



Italian Environmental Performance: Noise Pollution Activities Report

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(Inter-university centre of research on pollution by physical causes)

Introduction

During the past years, in particular after 1990, a large growth of researches about noise pollution takes place in Italy. A lot of national laws have been introduced to limit noise pollution; many activities in the field of acoustics have been developed following the impulse given by these laws. For instance, many municipalities have begun to plan noise abatement programs to limit noise pollution in their territories.

An Italian organisation with the purpose of giving an important aid to develop activities in the field of acoustics is Inter-university Centre for Research on Physical Causes Pollution (CIRIAF).

CIRIAF is a consortium among Italian universities to which over 100 university professors from Perugia, Rome Tre, Rome La Sapienza, Pisa, Florence, Genoa, Venice, L'Aquila, Polytechnic of Bari, Reggio Calabria



belong; CIRIAF's objective is to cooperate on a scientific research level on topics such as pollution due to physical causes (noise, vibrations, ultrasounds, ultraviolet rays, electromagnetic fields, ionized radiations, heat, humidity, etc).

1. Noise Legislation

Before 1990, there was not much awareness on noise pollution.

In 1991 the Italian government passed two important decrees:

- DPCM 1.3.91 on protecting room environment and outdoor environment from noise pollution;
- DL 277 of 15.8.91 on protecting workers from noise pollution and other risks (in receipt of directive 1988).
- In 1994 Law 626 was passed which concerned protecting workers from risks related to working environments in which the prescriptions of decree 277 were enforced.
- In 1995 there is a new awareness in national political policies toward the fight against noise pollution; in fact, Law no. 447/95 was passed destined to rule in all sectors: noise source, continual cycle plants, urban constructions, transportation and relative infrastructure, buildings or structures for sports events or public entertainment, professional positions (technicians in acoustics), measurement methodologies and noise monitoring, etc. After Law 447/95, 14 more decrees have been approved in the last five years and another 6 decrees are in the making.
- Specific norms have been established for the following topics: railway, road and airport noise (in Italy there are 31 Airport Commissions, see Table 1), the passive noise requirements of buildings, regional lists containing new professional positions (technician in acoustics). The number of technicians listed in the regional lists are more than 2500 (see Table 2).

Airports	Commission works
Palermo	ON
Catania	ON
Favignana	OFF
Pantelleria	ON
Reggio Calabria	ON
Malpensa	OFF
Bari	OFF
Napoli	ON
Pescara	ON
Brindisi	ON
Trieste	OFF
Verona	OFF
Pisa	ON
Venezia	ON
Ciampino	FINISHED
Olbia	ON
Bologna	ON
Forli	OFF
Linate	ON
Firenze	ON
Venezia	ON
Bergamo	OFF
Genova	OFF
Treviso	ON
Torino	OFF
Fiumicino	ON
Ancona	ON
Cagliari	OFF
Alghero	ON
Lamezia Terme	ON
Rimini	OFF
31 Airport Commissions	20 Commissions ON

Table 1: Airport Commissions in Italy

Regions	Qualified Technicians	Update
Abruzzo	60	
Basilicata	8	25/11/1999
Calabria	54	03/01/2000
Campania	115	24/02/2000
Emilia Romagna	131	27/12/1999
Friuli Venezia Giulia	122	07/01/2000
Lazio	413	22/05/2000
Liguria	141	08/09/1999
Lombardia	344	17/03/2000
Marche	141	
Molise	14	13/01/2000
Piemonte	242	19/01/2000
Puglia	124	09/02/2000
Sardegna	n.p.	
Sicilia	153	24/11/1999
Toscana	180	30/11/1999
Trentino Alto Adige	15	
Umbria	52	12/01/2000
Valle d'Aosta	12	22/02/2000
Veneto	280	05/11/1999
TOTAL	2601	among which 28% are high school gradu- ates and 72% have university degrees

Table 2: Technicians in acoustics in Italy classified by regions



At the moment, the Italian law has disposed to save on pollution behalf a percentage of budgets destined to the maintainance and extensions of the transportation infrastructure. Such percentages are 2.5% fpr ANAS (national entity for roads) and 7% for railway, autoroutes, airports and other transportation agencies or infrastructures.

The following are the points of Law 477/95:

1997

- differential criteria for plants at continual production cycle (DM 11.12.1996-G.U. no. 52 of 4.3.1997);
- measurement methodology of airport noises (DM 31 October 1997-G.U. no. 267 of 15.11.1997);
- determining limit values of noise sources (DPCM 14.11.97 . G.U. no. 280 of 1.12.1997);

1998

- rules describing norms to reduce noise pollution produced by civilian transportation (DPR 11.12.1997 no. 496 – G.U. 26.1.1998);
- Detecting and measuring techniques for noise pollution (DM 16.3.1998 –G.U. No. 76 of 1.4.1998);
- Document for addressing and coordinating general criteria for the technician in acoustics in compliance with art.3 comma 1, letter b) and art. 2, comma 6,7,8, of Law October 26, 1995 no. 447 “Law on noise pollution” (DPCM 31.3.1998- G.U. no. 120 of 26.5.1998);

1999

- rules concerning norms for carrying out art.11 of 26.10.1995 no. 447 regarding noise pollution from railway traffic (DPR. 18.11.1998 no. 459- G.U. no. 2 of 4.1.1999);

- on the bases of decree of 24.04.01 (G.U. of 2.8.2001) of the Ministry of environment along with the Ministry of transportation and navigation and the health Ministry, a committee was nominated by DPR 18.11.1998 no. 459 in charge of evaluating art 4 comma 6 and art 5 comma 4 of the same DPR
- Rules describing the norms to determine the noise requisites of the noise sources in dancing entertainment locations and of public entertainment and in general public places (DPCM 16.4.1999, no. 215 G.U. no. 153 of 2.7.1999). This annuls DPCM of 18.9.1997;
- Criteria to evaluate monitoring systems to control the noise pollution levels near airports and criteria to classify airports on the bases of noise pollution levels (DM 20 May 1999 –G.U. no. 225 of 24.9.1999);
- Rules describing modifications on the President of the Republic’s decree of 11.12.1997, no.496, regarding the ban on night flying (DPR 9 November 1999, no. 476 G.U. of 17.12.1999). Following numerous recourses, this has been annulled after suspension from TAR Veneto.

2000

- Criteria for establishing, on behalf of the entities and managing entities of public services for transportation and the relative infrastructures, of plans to contain and to reduce noise (DM 29.11.2000 –G.U. no. 285 of 6.12.2000);

2001

- Rules describing the limits of noise emissions produced by motoristic activity in compliance with art 11 of law 26.10.1995 no. 447 (DPR 3.4.2001, no. 304 – G.U., no. 172 of 26.7.2001).

Also to be mentioned:

- art 90 of Law 21.11.2000 no. 342 “Measurements in physical matters” which establishes a regional tax on noise emissions of automobiles;



- art 60 of Law 448/98 which recites modifications to art 10 of Law 447/95 modifying the fixed quotas taken from the budget allocated for maintenance programs to be destined to restoration activities on behalf of managements of transportation infrastructures between 5 to 7% and for ANAS from 1.5 to 2.5%;

Decreets in the elaboration stage

At the moment, the decrees foreseen by 447/95 are upon completion and concern:

- regulation in terms of noise pollution due to road traffic (art 11, comma 1);
- the criteria to design, execute and restore buildings and transportation infrastructure to protect from noise pollution (art 3, comma 1, letter f);
- criteria to measure noise emitted by any sort of boat or ship and the relative measures to limit noise pollution (art 3, comma 1, letter l);
- the noise requisites of alarm systems (also anti-theft) with acoustic signal and refrigeration systems, but also the measures to install, maintain and use of alarm systems (also anti-theft and anti-intrusion) with noise alarm installed on both mobile and fixed sources (art 3, comma 1 letter g);
- the criteria to contain pollution produced by noise relating to civil port activities (art 11, comma 1);
- an integrative decree to DM 29/11/2000.

2. Noise Planning

The Italian law is the only in Europe which provides a subdivision of municipal territories in 6 areas with noise limits depending on each area destination:

I – protected areas (hospitals, schools)	(50 dBA day, 40 dBA night)
II – residential areas	(55 dBA day, 45 dBA night)
III – mixed areas (residential and commercial)	(60 dBA day, 50 dBA night)



- IV – Intense activity area (residential, commercial and craftsmanship)
 (65 dBA day, 55 dBA night)
- V – Mainly Industrial area
 (70 dBA day, 60 dBA night)
- VI – Exclusively Industrial area
 (70 dBA day, 70 dBA night)

In 1994, the Italian government approved a three year plan for environmental protection which financed the realization of acoustic restoration in 53 main Italian cities among which Rome, Naples, Bologna, Florence, Genoa, Turin, Bari, Palermo, Venice, Cagliari, Catania, etc with a 20 million Euro budget (see Table 3).

REGIONS	MUNICIPALITIES (* Experimental Areas)	NOISE PLANS (in Italian Lira Billions)
Abruzzo	L'Aquila	0,5
	Pescara*	0,5
Basilicata	Potenza	0,5
Calabria	Reggio Calabria	0,5
	Catanzaro	0,5
	V.S. Giovanni*	0,5
	Cosenza	0,5
Campania	Napoli	1,9
	Salerno	0,5
E. Romagna	Bologna	1,5
	Parma	0,5
	Modena	0,5
	Reggio Emilia*	0,5
	Rimini*	0,5
F. V. Giulia	Trieste	0,5
	Udine*	0,5
Lazio	Roma	2
	Civitavecchia*	0,5
Liguria	Genova	1,4

	La Spezia*	0,5
Lombardia	Milano	2
	Brescia	0,5
	Como*	0,5
	Varese*	0,5
	Bergamo*	0,5
	Pavia*	0,5
Marche	Ancona	0,5
	S. Benedetto*	0,5
Molise	Campobasso	0,5
Piemonte	Torino	1,5
	Novara*	0,5
	Alessandria*	0,5
	Vercelli*	0,5
Puglia	Bari	1,4
	Foggia	0,5
	Taranto	0,5
Sardegna	Cagliari	0,5
Sicilia	Palermo	1,4
	Messina	0,5
	Catania	1,4
Toscana	Firenze	1,5
	Livorno	0,5
	Prato*	0,5
	Viareggio*	0,5
Umbria	Perugia	0,5
	Terni*	0,5
Val d'Aosta	Aosta	0,5
	Courmayeur*	0,5
Veneto	Venezia	1,5
	Padova	0,5
	Verona	0,5
	Cortina*	0,5
Trento	Trento	0,5



Bolzano	Bolzano	0,5
TOTAL		39,0

Table 3: Three Years Program for the Environmental Protection

CIRIAF carried out the first Italian plans for acoustic restoration in Perugia and Terni in Umbria. In 1996 following such an experience, CIRIAF in collaboration with ANPA (national agency for environmental protection) published the directives for municipal acoustic restoration which are to be followed by any Italian city.

The restoration plan is composed by 6 steps:

- a) Activities planning, establishing operative units and scientific technical committee of coordination;
- b) Measurement of noise and recognizing the pollution problems in the territory;
- c) Acoustic mapping and representation of the acoustic pollution status during the day-time and the night-time;
- d) Acoustic zoning (noise limits): subdivision of the territory in 6 classes established by law on the bases of the use of the territory;
- e) Plan of acoustic restoration. Comparison between zone limits and actual noise levels in order to single out the areas in which noise limits have been exceeded. Disturbing sources are also individuated. Listing the priorities of noise restoration interventions.
- f) Projecting the noise restoration interventions.



3. Researches, Applications and CIRIAF Activities

Following decree DPCM 5.12.97 – G.U. of 22.12.1997 on passive noise requisites of buildings, pertaining to Law 447/95 a large amount of certifications are being carried out in Italy on the products destined to construction sites for sound proofing.

- New materials and products have been tested at acoustic laboratories of CIRIAF such as ventilated windows with high sound proof qualities (see Figure 1);
- In the field of anti-noise barriers, systems with integrated technologies are being certified to reduce noise and produce photovoltaic energy (see Figure 2).

Pilot projects are being designed:

- for anti - noise barriers along the autoroute to Genoa (see Figure 3) on behalf of the autoroute company [12];
- for barriers with photo-voltaic cells in Perugia along the Perugia-Bettolle expressway on behalf of the ANAS (see design in Figure 4).

In the last few years, thanks to the laws already passed, numerous research activities have been developed in the field of materials, of control systems and noise reduction. The techniques used are of both the passive and active type.

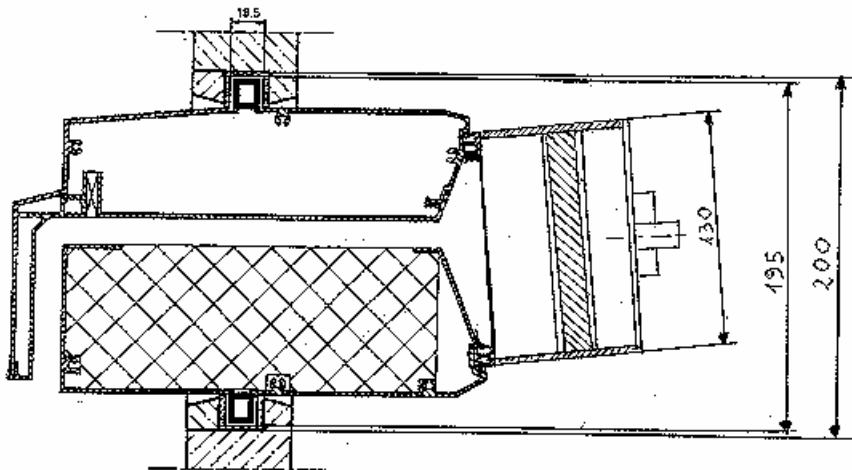


Figure 1: High Sound Insulation Windows

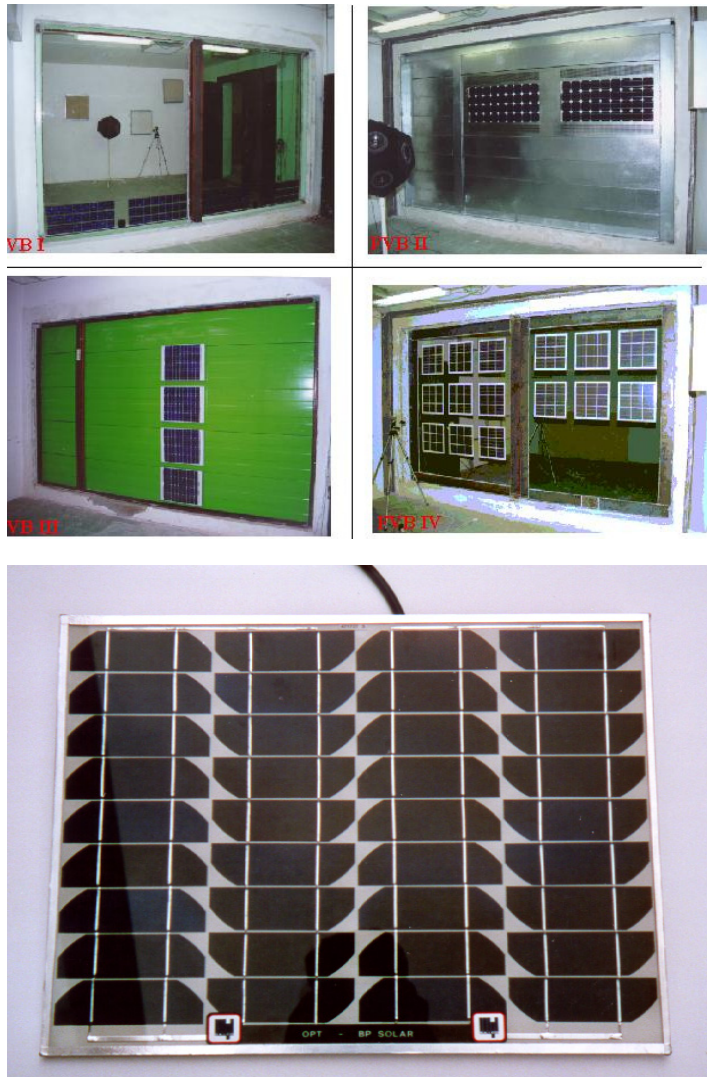


Figure 2: Noise Barriers and photovoltaic modules



Figure 3: High Sound Insulation Windows along the autoroute to Genoa

At CIRIAF three noise control systems have been patented:

- Glass with piezoelectrical devices to reduce vibrations due to noise (see Figure 5) [13];
- Electronic silencer to reduce exhaust noise in internal combustion engines (see Figure 6) [14];
- Electronic bumper to reduce noise produced by the tyres rolling on the road (see Figure 7) [15].

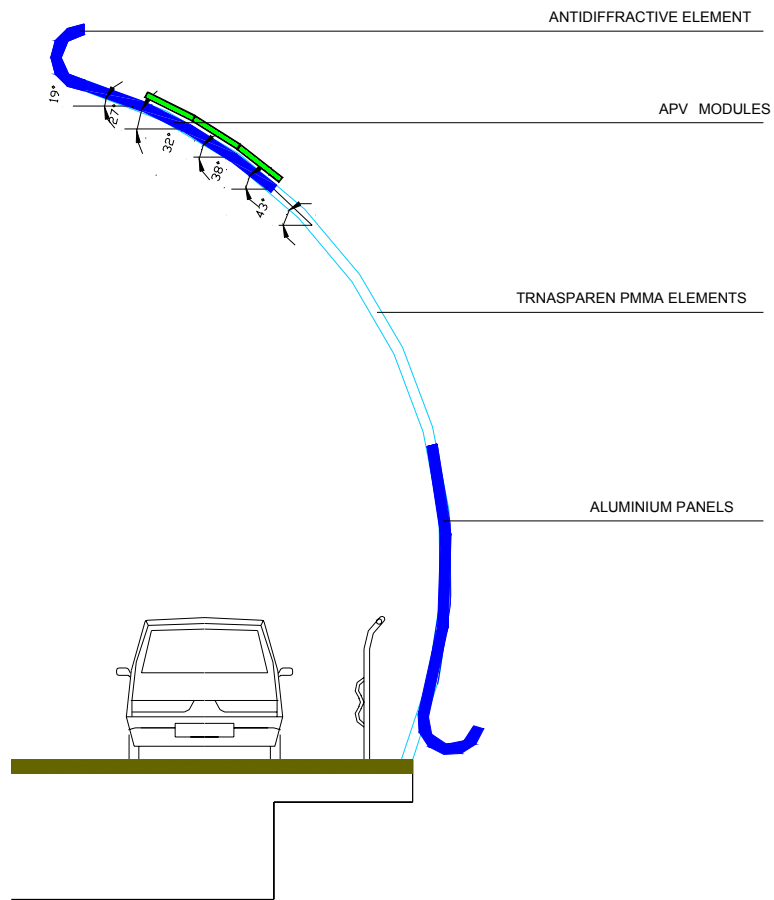


Figure 4: Design of a Noise Barriers and Photovoltaic Modules Application



Figure 5: Active Vibration Control on Glasses



Figure 6: Active Noise Control Muffler

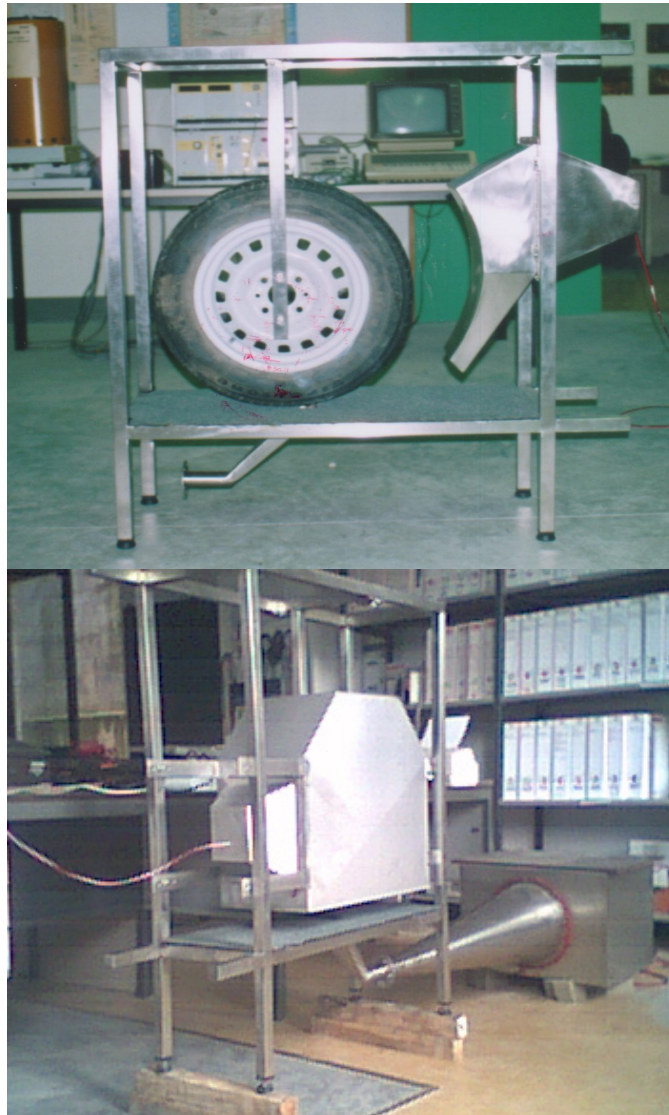


Figure 7: Active Noise Control Mudguard

4. International cooperation

1. CIRIAF has evaluated the impact of the new European Directive that has introduced a new indicator to evaluate the noise disturbance of L_{den} (see Figure 8 and Table 4) [16].
2. CIRIAF has evaluated the external costs on the transportation systems due to noise pollution with particular reference to the Umbria region (see Tables 5, 6 and 7). These costs have been compared to the average European costs reported in the green book on transportation.

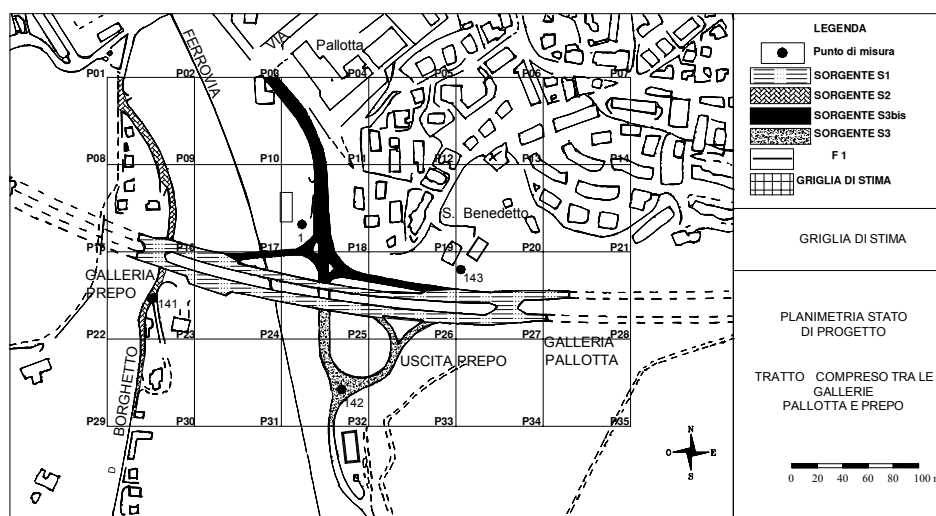


Figure 8: Measurements Points used to compare Indicator L_{DEN} (European Directive) and L_{DN} (Italian Law)



Measurement Points	L _{den} (dBA)	L _{dn} (dBA)	Difference (L _{den} -L _{dn}) (dBA)
1	77.8	77.1	0.7
141	65.2	65.0	0.2
142	75.4	75.2	0.2
143	77.5	77.3	0.2

Table 4: Comparison between Indicator L_{DEN} and L_{DN} in four measurement points

Transport Means	Costs (10 ⁻³ Euro/passenger Km)		
	Urban	Extra-urban	Global Average Value

External cost of noise	Road			Rail		Airport		Port
	Car ¹	Bus ¹	Freight ²	Pass ¹	Freight ²	Pass ¹	Freight ²	Freight ²
UE	4,5	4,2	12,7	3,1	4,7	3,0	16,5	*
Umbria	4,6	4,2	17,3	3,4	3,6	3,9	n.a.	n.a.
UE % Variation	+2,2	0,0	+36,2	+9,7	-23,4	+30,0	n.a.	n.a.
1 expressed in 10 ⁻³ Euro/pass. Km					2 expressed in 10 ⁻³ Euro/ton. Km			

Table 7: Unitary external cost in transportation: Europe and Umbria

3. CIRIAF, in collaboration with ANPA, has elaborated the NOISE system to store noise data [17].
4. Italy has given an important contribution to elaborating the European directive (Document 500PC0468) by participating with its own experts at the Working Group in charge of preparing the Directive:

Working Groups

WG 1: Noise Indicators

WG 2: Relation amount/effect

WG 3: Measurements and calculations (CIRIAF)

WG 4: Noise mapping (CIRIAF)

WG 5: Abatement (CIRIAF)

WG 6: Railway



WG 7: Machines for outdoors

WG 8: road transportation

WG 9: Airplanes (under discussion) (CIRIAF)

WG 10: Costs and benefits (CIRIAF)

The NOISE project (Noise Observatory Information Service) i.e. the conceptual outline at the base of the Computerised National acoustics laboratory. The basic structure of this system has been proposed by EEA (European Environmental Agency) expressed through the environmental DPSIR framework; according to this scheme, knowledge on the environment occurs at different levels: the Driver, the Pressure, the State, the Impact, the Response. The NOISE system, by applying DPSIR to noise, has been conceived as a comparative database in which all data and available information on the territory can be stored, analysed and managed. The aim is to create a managing and controlling tool of the territory for noise pollution. The European Directive n.61 of 24 Sept. 1996 IPPC, on the integrated prevention and control of pollution, stresses the need to establish general homogeneous principles for all environmental fields to make comparisons among environmental data possible; this was deemed necessary since a negative organisation of environmental data was one of the main obstacles in stimulating knowledge towards procedures for managing this type of data [1].

This work analyses the environmental field inherent to noise and presents the NOISE, Noise Observatory Information Service, carried out with regard to a research contract between ANPA and CIRIAF, i.e. a comparative database in which all acoustic data available on territory can be stored and through which future scenarios can be simulated in order to safely sustain a good environmental management on behalf of all suggested entities [2].

Noise System Structure

DPSIR model represents an efficient means to suitably organise data in various environmental fields, developed through EEA (European Environmental Agency), and provides a framework for developing assessments based on causal links between Driving forces (human activities), and Pressures (emissions and resources), contributing to changes in the State of the environment and cause Impacts on the environment and people's health. All this led to societal Responses in the form of the policy action. The system is composed of five modules: *Drivers, Pressures, State, Impact, Responses*. In the case of noise, DPSIR is developed as follows (Figure 9): in the drivers module, all data, which concern economic, productive and social activities able to produce pressure factors regarding noise, are singled out and organised. The pressure module records the effects of the aspects singled out in the drivers' module: the pressures in the NOISE system are acoustic emissions. The state module regards gathering data on the acoustic state of the environment investigated and subdivided, on the bases of the current laws in Italy, between internal and external environment. The qualitative and quantitative states of the environment have an impact both on the ecosystem and on the society, determining damage (economical, human health, etc) or benefits according to the trends recorded. The impact module records and verifies the effects due to acoustic emissions; the response module consists of the actions prompted on behalf of governmental representatives and of the preventative measures regarding the various problems linked with acoustic pollution. A common platform of the data known about the environment is represented by the *Integration Bases*, a storage of universal data in which it is possible to pick up general information regarding environmental media and factors (water, soil, atmosphere, waste, population, etc). Inside each module, access to the information contained in this supporting file is possible (graphics, information on the industrial activities in the territory, population data, topographic aspects, climatic conditions).

The structure of the NOISE system allows a double function: data storage (which can be downloaded according to the selection opted for), updateable in every section along with the Integration Base to which it is linked, and a programme of simulation and prevention of the environmental con-

dition according to the typologies of the selection made.

The graphic representation of the descriptive schemes explains the computer structure of the main software programmes most commonly used so to make it easier to understand the graphics, the internal links and those with Integration Base. Each descriptive scheme is composed of a main page, the contents of which is: Thematic Scheme for the Drivers, Emission Category Scheme for Pressures, Environmental Scheme for the State, Impact Sphere Scheme for Impacts, Response Typologies Scheme for Responses. In all NOISE modules references to space, time and data source are set in the scheme: space context, time context, detection type and detection source. All the main schemes have a descriptor parameter subscheme in which the relative indicators are listed.

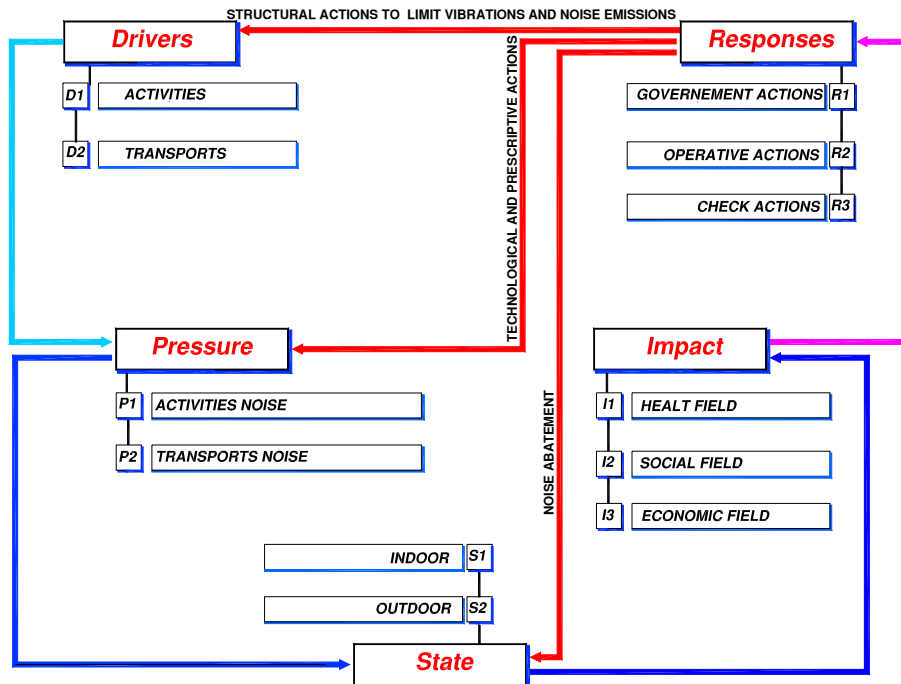


Figure 9: Basic scheme of the NOISE system: Noise Observatory- Information Service

Noise Indicators, Indexes and Functional Links

In order to have a qualitative evaluation of the noise problem, a large section was dedicated to researching, defining, analysing and listing the possible indicators and indexes [3]. Indicators were differentiated according to the information which could give: pressure indicators, state indicators, impact indicators, responses indicators. Pressure indicators describe how anthropic activity can affect the environment. State indicators show the environment condition through the analysis of qualitative and quantitative aspects. The impact indicators show how pressures act upon certain receptors by comparing them with the sensitivity of the others. Finally, response indicators describe how society responds to certain environmental problems, with decrees, laws, reclamation actions, etc.[4].

For instance, some pressure indicators are listed below:

- I_{p1} : average daily number of vehicles NGM(n), differentiated by typology, (trains, automobiles etc.), with reference to the relative infrastructure;
- I_{p2} : electrical supply P(kW), in the case of industrial activities in general;
- I_{p3} : number of clients/employees n, in the case of commercial activities of facilities, with reference to the territorial surface of concern (n/km^2).

Among the state indicators, some are taken from those cited by the Community's Fifth Environmental Action Programme: Towards Sustainability IS_1 pondered continuous equivalent level A $LeqA(dBA)$ (noise indicator) [6], or L_{den} as defined in DGENV Draft, concerning the proposal for a Parliament and Council Directive on the approximation of the laws of the Member States, relating to the Assessment and Reduction of Environmental Noise;

- IS_2 percentage of the population territory exposed to $LeqA$ above 65 dBA at night and to 55 dBA at night (%) [6].

Some of the impact indicators are:

- I_{i1} : Number of endorsements for noise with reference to a particular territory (n/km^2);
- I_{i2} : diffusion of passive protection systems, such as double glass win-

dows (n/km^2);

- I_{I3} : diffusion of health problems linked to noise (n/km^2).

Finally, for response indicators, there were:

- I_{R1} : percentage of the territory PTZ (%) and population PPZ(%) referring to noise zones [7];
- I_{R2} : percentage of territory PTM (%) and of population OTM (%) referring to noise mapping;
- I_{R3} : percentage of territory interested by noise mapping, subjected to noise reduction (%) PTR.

As in DPSIR scheme, even the NOISE system has functional links of cause and effects among the modules; they can be either direct, Drivers-Pressures, Pressure-state, State-Impact, Impact-responses, or indirect, Responses-Drivers, Responses-Pressure, Responses-State. The aspects involved in the system dynamics are so complex that only macroscopic links were defined: this is so both to predict the operability and manageability of the system and also to avoid case studies that, although elaborated, would anyhow appear to be incomplete. In particular, some links between impact and state indicators were described through the definition of relations like $I_s=f(I_p)$ in the two main cases with emissions deriving from activities or mobility.

In the case of emissions originating from infrastructures in road transportation, the data stored through the I_{p2} indicator, NMG (average daily number of vehicles), are input data of models to calculate the state indicator I_{s2} , $LeqA$. In the case of Pressures, some of the indicators thought to be more suitable for the Activity sector are those which assume a functional link between energetic type of quantities, such as electrical supply (I_{p3}) and the level of noise emitted, which is like $I_{s(dBA)}=f(P_{(kw)})$.



5. Conclusions

- **NOISE LEGISLATION:** before 1991 Acoustic Legislation in Italy was very poor. After 1991 many laws about noise pollution have been emanated; a large positive impact has been achieved in the innovative materials, active and passive noise abatement systems, simulation and noise mapping, noise planning.
- **RESEARCH AND COOPERATION:** CIRIAF is involved in a wide research program, both active and passive noise abatement system. CIRIAF gives a technical support to Italian Environment Minister and European Union. Also International agreement on Active Noise Systems is recently activated with University of Campinas (San Paolo, Brazil) and other companies in Italy (Ferrovie dello Stato, Società Autostrade, Centro Ricerche FIAT, etc.).

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