Helicopter operations: the environmental impact and ground facilities. Procedures and operational standards for the system's acceptance.

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Abstract

The link between the heliports, environmental quality and safety is an important challenge in the field of helicopter transport. This challenge is especially crucial when the helicopter operations are carried out on densely urbanized areas. Often these areas have significant constraints and obstacles, particularly in terms of noise pollution. These constraints make the approach/takeoff maneuvers very complicated.

The theme of the environmental sustainability of the rotorcraft is strongly felt in many countries. The production of noise is subjected to numerous rules and procedures, which tend to improve the acceptability of the helicopter by residents in neighboring areas to verti/heliports.

The attention of manufacturers towards the problems of noise compatibility has produced technological innovations to reduce emissions, such as the shape of the tip of rotor blades, a speed reduction of rotation of the rotors, etc.

Environmental concerns are becoming increasingly important when siting all aviation facilities. In particular, heliport facilities generate both positive and negative impacts on the surrounding environment. Negative impacts are mainly related to soil quality, water resources, safety issues, air environment (especially during the construction phase), noise (during operations) and biological environment. Positive ones could occur by the increase of emergency services, revenue generation, and the provision of a better connectivity with the neighborhoods located nearby the facility, the raise of employment opportunities and the general improvement of air transport facilities. The current international regulatory framework on heliport facilities seems to be lacking with regards to the evaluation of the environmental impacts of the heliport facilities. Moreover, the national rules on this topic are often undefined or vague. For this reason, it seems necessary to define guidelines to improve the awareness of the consequences which spontaneously arise from the planning and designing phase of heliports. Already from the site selection stage, heliport planners have to take into account all potential environmental issues. Noise is always the primary concern in these cases. A candidate site must be compatible with its surroundings. Compatibility must include any increase in activity resulting from IFR capability. Additional issues that citizens and municipalities are concerned about include air pollution, water pollution, ground access, and safety flight operations. Air pollution by helicopters is negligible although this issue may be brought up by concerned citizens and communities. Water pollution caused by fueling or maintenance facilities at a verti/heliport is coming

under greater scrutiny. The ability to deal with all these public issues must be addressed during final site selection and community standards must be upheld. Ground access to a new transportation mode may increase traffic at and en route to that location and create a potential increase in noise and air pollution. These concerns must be dealt with in the design of ground access to the facility and by incorporating the individual community's standards, regulations, and goals.

The receptivity of community leaders to work with the vertical landing facility to solve these problems should be measured in the final site selection process. Beyond the direct benefit of affecting the environment as little as possible, addressing environmental issues is an additional, albeit indirect tool, in obtaining and keeping good relations with the local government and its citizens. A heliport that has been developed into an IFR facility must be viable for a sufficient length of time to realize a return on investment (ROI) and to also achieve a contribution to the transportation system. In order to select a potentially viable heliport it is vital to consider the compatibility of surrounding land uses, both existing and future.

A heliport that, at the present time, is considered by its neighbors as a nuisance cannot be counted on to remain in operation for an acceptable amount of time. Plans for future land use in the area must be determined through an investigation of planning documents at the appropriate levels (city, county, regional, etc.). Issues that instead will be addressed are related to the identification of the flight phases producing noise, by analyzing the different type of noise emission regarding the flight phase.

Moreover, the role of helicopter's pilot into the restraint of helicopter's noise with particular regards to the driving behavior and its impact on noisiness' reduction will be treated. In general, it can be stated that pilots have to do everything for reducing helicopter's noise while remaining within the safety range's parameters of the rotorcraft. Here comes the need of developing a worldwide analysis of the regulatory constraints for restricting helicopters' impact on the populations residing nearby ground facilities. These constraints dictate operational rules for departure and approach phases of rotorcraft.

Others factors affecting noise emissions are, for instance, temperature, humidity, wind, rotor blades. Standard procedures for noise abatement are:

- to fly at the highest altitude possible among those compatible with the airspace and safety rules;
- to enhance the awareness of the different noise perception that can be induced depending on the overflown environment (e.g. urban areas or country);

The proposed study is articulated as follow:

- identification of measures to be implemented for reducing the environmental impact;
- analysis of current standard rules in several countries with regards to environmental constraints;
- proposals for initiatives aiming to the rules' standardization regarding operations on heliports and helipads;
- samples of operational actions to be implemented for departure and approach phases;
- review of international experiences in the flight procedures applied for noise abatement.

1. Environmental issues of heliport facilities: analysis of the impacts caused by helicopters operations

Public appreciation of the rotorcrafts has been improved in recent decades due to their increasing use by the law enhancement services, HEMS and SAR services, borders and area survey tasks, line or charter civil passengers services, etc. But the helicopter gives people a negative impression regarding its environmental impact, especially in terms of noise pollution: it is perceived as noisy and obtrusive. The environmental impact of helicopters could thus be minimized so that they should lose the appellative of "irritant". Often civilian operators encourage their pilots to observe a sort of Code of Conduct, which requires a strict compliance with the procedures for landing or take-off to minimize noise pollution, because a modern helicopter being flown over a congested urban area at 1,500 feet is rarely heard above the ambient noise level, but when it lands or takes off, the noise loses its limited impact, especially into densely urbanized areas. These last cases are characterized by small infrastructures on which to land, often without any form of "protected" area around the helipad. Besides ensuring the highest quality of the supply, the development of helicopter transport systems which respect operators' and passengers' needs has to preserve the quality of life of the residents near heliports, as an important aspect influencing the economic and social course of that territory. Many densely urbanized cities host at least one heliport and the presence of these infrastructures produces the need to face the environmental issues, by recognizing the key role of environmental management activities of the air transport supply, contributing to enhance traffic demand, business attractiveness and technological improvements. In large urban areas, there are physical barriers, such as high density of population and a progressive increase in the congestion of road traffic: all conditions that highlight the need of high-speed transport means. Heliport networks could play important roles by providing a better level of accessibility per unit cost, if compared to the airports: from this perspective they can be considered as instruments for economic development. The current role of helicopters is mainly related to the tasks of public utility, but it is becoming important to its inclusion as part of the whole system of mobility. The inclusion into commercial short range transport services needs a detailed analysis, divided into three stages:

1. a demand analysis for air transport, with the aim of identifying the potential share to be acquired from the helicopter used;
2. a technical and economic analysis resulting in the choice of helicopter fleet to be used in relation to the parameters characteristic of the commercial service such as, for example, autonomy, capacity, speed, flight times, frequencies and demand shares;
3. a cost/benefit analysis of the whole helicopter system, divided per services, operators, heliports.

Considering benefits created by VTOL, it is important to underline that these civil line services may also reduce congestion into major airports and, on the other hand, they could increase air traffic demand integrating conventional air services:

- using smaller airports near great hubs, able to route the helicopter's traffic or allocating to the traffic of non-conventional aircrafts minor areas within the airports, but so far from used runways to not influence scheduled conventional air traffic;
- giving to airports a gain of catchment area, using VTOL to quickly reach marginal areas within the region and downtown of the major congested cities.

To resume the theme of environmental compatibility of operations at heliports, this goal can be achieved by optimizing activities on heliports, operating both on qualitative and quantitative aspects (for instance by acting through spatial and temporal distribution of the scheduled operations). In that respect, in some cases the quantitative limitations of the number of operations at existing heliports seems to be the wisest thing to do.

While the design of new landing infrastructures should be also done taking in to account the traffic forecasts providing a heliport area enough wide in terms of expected amount of noise pollution. As regards the aspects linked to the environmental acceptability of commercial services operated by helicopters, the most important issues related to the analysis of the flight procedures during the maneuvers on the areas nearby the facilities (approach, landing, take-off, etc.) are, as we can see in figure 1.1:

- the study of the environmental compatibility of heliports: noise (approach, landing and other flight phases, methods of measurement, regulation);
- analysis of pollution from exhaust gases (characteristics of the engines, pollution abatement measures).

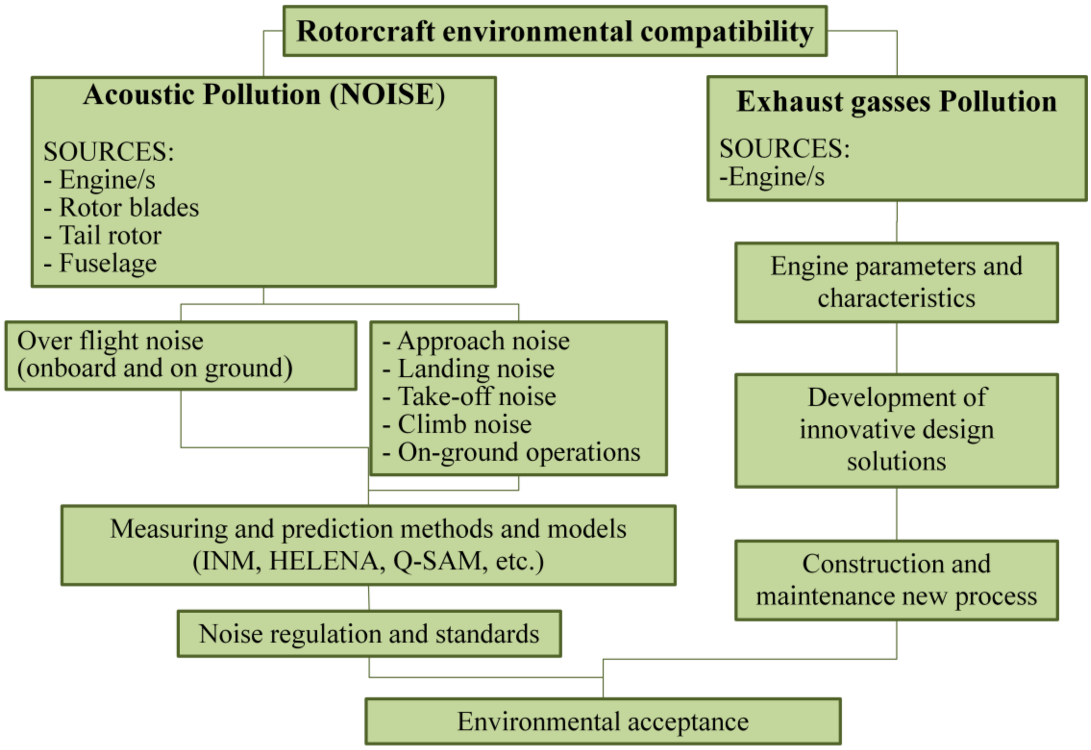

Fig.1.1 – Rotorcraft environmental compatibility involved factors.
(source: author's elaboration)

1.1 Public perception and acceptance

If we consider the community acceptance of environmental acoustic pollution generated by VTOL, we have to focus on noise rating procedures predicting the impact of fixed-wing aircraft noise around airports. The presence of a heliport appears to create a level of adverse reaction which is disproportionate to the measured and predicted noise levels using the mentioned procedures. A partial explanation for the disparity between noise assessments and community reaction to helicopter operations has been identified by some authors (Leverton and Pike, 2006, 2007) as deficiencies in the rating methods.

For a more complete analysis of this issue it is necessary to examine the way in which helicopters operations are perceived. Fixed wing aircraft operations typically involve a large number of flights per day and, because the noise characteristics of most of the large jets are similar to one another, the noise climate is relatively uniform, involving high and medium frequencies sounds. Away from airports aircraft over fly at very high altitude and there is little general concern over aircraft safety.

Helicopter operations are quite different. Generally the number of operations per day, even near a busy heliport, is relatively low and very variable in nature. VFR (Visual Flight Rules) flight paths, unlike those used by fixed-wing aircraft that flight using IFR (Instrumental Flight Rules), are not closely followed by pilots, varying widely and so at any one location the noise pattern could be much less consistent, but much annoying, because of its low frequency and complex nature.

In fact there is very large difference considering both the level and the character of noise created by different classes of helicopters and fixed wing aircrafts: helicopters sound noisier, because the “blade slap” produced by these machines involves low frequencies sounds that determine the diffusion of vibratory systems that affect greatly the perception and the annoyance. So on the basis of these differences many authors considered an additional “correction” to measured noise levels that takes in to account the greater annoying perception of the helicopter operations near a heliport if compared to fixed wing aircraft ones, as shown in section 3.

2. An overview of the existing guidelines and rules for the evaluation of the environmental impact of rotorcraft operations.

The helicopter noise generation and its related directivity depend on the flight phases and on the maneuvers. To mitigate the impact on the areas located in the proximity of the descent and takeoff paths, guidelines issued by Environmental Associations, local governments and Aviation Organizations are provided. It seems to be clear that the “perfect maneuver” to avoid noise sensitive areas doesn’t exist because it depends on the context and varies from case to case. More precisely it is a compromise among the provision of comfort to the passenger and the crew, the avoidance of artificial and natural obstacles and the fuel saving along with the provision of high safety levels the users. Following is shown an overview of the most important rules and guidelines about the helicopter noise certification, the environmental compatibility of the infrastructures and the operations.

2.1 European Rules

Part of the mandate of EASA is to promote, in the field of civil aviation, a high and uniform level of environmental protection for European citizens. Environmental Protection is therefore an integral part of EASA’s general structure of rules and regulations which aim to mitigate the negative impacts of the civil aviation industry.

The Agency focuses on regulations which aim to reduce the environmental impact of aviation by helicopters at source. As to the noise certification, EASA also provides the type-certificate data sheet for noise (TCDSN) for some of the most used helicopters. Each TCDSN contains general information about the helicopter model, the certification basis, the technical characteristic and Operational limitations and additional notes, as shown in figure 2.1.


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Type

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European Aviation Safety Agency

EASA

TYPE-CERTIFICATE
DATA SHEET

No. R.009

for
EC135

Type Certificate Holder
EUROCOPTER DEUTSCHLAND GmbH

Industriestrasse 4
D-86609 Donauwörth
Germany

For Models: EC135 P1, EC135 P2, EC135 P2+, EC 635 P2+, EC135 T1, EC 635 T1
EC135 T2, EC135 T2+, EC 635 T2+

Fig.2.1 – TCDSN for EUROCOPTER EC135
(source: EASA)

2.2 FAA Rules

The Federal Aviation Administration provides important guidelines on environmental impacts of airports and heliports by the issue in 2006 of the order 1050.1E CHG 1 “Environmental Impacts: Policies and Procedures”, according to the Appendix H 14 cfr. part 36 (Noise Requirements for Helicopters). Moreover, according to the National Environmental Policy Act (NEPA) – order 5050.4B, environmental issues shall be identified and considered early in an action’s planning process. Agencies shall use a systematic, interdisciplinary approach. As appropriate, agencies shall also involve local communities and coordinate with agencies and governmental organizations. NEPA requires each Federal agency to disclose to the interested public a clear, accurate description of potential environmental impacts that proposed Federal actions and reasonable alternatives to those actions would cause. Through NEPA, Congress directed Federal agencies to integrate environmental factors in their planning and decision making processes. This provides the public with a fair, open opportunity to review and comment on those alternatives and impacts and other important environmental matters related to a proposed Federal action.

Important guidelines for taking into account the avoidance of natural and artificial obstacles during the takeoff and the approach maneuvers are issued by the FAA by the provision of the Helicopter Route Charts. Helicopter Route Charts are three-color charts that depict current aeronautical information useful to helicopter pilots navigating in areas with high concentrations of helicopter activity. Information depicted includes helicopter routes, four classes of heliports with associated frequency and lighting capabilities, NAVAIDs, and obstructions. In addition, pictorial symbols, roads, and easily-identified geographical features are portrayed. Since helicopter charts have a longer life span than other FAA products, all new editions of these charts will be printed on synthetic paper. These charts are updated as requested by the Federal Aviation Administration. Unfortunately these charts are issued for a small number of airports, as, for example, the one shown in figure 2.2.

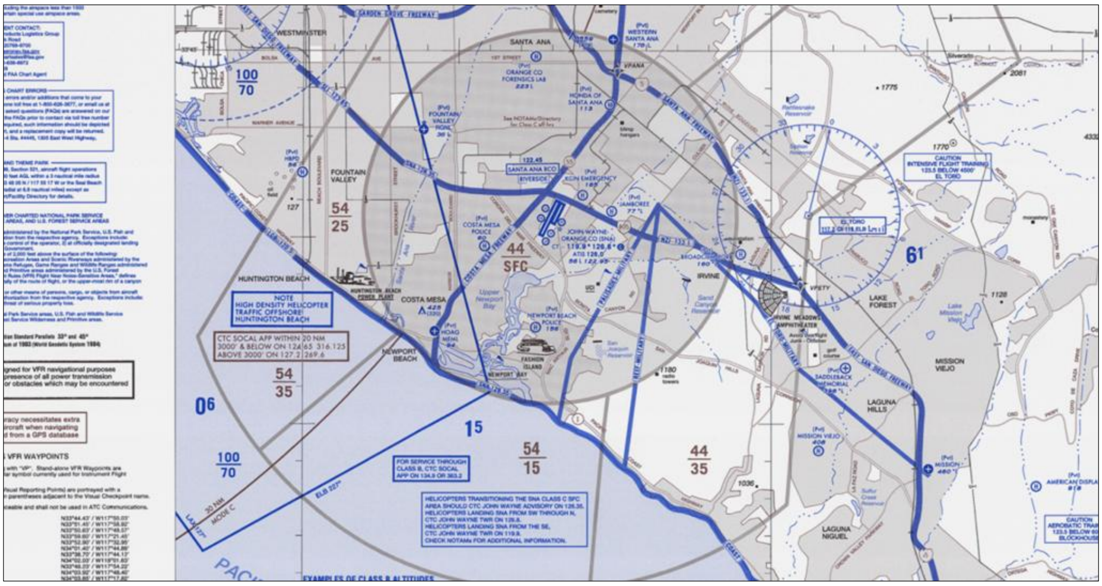


Fig.2.2 – Helicopter Route Chart for LAX
(source: FAA - Helicopter Route Charts)

2.3 HAI guidelines

The Helicopter Association International (HAI) has a Acoustics/Environmental Committee is composed of Association members whose objective is to review all matters related to helicopters and heliport acoustics. This committee serves as the "Noise Task Force" of the Regulations Committee. Serving in this capacity, the committee provides technical and political advice for the development of association positions on government and/or community aeronautical acoustics standards and regulations that affect the civil helicopter industry. In particular, HAI has:

- refined a "Fly Higher Chart" for distribution to helicopter operators. The Chart displays the acoustic benefits of flying higher, where doubling the altitude reduces the noise that reaches the ground by more than half.
- reviewed the Congressionally mandated FAA study on "Non-Military Helicopter Noise" providing significant input and peer review for the FAA.
- prepared HAI inputs on proposed ICAO noise stringency for new design helicopters and derivatives.
- participated in the preparation and review of a proposed "Helicopter Model Ordinance".

HAI also publishes the manufactures' noise abatement procedures for the most known helicopter models. Fly Neighborly Program is a voluntary noise abatement program developed by the HAI Fly Neighborly Committee. The program is designed to be implemented worldwide by large and small individual helicopter operators. This program applies to all types of civil, military and governmental helicopter operations. The Fly Neighborly Program addresses noise abatement and public acceptance objectives with guidelines in the following areas:

- pilot and operator awareness;
- pilot training and education;
- flight operations planning;
- public acceptance and safety;
- sensitivity to the concerns of the community.

One of the frameworks issued by the HAI, regarding the environmental compatibility of both infrastructures and operations with helicopters is the "*Fly Neighborly Guide*". This document contains important considerations about the helicopter sound generation, general guidelines for noise abatement operations, the pilot training, guidelines for implementing a correct noise abatement strategy and the management of the public acceptance. The highlights from the HAI's Fly Neighborly Program are:

- to fly at an altitude that is as high as practical;
- to avoid residential areas when possible;
- to fly over industrial areas and major roadways;
- to mask the sound of helicopters;
- to avoid late night/early morning flights;
- to fly at an altitude that is as high as possible over scenic and recreation areas such as parks and beaches;
- to identify noise sensitive areas and adjust routes to avoid them to the extent possible.

3. Indicators of environmental compatibility of a heliport facility (or land-use compatibility)

In order to control the environmental impact of a heliport all involved actors (the State, the local authorities, the local resident associations, the heliport users and the heliport managers) should adopt measures that aim to reduce the environmental pollution and its associated annoyance, especially noise and gas pollution, due to the helicopter activity in order to preserve the health and peacefulness of the local residents.

3.1 Acoustic pollution levels and virtual noise

The way to measure helicopter noise is crucial for environmental compatibility evaluations. The interest in the effect of noise on the community has led to the development of several noise metrics to best describe the effects of noise, as shown in figure 3.1. The indicators to characterize aircraft noise consider the measure interval (from the single event duration to 24 hours), always starting from the measure of energy dose or single event cumulative metrics (like EPNL - Effective Perceived Noise Level, SEL - Single Event Level, TA - Time Above level, or Leq - Equivalent sound Level).

The most commonly indicators used to measure the environmental impact of aircrafts on airports and neighbor area are the DNL (Day and Night Level), LDEN (Day, Evening and Night Level) or CNEL (Community Noise Equivalent Level), LVA (Livello di Valutazione del rumore Aeroportuale, used in Italy), etc. These indicators differ from each other by the subdivision of the 24 hours into periods contemplating specific dB penalties added for noise produced for examples during the evening or nighttime hours. The night period covered by DNL (+10dB) takes two hours more than the LVA one. The CNEL takes into account a penalty during the evening hours (+5dB). So while the CNEL protects residents more, it reduces the environmental capacity of an airport.

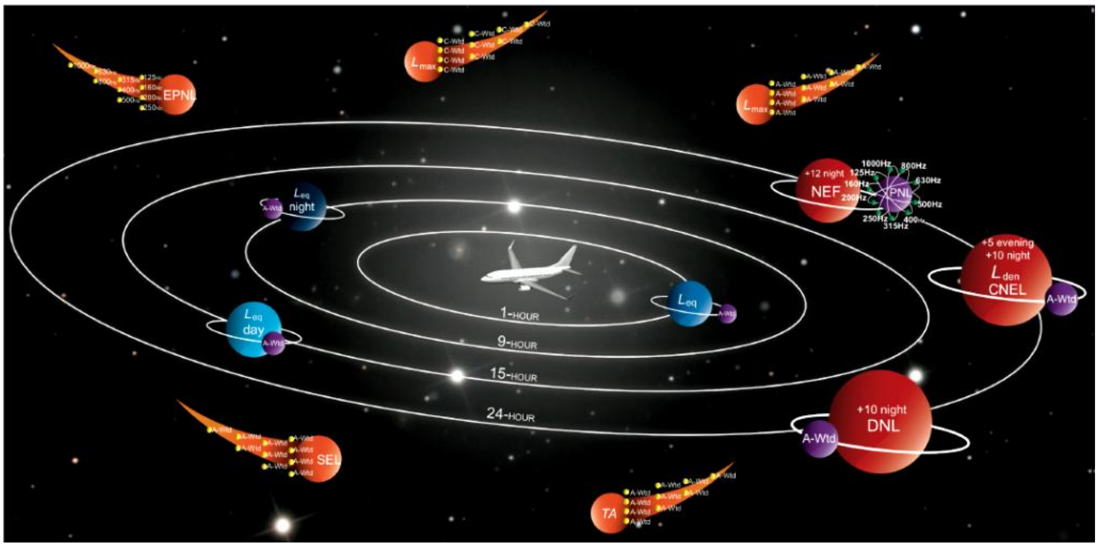


Fig.3.1 – Common noise metrics
(source: Mestre et al., 2011)

All that indexes can take in to account particular "weighting adjustments" due to the human characteristics of sound perception (A-weighting - dBA) or due to the need to emphasize the high or bass noises (C-weighting - dBC).

Many authors (Patterson et al., 1977; Powell, 1981; Molino, 1982; Schomer et al., 1985, 1989, 1996, 2002) demonstrated that these systems make "*Helicopter sounds … more readily noticeable than other sounds"*. On this basis, rating the subjective annoyance produced by real rotary-wing aircraft noise, these authors suggested to consider a +2 dB adjustment per event, for the annoyance of helicopter sounds as compared with fixed-wing aircraft sound producing the same A-weighted sound exposure level, and a +3 to +5 dB adjustment of the EPNL for outdoor simulations.

However the community perception of the noise source can play an important role on the degree of perceived annoyance. The U.S. EPA (Environmental Protection Agency) suggested that the measured noise levels could be lowered of 5 dB, if who generates the noise (helicopter or heliport operators) work to maintain good relations with neighboring communities convincing them that all possible solutions to reduce the noise were considerate (1974).

Other authors (Staples et al, 1999) studied community attitude as an important modifier of annoyance. They created a 10-item Environmental Noise Risk Scale combining elements regarding "noise prevention beliefs", "beliefs about the importance of the noise source" and "annoyance with non-noise impacts of the noise source", analyzing above 350 subjects living in a 55-60 dB DNL zone of a civil airfield. They found that the environmental noise risk scale accounted for 36 percent of the variation in individual disturbance from noise.

Other authors (Ollerhead and Jones, 1993, 1994) studied the subjective consideration of own privacy invasion, noise prevention beliefs, and fear of crashes in neighborhoods around the London Battersea Heliport. People feel that their privacy is invaded when a helicopter overflights, takes off or lands near their residence, considering the helicopter only as “*a rich man’s toy*”.

On the basis of previous researches some authors (Leverton and Pike, 2007) summarize the public acceptance of helicopter noise as a function of two factors: acoustic noise and non-acoustic factors referred to as “virtual noise”.

The virtual noise element is related to non-acoustic factors such as fears for safety, or poor community relations with operators. Virtual noise is not related to the absolute level of acoustic noise. It can be difficult to separate virtual and acoustic noise, as these factors are highly interrelated. Leverton suggests correction factors for taking into account non-acoustic effects of helicopter noise, as shown in table 3.1.

Tab.3.1 – Virtual noise: A-weighted correction factors

Non-acoustic effect	Equivalent A-weighted correction factor (dBA)
Negative reaction to leisure flying	+5
Poor community/airfield relations	+10
Fear of crashes	+10
Nobody acts on complaints	+20
Aircraft are flying too low	+20

(source: author’s elaboration on data by Leverton and Pike, 2007)

When flying over an area where the public have major concerns on helicopter safety, a helicopter generating low but perceivable levels of tonal or impulsive noise could create the same negative response as one with high levels of tail rotor, TRI HIS or BVI operating over communities which are generally more tolerant of helicopters. From this perspective, helicopter noise has to threaten carefully and evaluated at locations.

3.2 Real estate evaluations: environmental noise pollution and accessibility

The presence of a transport terminal like an airport or a heliport on the one hand involves more accessibility to the area, on the other implies a greater environmental pollution. These effects affect real estate values.

Nelson (1980) summarized the results of many early researches. He developed hedonic price equations for residential property, considering the noise level among the attributes of the examined properties, creating a Noise Depreciation Index (NDI). He founds a residential property values fall of 0.58% for every decibel increase in airport noise, while into another study (2004) he found near 23 airports that the noise discount was between 0.50 and 0.60 per decibel (dB).

Booz-Allen et al (1994) described a methodology for evaluating the impact of noise on housing values. The methodology essentially compared market prices in similar neighborhoods that differ only in the level of airport-related noise. They demonstrated that the effect of noise on prices was highest in moderately priced and expensive neighborhoods. The study found an average 18.6 percent higher property value in the quiet neighborhood, or 1.33% per dB of additional quiet.

Other researchers (Tomkins, et al, 1998) found a 0.84% discount of property value of per decibel of noise, while (Uyeno et al, 1993) reported a NDI of 0.68%. Although these relationships are validated for large airports and the HAI (Helicopter Association International) reports the case study of "Sommerset County" to state that the presence of a heliport does not influence the property value, a dedicated study investigating the influence of little flight terminals (like heliports or helipads) on real estate values seems to be necessary. This analysis should examine the relationship between heliport size (in terms of number and localization of helipads and total area occupied by the infrastructure) and property values into the areas near the facility, taking in to account both environmental aspects and accessibility.

3.3 Environmental pollution management

The goal of noise management is to maintain low noise exposures, such that human health and well-being could be protected. Its specific objectives are the development of criteria for the maximum safe noise exposure levels, to promote noise assessment and control as a part of environmental health programs. The management strategies depend on the sensibility of the local authorities to the environmental issues. More generally, we can distinguish three attitudes to face the problem:

- The "precautionary principle", according to which noise emission should be reduced to the lowest level achievable in a particular situation.
- The "polluter pays principle", according to which the full costs associated with noise pollution should be met by those responsible for the source of noise.
- The "prevention principle" according to which actions should be taken where possible to reduce noise at the source.

A legal framework to provide a background environment for noise management strategies is important. An example of framework is given in figure 3.2, showing a six stages process to develop and implement policies for community noise management. Every stage involves groups of 'policy players' who ideally would participate in the process.

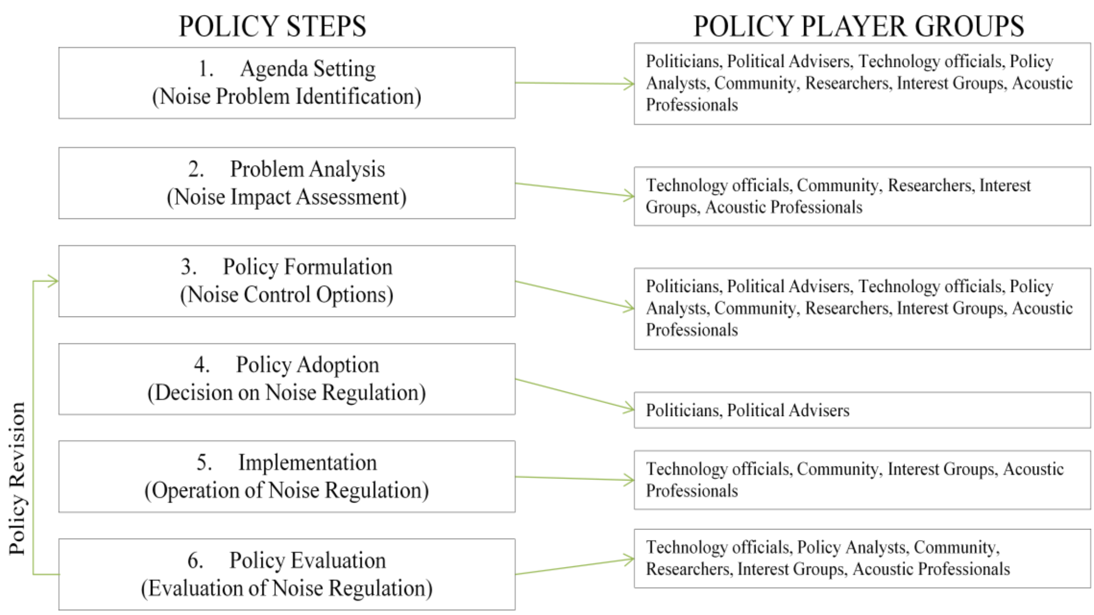


Fig.3.2 – Policy steps and player groups involved in a noise abatement strategy (source: author's elaboration on data by Berglund B. et al., 1999)

As shown in figure 3.3, a noise management strategy should be guided by an environmental health impact assessment that considers noise as well as other pollutants, comparing the costs connected to health effects to the ones linked to the noise mitigation measures, to assess what needed infrastructural, behavioral and operational changes could be performed, like those specifically thought for airports and heliports and shown in figure 3.4.

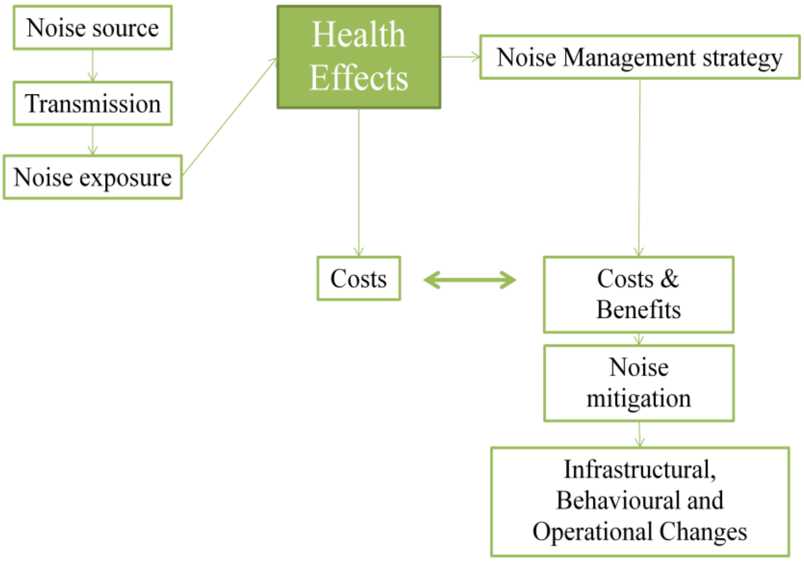


Fig.3.3 – Stages involved in the development of a noise abatement strategy (source: author's elaboration on data by Berglund B. et al., 1999)

The previously shown process could start with the development of noise standards or guidelines, identifying and classifying noise sources and exposed communities. The influence of meteorological conditions should be also taken in to account because of its influence on noise transmission and perception. Noise standards and noise level estimation model outputs should be considered to develop noise control strategies aiming at achieving the noise standards.

Fig.3.4 – Infrastructural, behavioral and operational intervention areas of a noise abatement strategy (source: author's elaboration on data by Berglund B. et al., 1999)

National noise standards are usually based on international or EU guidelines and on national ones, which consider the technological, social, economic, political and other factors specific for each country. Generally a periodic revision of the standards taking in to account all previously mentioned factors in necessary to consider changes of conditions in a country over time and scientific understanding improvements of the relationship between noise pollution and the health of the population.

4. Helicopter operations management: European experiences

Nowadays, the busiest heliports are constructed near the sea or the closest river within the urban areas (such as London Heliport, Monaco Heliport, Macau Heliport, Downtown Manhattan Heliport, Amsterdam heliport, etc.) and the arrival and departure paths are designed so as to mitigate the noise. Following some of the most proposed guidelines for the noise abatement, issued by the Environmental Committee of some European heliports, divided for each maneuver:

Ground Operations

Although startup and shutdown procedures are relatively quiet and are usually shielded from noise-sensitive areas, it is good practice to reduce the amount of time spent on the ground with the rotor turning. This reduces the noise exposure to ground handling crews and heliport/airport personnel. It is fundamental to minimize the duration of warm-up or cool-down periods (typically two to three minutes, although, on some engines it can be as short as 30 seconds) and do not idle at the heliport for extended periods of time. When feasible, the pilot has to park with the rotors running with the nose of the helicopter directed into the wind to minimize noise. If the wind speed is above 5 knots, it is important to avoid parking with the nose 15 degrees or more from the approaching wind. This will minimize tail rotor noise.

Hover / Hover Taxi / Ground Taxi

When hover turning, it is recommended to make the turn in the direction of the main rotor rotation. This minimizes the anti-torque thrust required and, therefore, minimizes the level of noise generated by the anti-torque system.

Takeoff and Climb (Departure)

Takeoffs are reasonably quiet operations, but it can be limited the total ground area exposed to helicopter sound by using a high rate-of-climb and making a smooth transition to forward flight. The departure route should be over areas that are least sensitive to noise.

Enroute and Cruise Flyover

For the enroute and cruise flyover the following guidelines are recommended:

- Fly at least at the heights recommended in the Fly Higher Chart;
- Fly at the highest practical altitude when approaching metropolitan areas;
- Follow major thoroughfares, railway tracks or rivers (see figure 4.1);
- Avoid flying low over residential and other densely populated areas;
- If flight over noise-sensitive areas is necessary, maintain a low to moderate airspeed;
- Select the final approach route with due regard to the type of neighborhood surrounding the landing area, and the neighborhood’s sensitivity to noise. Assess this sensitivity beforehand for each landing area.

Turns (Maneuvers)

As a general rule, it is proposed to avoid rapid, 'high g'/high bank angle turns. When the flight operation requires turns, perform control movements smoothly.

Descent/Approach and Landing

The approach techniques are designed to avoid the impulsive (BVI – Blade Vortex Interaction) noise generated by the main rotor. These techniques typically use a glide slope that is a few degrees steeper than a normal approach. In addition to avoiding high BVI regimes, steep approaches are suggested to ensure a greater height over the noise-sensitive area. Once the transition from cruise to the approach glide slope has been made, the airspeed and rate of descent can be 'tailored' to fit local conditions, avoid unsafe regimes, and still guarantee minimum noise.

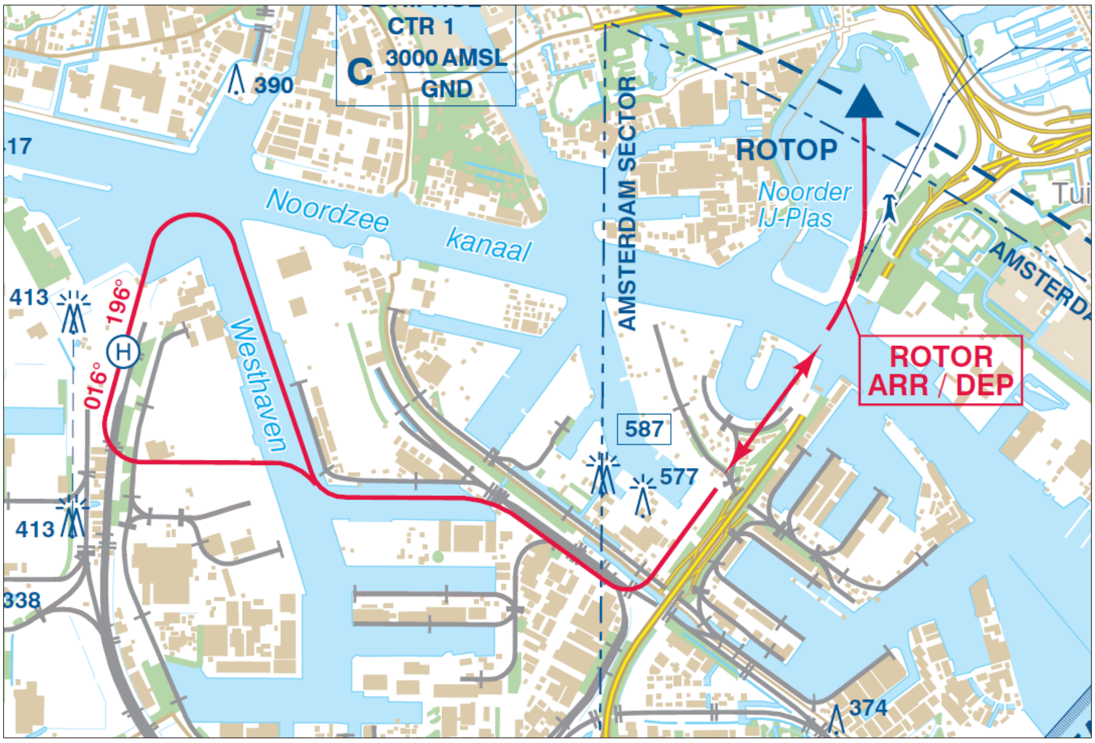


Fig. 4.1 – Amsterdam heliport Visual Flight Chart
(source: Amsterdam Heliport)

4.1 London Battersea Heliport

The Barclays London Heliport takes any environmental issues, such as noise pollution, very seriously and operates a "Fly Neighborly" policy. The London Heliport has airspace assigned to it which covers the area of a circle with a diameter of 2 nautical miles with the heliport being the centre of that circle, called an Air Traffic Zone (ATZ). The vertical airspace varies but the area to the west (upstream) of the lines designated as being "10 to 6", if using a conventional clock face, has a maximum height of 1000 feet and the area to the east of the clock's hands (downstream), a maximum height of 1500 feet. These maxima are imposed by the required vertical separation distance (for enhanced safety) between helicopters landing at or passing by the heliport and aircraft landing at Heathrow.

The London Heliport strives to ensure that any environmental impact on its local area is kept to a minimum. In order to achieve this all helicopter operators require a thorough briefing on the "do's and don'ts" when using the Heliport and their behavior is closely monitored. However, the airspace surrounding the Heliport and over London generally does not belong to the Heliport but to the London Control Zone (known as the London CTR) in the west and, to the east, London/City Control Zone (known as the London/City CTR). Helicopters are legally permitted to fly anywhere within this ATZ and, if making an approach to or taking off from the heliport, they could be below 500 feet although in reality this is most unlikely – except when over the river or, perhaps, if a police or HEMS helicopter.

Whenever possible helicopters operating to or from the heliport will fly over the centre of the river and be at the highest possible safe altitude whilst making an approach or departure. However, there may be circumstances when safety considerations over-ride all others and the helicopter will be told to fly off river in order to provide adequate separation from another helicopter. This means that both helicopters may fly over populated areas but they will be at a safe height and they will pass over as quickly as possible.

4.2 Paris Issy Les Moulineaux

Operators' attention in Paris Issy Les Moulineaux heliport (figure 4.2) is drawn to the fact that the possibilities of collect areas in case of engine failure on the take-off and landing pattern are limited. Operators (or general aviation pilots) are in charge of determining, within the frame of operational regulations, the flight paths, instructions and limitations to be complied with for aircraft take-off and landing.

The highly urbanized environment of Issy Les Moulineaux heliport, the presence of highly number of obstacles (cranes) as well as the departure routes in 06 and arrival routes in 24 require a specific analysis and may limit significantly the possibilities of use of some aircraft. Thus, helicopter take-off requires a prior detailed operational study performed by the aerial work or public transport operators; this study shall analyze specific flight parameters (slope, speed, climb profile, etc.) imposed by the characteristics of the site.

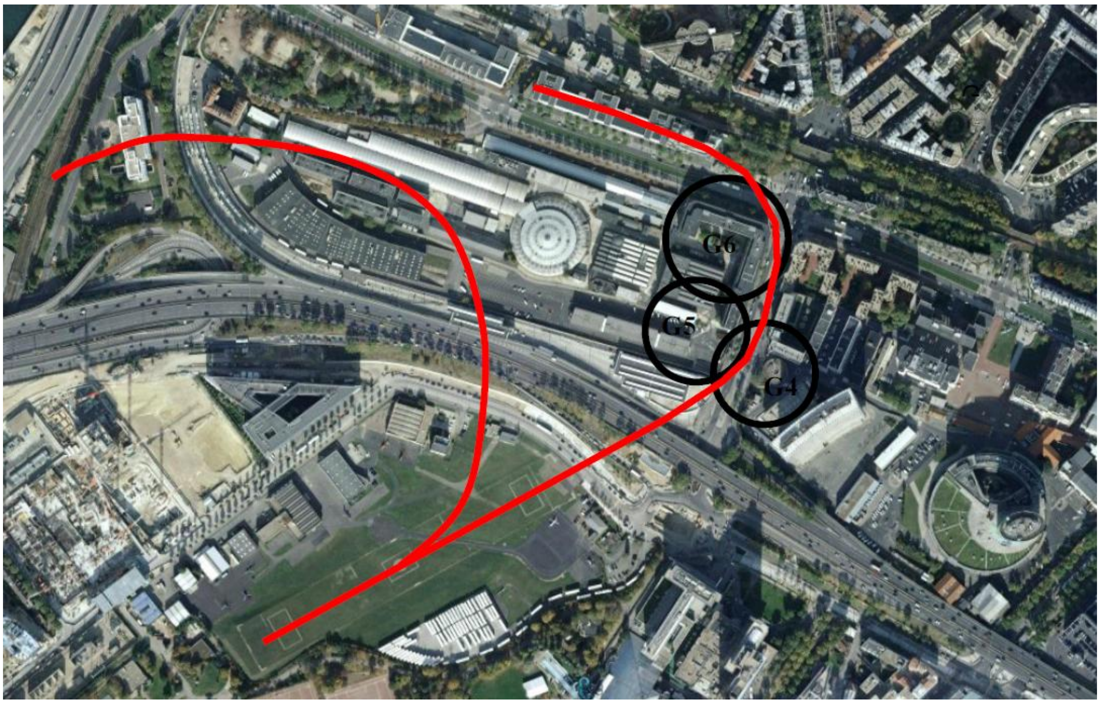


Fig. 4.2 – Paris Issy Les Moulineaux Environment
(source: Bruit parif - Observatoire de bruit en Ile-de-France)

5. Case study: Boccadifalco Airport

This paragraph contains the results of one of the several simulations we have performed by using the INM (Integrated Noise Model), for one of the facilities included in the network of heliports designed for the provision of a transport service by helicopters in Sicily, using certified take off and landing procedures and supply data descending by previous studies (Amoroso et al, 2012).

The facility is represented by the old airport of Palermo "Boccadifalco", as shown in figure 5.1. It was built in 1920, used for military operations during the war and in 2009 the sole was acquired by the National Civil Aviation Authority and used by one of the local Aeroclub and for general aviation. The airport, characterized by low traffic, has one runway and it's located on the outskirts of the town, outside the perimeter of the ring road. According to the previsions of traffic resulted from the demand analysis (Amoroso et al, 2012), this facility, converted to heliport, will ensure 42 daily civil movements and 2 law enforcement movements.

For the simulation, we assumed operations with standard certified approach and takeoff profiles, with takeoffs from the threshold 35 and landings to the threshold 17, according with the current regime imposed by the National Air Navigation Agency, as shown in figure 5.2.

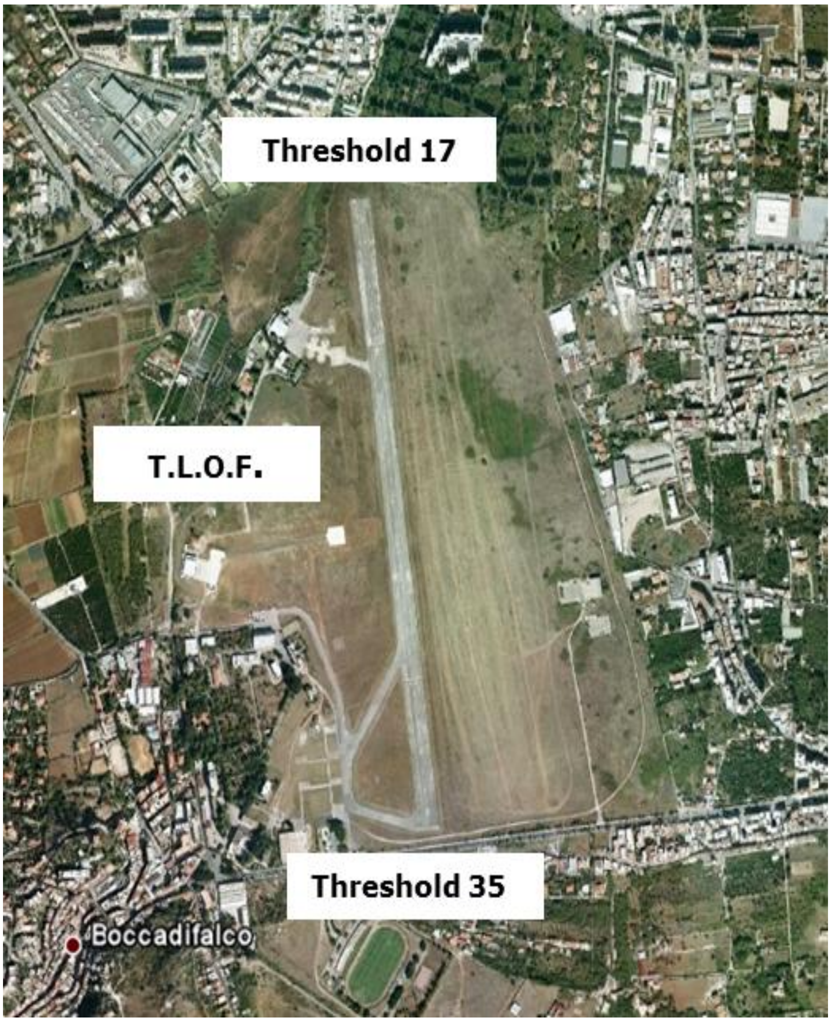


Fig. 5.1 – Palermo Boccadifalco airport
(source: author's elaboration)

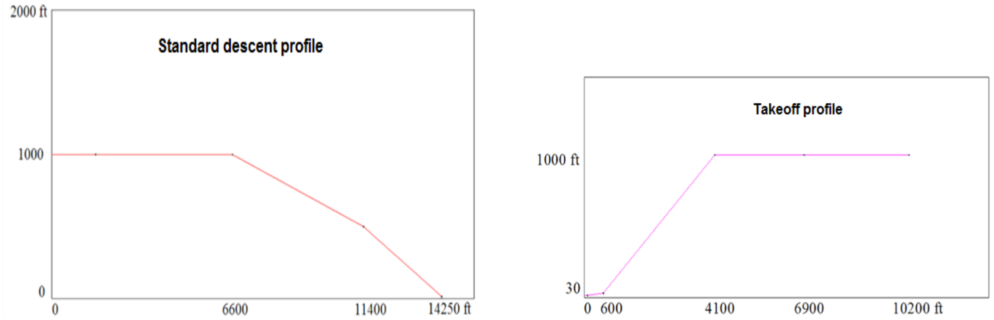
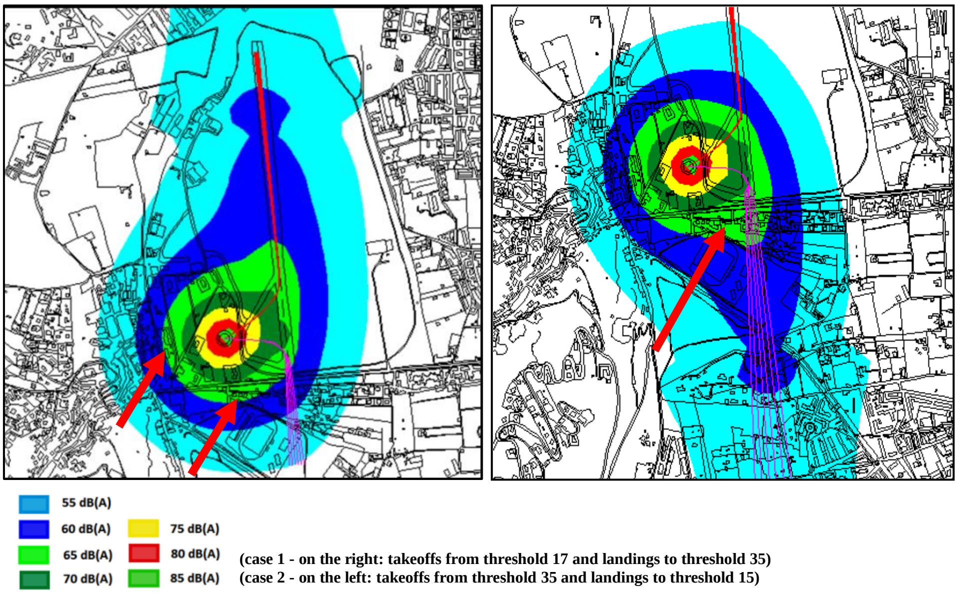


Fig. 5.2 – Standard descent and takeoff profiles implemented for the simulations (source: author's elaboration on INM data)

The outcomes showed how the 65dBA noise footprint overlaps part of the built area with high density of population involved, as shown in figure 5.3.



(case 1 - on the right: takeoffs from threshold 17 and landings to threshold 35)
(case 2 - on the left: takeoffs from threshold 35 and landings to threshold 15)

Fig. 5.3 – Outcomes of the simulation (source: author's elaboration on INM data)

More precisely, the simulation case that considers takeoffs from the threshold 17 and the landings to the threshold 35 produces a larger 65 dBA noise footprint that involves a greater residential area, as shown in table 5.1. Between two cases the simulation parameters differ only in terms of takeoff and landing directions, so footprints result symmetric, but the residential area interested by a too high noise exposure is different.

Tab. 5.1 – Simulated noise footprints.

DNL	Noise footprint it to different cases
55	1,890,000
60	552,000
65	219,000
70	100,000
75	41,000
80	15,000
85	200
Residential area covered by a noise footprint upper than 65 dBA	(case 1) 57,400 (case 2) 50,300

(source: author's elaboration on INM data)

For this reason, it would be interesting to develop an analysis to determine the depreciation of the land-value nearby of the facility due to the noise exposure levels. Moreover it would be important to compare the loss of property value with the cost of possible mitigating measures in order to point out the gain obtained by applying the lasts.

This has led us, for example, to re-evaluate the position of the Touchdown and Lift-Off Area on the air-side, to study new descent and takeoff profiles in relation to safety standards for the reduction of the noise footprint and to take into account the implementation of instrumental approach and landing systems (ILS), where simulated noise footprints are overlapped to a urban map, measuring the residential area covered by the footprint upper than 65 dBA.

A further investigation should consider also the effects of low frequency and impulsive noise on residents to understand how the extension of noise footprints can vary if the model penalizes these particular frequencies.

Conclusions

Rotorcrafts have unique flight capabilities, such as hover and lateral or vertical operations. But these additional operational degrees of freedom are balanced by complex source noise mechanisms that can enhance annoyance. Conventional aircraft require extended airports, while helicopters may operate on much smaller landing sites that unfortunately could often be relatively close to residential communities. This fact can create an immediate local climate of high noise levels that can be further compounded by the other dynamic helicopter noise effects. The future challenge of the research concerning the environmental compatibility of heliports should be based both on the improvements of helicopters' technology and the planning and design of the facilities, in terms mitigating measures. In addition to these enhancements, the legislation concerning flight procedures for rotorcraft has to take into account the environmental issues of the facilities and the areas just located under the takeoff and landing paths. In particular, it is important to do specific tests to compare different possible localizations of an heliport, considering territorial and urban particular situations.

In conclusion, it can be stated that the future solutions for a sustainable helicopter transport pass through the mitigation of exhaust gas and acoustic emissions of the rotorcraft engines, the implementation of segmented take off and landing procedures to obtain lower acoustic impacts and interventions to encourage multimodality based on public local transport and discouraging the use of private mean of transport.

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