Open Journal of Acoustics, 2026, 14(1), 1-20
https://www.scirp.org/journal/oja
ISSN Online: 2162-5794
ISSN Print: 2162-5786

Determination of Aviation Noise Impact Maps from Few Acoustics Measurement Stations

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How to cite this paper: Annunziato, A. (2026) Determination of Aviation Noise Impact Maps from Few Acoustics Measurement Stations. *Open Journal of Acoustics*, **14**, 1-20.
https://doi.org/10.4236/oja.2026.141001

Received: January 9, 2026
Accepted: March 27, 2026
Published: March 30, 2026

Abstract

A new method is presented that allows the generation of aviation noise maps using a minimum number of measuring stations positioned in strategic points in the vicinity of airports. The data from these measurement stations data, together with the database of aircraft radar tracks, allows for the list of flights (coupled events) that contribute to the estimation of the basic noise parameters. With the described procedure, it is possible to estimate the noise in any point of the space close to the airport and therefore obtain a map of the required parametric quantity, such as Leq day or night, Lden or, as in the case of Italy LVA, a parametric overall daily quantity. The methodology could be used with any other parametric mapping, just by implementing the definition of the specific parameter representative of the local national legislation. For this reason, it could be adopted for any airport provided to have: a measurement at the vicinity of the take-off of each runaway and the track of each flight.

Keywords

Noise, Airport, dBA, Acoustics Maps, LVA

1. Introduction

In Italy, the assessment of the effects of airport noise is codified by the Ministerial Decree of 1997, which establishes the methodology of how to derive the LVA parameter (Airport Noise Assessment Level); the definition of the quantity is reported in **Appendix A**. The LVA values are estimated by measuring the noise at specific points, by means of measuring noise stations, and then processing the data according to the specifications contained in the aforementioned Ministerial Decree. The result is the LVA value at that specific point. The importance of this quantity is that the "airport proximity area" is defined as the area with LVA exceeding 60 dBA and no residential activity is allowed for areas with LVA exceeding 65 dBA. Therefore, the determination of the LVA mapping is particularly important for an airport.

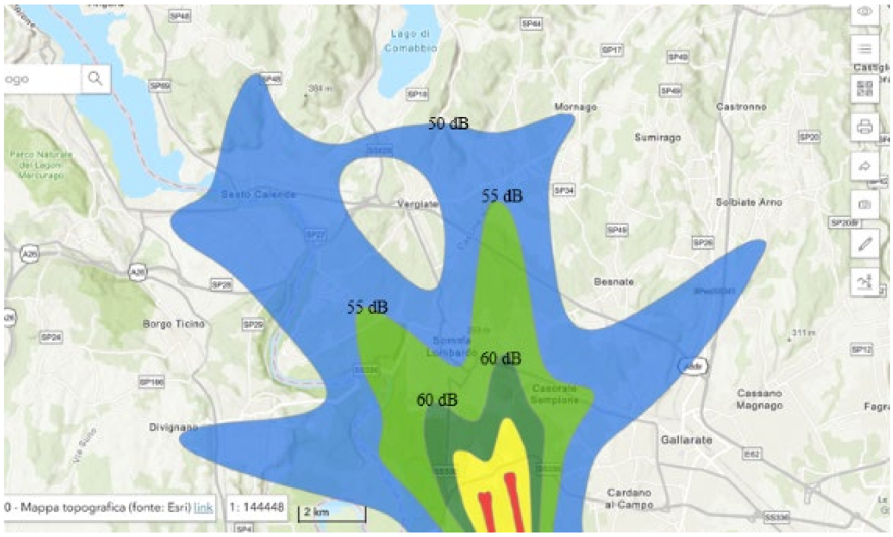
To have a noise map in a territory (province or region) instead of in a specific point, it is necessary to have a large number of measuring stations working at the same time and then analyse and process them. This method is very expensive for the cost of the monitoring stations and for their subsequent analysis task. Calculation codes (e.g. the US AEDT [1]) are available, which, using flight radar tracks and using mathematical models, allow an estimate to be made on the territory and provide LVA maps; an example is presented in **Figure 1** [2]. In order to carry out the calculations, however, it is necessary to provide the characteristics of the aircraft for each individual flight in order to obtain its noise in flight and therefore to be able to estimate the ground effect at each point. Aircraft libraries are available which, however, may not represent or are not be calibrated to the specific flight of that day (load, fuel weight, speed, instantaneous thrust, etc.).

In this report, a new method is presented that allows LVA maps to be estimated using a minimum number of measuring stations positioned in strategic points in the vicinity of airports [3], generally installed and processed by airport managers or control bodies. The data from these measuring stations, together with the database of aircraft radar tracks, allow you to have the list of flights (coupled events) that contribute to the estimation of the LVA parameter. These measurements are used to define, for each paired event, the value of the noise at the source (engine noise). This value, assumed to be constant throughout the subsequent flight path, can be used to estimate ground noise, as in the case of the calculation models mentioned above.

The advantage of this method is that there is no need to assign characteristics to each individual aircraft because these are extracted from the noise peak at the measurement points. With this method it is possible to create automatic procedures and obtain a daily estimate of LVA for the whole territory, to identify critical areas, particularly heavy days, places that should be better protected, etc.; from these maps it would then be possible to extract the global data for the whole territory by choosing the 3 weeks of greatest traffic, as required by the 1997 Ministerial Decree and thus generate an overall map and not the individual values in specific points.

The methodology, as outlined above, could be used with any other parametric mapping (Lden, Leq day, Leq night, or any other), just by implementing the definition of the specific parameter representative of the local national legislation. For this reason, it could be adopted for any airport in the world provided it has: a measurement at the vicinity of the take-off of each runway and the track of each flight.

The report here presents the detailed methodology and the results of the application to the Milano Malpensa Airport; the study is a proof-of-concept for the northern departure sector, and these weekly maps are not a replacement or a contrast with the from official regulatory LVA zoning under the ministerial decree.



(https://geoportale.arpa.piemonte.it/app/public/?pg=mappa&ids=24794feb52184a4498e87055f0b859dd)

Figure 1. LVA distribution estimated by ARPA Piemonte for the Malpensa Airport.

2. Correlation between Signals Detected along the Same Flight Track

2.1. Noise Transfer Model

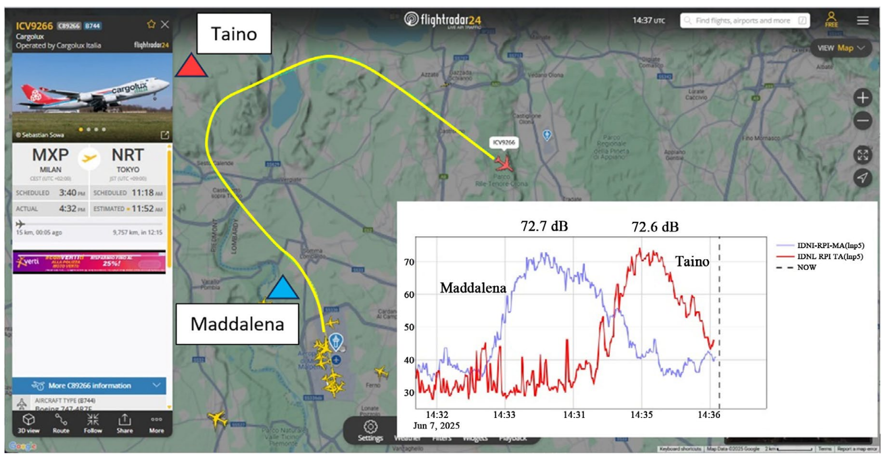


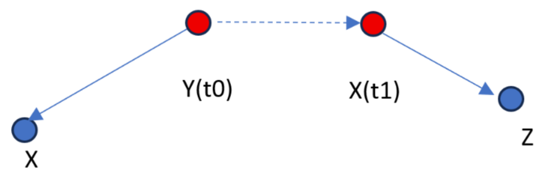
Figure 2. Noise recordings and flight track for ICV9266 of June 5, 2025. Recordings are available for both Maddalena and Taino; background image from http://www.flightradar.com/.

For some time, we have been using experimental noise detection units IDNL (Inexpensive Device for Noise Level) that record the perceived noise through a class II microphone, collected in real time; as such those measurements are not usable to obtain official data but can still give important information on noise trends and signals correlations.

On 7 June, two identical measuring stations were active: one in Maddalena (a hamlet of Somma Lombardo, a city north of Malpensa airport) and one in Taino, a village located about 10 km from Malpensa. The Cargolux flight ICV9256 produced a very similar signal on the two sensors, with peak noise of 72.7 dB in Maddalena and 72.6 dB in Taino. The signal in Taino has a shorter duration than that of Maddalena but the overall trend is very similar. This behavior suggested that perhaps it is possible, by measuring at Maddalena and using the route and altitude of the plane, to estimate the noise felt at Taino.

More generically, given a source at a point Y(t0) and measured the noise value at a point X, distant Dxy (m), it is possible to calculate the noise value at a different point Z at a distance Dxz from the source, from the relation [4] [5]:

$$Noise_Z = Noise_Y + 20 * \log10 (Dxz/Dxy)$$



Suppose we measure 57 dB in X which is 2.5 km away from source Y(t0), if I want to know the noise in Z at time t1, which is 1.5 km away from source Y(t1), it will be:

$$Noise (Zt1)= 57 + 20 * \log10 (2.5/1.5) = 61.4 \text{ dB}$$

This is true if the noise produced at time t0 remains the same at time t1. If it changes, for example due to a reduction or increase in engine power, the relationship should be modified to take into account the changed engine power. However, within the first minutes of departure, a constant value of this parameter could be assumed, even knowing that, according to take-off procedures at a certain height (between 800 and 1000 ft, or between 2600 and 3200 m) an engine reduction and levelling is carried out. In this case, the estimated data would be overestimated in the final part of the take-off in the area in question.

In the case shown in **Figure 2**, the minimum distance between the source and the sensor of Maddalena, where a maximum of 72.7 dB was measured, was 2051 m (1964 m horizontal and 822 m flight altitude minus 233 m location altitude). In the case of Taino the minimum distance was 2142 m (1928 m horizontal and 1216 m altitude minus 281 m altitude); The calculation indicated above would give:

$$Noise\ Taino = 72.7 +20 * \log10 (2051/2142) = 72.3 \text{ dB}$$

which is approximately what was measured in Taino (72.6 dB). Obviously, this calculation will not always be so precise, also because the orientation of the aircraft must be kept in mind and the fact that as it moves away from the measurement point, the power supplied (and therefore also the noise) change.

A model has been built based on (**Figure 3**):

- The measurement in dB at a point close to the airport (e.g. Maddalena)
- The series of tracks of the flights that were "paired", *i.e.* identified as responsible for that noise, obtained from the site https://malpensaDB.comune.taino.va.it

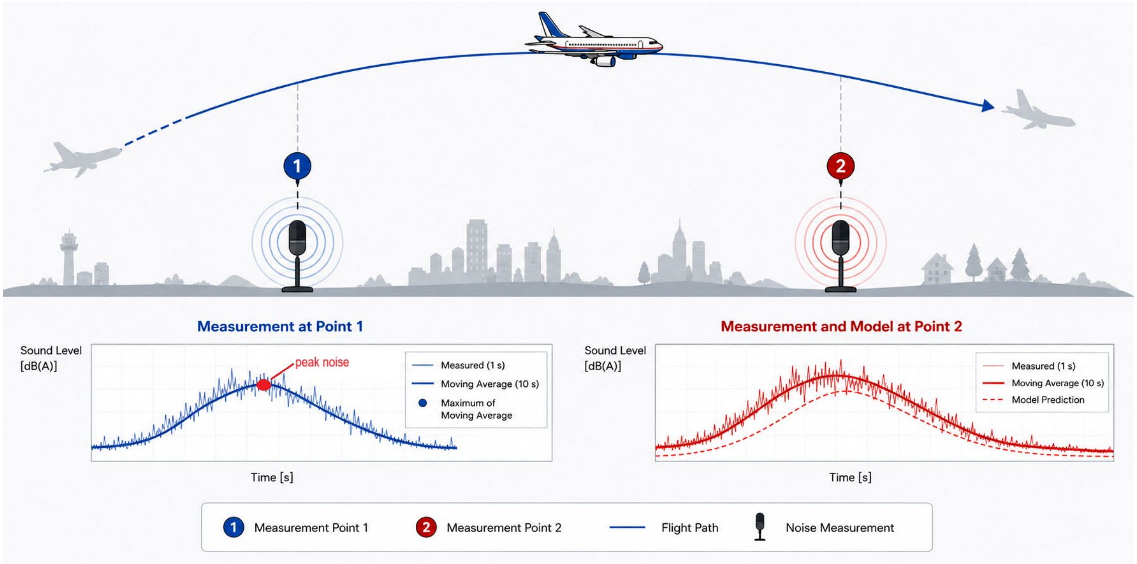


Figure 3. Graphical illustration of the model adopted to estimate the noise in a second point using the peak noise measurement in a first point.

For each peak noise measured, *PeakNoise*, in Maddalena, one specific flight "coupled" *v* was identified and its characteristic parameter called *engine* was determined and calculated as

$$engine_v = PeakNoise + 20\log10\,(DistMin)$$

with *DistMin* the minimum distance between the aircraft and the measurement sensor. The noise $Noise_x$ at a distant point *Dx* will be:

$$Noise_x = engine_v - 20 * \log10\,(Dx)$$

To verify the methodology, the case illustrated in the initial figure was analysed and, having determined the engine value, $engine_v$, from the measurement made in Maddalena [6], the trend in both Maddalena and Taino were estimated. As can be seen, **Figure 4**, the noise value is very close to the measurements both in Maddalena and Taino.

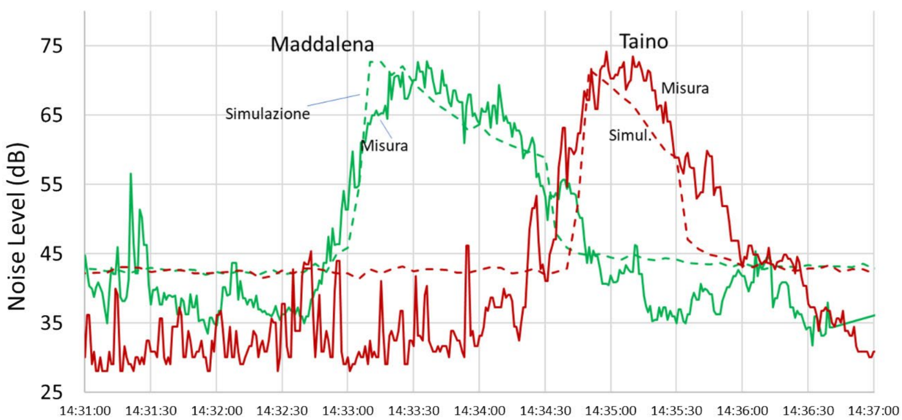


Figure 4. Measurements and simulations in Maddalena and Taino, of the noise caused by the ICV9226 flight of June 5, 2025.

2.2. Model Hypothesis Verification

To verify the hypotheses in the previous chapter, we examined another case, the flight IBE676, Iberia Milan-Madrid on 23 August 2025 departing at 17:18. This flight was recorded by 4 stations we had active at the time in the territory north of Malpensa: Casorate Sempione, Taino, Sesto Calende, and Golasecca; except for Sesto Calende, the others are IDNL type.

As seen in the graphic below, the passage caused a noise value from 78 dB gradually decreasing. We therefore evaluated the minimum distance parameters from the measurement point (DistMin) considering the ground position, airplane altitude and elevation of the measurement point and estimating the engine value as defined in the previous chapter (Figure 5).

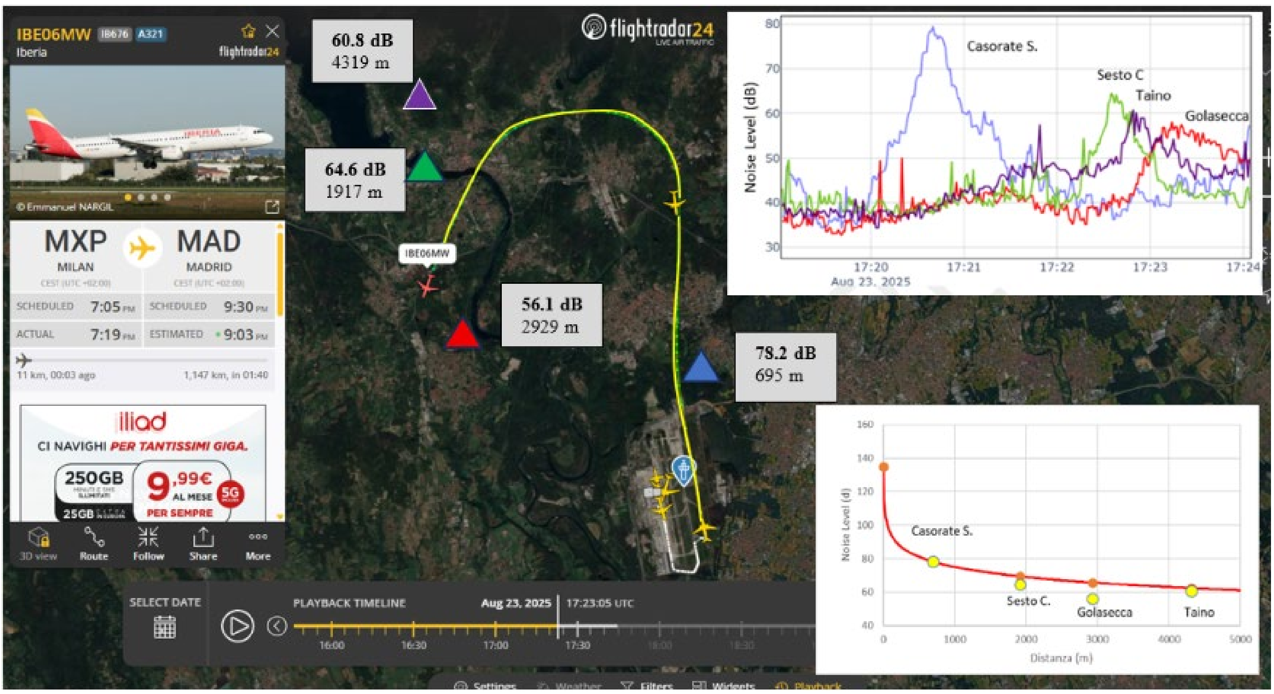


Figure 5. Situation related to the flight IBE676 on 23 Aug 2025.

Table 1. Parameters to determine the engine value.

	Elevation (m) A	Horiz. Dist (m) B	Flight Elevation (m) C	Distance (m) $D=\sqrt{A^2+(C-B)^2}$	Peak Noise (dB) E	*engine* E + 20 log10 (D)
Casorate Sempione	277	470	790	695.8	78.2	135.0
Sesto Calende	210	1,048	1,815	1,916.9	64.6	130.3
Taino	281	4,038	1,815	4,319.6	60.8	133.5
Golasecca	286	2,175	2,248	2,929.2	56.1	125.4

As noted in Table 1, except for the Golasecca data, the other values are between 130 and 135 dB. The data aligns almost perfectly with the curve representing the engine (red curve alongside). At Golasecca, however, the value is about 10% lower; this could be due to a reduction of engine due to levelling after the reaching of correct altitude.

3. Methodology for the Study

In order to apply the model described above to a whole area a number of steps are necessary and will be explained in this section. A list of daily activities are here listed

- Collection and storage of flights tracks
- Collection of noise measurements
- Processing of noise measurements and coupling with flights
- Determination for each point of a map of the noise timeline during the day obtained with the model in the previous chapter
- Determination of noise parameters (LVA, Leq, Lden etc) for each point in the map

A brief description of each step is outlined.

3.1. Collection and Storage of Flights Tracks

We use the data provided from two sources that offer the tracks on a continuous bases: FlightAware [7] and Open Sky Network [8]. Both offer APIs (Application Programming Interface) to retrieve the flight tracks and parameters. In particular they provide the flight number, the time, the coordinates and the elevation for each flight. Python scripts have been developed to continuously retrieve these data and store in a database for further processing. The data are stored since August 2024.

The individual tracks are analysed and if the distance between two points of the track is larger than 500 m, a linear interpolation of the position (horizontal and vertical) is performed in order to have segments smaller than 500 m.

An example of the flights points obtained for the day of 6 June 2025 is presented in Figure 6; the two white stars represent the measuremnts points used in the study.

Figure 6. Flight tracks points for the 6 June 2025. The white stars are the measurement locations used for this study: Maddalena on the left, Casorate Sempione Monte Rosa on the right.

3.2. Collection of Noise Measurements

The noise measurements have been provided by SEA (Società Esercizi Aeroportuali), that is the company that manages and operates Milan Malpensa (MXP) and Milan Linate (LIN) airports in Italy. It handles airport infrastructure, including the noise monitoring station around Malpensa airport. Of the noise stations available around the Malpensa airport, we have used Maddalena and Casorate Sempione Monte Rosa (**Figure 6**). The precise coordinates of the measurements are the following:

Maddalena		Casorate Sempione Monte Rosa	
45.6604596	8.684743	45.6711041	8.73052597

The Maddalena measurement station [10] is located at the elementary school in Maddalena, a fraction of Somma Lombardo municipality. The background noise is generally low, except during school entry/exit hours. The microphone is positioned according to regulations on the north wall of the building, and the phonometric equipment is fixed to the same wall. It detects noise from aircraft taking off from runway 35 L

The Casorate Monte Rosa monitoring station [10] is located on a private property at the end of Via Monte Rosa. The area is residential, with houses situated among woods. The microphone is positioned according to current regulations and is fixed to the east wall of a building near the main villa. The phonometric station is attached to the same wall. It detects noise from aircraft taking off from runway.

The measurement devices should be class 1 type, by Larson and Davies, but we ignore the precise model.

3.3. Processing of Noise Measurements and Coupling with Flights

The noise measurements are processed in order to estimate the relevant peaks. A minimum threshold is established, 50 dB; when the noise exceeds this value for a period of at least 10 s and not exceeding 300 s (to avoid individual non-aviation related events), that is marked as "peak" or "event" and the Leq and Time duration are calculated. Leq, or Equivalent Continuous Sound Level, is the constant sound level in decibels (dB) that contains the same total acoustic energy as a fluctuating, time-varying noise over a specific period [9].

An example is shown in **Figure 7** for a portion of the measurement done in Casorate Sempione Monte Rosa. It shows that peaks are identified (red dots for the maximum value) and the Leq (gray curve) is calculated in the period exceeding 50 dBA. For each peak we identify the initial time, the peak time, the maximum peak, the duration (s) of the peak and the Leq value.

For every identified peak, we search in the flights database in section 3.1, if there is a flight within a certain radius (8 km) within the period of the peak. If we find at least one flight, that is attributed to the peak; if we find more than one flight we assign that peak to the closest one. This is the "pairing" or "coupling" procedure.

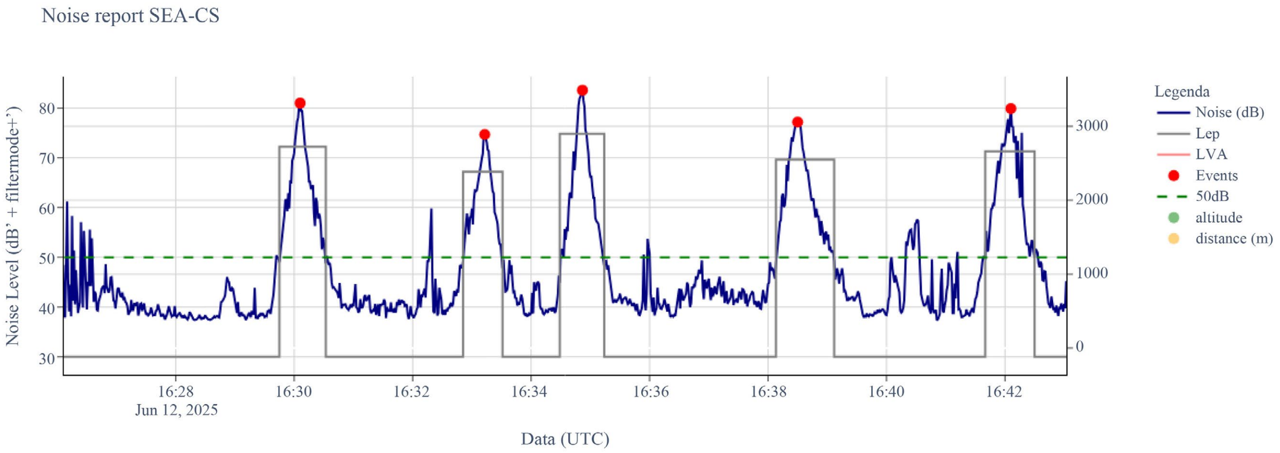


Figure 7. Noise timeline and identification of the peaks. The gray line reprensent the estimation of the Leq for that particular peak. The duration is the period in which the peak is above the setpoint, in this case 50 dBA. The red dot represents the peak maximum value.

3.4. Determination of the Noise Timeline

Having the list of events and distance from the measurement we can calculate the engine parameter for each flight, using the model described in the previous chapter.

For each flight and for each position of a map area, using the engine for that flight we can estimate the impact in that position of at each second. The distance at each second is calculated by linearly interpolating the tracks and maintaining the engine constant.

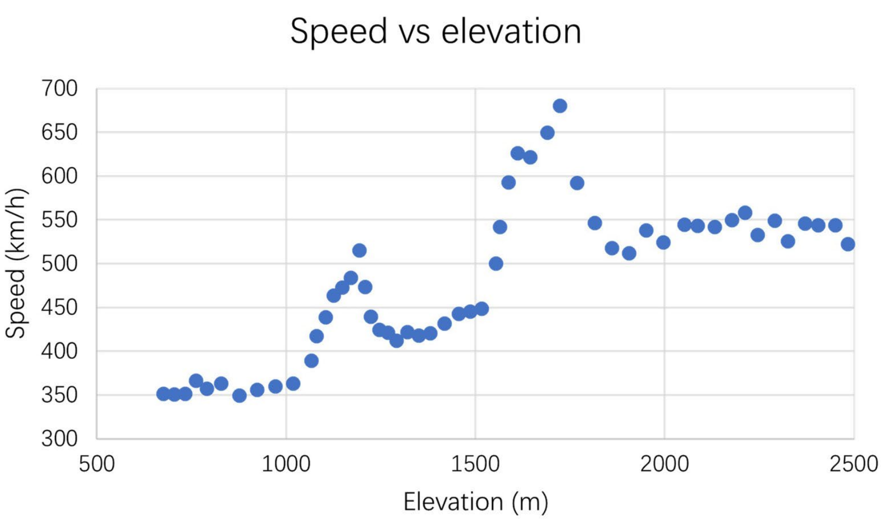


Figure 8. Speed vs elevation for a sample flight.

Limitation

The model assumes that the derived noise emission parameter remains entirely *constant throughout the flight path after the initial measurement. This is not exactly true because we know that standard aviation take-off procedures require significant thrust reduction at specific altitudes. In principle we could take this into account as we know the altitude and we could derive the climbing rate; however the calculation of the climbing rate is not so precise and we could have difficulties in establishing the correct engine at each time. An example is shown in* ***Figure 8****. From the figure it is evident a change in the engine thrust at about* 1,500 *m but as it can be seen the curve is not very regular and we thought that we could risk to introduce incorrect engine estimations. If we could have more reliable speed/elevation data, the change in the engine parameter could be included in the model.*

3.5. Determination of Noise Parameters

Once we have for each point of the map the timeline of each flight, we can compute the overall noise by summing up all the contributions (logarithmic sum) and therefore we can compute the various global daily parameters such as LVA, Leq day, night and or Lden, using the methodology described in **Appendix A**.

4. Application of the Methodology in the Northern Area of Malpensa

4.1. Area Mapping

We have shown that using only one measurement close to the airport, it is possible to obtain the noise evolution in another point if you know the flight trajectory. This means therefore that, in principle, we could know the noise vs time in any point of an area close to the airport caused by each individual flight. Also, that we could implemente and calculate any overall parameter, such as the LVA, Leq, Lden by summing up the contribution of each individual flight.

If you want to map the LVA value in a space with respect to a precise point, you can define the analysis points uniformly in an area and for each point of the analysis space you can calculate the time trends due to each individual flight using the $engine_v$ parameter for each flight and get the noise from the previous relationships, calculating the distance between the point in space and the plane. The overall trend due to the various flights is calculated by logarithmically adding the contributions of each individual flight. Once the time trends at the points of the analysis space have been obtained, the analysis is carried out to determine the LVA (or any other parametric value) at each of the points in the space.

In essence, therefore, using a single measurement point it is possible to calculate the effect in the entire analysis space due to the planes that have passed through that point. It is clear that the closer the planes are to the measurement point, the better and more precise the resulting map will be. This means that we need to have measurement points very close to the departure point of each runaway.

4.2. The Noise Data

In order to proceed, we have therefore requested the data from SEA. Of the 12 monitoring stations, we have selected the two that, in our opinion, can well represent the flights departing from the two existing runways: the left one or 35 L (for which we requested the Maddalena monitoring station) and from the right one or 35 R (for which we requested the data from the Casorate Sempione Monte Rosa monitoring station).

In **Appendix B** the list of dates analyzed, the number of aircraft tracks processed, the number successfully paired, and pairing percentage are reported. It can be noted that in the case of Casorate Sempione the average percentage is 88.5% with 3.8% of standard deviation; in the case of Maddalena the average percentage is 75% with 5% standard deviation. The same table reports the estimated value of LVA from the coupled flights; the comparison with the measured and computed LVA is shown in **Figure 9**.

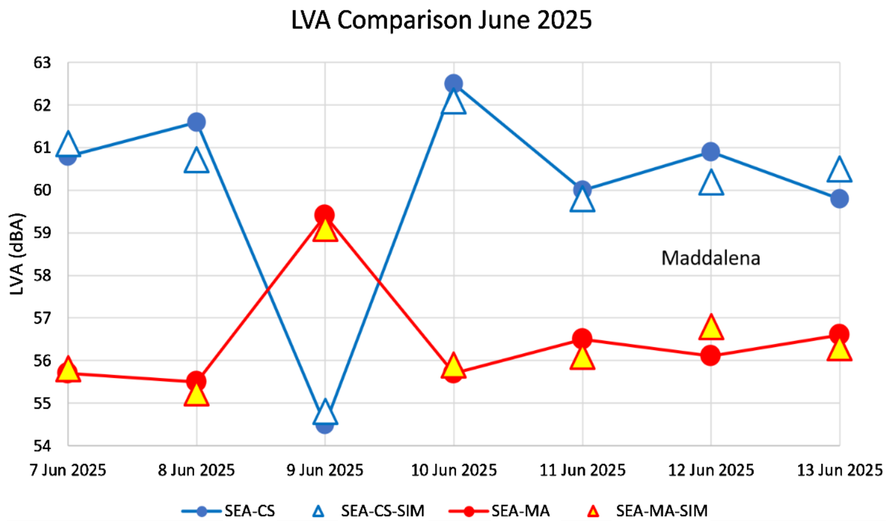


Figure 9. Comparison of LVA parameter estimated with the measured and calculated data on the two.

4.3. The Calculation Space

The calculation space for which the time trends for each individual flight were determined (and then added together in a logarithmic way) and subsequently calculated the LVA value is the one identified by the following coordinates:

latitude= min 45.629 – max 45.810, longitude: min 8.506 – max 8.892

This space has been divided into 59 × 28 cells with a size of 0.0064642 degrees (about 70 0m).

Approximately 4 CPU hours were required to analyze a case. Having more computing resources available, the resolution could also be improved. However, the fact that the complete analysis is completed in about 4 hours would allow this analysis to be carried out every day continuously.

For each point in the map, elevation was estimated using SRTM30 data [11], as elevation is important in estimating the distance between the point and the sound source. The elevation data have been obtained as tiles come as zipped SRTMHGT files at 1-arcsecond resolution (3,601 × 3,601 pixels) in a latitude/longitude projection (EPSG: 4326) [12]. (**Figures 10-11**)

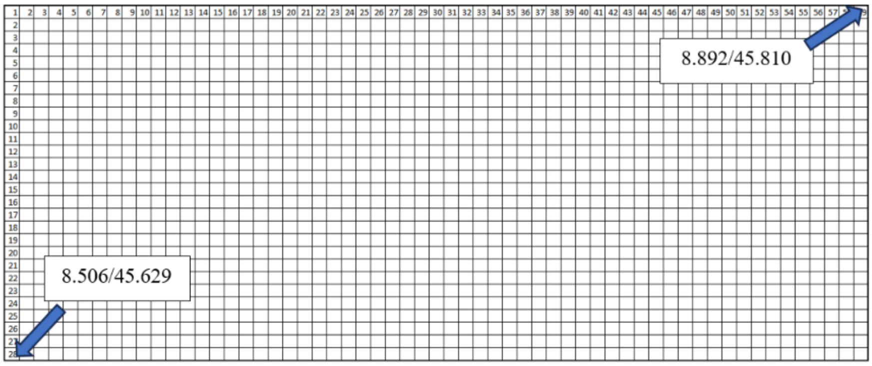


Figure 10. Calculation grid corresponding to the limits Latmin = 45.629, latmax = 45.810, Lonmin = 8.506, lonmax = 8.892.

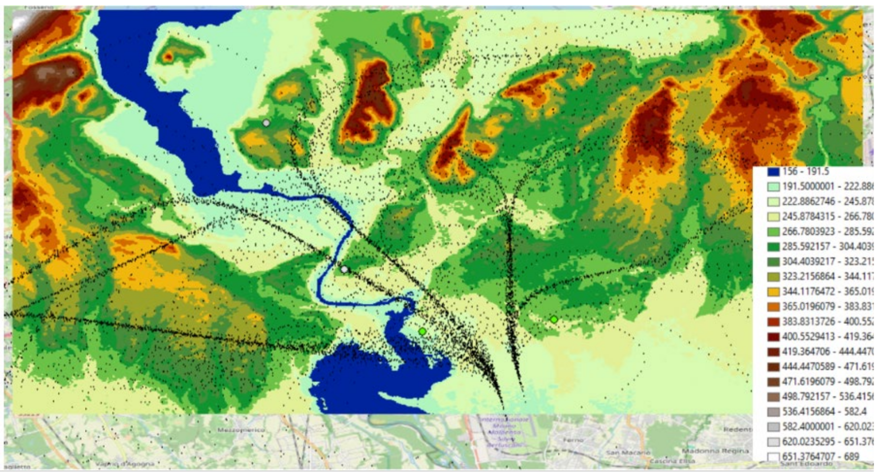


Figure 11. Elevation map according to SRTM30 data.

4.4. Maps Generation

Calculation experiments were carried out for each day from 6 to 12 June and from 6 to 13 September. For each of the days, the expected trends were generated, due to each recognized flight and a maximum noise parameter (engine) was attributed, according to the formula described in the previous chapter. The value of $engine_v$ thus determined was then used to estimate the noise timeline, estimating for each flight and each point of the map the distance at each second from the aircraft that was generating that noise. Once the noise time trend for each individual flight and for each single point was obtained, the final amount of noise for each point and each second was obtained by summing up logarithmically the contributions of the individual flights. The final curve found was then used to estimate the LVA, Leq day and Leq night value at each point of the map.

The maps were different every day due to the variations of flights density; An example of a result for a single day (7 June 2025) is presented in Figure 12. As expected, the highest LVA values and in particular values over 60 dB are estimated in the proximity of the airport and along the two main take-off exit directives.

Figure 12. LVA estimated for 7 June 2025, obtained from measurements from Casorate Sempione and Maddalena. The points represent the airplane tracks. The two starts represent the points where the measurements have been done.

We have also determined the resulting average LVA for each of the 2 weeks analysed, obtained from the logarithmic mean at each individual point of the map[1] and the following map is obtained that would represent the LVA value in the analyzed region for that week. The results of the week of June 2025 are presented followed by that of September 2025. The data are also compared with the results of the various measurement campaigns with the IDNL instrument carried out in recent months.

Up to the value of 55 dBA, the iso-LVA curves are very similar between June and September; for lower values, consistency is lost. In particular, the 50-55 dB area is much wider in the case of September 2025, due to different traffic in the two weeks.

The results seem to show great consistency with the experimental measurements carried out in the vicinity of the airport (Maddalena, Casorate Serene and Casorate S Bianchi, Golasecca, Varallo P, Borgo Ticino, Taino, Sesto C., Azzate, Vergiate, Mercallo, Oriano). As the overall maps, obtained from 2 different weeks, show some differences among them we may expect that some differences may exist in the various measurement points because many of them have been obtained during different periods, see 4.4. (Figures 13-14)

[1]LVA_average = 10 * Log10 ((10**("LVA 2025-09-06"/10) + 10**("LVA 2025-09-07"/10)+10**("LVA 2025-09-08"/10) + 10**("LVA 2025-09-09"/10) + 10**("LVA 2025-09-10"/10) + 10**("LVA 2025-09-11"/10) + 10**("LVA 2025-09-12"/10))/7)

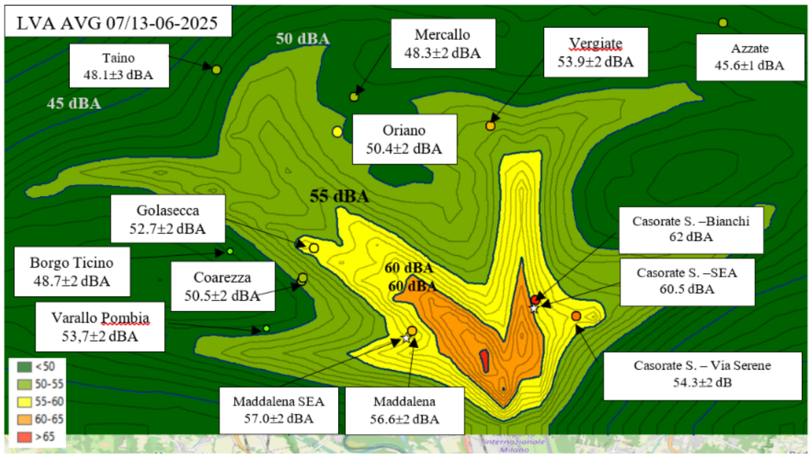


Figure 13. Average LVA for the week 7 - 13 June 2025.

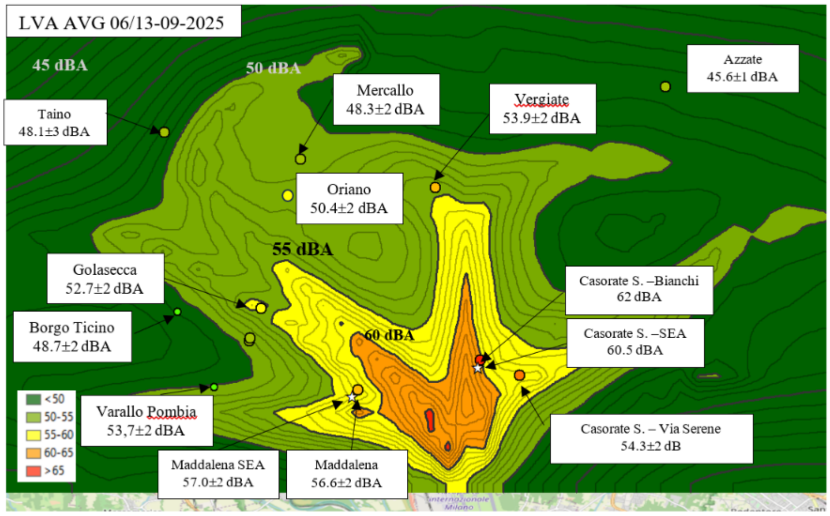
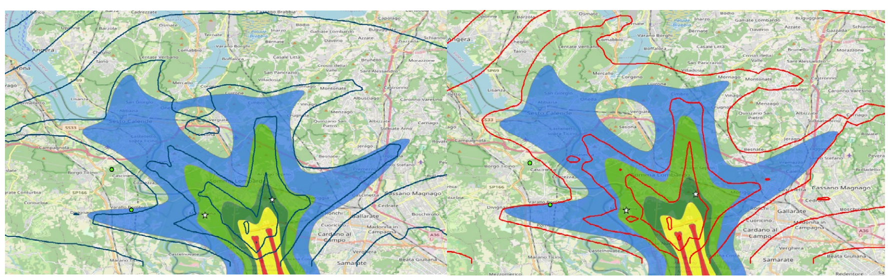


Figure 14. Average LVA for the week 6 - 13 September 2025.

The shapes identified are also reflected in the ARPA zoning curves, although in some cases there are extensions along the exit SIDs. On the other hand, the week for which they were evaluated are not the same and there could be some significant variations in Figure 15.



June 2025 September 2025

Figure 15. Comparison of AEDT estimation by ARPA Piemonte with the isol LVA curves estimated with the proposed procedure.

4.5. Comparison of Estimated LVAs Values and the on—Site Measurements Data LVA

In order to verify if the values determined with the map are coherent with the measurements onsite, we have extracted the LVA values for the two analysed weeks with the values determined in the various noise campaigns. The measurement campaigns, mostly performed using the IDNL instruments, do not coincide with the two weeks of analysis of this study and therefore differences are unavoidable. The average value of the difference between June and September is 0.8 dBA: this can represent the variability of LVA considering two weeks of the year. In addition the analysis was conducted using only two weeks while the campaign represent an average of at least 4 weeks; and infact the values of measured LVA should be considered with a standard deviation of about 2 dBA.

The average difference between the measured LVA onsite and the estimated LVA ranges between 1.5 and 1.7 dBA depending which week is compared. In general the agreement is rather good, considering the differences in campaign periods.

At some locations the differences are noticeable, like in Varallo Pombia in which the difference is underestimated 4 dBA. One possible reason is that the flights towards this direction are not well identified by the device in Maddalena and probably another device would be necessary to intercept the flights to this direction. (Table 2)

Table 2. Comparison of measured values of LVAs in the various campaigns with the estimated LVA values for the two weeks of analysis.

Location	Lat	Lon	Period of campaign	LVA meas (dbA)	LVA June (dbA)	LVA Sept (dbA)
Azzate	45.77293	8.798125	14.2 - 9.3 2026	45.6	46.7	47.3
Borgo Ticino AlbArm	45.69116	8.621664	14.1 - 22.2 2026	48.7	48.1	49.1
Casorate Sempione Bianchi	45.67384	8.731118	19.8 - 17.9 2025	62.0	58.9	60.3
Casorate Sempione SEA	45.6711	8.730525	7.6 - 13.6/6.9 - 13.9 2025	60.5	59.4	60.8
Casorate Sempione Serene	45.66818	8.745597	27.6 - 3.8 2025	54.3	56.5	58.3
Coarezza	45.68067	8.647532	30.9 - 22.10 2025	49.1	50.4	50.6
Coarezza via Colombo	45.6818	8.6479	25.10 - 4.11 2025	50.5	51.2	51.2
Golasecca Sud	45.6906	8.6519	6.8 - 3.9 2025	52.7	55.3	54.7
Inarzo	45.78504	8.737032	26.2 - 22.3 2026	48.7	46.1	46.7
Maddalena	45.66299	8.685973	9.2 - 2.3 2026	56.6	56.9	57.0
Maddalena SEA	45.66046	8.684743	7.6 - 13.6/ 6.9 - 13.9 2025	57.0	56.4	56.6
Mercallo	45.7466	8.6662	30.9 - 22.10 2025	48.3	49.3	50.3
Sesto Calende loc. Oriano	45.73542	8.654756	14.12.2025 - 25.1.2026	50.4	50.5	51.1
Somma Lombardo	45.6749	8.7171	ongoing	n.d.	57.2	58.6
Taino	45.75618	8.616899	Continous	48.1	47.4	48.1
Varallo Pombia	45.6639	8.634794	28.1 - 25.2 2026	53.6	49.1	50.0
Vergiate loc. Cimbro	45.73619	8.714861	5.11 - 28.11 2025	53.9	52.2	54.4

5. Conclusions

The report presented an innovative method for the estimation of the mapping of the airport noise parameter LVA using a limited number of monitoring stations and appropriately processing the data with the help of the radar tracks available on the website https://malpensaDB.comune.taino.va.it.

The methodology and the results of the application to the Milano Malpensa Airport; the study is a proof-of-concept for the northern departure sector, and these weekly maps are not a replacement or a contrast with the from official regulatory LVA zoning under the ministerial decree. The presented methodology is based on the measurements actually recorded in the field. For the study, official data from the SEA monitoring stations of Maddalena and Casorate Sempione - Monte Rosa were used; through the data of these two monitoring stations, we were able to estimate the time trends caused by the flights that were coupled during the evaluation procedure of the LVA parameter for these sensors, for the entire space north of the airport. Once the time trends were obtained, it was possible to estimate the LVA at all points in the analysis space and then create the relative maps. In principle, it would be possible to determine the LVA parameter of the area north of Malpensa on a daily basis, but it would be necessary to have the data of these two monitoring stations continuously available. The use of this method could provide an LVA (or any other global parameter) map every day automatically.

Another possible use would be the specific analysis of the distribution of LVAs for particular conditions, such as during the 2024 trial of new routes. If we had the data from the two monitoring stations available, we could check and compare the LVA map even in the territories far from the airport.

Last but not least, the procedure, applied for the determination of the specific Italian definition of noise, LVA, can be applied to any definition of noise because through the system we obtain the noise timeline in each point of the map; it is sufficient to change the definition of the overall parameter (*i.e.* Lden) and you can obtain the noise mapping the different parameter.

Acknowledgements

The author would like to thank SEA Milano for providing the noise measurements utilized to derive the maps presented in the report.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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Appendix A: The LVA Quantity

The LVA (Airport Noise Assessment Level), expressed in dB(A), is the Italian regulatory index (DM 31/10/1997)[2] used to measure and monitor noise pollution caused exclusively by aircraft movements (take-offs, landings, overflights) around airports.

The official definition is in the Dm 1997 (https://www.gazzettaufficiale.it/eli/id/1997/11/15/097A9090/sg), for which an (automatic) translation to English is presented below.

1) Definition of LVA.

$$L_{VA} = 10\log\left[\frac{1}{N}\sum_{j=1}^{N} 10^{\frac{L_{VAj}}{10}}\right] \text{dB}(A)$$

where L_{VA} represents the level of evaluation of airport noise; N is the number of days of the period of observation of the phenomenon and L_{VAj} is the daily value of the level of evaluation of airport noise.

2) The number of days N of the period of observation of the phenomenon must be twenty-one, equal to three weeks, each of which must be chosen within the following periods:

- 1 October - 31 January;
- 1 February - 31 May;
- 1 June - 30 September.

The week of observation within each period must be the one with the highest number of movements, according to the data provided by the Ministry of Transport and Navigation, or detected by the monitoring systems installed. The measurement of noise, during each week of observation, must be carried out continuously over time.

3) The daily value of the Airport Noise Assessment Level (LVAj) shall be determined by means of the following report, taking into account all ground and overflight operations that occur during the day between 00:00 and 24:00:

$$L_{VAj} = 10\log\left[\frac{17}{24}10^{\frac{L_{VAj}}{10}} + \frac{7}{24}10^{\frac{L_{VAn}}{10}}\right] \text{ dB(A)}$$

where L_{VAd} and L_{VAn} represent respectively the Airport Noise Assessment Level during the day (06.00 - 23.00) and at night (23.00 - 06.00).

4) The Airport Noise Assessment Level during the daytime period (LVAd) is determined by the following relationship: -

$$L_{VAd} = 10\log\left[\frac{1}{T_d}\sum_{i=1}^{N_d} 10^{\frac{SEL_i}{10}}\right] \text{dB}(A)$$

where T_d = 61,200 s is the duration of the daytime period, N_d is the total number of aircraft movements in that period, SEL_i is the level of the i-th sound event as-

[2]https://www.gazzettaufficiale.it/eli/id/1997/11/15/097A9090/sg

sociated with the single movement.

5) The Airport Noise Assessment Level during the night period ($LVAn$) is determined by means of the following relationship:

$$L_{VAn} = \left[10\log\left(\frac{1}{T_n} \sum_{k=1}^{N_n} 10^{\frac{SEL_k}{10}} \right) + 10 \right] \text{dB}(A)$$

where T_n = 25,200 s is the duration of the night period, N_n is the total number of aircraft movements in said period, SEL_k is the sound level of the i-th event associated with the single movement.

6) The level of the ith sound event associated with the single movement of aircraft SEL_i is determined according to the following relation:

$$SEL_i = 10\log\left[\frac{1}{T_o} \int_{j=t_1}^{j=t_2} \frac{P_{A_i}^2(t)}{P_0^2} dt \right] = \left(L_{AeqTi} + 10\log\frac{T_i}{T_0} \right) \text{dB}(A)$$

where: T_o = 1 s is the reference time; t_1 ,and ,t_2 represent the initial and final instants of the measure, *i.e.* the duration of the event $T_i = (t_2 - t_1)$ in which the level L_A is higher than the threshold: $L_{AF\max}$ - 10 dB(A); $P_{A_i}^2(t)$ is the instantaneous value of the sound pressure of the event A-weighted i-th; Po 20 micron Pa represents the reference sound pressure; L_{AeqTi} , is the equivalent continuous A-weighted sound pressure level of the i-th sound event. L_{AFmax} is the maximum sound pressure level in the "A" weighting curve, with the time constant "Fast", linked to the event.

Appendix B: List of Measurements Days

The list of days analysed to derive the average maps presented in the report is presented below. For each day we have analysed the noise measurements every 1 second and have derived a number of peaks (first column); not all the peaks were related o airplanes or were large enough to be considered in the analysis. The "coupled" peaks (second column) represent specific flights considered responsible of the peak. The third column is the coupling percentage, about 77% for Casorate Sempione and 75% for Maddalena. The last column is the value of LVA determined for each day.

Day	Identified peaks	Coupled peaks	Coupled Percentage	LVA (dBA)
		Casorate Sempione		
2025-06-07	309	272	88	**60.8**
2025-06-08	365	296	81	**61.6**
2025-06-09	333	304	91	54.5
2025-06-10	319	306	96	**62.5**
2025-06-11	341	284	83	60.0
2025-06-12	347	310	89	**60.9**

Continued

2025-06-13	341	295	87	59.8
2025-09-06	359	305	85	**60.2**
2025-09-07	344	316	92	**60.2**
2025-09-08	389	348	89	**63.9**
2025-09-09	370	321	87	**61.9**
2025-09-11	365	334	92	**60.9**
2025-09-12	372	334	90	**62.5**
2025-09-13	321	298	90	**60.6**
Maddalena				
2025-06-07	331	232	70	**55.7**
2025-06-08	306	205	67	**55.5**
2025-06-09	465	327	70	**59.4**
2025-06-10	344	238	69	**55.7**
2025-06-11	285	207	73	**56.5**
2025-06-12	311	238	77	**56.1**
2025-06-13	276	209	76	**56.6**
2025-09-06	268	208	78	**55.0**
2025-09-07	265	213	80	**56.4**
2025-09-08	313	269	86	**57.1**
2025-09-09	292	238	82	**58.2**
2025-09-11	391	291	74	**58.1**
2025-09-12	303	228	75	**56.3**
2025-09-13	250	197	79	**56.9**