USING ECOFLIGHT BUILDING SOFTWARE SUITE FOR PREDICTIVE ASSESSMENT AND DEVELOPMENT OF COMPENSATION MEASURES TO MITIGATE IMPACTS OF AIRCRAFT NOISE IN AREAS NEAR AIRPORTS

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Urban encroachment into airport areas and changing noise zoning policies in the vicinity of airports make it ever more challenging for airport administrations and local governments to manage noise around airports.

An element of the ICAO Balanced Approach to aircraft noise management is land-use planning and management in noise-sensitive areas[1]. These days, land-use planning and the adoption of noise mitigation measures often involve the definition of noise zones. Various noise zones are defined on the basis of noise exposure levels, both through measurement and computer modelling. As a result, the application of appropriate architectural planning techniques, as well as construction, acoustic engineering, and other methods will ensure that noise protection is in-place in areas of urban development. The Ecoflight Building Software was created to assist in identifying the measures required to compensate for noise exposure, so as to meet specific noise level inside dwellings.

Traditionally, zoning procedures consist of establishing noise maps along aircraft flight paths, more rarely of establishing gradual construction restriction zones. Depending on the classification of a noise zone and its noise exposure, newly constructed buildings are subject to specific requirements regarding soundproofing. In such cases, the real estate developer is responsible for the engineering and implementation of soundproofing solutions. This entails a few challenges for local governments, including: the difficulty of developing noise maps, the large number of necessary noise measurements, and ongoing monitoring to ensure the developer's compliance with the soundproofing requirements at the design and construction stages. Another issue is the lack of a predictable description of aircraft noise impacts after the construction is finished, so that potential real estate buyers can be fully informed about the noise situation of the property they are considering.

New Approach

The assessment of the current acoustic situation at the monitored facilities is usually carried out by onsite measurement campaigns. However, these measurement campaigns are of limited use for predicting the future noise climate around airports. In practice, the data obtained from measurements are highly error-prone for a number of reasons, including: the influence of weather conditions, acoustic background, differences in location of moving noise sources, and variability of engine operating modes during measurements. These factors will all come into play to one degree or another at the location considered for the development of new facilities.

Therefore, the prediction of expected noise levels in areas adjacent to the flight path and inside buildings should be based on noise models, which take into account changes in noise spectral characteristics and the effect of building structures on the reflection and absorption of sound.

Ecoflight Building ensures the high quality analysis of the noise situation of the facility under study. Its acoustic assessment error margins are similar to the results of the other noise assessment models it was compared with. It forms the foundation of a reliable forecast of the noise situation in relation to existing or expected sound levels for investigated facilities[2].

The acoustic characteristics of noise exposure are normally calculated at up to 2 meters from facades, roofs and other enclosure elements of buildings, as well as in the adjacent areas at the specified distance from the ground along the entire height of the building. The characteristics specified can be used to assess the level of acoustic impact on the building, or as source data for subsequent calculations of acoustic characteristics inside protected buildings. These calculations can also be used to compare acoustic characteristics of alternative architecture design and layout, structural and technical components, and other decisions made at the various design and development stages of new dwellings.

The calculation of aircraft noise levels that penetrate inside dwellings is more complicated than the calculation of noise levels from stationary sources. Such calculations are based on the assumption that an aircraft flight path can be broken down into a series of simultaneously radiating acoustic source points, which form an aircraft noise source. These are then represented as a set of aircraft systems and mechanisms with linear dimensions comparable with the length of sound waves radiated by them. This allows them to be analyzed as simulation models of linear sources, which consist of separate sound sources points.

This approach allows the assessment at the pre-engineering stage of: the suitability for construction of investigated areas, the validity of corresponding layouts, and the appropriateness of the construction methods chosen. At the design stage, it is possible to forecast and propose in advance an optimal solution for soundproofing of premises to avoid unreasonably high costs.

Software Design and Features

The Ecoflight Building software suite is designed for modelling and calculating sound levels in specified locations including built-up areas, construction-free zones and buildings. It enables to visualize the sound field attributes of aircraft noise sources in any of those types of locations.

The Ecoflight suite allows the modelling of point, linear, planar, and spatial sound sources. It also covers their other acoustic, spatial and time parameters, taking into account the directionality of acoustic radiation of the sources, their spectral parameters, and the nature of sound emission. The software uses various acoustic and time correction scales; and takes into account the geometrical shapes and sizes of the sources.

The results of the calculations can be displayed in the form of 2D or 3D noise maps for equivalent, maximum, SEL, LDEN, octave (third octave) sound frequencies, linear or A-weighted sound exposure levels (sound pressure). **Figure 1** shows a 3D model of a residential area being designed near Vnukovo International Airport. Also, if needed, the user can change the altitude of the horizontal slice in the calculated model, as shown in **Figure 2**.

The designer can choose intermediate or final calculation results, visualize acoustic pictures (displaying isolines and labels, with or without noise numeric values), and forecast the expected acoustic characteristics of the facilities being designed, constructed, or reconstructed. It is recommended that modelling results be checked against on-site measurements, and the source data be adjusted before the final calculations.

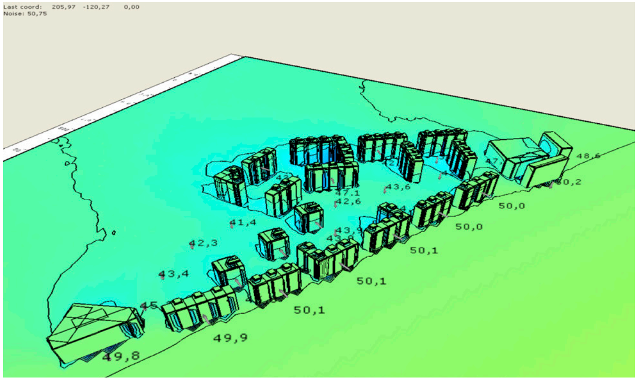

Figure 1. Visualization of Aircraft Noise Impact at Night (L_{eq}).

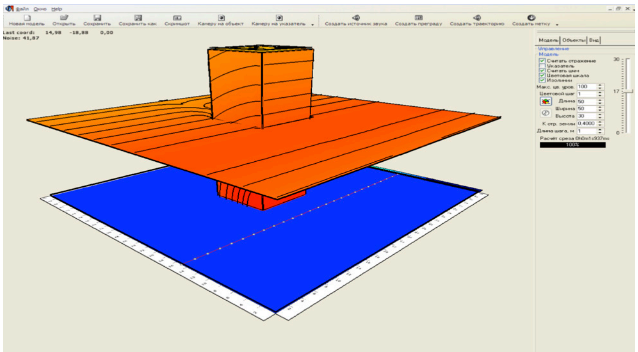

Figure 2. An Example of a 3D Model Visualizing Sound Fields Appearing at the Outside Surfaces of Buildings and in the Adjacent Areas.

This approach ensures the robustness of the forecast.

AcousticLab aircraft noise contour calculation software developed by CA ESC Ltd. (Civil Aviation Environmental Safety Center) was improved as part of the ICAO CAEP/10 cycle and was approved at the 10th meeting of ICAO CAEP. The CAEP Modelling and Database Group played an important role in assessing the robustness of AcousticLab, which resulted in its approval by CAEP.

Practical Application

The AcousticLab software takes into account the type(s) of aircraft, their flight paths, and the directionality of aircraft noise source for both the calculation of individual and aggregated impact. This led to the qualitative improvement of the Ecoflight Building software suite, especially the modelling and the calculation of sound levels in specified locations in the airport vicinity.

The assessment of the acoustic situation in the vicinity of Vnukovo International Airport shown in **Figure 3** illustrates the capabilities of the software suite. The territory of a residential district comprising 7 high-rise apartment buildings is exposed to aircraft noise L_{Amax} = 73 dBA at facades relative to the noise source and L_{Amax} = 60-62 dBA relative to the yard area of the "investigated area" (i.e. Building #5).

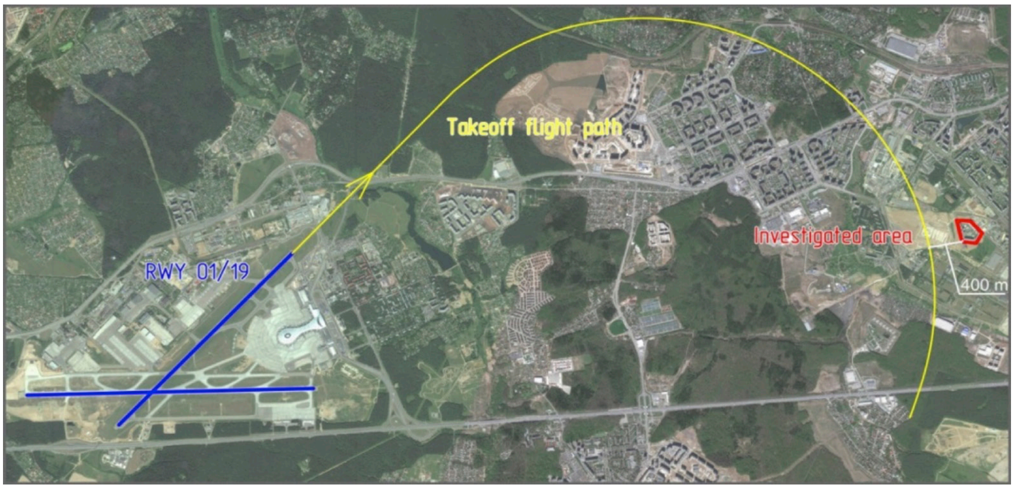

Figure 3. The location of the development site being designed relative to the aircraft take-off flight path.

Figures 4a and 4b graphically illustrate the detailed noise situations at the specific areas being investigated in this example: *the South-west Facades of Building #5(4a) and the North-east Facades of Building #5 and Adjacent Area (4b).*

The predictive calculation based on the design documents shown in **Figure 5** indicate that the construction materials intended for use would not compensate for the external aircraft noise, and all premises were exposed to significantly higher noise exposure than acceptable.

The impact of the most cost-efficient set of corrective measures was assessed. However, as **Figure 6** illustrates, the soundproofing of two end rooms failed to meet the regulated noise levels. To ensure that regulated noise levels are met and mechanical ventilation is performed inside the end rooms, designers had to propose additional corrective measures.

Conclusion

The Ecoflight Building software suite has been successfully used in the vicinity of airports of the Moscow air hub since 2009[4]. Fourteen (14) projects have since been completed, which involved the definition of residential areas based on the noise exposure and recommendations on land-use planning for new buildings, as well as on the required level of soundproofing for individual and collective housing in the investigated region.

As the software has gained popularity, real estate development companies have become increasingly interested in obtaining detailed cost analyses of the materials and soundproofing structures needed for construction, which allows them to meet soundproofing requirements and keep their costs under control. In parallel, predictive information allows airports to share information about expected future noise levels.

This approach meets the objective of identifying the soundproofing and mechanical ventilation levels needed for living areas and schools. This method provides knowledge about noise situation assessment both outside and inside regulated premises for all stakeholders including: aircraft organizations, local governments, and society at large. This information allows stakeholders to base their communications strategies on reliable, robust and transparent data, which is in line with the good practices identified in the newly adopted ICAO Circular on *Community Engagement for Aviation Environmental Management.*

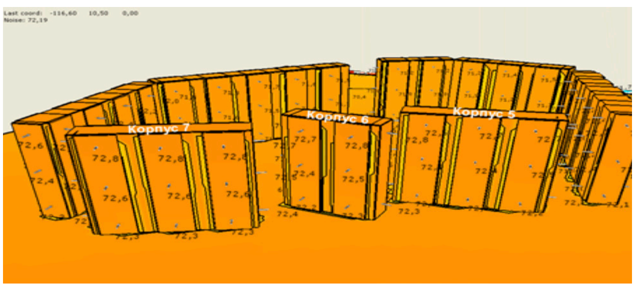

Figure 4a. Cartographic Visualized Assessment of the Noise Situation of Protected Facilities Exposed to Maximum Aircraft Noise Levels at Night. Perspective Projection of the Noise Picture of the South-west Facades of Building #5.

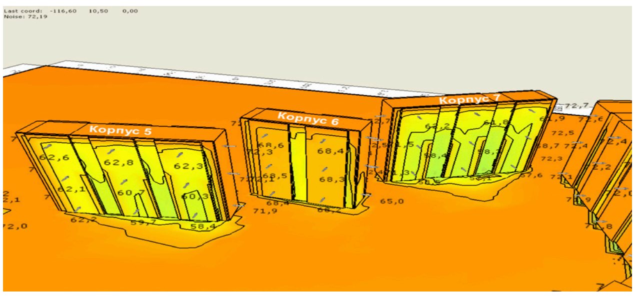

Figure 4b. Cartographic Visualized Assessment of the Noise Situation of Protected Facilities Exposed to Maximum Aircraft Noise Levels at Night. Perspective Projection of the Noise Picture of the North-east Facades of Building #5 and Adjacent Area.

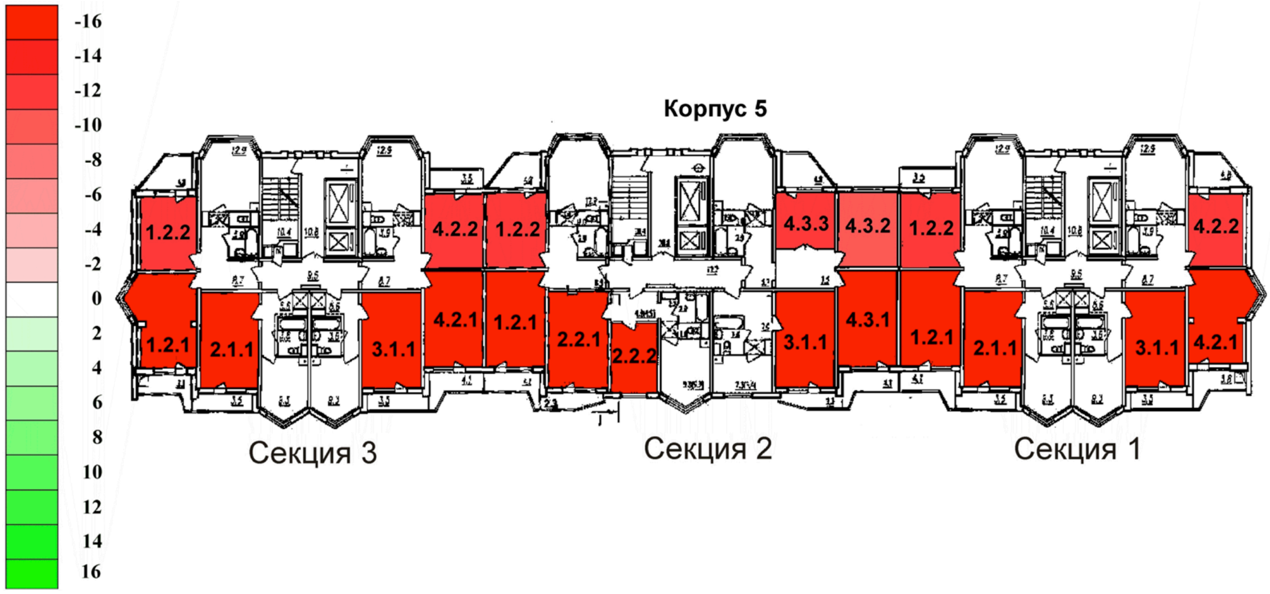

Figure 5. Predicted Excess of Acceptable Noise Levels in Living Areas of Apartments at Night.

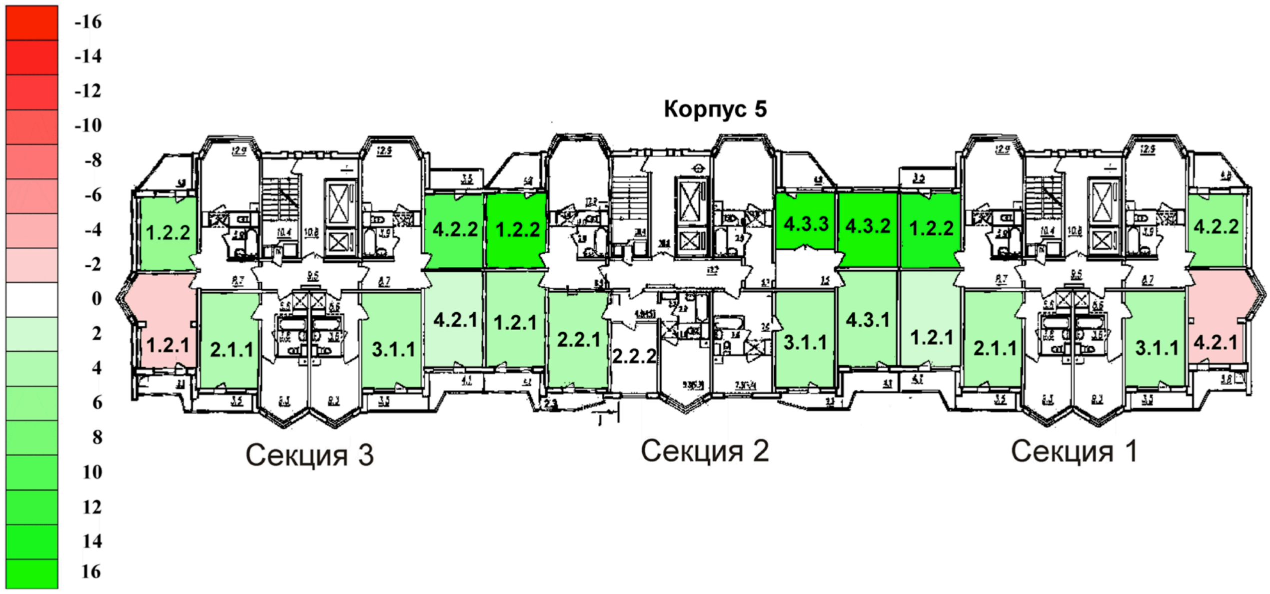

Figure 6. Predicted Excess of Acceptable Noise Levels in Living Areas of Apartments at Night After Implementing the Planned Soundproofing Measures.

References

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2. Oleg Kartyshev & Yuriy Zakharov. *Calculation method with measurement corrections. X-Noise seminar on Aviation Noise Mapping.* 7-8 November 2011, Madrid, Spain.
3. Oleg Kartyshev. *Calculation and experimental method to assess aircraft noise contour zoning in the vicinity of airports.* Research herald, MSTU CA, Moscow 2012.
4. Oleg Kartyshev. *New methodological approaches to establishment of the sizes of the sanitary protection zone and roadside clear zones of civil airports.* Hygiene and sanitary magazine, 2013.