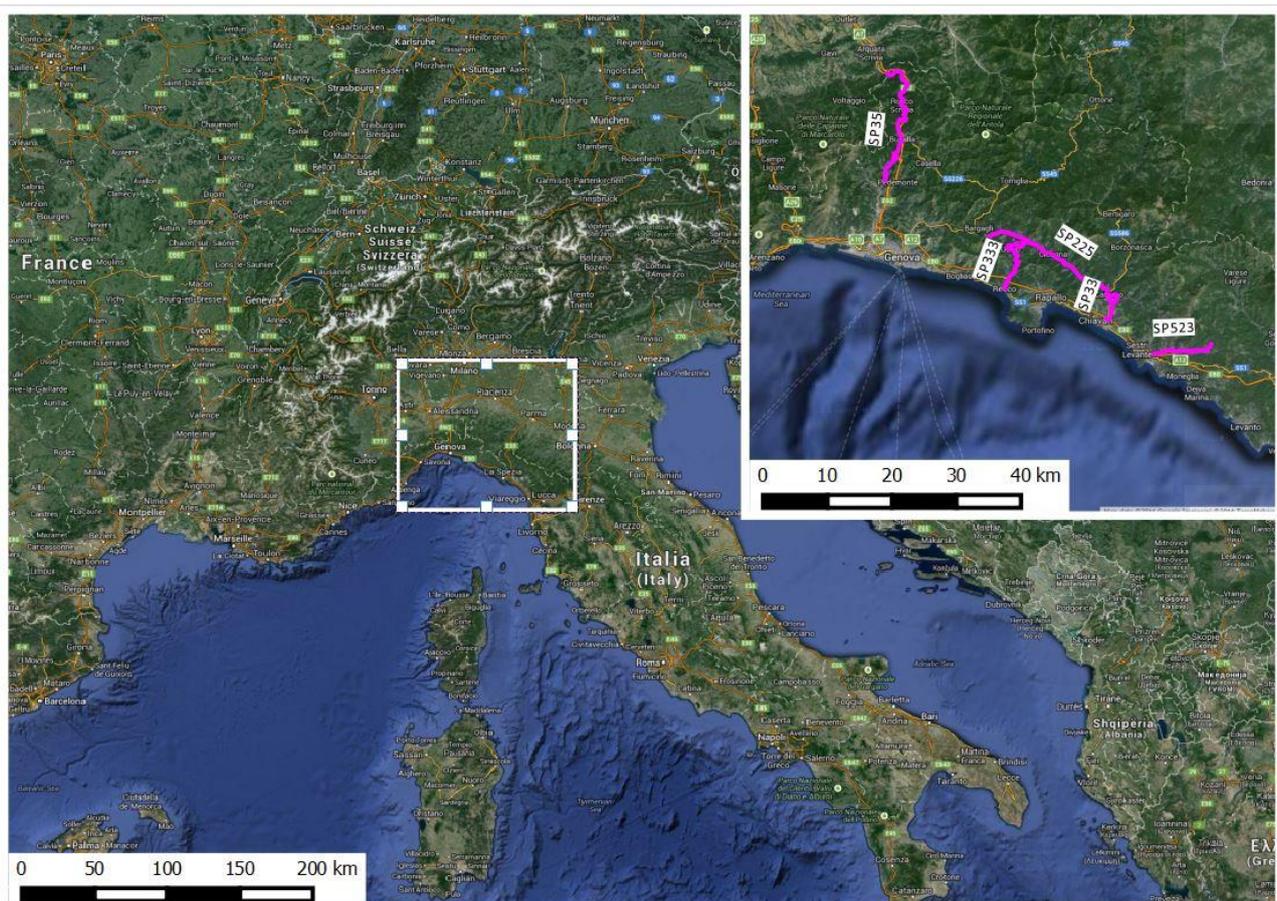


Figure 2: Overview of the roads managed by the Province of Genova analysed in the project.

2.1.1 S.P.33

The S.P. (*strada provinciale*) 33, also called “di San Salvatore”, links the towns of Lavagna and Carasco. The road is one of the most important of the province of Genova as it connects the Ligurian hinterland with the sea. Moreover the S.P. 33 ends nearby the A12, an Italian motorway that is a part of the European route E 80. The road passes through the municipalities of Lavagna, Cogorno and Carasco and has a length of 7,800 km. The road is characterized by a tortuous path and passes through several urban areas; for this reason the measured vehicles speed unlikely exceeds 50 km/h.

2.1.2 S.P. 35

The S.P. 35, also called “dei Giovi”, links Genova with the province of Alessandria (in Piemonte region) and passes through the municipalities of Genova, Campomorone, Mignanego, Busalla, Ronco Scrivia and Isola del Cantone. The A7, an Italian motorway linking Milano with Genova, runs parallel to the S.P. 35 inside the Liguria region. Between Genova and the town of Busalla the road has a tortuous path and has a purely local use. Between the towns of Busalla and Pietrabissara (the last town within the province of Genova before the border with the province of Alessandria) the road is used to move between the regions of Liguria and Piemonte. The length of the road is about 27,800 km.

2.1.3 S.P.225

The S.P. 225, also called “*della Fontanabuona*”, was managed by ANAS¹ until 2001 and is now managed by the Province of Genova. The road connects the towns of Chiavari and Bargagli. The importance of the S.P. is due to its strategic position; moreover the road connects two important roads managed by ANAS, the S.S. 1 and the S.S. 45. The first one connects Rome with the French border (nearby Ponte San Luigi) while the second one links Genova with Piacenza. Therefore the S.P. 225 is important both for touristic and industrial routes. The road passes through the municipalities of Lumarzo, Moconesi, Cicagna, Orero, Coreglia Ligure, S. Colombano Certenoli, Carasco and Chiavari. The length of the road is about 26,700 km.

2.1.4 S.P.333

The S.P. 333, also called “*di Uscio*”, connects the towns of Recco and Gattorna and passes through the municipalities of Recco, Avegno, Uscio and Moconesi. The road is mainly characterized by a tortuous path and many slope variations. Between the towns of Recco and Colle Caprile the road has a local usage, but it is also used to connect the industrial and commercial areas of Recco with the

¹ Italian government-owned company deputed to the construction and maintenance of Italian motorways and state highways under the control of Italian Ministry of Infrastructure and Transport.

surrounding towns. Between the towns of Colle Caprile and Gattorna the S.P. 333 has a very tortuous path and a purely local usage. The length of the road is about 19,700 km.

2.1.5 S.P. 523

The S.P. 523, also called “Cento Croci”, links the town of Sestri Levante, located in front of the Ligurian Sea, with the peripheral areas of the province of Parma. The road passes through the municipalities of Sestri Levante, Casarza Ligure and Castiglione Chiavarese. The managing authority of the road is the Province of Genova, except for the part inside the municipality of Sestri Levante that is directly managed by the municipality. The road connects the urban areas of the Ligurian coast nearby Sestri Levante with the provinces of La Spezia and Parma. The length of the part of the S.P. 523 managed by the Province of Genova is about 12,565 km. The road passes through several small villages located in hilly and mountainous zones; the road carriageway is limited in these stretches.

2.2 Roads managed by the Province of Savona

Figure 3 reports an overview of the five roads analysed in the project. A brief description of the roads is reported in the following paragraphs.

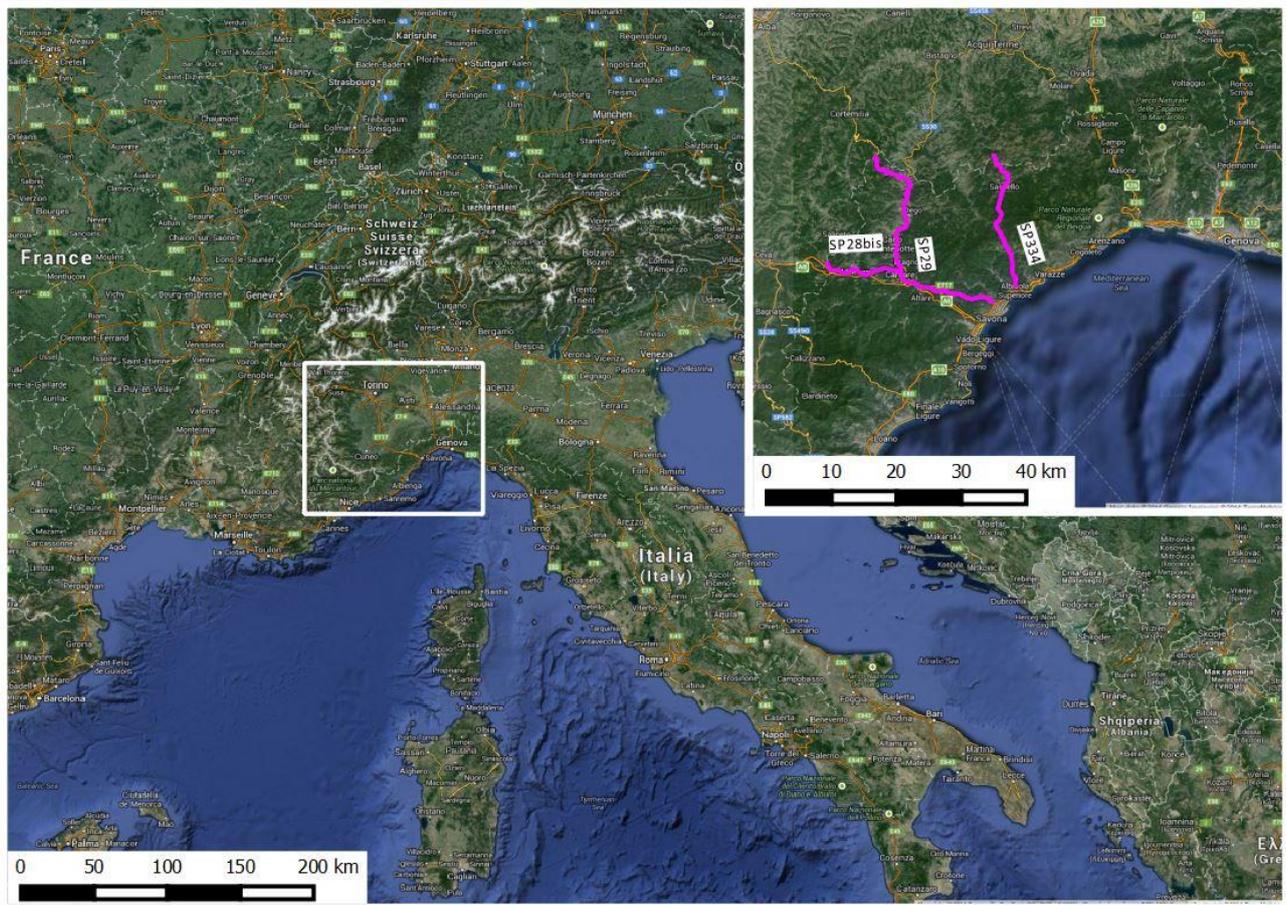


Figure 3: Overview of the roads managed by the Province of Savona analysed in the project.

2.2.1 S.P. 28bis

The S.P. 28bis, also called "*del Col di Nava*" connects the towns of Carcare and Millesimo and stretches to the town of Montezemolo located in Piemonte region. The road represents an alternative path to the motorway A6 for the traffic between Carcare and the Piemonte southern areas. For this reason the road has not only a local usage. Nearby the town of Carcare the S.P. 28bis is connected to another road taken into account inside NADIA project, the S.P. 29. The length of the road is about 13,500 km.

2.2.2 S.P. 29

The S.P. 29, also called "*del Colle di Cadibona*", links the northern area of Savona (and consequently the Ligurian coast nearby Savona) with the inland part of the province of Savona and with the southern part of Piemonte region (this second usage is due also to its link with the S.P. 28bis nearby the town of Carcare).

Between Savona and the town of Altare the road has a tortuous path but it has not only a local usage. It is also used to connect (in particular the heavyweight traffic) the inland areas with the Ligurian Sea and with the motorway A6.

The road has a less tortuous path Between Altare e Cairo Montenotte and has almost the same usage of the previous path. The last road segment has a very tortuous path as it passes through mountainous areas. The length of the road is about 44,100 km.

2.2.3 S.P. 334

The S.P. 334, also called "*del Sassello*", connects the towns of the Ligurian coast near Savona with the inland part of the province of Savona and with the southern part of Piemonte region. The road passes through the municipalities of Albisola Superiore, Stella, Pontinvrea and Sassello.

The tortuosity of the road is higher between the towns of Sassello and Ponte dell'Erro. The road has not only a local usage as It is also used to connect (in particular the heavyweight traffic) the inland areas with the Ligurian Sea and with the motorway A6. The length of the road is about 26,300 km.

2.3 Agglomerate of Vicenza

2.3.1 Brief description of the city

The agglomerate of Vicenza is included within the administrative boundaries of the municipality of Vicenza. Vicenza is located in north-eastern Italy, approximately 60 km west of Venice and 200 km east of Milan. The city is located in the area of the Venetian Plain limited on the southern part by the Monti Berici and on the western part by the Monti Lessini. The city is crossed by the Bacchiglione River.

The municipality of Vicenza covers an area of 80,49 km² with an average altitude of 39,37 m a.s.l. and the following uses:

- Urban Area (27,09 km², 34% of the municipal area);
- Non-urban industrial areas (5,15 km², 6%);
- Cultivated for agricultural purposes (4,07 km², 5%)
- Forests and woods (2,57 km², 3%)
- Body of water (1,27 km², 3%);
- Others.

As of 31/12/2011, Vicenza had an estimated population of 115.665 (Source: ISTAT, the Italian National Institute of Statistics).The city is widely characterized by the works of Andrea Palladio, one of the most important architects of the sixteenth-century. For this reason the city has been enlisted as UNESCO World Heritage Site since 1994. The urban area is affected by the noise emission of:

- Municipal road network;
- Controlled-access highways A4 and A31;
- Other road networks;
- Rail networks.

The Noise Action Plan of the agglomerate of Vicenza is limited to the urban area of the municipality of Vicenza.

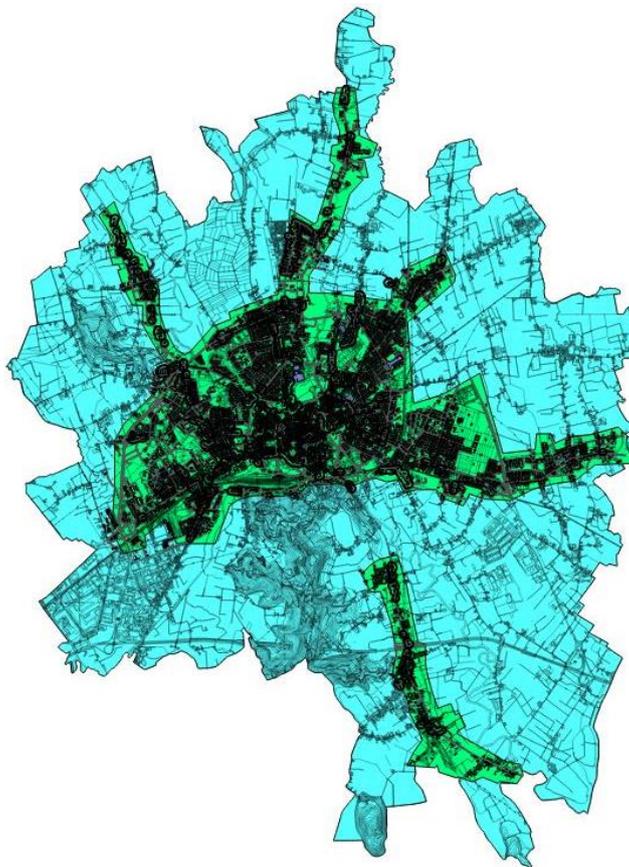


Figure 4: In green the urban area studied within NADIA Project. In cyan the agglomerate of Vicenza.

2.3.2 Municipal road network

The road network managed by the Municipality of Vicenza is constituted by three elements:

- the three ring roads:
 - the ring road around the thirteen-century wall;
 - the ring road around the old town of Vicenza;
 - the external ring road.
- the roads connecting the center of the city with the extra-urban area;
- the roads connecting the center of the city with the highways exits of Vicenza Est and Vicenza Ovest.

Inside the old town of Vicenza there is a restricted traffic zone (ZTL) regulated by 8 access points controlled by cameras. Only the following categories of vehicles are admitted inside the ZTL:

- vehicles owned by residents in buildings inside the ZTL (only for the path between their own parking area and the ZTL access points);
- vehicles having disability access permit;
- vehicles of the Police, Fire Brigade and of the Emergency Department.

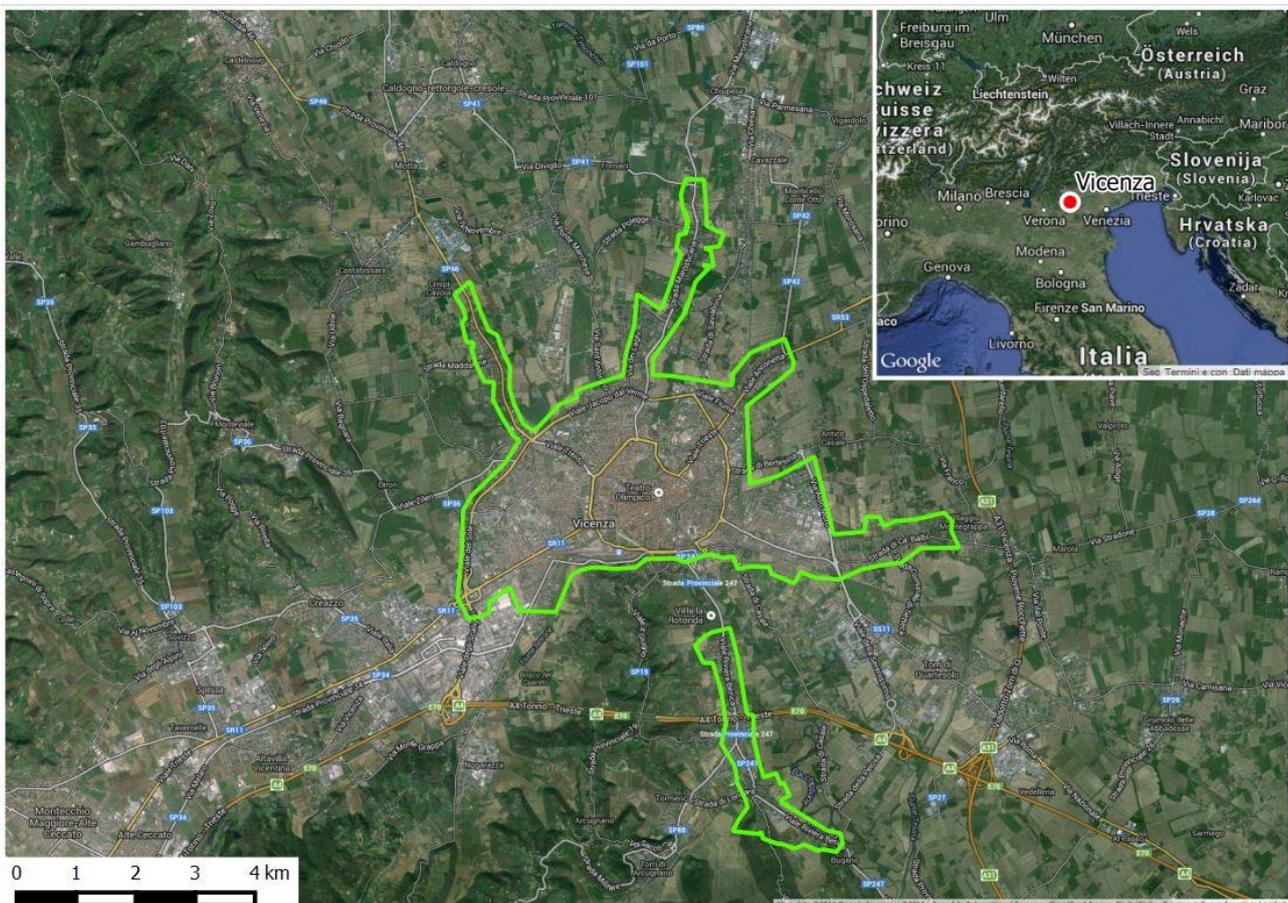


Figure 5: Overview of the municipality of Vicenza. The boundaries of the urban area are marked in green

2.3.3 Highways A4 and A31

The controlled access highway A4 links the cities of Turin and Trieste passing also near the cities of Milan, Brescia Verona, Padova, Vicenza and Venice. The A4 is a dual-carriageway, six-lane motorway for the most of its length. The urban area of Vicenza is slightly affected by the noise emission of the A4; the motorway crosses the area considered within the NADIA project only in a little southern part.

The A31 is a dual-carriageway, four-lane motorway passing outside the urban area of Vicenza (and consequently outside the area considered within the NADIA project). Both the infrastructures have their own noise action plan, realized by their managing authority, the "Autostrada Brescia Verona Vicenza Padova" S.p.A. [10].

2.3.4 Other road networks

The municipality of Vicenza is crossed by roads managed by ANAS (government-owned company deputed to the construction and maintenance of Italian motorways and state highways under the control of the Italian Ministry of Infrastructure and Transport.), Veneto Region and Province of Vicenza. Nevertheless the noise emission of these roads does not affect the urban area of the agglomerate.

2.3.5 Rail networks

The urban area of the agglomerate of Vicenza is affected by the noise emission of three railways:

- Milan-Venice. Classified by RFI (the owner of Italy's railway network that provides signalling, maintenance and other services for the railway network) as a *fundamental line* (rail infrastructures having high traffic and high quality);
- Vicenza-Treviso. Classified by RFI as *complementary line* (rail infrastructures having a medium traffic that connects the *fundamental lines*);
- Vicenza-Schio. A line for Diesel locomotives that links Vicenza with the other cities and town of the Province of Vicenza.

RFI manages all the three railways.

2.4 Agglomerate of Prato

2.4.1 Brief description of the city

The agglomerate of Prato is included within the administrative boundaries of the municipality of Prato. Prato is located at the outlet of the Bisenzio Valley half way of the plain - which had its origins in a large lake gradually filled up with sediments transported by rivers - on which rise Florence and Pistoia. The town is surrounded by the Calvana Mountains and the Monteferrato hills. From industrial and unhabituated areas, woods and cultivated lands can be easily reached. The municipality of Prato covers an area of 97,56 km². The city is situated at the foot of

Monte Retaia (768 m (2,520 ft)), the last peak in the Calvana chain. The lowest altitude in the municipality is 32 m (105 ft), near the Cascine di Tavola, and the highest is the peak of Monte Cantagrillo at 818 m (2,684 ft). The Bisenzio River, a tributary of the Arno, flows through it. The Municipality of Prato has an estimated population of 191.791 (Source: ISTAT, the Italian National Institute of Statistics).

The Municipality of Prato has approved in 2005 the first step of the Action Plan and in 2009 the second step. The Plan led to the realization of a noise barrier along Viale Leonardo da Vinci and Viale Nam Dinh.

Moreover in 2013 the Municipality, in collaboration with Tuscany Region and RFI (national railroad company,) has designed and approved the project of acoustic barriers along railroad from the administrative border to the central station.

The city area is affected by the noise emission of:

- Municipal road network;
- Controlled access highways A11;
- Rail networks.

The Noise Action Plan of the agglomerate of Prato is limited to the urban area of the municipality of Prato.

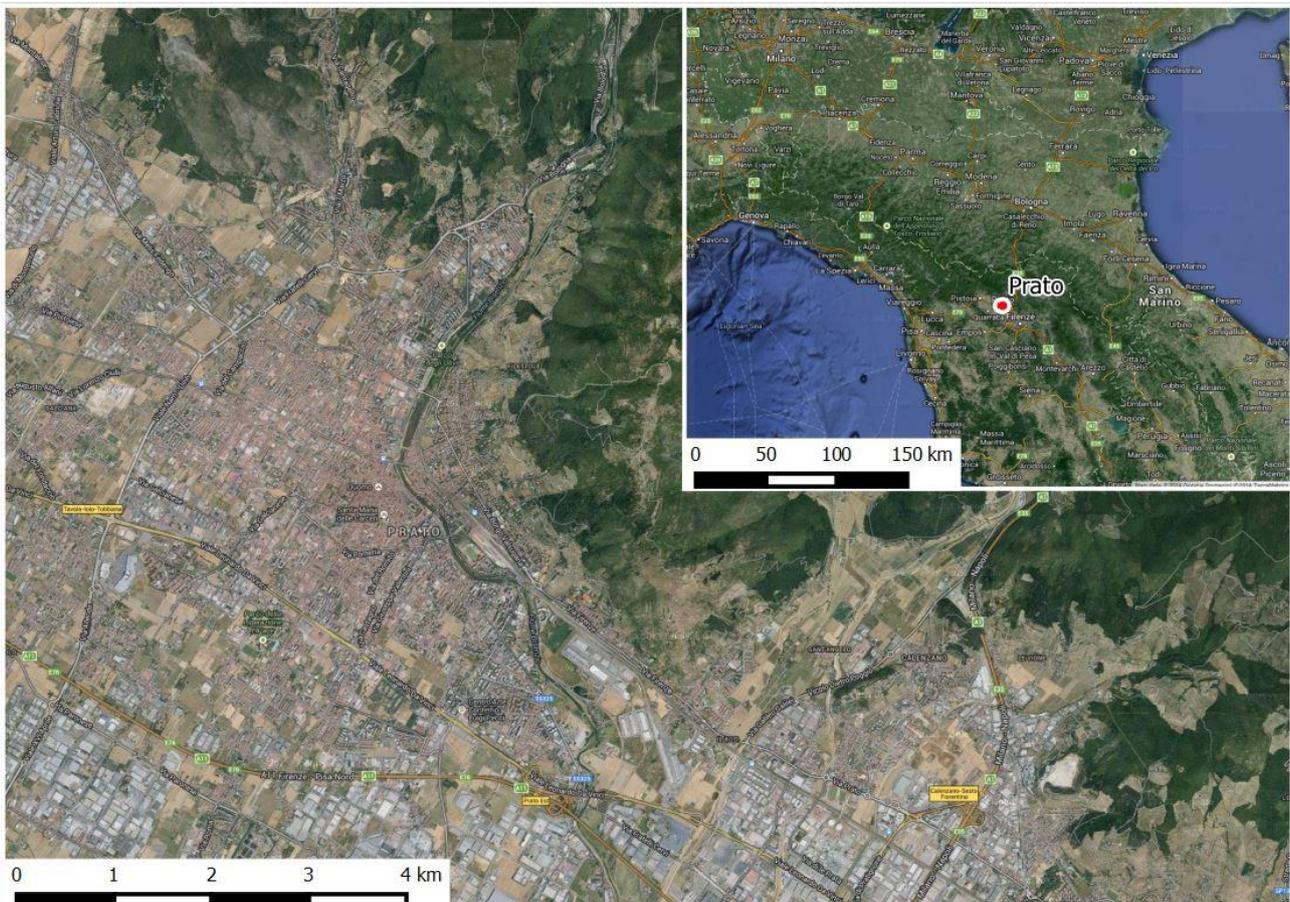


Figure 6: Overview of the municipality of Prato.

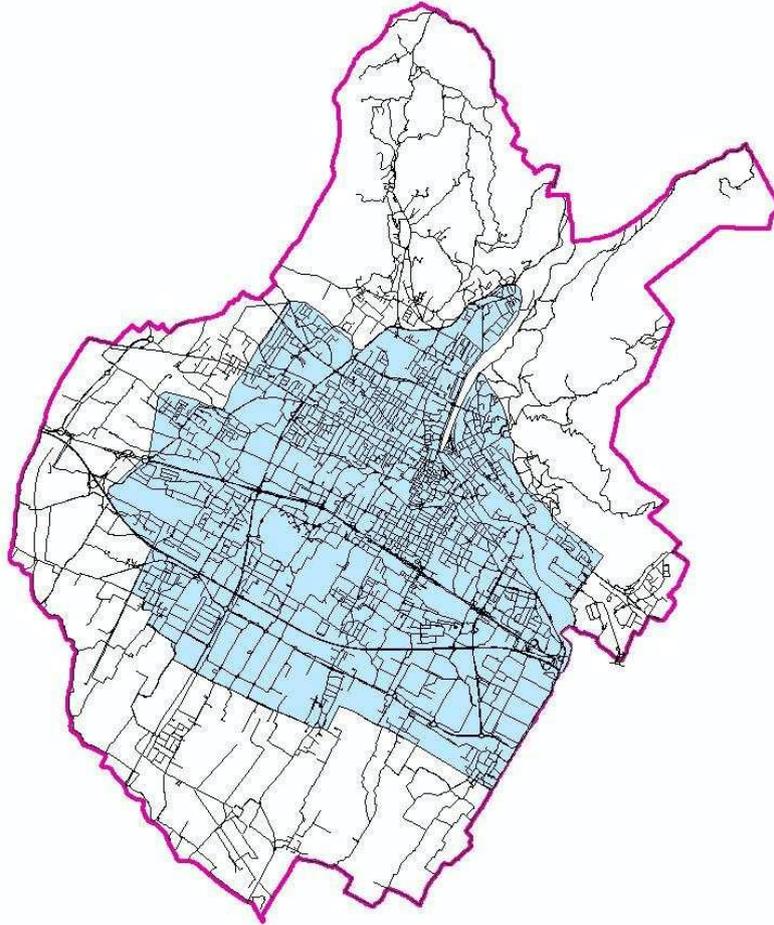


Figure 7: The urban area studied within NADIA Project is coloured in cyan. The magenta line is the administrative boundary of the municipality of Prato.

2.4.2 Municipal road network

The roads managed by the Municipality of Prato characterized by high traffic flow are:

- Viale Leonardo da Vinci;
- The 1st part of the "Tangenziale Ovest" (Viale Nam Dinh, Viale S. Allende and Viale F.lli Cervi);
- The 2nd part of the "Tangenziale Ovest";
- Via Aldo Moro, Via Paronese and Via di Baciacavallo (these roads play an important role for the industrial area of Prato).

The length of the road network managed by the Municipality of Prato is higher than 600 km. The viability in the old town of Prato, positioned in the centre of its urban area, is conditioned by:

- Pedestrian zone named APU (*Area Pedonale Urbana*). In Figure 8 the roads in which the transit of motor vehicles is forbidden are highlighted in red;

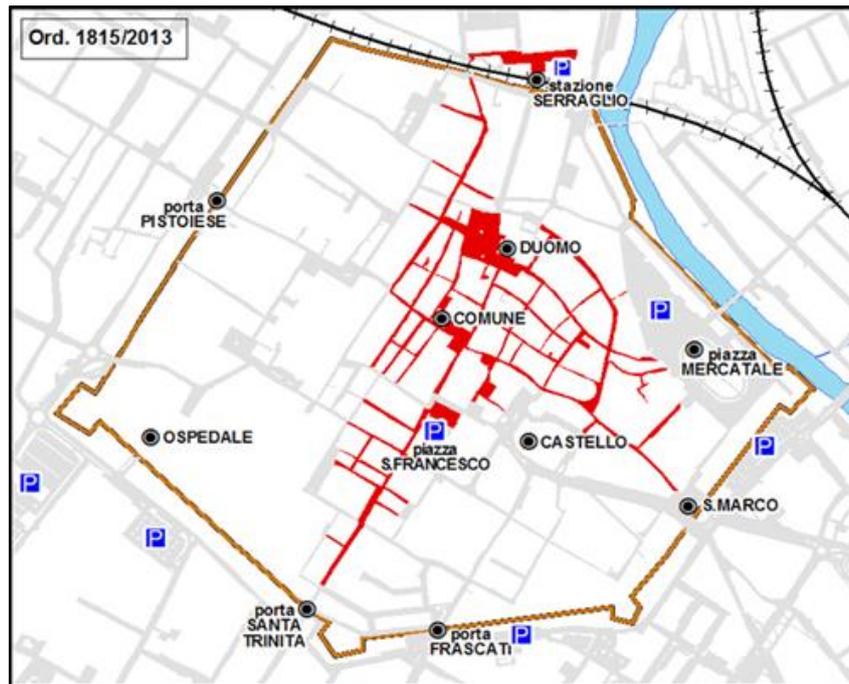


Figure 8: Pedestrian zone (in red) in the urban area of Prato

- Restricted traffic zone ZTL. In Figure 9 the roads in which the transit of motor vehicles is forbidden from 07:30 to 18:30 are highlighted in blue;

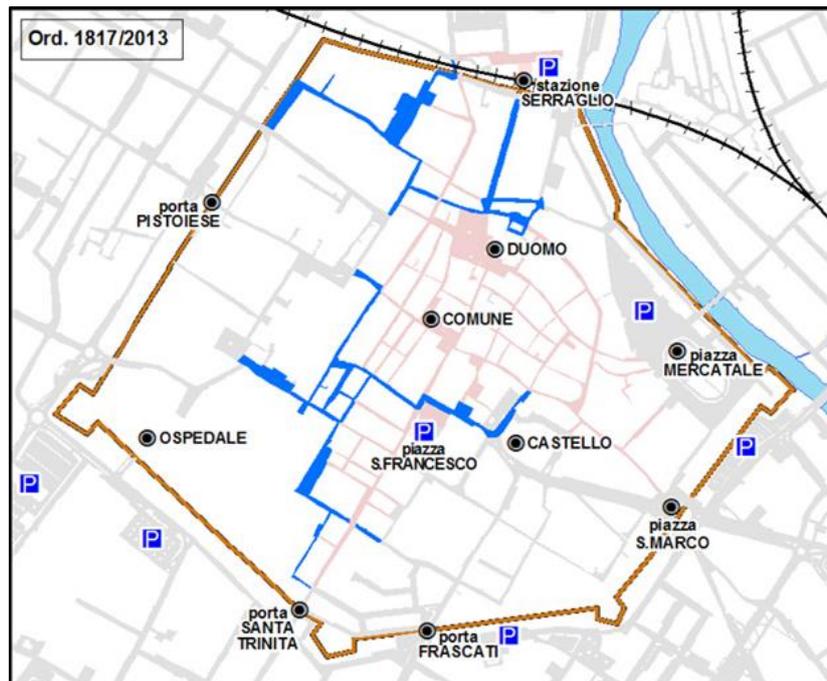


Figure 9: Restricted traffic zones (in blue) in the urban area of Prato

- Controlled traffic zones ZTC (coloured in green, brown, yellow and pink in Figure 10). Only the vehicles holding a permit (*bollino blu*) can transit in these areas.

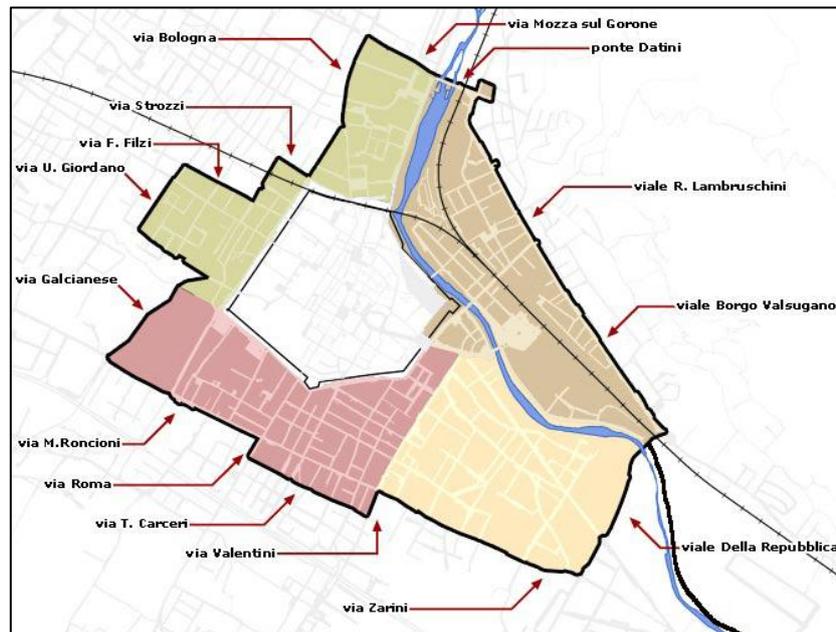


Figure 10: Controlled traffic zones

2.4.3 Highway A11

The controlled access highway A11 connects the cities of Florence and Pisa passing also near the cities of Prato, Pistoia and Lucca. The A11 is a dual-carriageway, six-lane motorway for the most of its length.

The A11 crosses the area considered within NADIA project only in a southern part.

2.4.4 Rail networks

The northern area considered within NADIA project is affected by the noise emissions of these railways:

- Bologna-Florence. Classified by RFI as a *fundamental line*;
- Florence-Lucca. Classified by RFI as a *complementary line*.

RFI manages all the two railways and it is realizing 5 km of noise barrier between the Prato railway station and the eastern boundary of the municipality.

3 Summary of noise mapping activities results

The noise mapping activities carried out within the NADIA project are described in detail in the Deliverables 1, 2 and 3. These documents are available on the NADIA project website [3].

3.1 Province of Genova and Savona

Table 6 and Table 7 contain respectively the number of people exposed to noise considering the indicators L_{den} and L_{night} . The number of people living in buildings having a quiet façade is reported in Table 8. These data were calculated in compliance with the European Directive 2002/49/EC [1] using the guidelines of the European Commission Working Group Assessment of Exposure to Noise (WG-AEN) [11].

Table 6: Population exposed to noise: L_{den}

Class L_{den}	Number of people exposed to noise							
	SP33	SP35	SP225	SP333	SP523	SP28bis	SP29	SP334
55-59	2200	2200	1500	2400	1000	1400	5400	600
60-64	1200	1400	1200	1700	600	400	1200	500
65-69	600	1100	1000	700	600	400	700	400
70-74	1300	1500	1300	1000	700	200	700	200
>75	200	100	200	400	200	0	300	0

Table 7: Population exposed to noise: L_{night}

Class L_{night}	Number of people exposed to noise							
	SP33	SP35	SP225	SP333	SP523	SP28bis	SP29	SP334
45-49	2400	2500	1700	2700	1100	400	1800	500
50-55	1300	1400	1400	1900	600	300	800	500
55-59	600	1100	900	800	700	400	800	500
60-64	1300	1600	1400	1000	700	100	400	300
65-69	200	100	200	400	200	0	0	0
>70	0	0	0	0	0	0	0	0

Table 8: Data regarding the number of people living inside building with a quiet façade (NPQ)

Road	Managing Authority	NPQ	% of NPQ	Road	Managing Authority	NPQ	% of NPQ
SP33	PROVGE	1300	10	SP28 bis	PROVSV	400	18
SP35	PROVGE	1600	13	SP29	PROVSV	700	8
SP225	PROVGE	1800	19	SP334	PROVSV	500	19
SP333	PROVGE	3100	26				
SP523	PROVGE	800	13				

3.2 Agglomerate of Vicenza

Table 9 and Table 10 report the number of people exposed to noise, rounded to the nearest hundred, considering respectively indicators L_{den} and L_{night} .

Table 9: Population exposed to noise: L_{den}

Class L_{den}	Population exposed to noise	
	N° of residents	Percentage (%)
<55	31.900	31,9
55-59	19.500	19,5
60-64	15.800	15,8
65-69	18.900	18,9
70-74	12.000	12,0
>75	2.000	2,0

Table 10: Population exposed to noise: L_{night}

Class L_{night}	Population exposed to noise	
	N° of residents	Percentage (%)
<50	46.300	46,3
50-55	15.800	15,8
55-59	18.300	18,3
60-64	15.300	15,3
65-69	3.800	3,8
>70	500	0,5

3.3 Agglomerate of Prato

Table 11 and Table 12 report the number of people exposed to noise, rounded to the nearest hundred, considering respectively indicators L_{den} and L_{night} .

Table 11: Population exposed to noise: L_{den}

Class L_{den}	Population exposed to noise	
	N° of residents	Percentage (%)
<55	12.600	8,0
55-59	14.400	9,1
60-64	61.900	39,2
65-69	67.400	42,7
70-74	1.500	0,9
>75	100	0,1

Table 12: Population exposed to noise: L_{night}

Class L_{night}	Population exposed to noise	
	N° of residents	Percentage (%)
<50	22.100	14,0
50-55	41.900	26,6
55-59	88.200	56,0
60-64	5.300	3,4
65-69	100	0,1
>70	0	0,0

4 Measures for noise reduction included in other Plans

4.1 Province of Genova and Savona

4.1.1 Extra-urban Traffic Plan of the Province of Genova (PTVE)

The Province of Genova issued the Extra-urban Traffic Plan (*Piano del traffico della viabilità extraurbana, PTVE*) in 2008 in order to:

- reduce traffic congestion;
- improve road safety;
- reduce air and noise pollution;
- improve energy savings.

The PTVE contains short and mid-term strategies aimed at improving the use of public transport and to make dangerous roads safer by reducing the number of vehicles on congested roads managed by the Province of Genova.

The measures foreseen by the PTVE for the roads considered within NADIA project that could have an acoustical impact on the surrounding areas are

1. **Realization of the S.P.523 bypass nearby Casarza Ligure:** The first part of the S.P. 523 bypass was completed in 2009. The new road avoids that a part of the extra-urban traffic passes inside the town of Casarza Ligure while it has no effect on the local traffic. Traffic flow measurements have shown that the by-pass causes a 17% reduction of the daily traffic flow. The reduction reaches 26% considering only the heavyweight vehicles inside the urban area of Casarza Ligure. The second part of the S.P. 523 by-pass has not been realized yet and its construction is not scheduled for the next five years (validity period of a Noise Action Plan) due to budget issues. This project foresees to connect directly the towns of Sestri Levante and Battilana. The completion of the bypass could further reduce the passage of extra-urban traffic within Casarza Ligure and its surroundings. Unfortunately, a reduction of traffic volume often leads to increases in speed because the remaining vehicles can drive more freely. It is suggested to adopt measures to keep the speed down in order to ensure road safety and to reduce noise emissions.
2. **Public transport improvement:** The PTVE suggests fostering public transport through the realization of interchange car parks and of extra-urban bus lines. The interchange car parks are planned to be placed nearby the motorway exits of Chiavari and Busalla, allowing a traffic reduction in the S.P. 523 inside the town of Busalla and in the S.P. 33 and in the SP. 225 inside the town of Chiavari. The new extra-urban lines affecting the traffic of the roads considered within NADIA project will be:
 - line Serra Riccò – Sant'Olcese – Genova (impact on S.P. 35);
 - line Ronco Scrivia – Busalla – Genova (impact on S.P. 35);
 - line Recco – Rapallo – Chiavari (impact on S.P. 333).

3. **Safety improvement of dangerous road segments** The PTVE identified the road segments in which it is most likely for car accidents to occur. One of this road segments is the part of the S.P. 225 passing through San Colombano. To this effect, the road markings in the urban area of San Colombano were implemented using standard vertical road signs. Nevertheless the effect of this measure on road noise emission is negligible since a reduction of emission can be achieved only combining the reduction of speed limits with stricter controls of vehicles speed [10].

4.1.2 Plan for air pollution reduction of Liguria region

The goal of the Plan (*Piano di risanamento e tutela della qualità dell'aria e per la riduzione dei gas serra*) is to reduce air pollution in the most important ligurian municipalities.

The Plan proposes measures only at a strategic level; nevertheless some measures, if applied, could bring important benefits to the traffic and, as a consequence, to noise emission of the road considered within NADIA project:

- *M7 measure*: Actions for traffic and parking. The measure foresees the financing of cycling lanes (together with *M22 measure*); this action, if applied, could bring to an important reduction of the local traffic in the urban areas. Unfortunately the orography of Liguria region (mountainous and hilly territory) limits the applicability of the measure in the towns located in the valleys;
- *M22 measure*: Carpooling and Carsharing. The action could lead to a traffic reduction.

In order to improve the effects of the measures, the Plan foresees proper dissemination activities.

4.1.3 Provincial Coordination Territorial Plan of the Province of Genova (PTC)

The PTC identifies several measures on road infrastructures that could lead to beneficial effects on noise pollution:

- completion of the road network of high Polcevera Valley;
- creation of a bypass to reduce the traffic inside the urban center of Busalla;
- creation of a bypass of S.P. 255 in high Fontanabuona Valley;
- redefinition of S.P. 523 alignment in Petronio Valley;
- redefinition of the road connection between Fontanabuona Valley and the coast (Rapallo, Recco);
- Creation of a new road connection between Petronio and Moneglia.

According to the engineering departments of the Province of Genova, no measure is scheduled for the next five years (validity period of the Noise Action Plan) due to budget issues; therefore the interventions defined in PTC are not considered in the Noise Action Plan.

4.2 Agglomerate of Vicenza

4.2.1 Urban Mobility Plan (PUM) of the Municipality of Vicenza

The Municipality of Vicenza approved the Urban Mobility Plan (*Piano Urbano della Mobilità*, PUM) on 11/10/2012. The plan is requested by the Italian legislative frameworks for all the cities having more than 100.000 inhabitants. The PUM defines a group of action that could affect the noise impact of the road network:

1. **Public transport:** One of the goals of the PUM is to reduce traffic improving the public transport. At this purpose the following measures are defined:
 - increase the frequency of 6 bus lines;
 - realization of three bus lane;
 - enlarge the parking near the Hospital.Moreover the PUM fosters the use of public transport modifying the traffic schemes inside and nearby the old town of Vicenza, also through an extended uses of traffic restricted zones. These actions aim to obtain a faster and better organized public transport service.
2. **Modification on road network:** 7 actions contained in the PUM should substantially affect the noise emission of the roads considered within NADIA Project inside the agglomerate of Vicenza.
 - a. *Pasubio pass-by:* It reduces the traffic of the *Strada del Pasubio*;
 - b. *Marosticana pass-by:* It reduces the traffic of the *Strada Marosticana*;
 - c. *realization of two new links:*
 - i. a new road connecting *Strada del Pasubio* and *Strada Marosticana*;
 - ii. a new road connecting *Strada Marosticana* and *Via Postumia* nearby Ospedaletto;
 - d. *extension of Via Martiri delle Foibe:* realization of the bus lane;
 - e. *traffic forbidden to private transport on Via Ferretto de Ferretti*;
 - f. *realization of a new link between Viale Divisione Julia and Via dei Cappuccini*;
 - g. *realization of a new road on the path previously used by the local FTV (Ferrovie Tramvie Vicentine) rails.*
3. **Encouraging cycling:** The PUM designs the Strategic Cycling Network, composed by 12 radial and 2 round paths. Moreover the PUM defines some action to improve the usage of cycle for private transport:
 - a. increase the cyclist safety in the road junction of Viale Margherita and Viale A. Giurolo;
 - b. increase the cyclist safety in Via Cairoli;
 - c. reduction of the number of vehicles in Contrà Vittorio Veneto;
 - d. refurbishment of the roads nearby the railway station;
 - e. traffic forbidden to private motor vehicles in Via Ferretti.
4. **Delimitation of the 30 km/h zone:** In order to encourage cycling, to limit the noise emission of the roads and to improve the road safety, the PUM identifies a 30 km/h zone inside the urban area. The area interested by this action is the one reported in Figure 11. The measure will not affect Via Riviera Berica and other major roads.

5. **Other actions:** The PUM foresees other actions having a lower effect on roads noise emissions:
- car sharing;
 - Improvement of electric vehicles;
 - stricter traffic control;
 - education activities focused on sustainable mobility.

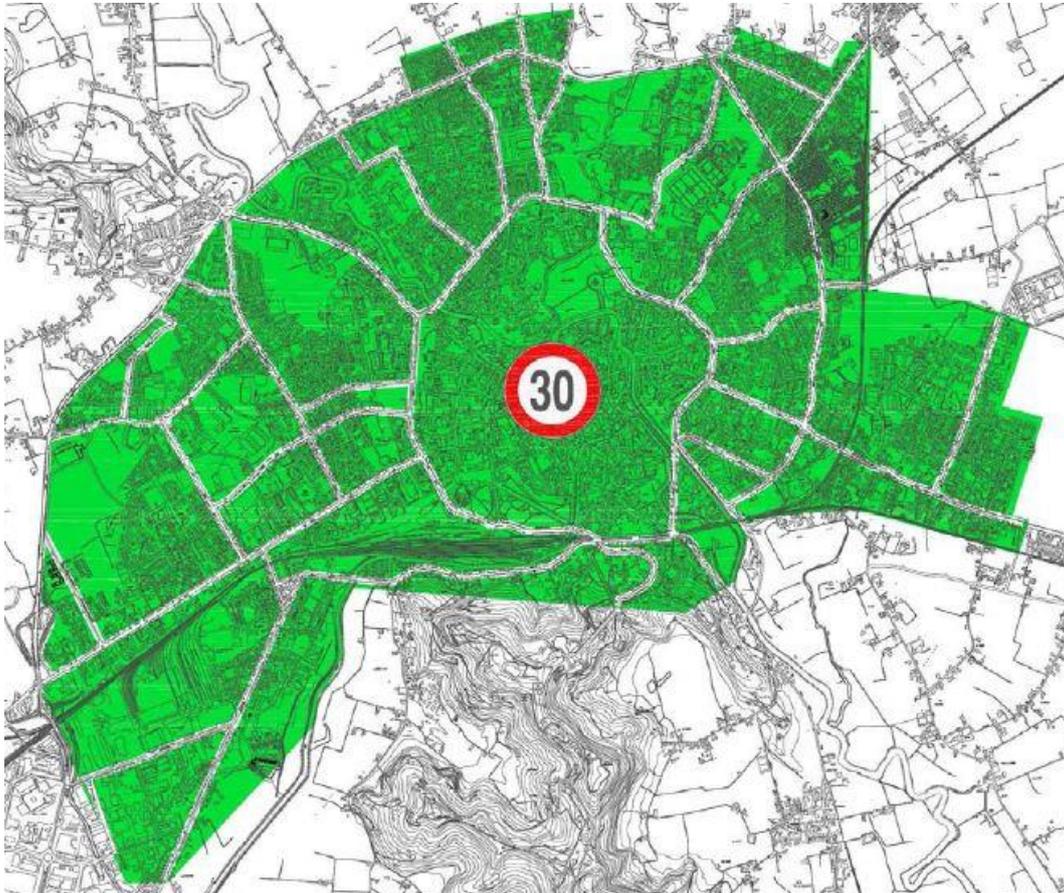


Figure 11: In green, the 30 km/h zone identified by the PUM inside the urban area of Vicenza

4.2.2 Plan for air pollution reduction of Vicenza

The plan, updated on 03/2012, analyzes the state of the air pollution in Vicenza and its surrounding area. The plan accepts and strengthens the outcomes of the PUM: the actions described in section 4.2.1 decreases the number of motor vehicles circulating in Vicenza road network, reducing consequently the air pollution.

4.3 Agglomerate of Prato

The following Plans contain measures affecting noise emissions:

- Urban Mobility Plan (PUM) of the municipality of Prato;
- Plan for air pollution reduction of the municipality of Prato (*Piano di azione comunale per la riduzione dell'inquinamento atmosferico*);

4.3.1 Urban Mobility Plan (PUM) of the Municipality of Prato

In 2004 the Municipality of Prato issued the Urban Mobility Plan (*Piano Urbano della Mobilità*, PUM). The plan defines actions to:

1. **Relieve the traffic congestion on the main roads.** The plan aims at obtain these goals through:
 - a. extension of the carriageway between Via Marx and Via Nenni;
 - b. creation of new underpasses and new roundabouts;
 - c. realization of an overpass linking Via Roma and Via Paronese;
 - d. new road links.
2. **Enhance the public transport.** One of the goals of the PUM is to reduce traffic improving the public transport. At this purpose the following measures are defined:
 - a. Increased frequency and speed of four bus lines;
 - b. Realization of new bus lanes;
 - c. Improve the use of parking by citizen in which they can leave their car and use public transport.
3. **Creation of 30 km/h zone**
4. **Improve cycling.** The plan define new cycle paths connecting different zones of Prato;
5. **Other actions:** The PUM foresees other actions having a lower effect on roads noise emissions:
 - a. Car pooling;
 - b. Car sharing;
 - c. Foster the realization of associations for the logistics inside the urban area.

4.3.2 Plan for air pollution reduction of Prato

The plan issued by the Municipality of Prato in 2009 includes the following actions:

1. A 24 h traffic ban for gasoline vehicles without catalytic converter, diesel vehicles built before 1993, commercial vehicles not conform to the European Directive 93/59 and motorcycles: this will allow an estimated PM10 reduction of 10-11%;
2. A 8-10 h traffic ban for gasoline vehicles without catalytic converter, diesel vehicles built before 1993, commercial vehicles not conform to the European Directive 93/59 and motorcycles: this will allow an estimated PM10 reduction of 3-4%;
3. The same results could be obtained limiting the traffic according to even and odd numbers of license plates.

5 Noise reduction measures

In order to identify which measure was technically feasible in each critical area, a classification of critical areas was defined.

Three fields of application have been defined:

- *Urbanized area* as defined by the Italian Rules of Road [9]²;
- *Rural area*: small group of buildings that cannot be identified as an Urbanized area as stated by Italian Rules of Road;
- *Special Buildings*: hospital, nursing homes, retirement homes, schools and kindergartens.

The following sections briefly describe the noise reduction measures considered in the Noise Action Plan. Further information can be found in the Deliverable 1 of the NADIA project. The area managed by the Municipality of Vicenza and analysed within NADIA project has no critical area classifiable as *rural area*.

Table 13 reports the cost and the field of application of each measure for the critical areas of the provinces of Genova and Savona.

Table 14 reports the cost and the field of application of each measure for the critical areas of the municipality of Vicenza and Prato.

The inner cities characterized by high cultural and artistic value could unlikely be preserved using noise barriers or low-noise asphalts. In that areas the anti-noise measure should be focused on the reduction of the private vehicle traffic flows, encouraging the use of cycle or public transports.

5.1 High insulating windows

The improvement of the sound insulation of a building should be considered only if the other noise reduction measures are ineffective or too expensive. The modern high insulating windows are characterized by a noise reduction index R_w higher than 40 dB. In the plan two kinds of windows have been considered: *standard* and *auto-ventilating*. Auto-ventilating windows are equipped with an aerator that allows airflow through the window itself; such a performance matches summer indoor ventilation and refreshment needs. The aerator is a box-shaped structure whose outdoor and indoor sides are equipped, respectively, with an inlet and outlet gate. The aerator duct walls have a labyrinth profile and are covered by acoustic absorbing material in order to absorb entering noise (Figure 12).

² "A group of buildings, delimited on the access roads by appropriate signs of beginning and end. A group of buildings is defined as a continuous group, even interrupted by streets, squares, gardens and similar, consisting of at least twenty-five buildings and of areas of public use with pedestrian or vehicular access on the road".

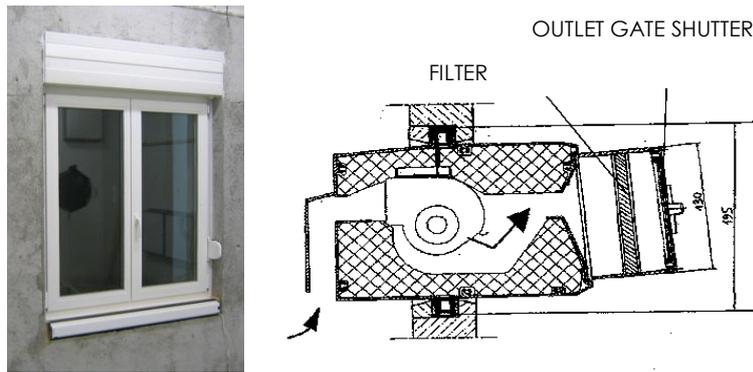


Figure 12: Auto-ventilating window (on the left, the aerator is located in the lowest part of the window) and section of the aerator (on the right)

As far as noise abatement, both windows and auto-ventilating windows were considered able to completely rehabilitate any kind of limit exceed.

Even using auto-ventilating windows, this set of measures cannot be considered efficient as the other proposed in the following sections, since it does not affect the environmental noise: outdoor parts of the building, such as gardens, balconies, etc..., will still suffer of high sound pressure levels.

To this effect, a penalization coefficient k was introduced in the calculation of the benefits (see § 6.3): its value is 0.5 for normal windows and 0.75 for auto-ventilating windows. This means that the installation of windows leads to only half (or $\frac{3}{4}$ for auto-ventilating windows) of its potential benefits in terms of reduction of priority index.

The cost of a standard high insulating window considered for the critical areas of the provinces of Genova and Savona (550 € per square meter) was supplied by the engineering departments of the Province of Genova; when the auto-ventilating option is applied the cost is increased by 200 € per square meter.

The cost of a standard high insulating window considered for the critical areas of the municipality of Vicenza (450 € per square meter) was calculated by the official price list of Veneto Region [13]; when the auto-ventilating option is applied the cost is increased by 200 € per square meter. The Municipality of Prato has used the data obtained by the Municipality of Vicenza. The opportunity to install high insulating window only in the façades in which the noise exceed the noise limits over 5 and 10 dB has been considered. These choices do not completely rehabilitate a critical area, but allow to find a solution for the most critical buildings containing the economic investments.

5.2 Low-noise road pavement

Road surfaces influence the generation of noise by tyre/road interaction and the propagation of noise from the vehicle engine and transmission system.

The relevant factors for noise emission are the texture of the surface, the texture pattern and the degree of porosity of the surface structure.

Low-noise road surfaces today are usually porous asphalts with one or two layers, characterized by an open structure with about 20-25% air void inbuilt. As a result, they absorb noise and drains water, thus increasing road safety (Figure 13).

Porous asphalts are efficient for speeds higher than 50 km/h, when the rolling noise emission from noise become predominant.

The noise abatement produced by low-noise road surfaces decreases with time because of the clogging of the voids; an average value of 3 dB(A) was considered for noise abatement of this measure in the Noise Action Plan.

The costs for standard low-noise road surface for the provinces of Genova and Savona were supplied by the engineering departments of the Province of Genova.

The costs for standard low-noise road surface for the municipality of Vicenza were established by the engineering departments of the Municipality of Vicenza. The costs for standard low-noise road surface for the municipality of Prato were established by the engineering departments of the Municipality of Prato.

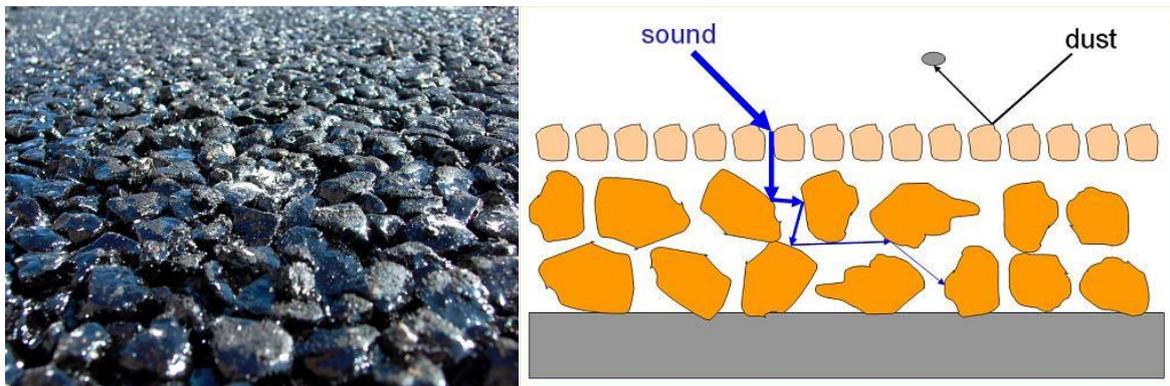


Figure 13: Low-noise road surface [12]

5.3 Noise barriers

Noise barriers are the most common measures for noise rehabilitation of road infrastructures.

The main requirement is that the barrier should be high and long enough to intercept the visual path between the source and the receiver. For the construction of barriers, a range of materials with different characteristics regarding absorption and reflection of sound is used.

Noise barriers cannot be used inside urbanized areas (as defined at the beginning of section 5) for geometrical, aesthetic and functional reasons.

Noise abatement and cost for standard noise barriers were taken from [12].



Figure 14: Noise barrier equipped with photovoltaic modules installed on the Italian Motorway A22 “del Brennero” [14]

5.4 Creation of cycle lanes

This measure can be successfully applied inside urbanized areas leading to a consisting reduction of traffic flow (about 20-30%) with the obvious benefits in terms of air and noise pollution.

Of course cycle lanes can be created only at certain conditions, such as flat roads, wide carriageways, etc..; in the mainly hilly and mountainous Ligurian territory this measure can be applied only in valley floors.

The noise abatement was calculated considering a traffic reduction of 25% while cost was taken from [15].



Figure 15: Cycle lane

5.5 Reduction of vehicles speed

The speed limits for the roads considered in the NADIA projects are:

- 50 km/h in urbanized areas;
- 70 km/h in rural areas.

It is important to keep vehicles speed under these limits both for safety and for noise issues. The limits tend to be exceeded especially at night when the traffic is low.

As agreed with the Provinces of Genova and Savona, the reduction of speed limit was not considered while measures concerning stricter controls on vehicles speed (using electronic devices like those shown in Figure 16) were included in the Noise Action Plan.

These measures generally lead to average reductions of 2 dB(A) [12].

Data related to costs of construction were given by the engineering departments of the Province of Genova

In the calculation of costs the presence of 2 speed control devices every 500 meters was considered; however a minimum number of four speed control devices for each critical area were defined.



Figure 16: different types of speed reduction devices: speed checker (on the left) and radar speed sign (on the right)

5.6 New road infrastructure

The construction of a bypass can be considered only for large urbanized areas because of the huge investment needed.

Considering a traffic flow reduction equal to 75%, the corresponding noise abatement is 6 dB(A).

Data related to costs of construction were taken from [12].

Table 13: Description of the noise reduction measures taken into account within Noise Action Plan for the critical areas of the provinces of Genova and Savona

Name	Abatement dB(A)	Cost	note	Urbanized area	Rural areas	Special buildings
Installation of high sound insulating windows in each critical building <u>façade</u> in which the noise limits are exceeded;	Complete rehabilitation	550 €/m ²		X	X	X
Installation of high sound insulating windows in each critical building <u>façade</u> in which the noise limits are exceeded by more than 5 dB(A);	Complete rehabilitation	550 €/m ²		X	X	
Installation of high sound insulating windows in each critical building <u>façade</u> in which the noise limits are exceeded by more than 10 dB(A);	Complete rehabilitation	550 €/m ²		X	X	
Installation of high sound insulating ventilating windows in each critical building <u>façade</u> in which the noise limits are exceeded;	Complete rehabilitation	750 €/m ²	The presence of fans integrated in the frame guarantees the correct air change rate in the room	X	X	X

Name	Abatement dB(A)	Cost	note	Urbanized area	Rural areas	Special buildings
Installation of high sound insulating ventilating windows in each critical building <u>façade</u> in which the noise limits are exceeded by more than 5 dB(A);	Complete rehabilitation	750 €/m ²	The presence of fans integrated in the frame guarantees the correct air change rate in the room	X	X	X
Installation of high sound insulating ventilating windows in each critical building <u>façade</u> in which the noise limits are exceeded by more than 10 dB(A);	Complete rehabilitation	750 €/m ²	The presence of fans integrated in the frame guarantees the correct air change rate in the room	X	X	X
Laying of low-noise road surfaces	3	15,1 €/m ² + 0,5 €/m		X	X	X
Installation of noise barriers	10	300 €/m ²	Source [12]		X	X
Creation of cycle lanes	1.5 [12]	100 €/m	Source [15]	X		
Reduction of vehicles speed	2 [12]	3.000€/device	2 devices/500m, but 4 at least.	X	X	
New road infrastructure (bypass)	6 [12]	10000 €/m	Considering a reduction in traffic volume of 75%	X		

Table 14: Description of the noise reduction measures taken into account within Noise Action Plan for the critical areas of the municipality of Vicenza and Prato. * The Noise Action Plan of the agglomerate of Prato considers only special buildings.

Name	Abatement dB(A)	Cost	note	Urbanized area*	Special buildings
Installation of high sound insulating windows in each critical building <u>façade</u> in which the noise limits are exceeded;	Complete rehabilitation	450 €/m ²		X	X
Installation of high sound insulating windows in each critical building <u>façade</u> in which the noise limits are exceeded by more than 5 dB(A);	Complete rehabilitation	450 €/m ²		X	
Installation of high sound insulating windows in each critical building <u>façade</u> in which the noise limits are exceeded by more than 10 dB(A);	Complete rehabilitation	450 €/m ²		X	
Installation of high sound insulating ventilating windows in each critical building <u>façade</u> in which the noise limits are exceeded;	Complete rehabilitation	650 €/m ²	The presence of fans integrated in the frame guarantees the correct air change rate in the room	X	X
Installation of high sound insulating ventilating windows in each critical building <u>façade</u> in which the noise limits are exceeded by more than 5 dB(A);	Complete rehabilitation	650 €/m ²	The presence of fans integrated in the frame guarantees the correct air change rate in the room	X	X

Name	Abatement dB(A)	Cost	note	Urbanized area*	Special buildings
Installation of high sound insulating ventilating windows in each critical building <u>façade</u> in which the noise limits are exceeded by more than 10 dB(A);	Complete rehabilitation	650 €/m ²	The presence of fans integrated in the frame guarantees the correct air change rate in the room	X	X
Laying of low-noise road surfaces	3	10,6 €/m ² + 1,2 €/m (Vicenza) 10,85 €/m ² (Prato)		X	X
Installation of noise barriers	10	300 €/m ²	Source [12]		X
Creation of cycle lanes	1.5 [12]	100 €/m	Source [15]	X	
Reduction of vehicles speed	2 [12]	3.000€/device	2 devices/500m, but 4 at least.	X	
New road infrastructure (bypass)	6 [12]	10000 €/m	Considering a reduction in traffic volume of 75%	X	

6 Individuation of noise critical areas

The areas that require noise abatement measures are identified comparing the results of noise propagation simulations with the noise limits defined by the municipalities for their territory according to the national laws. Noise abatement actions are needed where the estimated sound pressure values are higher than the limits.

At this purpose new noise simulations have been carried out in compliance with the Italian legal context. This operation was necessary for the calculation of the priority index according to the Italian law (see following chapter) since it requires noise levels in day-time (*periodo diurno*, from 06 to 22) and night time (*periodo notturno*, from 22 to 06) in points (receivers) located at a distance of 1 m from each building façade instead of L_{den} and L_{night} in points (receiver) located on the façade as required by the END directive.

The noise evaluations have been carried out also for buildings that require particular conditions of quiet like schools, hospitals, kindergartens and nursing homes. These buildings are referred as “special buildings” in the following.

There are no green areas characterized by high naturalistic quality requiring particular quiet conditions nearby the roads analyzed in the NADIA project.

The residential and special buildings characterized by sound pressure levels higher than the limits are called “critical buildings”. Critical buildings that can be acoustically rehabilitated using the same anti-noise measure have been gathered in groups forming a “critical area”.

In this stage the Noise Action Plan of the agglomerate of Prato is focused on rehabilitating the noise problems of special buildings; urbanized and rural areas will be analysed in future updates of the Plan.

6.1 Definition of critical areas

The procedure is based on the following criterion: “Inside a critical area, the distance between a critical building and the one nearest to it is lower than 100 m”. The critical buildings have been identified and separated from the others. An offset of 50m has been done for each critical building perimeter (an example is shown in Figure 17).

If two or more areas created by the offset procedure intersect, they have been merged to a unique area (*critical area*) (Figure 18).

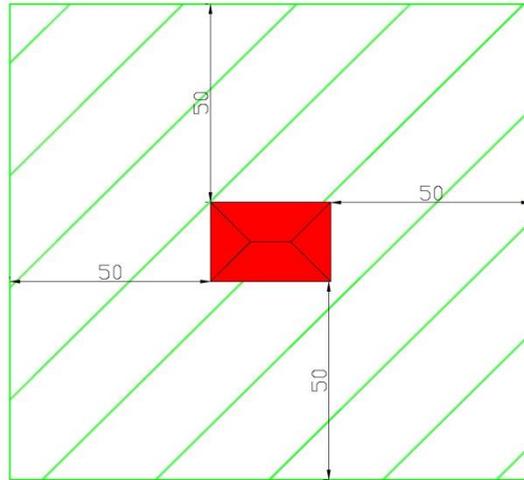


Figure 17: In red the critical building, in green its offset

In highly dense and noise polluted urban agglomerations this approach could not be easily applied; in fact the whole urban agglomeration could be divided into a small number of too wide critical areas. In this case two alternative procedures can be applied:

- a) to use a lower distance between critical buildings (e.g. 80 m instead of 100 m);
- b) to consider only the buildings in which the noise limit excess is over a defined threshold (e.g. 5 dB(A)).

The critical areas inside the agglomerates of Vicenza and Prato are designed using the procedure b).

A priority index has been calculated for each critical area in order to determine where the noise abatement measures were most urgent. Cost/benefit analyses have been performed in order to evaluate in each critical area the most efficient measure between those that are technically feasible.

A description of each critical area identified and considered in the Noise Action Plan is reported in Annexes 4 (Province of Genova), 5 (Province of Savona), 6 (Municipality of Vicenza) and 7 (Municipality of Prato).

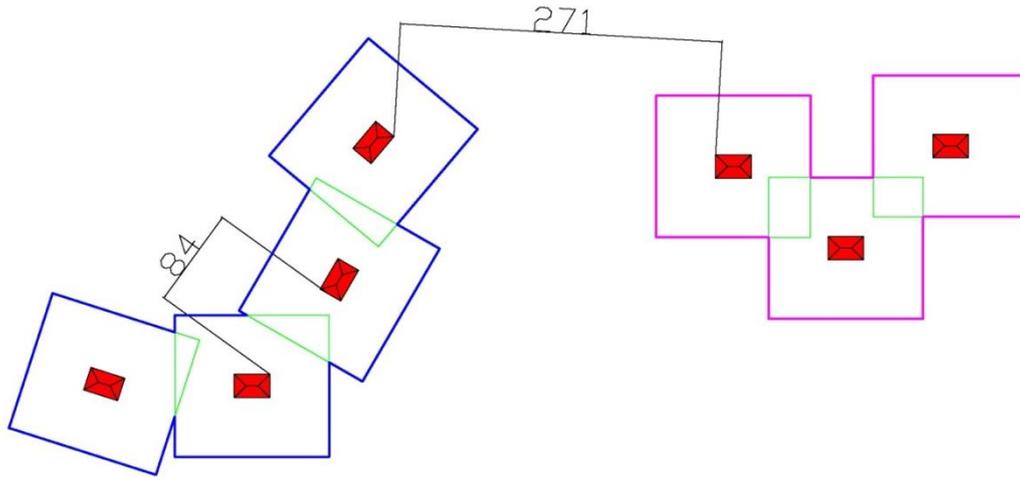


Figure 18: Example of critical areas definition. The contours of two critical areas are coloured in blue and magenta

6.2 Evaluation of the priority index

The methodology for the calculation of the priority index used for NADIA Noise Action Plan is based on the one given by the Italian decree D.M. 29/11/2000 [7]. An Index of Priority (IP) has to be calculated for each critical area using the following equation:

$$IP = \sum_{i=1}^n IP_i$$

In which:

- n is the number of critical buildings included in the critical area under consideration;
- IP_i is the product of the number of residents R_i and the maximum difference between noise level (on the most exposed façade, L_{obs}) and limits (considering the two periods of Italian normative, *diurno* and *notturmo*, L_{lim}) for the i -th critical building:

$$IP_i = R_i * \max[(L_{obs,diurno,i} - L_{lim,diurno,i}), (L_{obs,notturmo,i} - L_{lim,notturmo,i})]$$

The value of R_i in special buildings is calculated in a different way, in order to consider their higher requirements in terms of quiet:

- schools and kindergartens: R_i is equal to the number of pupils, teachers and technical/administrative staff members multiplied by 3. The D.M. [7] takes into account only the number of pupils, whilst this Noise Action Plan considers also the teachers and technical/administrative staff;
- Hospitals and nursing homes: R_i is equal to the sum of the number of beds and staff multiplied by 4. The D.M. [7] considers only the number of beds without considering the staff.

The evaluations for schools and kindergartens without sleep accommodation are made only for the *diurno* period.

For hospitals and nursing homes the population inside the building varies considerably between *diurno* and *notturno* period. In order to evaluate this, two values of IP were calculated; one for the *diurno* and one for the *notturno* period; then the highest of them was used.

Table 15 reports an example of IP calculation for a special building.

Table 15: Example of the evaluation of IP for special buildings

<i>Example: Comunità alloggio ANFFAS "S. Giustina", nursing home</i>			
Table 15 reports the noise limit exceed, population and the IP for a nursing home located in the province of Savona, both for <i>diurno</i> and <i>notturno</i> period. The IP assigned to the nursing home is 1420.			
	Noise limit exceed	Population	IP
<i>Diurno (06-22)</i>	14,2 dB(A)	25	1420
<i>Notturmo (22-06)</i>	17,4 dB(A)	20	1392

The value of the priority index depends on the criteria used for the definition of the critical area; however the procedure used to design the critical areas is reasonable and objective (see § 2.1). The index of priority calculated in this way can be used to define a rank of the critical areas where a noise abatement intervention is more necessary.

The IP value of each critical area/special building considered within the provinces of Genova and Savona and the municipalities of Vicenza and Prato are reported in Annex 2.

6.3 Cost-benefit analysis

A procedure for the cost-benefit analysis was developed to:

- *Identify the most efficient noise measure for each critical area:* the cost-benefit analysis aims to identify which is the cheaper noise reduction measure that solve the noise limit exceed in a critical area;
- *Establish an innovative index of priority for the realization of noise reduction measures:* a ranking based on the results of the cost-benefit analysis was prepared.

The ranking based on the index of priority (IP) is useful to determinate in which areas the acoustic environment is more critical.

The ranking based on the cost-benefit analysis (CBI) is useful to optimize the budget available for the managing authority for the acoustic rehabilitation. If for the *i*-th area/special building the noise measure A has the same cost of B, the most efficient noise measure in terms of IP reduction will be preferred for the *i*-th area/special building.

The cost-benefit ranking considers also the noise reduction measures that do not completely rehabilitate the critical area.

The noise reduction measures taken into account are reported in Table 13; moreover the following combinations were considered:

- Noise barrier and low noise asphalt;
- Noise barrier and reduction of vehicle speed;
- Low noise asphalt and cycle lanes;
- Low noise asphalt and reduction of vehicle speed.

For each critical area the cost-benefit indicator (CBI) for the technically feasible noise abatement measures (see § 5) was calculated using the following equation:

$$CBI = \frac{\text{cost of the measure}[\text{€}]}{(IP_{\text{before the measure}} - IP_{\text{after the measure}}) * k}$$

The penalization coefficient k was introduced in the calculation of the benefits: its value is 0.5 for normal windows and 0.75 for auto-ventilating windows. This means that the installation of windows leads to only half (or ¾ for auto-ventilating windows) of its potential benefits in terms of reduction of priority index.

The reduction of IP index has been chosen for the evaluation of benefit because it considers at the same time:

- the number of people exposed to noise;
- how much the noise level exceeds the limit;
- the noise sensibility of special buildings.

Of course the measures that have the lowest values of CBI are to be preferred.

As far as the calculation of the costs, the determination of the real number of windows to be replaced is impossible due to the high number of buildings (and consequently of façades) to be considered. The number of windows to be replaced ($N_{w,i}$) has been estimated considering for the i-th building the length of the façade in which the noise limits are exceeded ($L_{c,i}$) and supposing the presence of a window every 3 meters. The obtained value was rounded to nearest integer.

Table 16: Estimation of the number of high insulating windows needed for a typical building

<i>Example: Evaluation of the numbers of high insulating windows for a critical building</i>						
<i>Critical building (software code)</i>	<i>Façade (software code)</i>	<i>Floor</i>	<i>Maximum noise limit exceed dB(A)</i>	<i>Length of the façade ($L_{c,i}$) (m)</i>	<i>Number of windows</i>	<i>Rounded number of window ($N_{w,i}$)</i>
211358	A	1st	11	8	2,66	2
211358	A	2nd	7	8	2,66	2
211358	B	1st	2	10	5	5
211358	B	2nd	0	10	0	0
...

For the building reported in Table 16:

- The solution "Installation of high insulating windows in each critical building façade in which the noise limits are exceeded" foresees the installation of 2+2+5=9 high insulation windows;
- The solution "Installation of high insulating windows in each critical building façade in which the noise limits are exceeded by 5 dB(A)" foresees the installation of 2+2=4 high insulation windows;
- The solution "Installation of high insulating windows in each critical building façade in which the noise limits are exceeded by 10 dB(A)" foresees the installation of 2 high insulation windows;

The lengths of the low noise surfaces have been determined analyzing each critical area. An example of the calculation of the CBI indicator has been reported in Table 17.

Table 17: Evaluation of CBI for different measures for "Savona Nord" critical area

<i>Evaluation of the CBI for different anti-noise measures in the "Savona Nord" critical area (IP=1308, urbanized area)</i>			
<i>Anti-noise measure</i>	<i>IP reduction</i>	<i>Cost [€]</i>	<i>CBI</i>
<i>Installation of high insulating windows in each critical building façade in which the noise limits are exceeded;</i>	1308	750.750	1.148
<i>Installation of high insulating windows in each critical building façade in which the noise limits are exceeded by 5 dB(A);</i>	1284	439.725	685
<i>Installation of high insulating windows in each critical building façade in which the noise limits are exceeded by 10 dB(A);</i>	445	234.878	1.053
<i>Installation of high insulating and ventilating windows in each critical building façade in which the noise limits are exceeded;</i>	1308	1.023.750	1.043
<i>Installation of high insulating and ventilating windows in each critical building façade in which the noise limits are exceeded by 5 dB(A);</i>	1284	599.625	622
<i>Installation of high insulating and ventilating windows in each critical building façade in which the noise limits are exceeded by 10 dB(A);</i>	445	320.288	958
<i>Noise barrier</i>	NA*	NA	NA
<i>New Infrastructure</i>	893	15.255.000	17.071
<i>Low-Noise asphalt</i>	458	46.172	101
<i>Reduction of vehicle speed</i>	309	12.000	39
<i>Creation of cycle lane</i>	232	203.400	875
<i>Noise barrier and Low-noise asphalt</i>	NA	NA	NA
<i>Noise barrier and reduction of vehicle speed</i>	NA	NA	NA
<i>Low-Noise asphalt and creation of cycle lane</i>	678	249.572	368
<i>Low-Noise asphalt and reduction of vehicle speed</i>	750	58.172	78

* NA: not applicable (in this case noise barriers cannot be installed in urbanized areas)

The measure having a lowest CBI value that solve the noise limit exceed in "Savona Nord" critical area is the installation of high insulating windows.

Nevertheless the reduction the vehicles speed and the lying a low-noise asphalt allows to halve the Index of Priority, using above the 7,7% of the budget requested for the windows.

The results of the cost-benefit analysis carried out within NADIA project are reported in the Annex 3. The analysis aimed to identify the more appropriate noise measure for each critical area/special building considered.

The more appropriate measure was chosen considering its effect (it should rehabilitate completely the noise limits exceed) and its costs (the measure with a lower value of CBI was preferred).

The noise measure for the roads managed by the Province of Genova and Savona analysed within NADIA project are reported respectively in the Annex 4 and 5. The noise rehabilitation measures realized by the Municipalities of Vicenza and Prato analysed within NADIA project are reported respectively in the Annex 6 and 7.

6.4 Anti-noise measures foreseen by NADIA project

The NADIA project foresees to carry out noise abatement measures considering costs, available budget and especially to the *IP* and *CBI* values for the critical areas and for the special buildings. Priority will be given to actions for special buildings and for highly annoyed areas.

A brief state of art of the innovative anti-noise measures has been provided in the Deliverable 1 available in the project website [3]. The actions taken into account within NADIA project are:

- Replacement of installed windows with innovative and high performing sound insulating windows in schools;
- Application of innovative low noise road surfaces;
- Installation of innovative noise barriers. The barriers should be characterized by a high sustainability and should be designed considering the area in which they will be installed.

In the Noise Action Plans priority will be given to the anti-noise measures foreseen by NADIA project, because the Life funds are available only until the end of the project.

7 Stakeholder involvement

Each partner organized communication events to disseminate the results of the project and to increase citizens' awareness on road traffic noise. The events involved local stakeholders, citizen and, above all, pupils. Deliverable 6 reports a detailed description of the lessons carried out for pupils. The following paragraphs report a description of the meetings organized by each partner for citizens and local stakeholders.

7.1 Province of Genova

In order to promote a discussion with citizens and stakeholders, the Province of Genova organized several meetings and a workshop and made the Noise Action Plan available on-line on its official website for 45 days.

Before the approval of the Noise Action Plan, the Province of Genova organized four meetings in order to establish a first step of the participated processes. The meetings were advertised through posters (

Figure 19) placed in public areas like schools, kindergartens, public offices etc. of the municipalities involved in the event.



Figure 19: Example of the poster used to promote the meetings with citizens

The meetings were addressed to citizens, local stakeholders and institutional spokesmen of the Municipalities interested by the Noise Action Plan. The first two meetings were done before the publication of the Noise Action Plan and were focused on:

- Innovations carried out within NADIA projects;
- Results of noise mapping activities;
- Explanation of the EU co-funding for the NADIA project;
- Analysis and results of the noise traffic measurements used for noise mapping activities;
- State of the art of the noise abatement measures that could be applied within NADIA project.

The first of these two meetings took place in the town hall of the Municipality of San Colombano Certenoli for the citizens and institutional stakeholders of the municipalities of Avegno, Carasco, Casarza Ligure, Castiglione Chiavarese, Coreglia Ligure, Cicagna, Cogorno, Lumarzo, Moconesi, Orero, Portofino, San Colombano Certenoli, Santa Margherita Ligure and Uscio ("*Levante Group*") on 30/01/2013. The meeting was attended by the spokesmen of the Municipality of Avegno, Carasco, Lumarzo, Moconesi, Orero, San Colombano Certenoli, Santa Margherita Ligure e Tribogna. The second meeting took place in the town hall of the Municipality of Ronco Scrivia for the citizens and institutional stakeholders of the municipalities of Busalla, Campomorone, Casella, Isola del Cantone, Mignanego, Montoggio, Ronco Scrivia, Savignone and Torriglia ("*Ponente Group*") on 31/01/2013. The meeting was attended by the spokesman of the Municipality of Ronco Scrivia and by few citizens. Citizens and spokesman were particularly interested in the noise abatement action on the kindergarten called "La Carica dei 101". The kindergarten is placed inside the urban area of Ronco Scrivia. The citizens that attended to event requested some information about:

- the realization of noise abatement measures for a school in Ronco Scrivia;
- low noise asphalts;
- noise zoning and limits.

The Province explained that the situation of the schools in Ronco Scrivia would be taken into account in the following meeting carried out after the realization of the definitive ranking of acoustical priority. The Province of Genova reported the contents of the Deliverable 1 of NADIA project, regarding the acoustical performance on anti-noise asphalts. Finally the methodologies that should be used by the Municipalities for the redaction of the Acoustic Zoning Plan of a municipality were presented.

After the presentation of the Noise Action Plan, two additional meetings were organized with the following agenda:

- Analysis of the methodology chosen for the individuation of critical areas;
- Analysis of the methodology chosen for the calculation of the index of priority;
- Divulgation of the noise abatement measures scheduled for each critical area;
- Discussion about the demonstrative actions for noise reduction that will be realized, even thanks the EU co-funding, in the Province of Genova within NADIA project.

The first of these meetings took place at the town hall of the Municipality of Ronco Scrivia for the “*Ponente Group*” on 07/03/2013. The attendance for the event was minimal. No significant questions were made to the spokesmen of the Province of Genova maybe because the ranking of priority of the Noise Action Plan showed the acoustical criticality of a school in Ronco Scrivia (“Edmondo de Amicis”). As reported before, the stakeholders requested information about that school in the previous meeting carried out for the “*Ponente Group*”.

The last meeting was done at the town hall of the Municipality of San Colombano Certenoli for the “*Levante Group*” on 08/03/2013. The event was attended by the spokesmen of the Municipalities of San Colombano Certenoli and Casarza Ligure. A brief presentation of the Noise Abatement measures foreseen by the Noise Action Plan for the critical areas located in the municipalities of San Colombano Certenoli and Casarza Ligure was done. The Province of Genova stated that the noise abatement measure not foreseen within NADIA project will be carried out taking into account the budget available.

The Noise Action Plan was published by the Province of Genova on his official institutional website in order to foster a decisional participated process with citizens. Citizens had the possibility to suggest changes to the Noise Action Plan; the Province had to consider and answer to all the observations sent. The realization of the Noise Action Plan was advertised also in the official weekly video magazine of the Province of Genova “*Tabloid*” [16] and in the local newspaper *Corriere Mercantile* on 04/05/2013. Citizens could propose observation to the Noise Action Plan from 04/05/2013 to 17/06/2013. Only one observation was sent by citizens requesting:

1. The elimination of two traffic lights on SP33 near the town of San Salvatore through the realization of roundabouts;
2. The realization of a roundabout on the SP33 near the Caperana bridge;
3. The installation of a fixed speed camera in Corso XXV Aprile (a road segment of the SP33) in the town of San Salvatore.

The citizen affirmed that these measures could reduce the noise emissions of the road network through a regularization of the traffic flow and the reduction of the vehicle’s speed. The Province of Genova took into account the observations answering that:

- a) The measures n° 1 and n°2 suggested by the citizen request the authorization of the Municipality of Cogorno and not of the Province of Genova. Indeed the management of the SP33 in the areas affected by the first two observations of the citizen is in charge of the Municipality of Cogorno, while the Province of Genova is only the owner;
- b) The SP33 inside the town of San Salvatore is classified as “local road” in compliance with [9]. The installation of fixed speed trap is forbidden in this kind of road.

The Noise Action Plan proposal was removed from the institutional website on 19/06/2013. Before the removal of the proposal and the approval of the Noise Action Plan, the Province of Genova organized a workshop on 31/05/2013 (Figure 20) in order to:

- Disseminate the methodology and the results of the Noise Action Plan;
- Improve the connection and the relationships with the other Life projects (HUSH and QUADMAP).

The event was attended by the spokesmen of the Province of Savona, Province of Torino, Municipality of Genova, Municipality of Firenze, Municipality of Chiavari, Municipality of Cogoleto, Municipality of San Colombano Certenoli, Municipality of Sestri Levante, ARPAL (Environmental Protection Agency of Liguria region), ARPAP (Environmental Protection Agency of Piemonte region), VIE.EN. RO.SE. S.r.l. (private company involved in HUSH and QUADMAP project) and Fondazione MUVITA (foundation owned by the Province of Genova). The technical outcomes of NADIA Project were compared with the other Life project and with similar activities carried out by public bodies. The comparison showed that the methodology developed within NADIA Project for the realization of the Noise Action Plan is adequate and in compliance with the best practice available.



Figure 20: Image from the workshop organized by the Province of Genova on 31/05/2013

7.2 Province of Savona

According to the provisions of the Province Committee Resolution n°101 of 25/06/2013, the Province Committee published the Proposal of the Noise Action Plan on its official institutional website on 27/06/2013. The proposal was published in order to describe the contents of the Noise Action Plan, also through a non-technical description of the Plan, and to foster the development of a participated process with citizens on this topic. The Proposal of the Noise Action plan was removed on 12/08/2013.

Before the removal of the proposal, the Province of Savona organized a special event for the 15 Municipalities involved in the Noise Action Plan on 31/07/2013

(Figure 21) in the “Sala del Consiglio” (Via Sormano 12, Savona). The spokespersons of 4 Municipalities and of the Province of Savona (overall 20 people) attended the event. The event enabled the Province of Savona to explain the contents of the Noise Action Plan and of the activities foreseen within NADIA Project. The participants received a copy of the Noise Action Plan at the event.



Figure 21: Photos of the event organized by the Province of Savona on 31/07/2013.

Table 18: List of the Municipalities involved in the event organized by the Province of Savona on 31/07/2013. The Municipalities that attended the event are highlighted in bold.

Albisola Superiore	Altare	Cairo Montenotte	Carcare	Cosseria
Dego	Millesimo	Piana Crixia	Plodio	Pontinvrea
Quiliano	Roccapignale	Sassello	Savona	Stella

7.3 Municipality of Vicenza

The first activity organized by the Municipality of Vicenza to discuss about Noise Action Plan and, more generally, about noise topics was carried out on 09/03/2012. The workshop was advertised using the official websites of the Municipality of Vicenza and of Nadia project. Moreover, posters were placed in public areas (Figure 22). Citizens (mostly technicians of the building sector), ARPAV (Environmental Protection Agency of Veneto region), CIRIAF and Polytechnic of Milan attended the event.

The speech of the spokesmen of Municipality of Vicenza, ARPAV, Polytechnic of Milan and CIRIAF aimed to increase the knowledge and to foster a discussion with the Citizens about:

- Goals of NADIA Project;
- Noise legislative frameworks of Italy and Veneto Region;
- Anti-noise measures for buildings;
- Noise Action Plan of a road network.



Figure 22: Poster of the workshop organized by the Municipality of Vicenza on 09/03/2012



Figure 23: Photos of the workshop organized by the Municipality of Vicenza on 09/03/2012

A deeper dissemination of the activities done within NADIA Project on the field of Noise Action Plan was organized by the Municipality of Vicenza on 14/03/2013 (Figure 24). On this data the Municipality organized a workshop focused on:

- Innovations carried out within NADIA projects;
- Results of noise mapping activities;
- Explanation of the EU co-funding for the NADIA project;
- Analysis and results of the noise traffic measurements used for noise mapping activities;
- State of the art of the noise abatement measures that could be applied within NADIA project.

The event was attended by the spokesmen of CIRIAF, Province of Trento, Municipality of Bolzano, Province of Bolzano, Municipality of Modena, Province of Treviso, Municipality of Padova, Province of Verona, Municipality of Prato and Sogesca srl (private company that deals with environmental, energy and occupational health and safety issues).



Figure 24: Photos of the workshop organized by the Municipality of Vicenza on 14/03/2013.

The results of the noise mapping activities were advertised also by a press conference on 22/03/2013 (Figure 25).

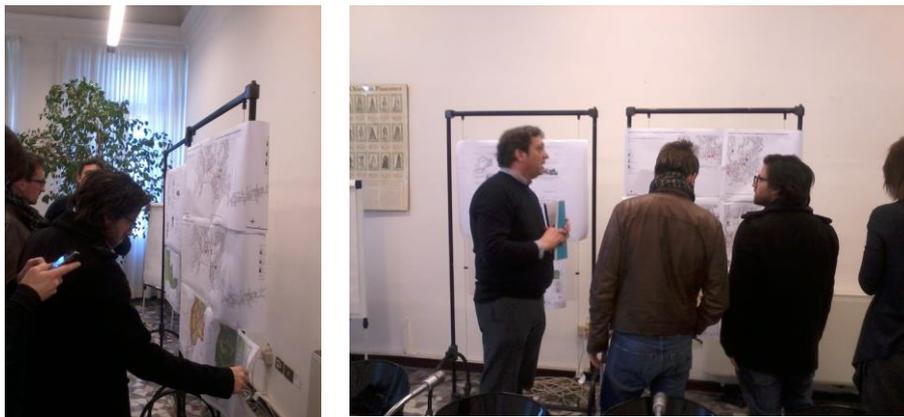


Figure 25: Photos of the press conference organized by the Municipality of Vicenza to disseminate the activities of NADIA project

The Municipality of Vicenza showed the activities of the project during the 2nd edition of “Smart City Exhibition” (16-18 October 2013 - Bologna), one of the largest national fair dedicated to smart projects for Smart Cities (Figure 26). The affluence was very high and the participants were technically prepared and interested on the outcomes of NADIA project.



Figure 26: Photos of the "Smart City exhibition"

The Municipality of Vicenza organized a workshop on 06/02/2014. The Noise Action Plan of the agglomerate of Vicenza was implemented for the first stage of the approval process by the Vicenza Town Council on 08/04/2014 (deliberation n°56).

After this data the plan was published on-line in the official site of the Municipality of Vicenza until 23/05/2014 for the participated process by citizens.

In order to encourage this activity, the Noise Action Plan was presented to citizens on 22/04/2014. The event was advertised on-line and in a local newspaper. Moreover the following associations were invited:

- Province of Vicenza;
- Professional Associations;
- Adjacent Municipalities;
- ARPA Veneto;
- WWF Vicenza and other local environmental associations.



Figure 27: Article of the newspaper "Il Giornale di Vicenza" advertising the event carried out in Vicenza on 22/04/2014

The contents and the goals of the Noise Action Plan were described by CIRIAF which also illustrated the anti-noise measure carried out within NADIA Project in the schools "Lattes" and "Cabianca".

After the presentation of the Plan, a fruitful discussion was made by the audience of the event with the spokesmen of CIRIAF and the Municipality of Vicenza about the contents of the plan. A synthesis of the discussion is reported in Table 19.

Table 19: Brief synthesis of the discussion carried out with the audience in the event on 22/04/2014

Who made the question?	Question/Remarks	Answer
A citizen of the historic centre	The citizen requested more information about the noise abatement measure foreseen by the Plan for the historic centre.	The spokesman of CIRIAF answered that the noise problems of the historic centre will be solved through the actions defined by the Urban Plan of Mobility (see paragraph 4.2.1).
A member of CONFARTIGIANATO (an autonomous national association of artisans and small enterprises)	A stronger cooperation between the Public Administration and technicians about noise pollution is desirable.	The spokesman of Municipality of Vicenza answered that some indirect goals of the Noise Action Plan are to make the citizens more conscious of high noise exposure and of the existing technically feasible mitigation measures.
Spokesman of the Municipality of Quinto Vicentino (a municipality adjacent to Vicenza)	The Municipality of Vicenza could support other Municipalities with less than 100.000 inhabitants affected by road noise.	The spokesman of the Municipality of Vicenza answers that it could be a good idea to improve the relationship with other Municipalities affected by road noise. Moreover the spokesman of CIRIAF stated that the methodologies developed for the Noise Action Plan could be easily used for the management of noise problems in little cities.

7.4 Municipality of Prato

The Municipality of Prato presented the results of the Noise Mapping activity and the proposal of the Noise Action Plan, at the "Palazzo dell'Industria" (Prato) on 30/09/2013. Citizens, ARPAT (Environmental Protection Agency of Tuscany region) and other local stakeholders attended the event. The promotion of the meeting was done through newspapers and the institutional website of the Municipality of Prato. The spokesmen of the Municipality of Prato reported the number of people exposed to noise and described the most important anti-noise measures included in the Noise Action Plan:

- Realization of a noise barrier (length 550 m, high 4-5 m) in via Aldo Moro. The measure is co-funded by the Tuscan Region;
- Installation of high noise insulation window in the primary school "Meoni". The green areas of the primary school will be acoustically improved laying low noise asphalt in the *Tangenziale Ovest* (the most impacting road for the garden of the primary school considered) and realizing a noise barrier. The asphalts and the high insulation windows are co-funded within NADIA Project.

At the meeting the Municipality of Prato reported that for other two important anti-noise measures there is yet no financial support:

- At the crossroad between Via Galcianise and the *Tangenziale Ovest*;
- Nearby Prato Est motorway exit. The measure aims at mitigate the acoustical situation of the urban area of Via dell'Agio a Mezzana.

The meeting led the way to a discussion between technicians about the Noise action plan contents. For this reason, the Acoustic Commission of the Associations of the Engineers of Prato presented three remarks on the Noise plan content on 11/11/2013:

- The noise abatement measure for the quite areas should be defined;
- The survey activity should be done in the area where the noise abatement actions were planned after their realization;
- The measures included in the noise action plan should change the road network in order to mitigate the noise emission. Moreover they requested more information about:
 - use of anti-noise asphalt and noise barrier;
 - installation of high insulating window. The Municipality of Prato could exploit the funding opportunity given by the I DM 28/12/12 (*Conto Termico*) and the selling of *White Certificates*.

The Municipality of Prato considered the outcomes of this discussion in the realization of the Noise Action Plan:

- A quite area (*Cascine di Tavola*) was identified. The analysis of the noise level proves that no anti-noise measure is needed;
- The survey activity will be done to evaluate the efficiency of noise abatement measures;
- The noise action plan contains data about the performance and the cost of anti-noise asphalts, noise barriers and high insulating windows.

The noise action plan proposal was presented also to the Environmental Commission of the Municipality of Prato on 17/12/2013 (Figure 28).



Figure 28: Noise action plan presentation to the Environmental Commission of the Municipality of Prato

References

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- [2]. Decreto Legislativo 19 agosto 2005, n. 194, *Attuazione della direttiva 2002/49/CE relativa alla determinazione e alla gestione del rumore ambientale*, Gazzetta Ufficiale della Repubblica Italiana, Serie generale n. 222, 23/09/2005;
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