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MODELLING OF THE PROPAGATION OF AIRCRAFT NOISE, TAKING INTO ACCOUNT THE DIRECTION OF ITS ACOUSTIC RADIATION

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Abstract. ***Statement of the problem.*** The increasing levels of noise pollution caused by infrastructure development and growing traffic flows, particularly aviation traffic, have become a serious environmental and social issue. Excessive noise levels negatively affect human health, leading to physiological and psychological disorders and reducing the quality of life. In this context, the study of noise conditions at sites requiring protection from acoustic impacts is of particular relevance. ***Methods of research.*** This paper examines the methodology for predicting and assessing noise pollution using modern computational modeling tools. Specifically, the "AcousticLab" software package is utilized, based on the principles of applied acoustics, enabling the analysis of sound wave propagation processes in various environments. The primary focus is on modeling aviation noise, one of the most prevalent sources of acoustic impact in urban areas and near airports. ***The research results*** demonstrate the possibility of creating detailed models of noise propagation that take into account geometric and physical features of the area, types of noise sources, and their characteristics. This approach allows for accurate calculations of acoustic impact levels, prediction of their spatial distribution, and assessment of risks to public health. ***Scientific novelty.*** The proposed methodology provides instrumental support for developing noise protection strategies, including designing screens, barriers, and optimizing spatial planning of territories. Thus, the use of the "AcousticLab" software package enhances the effectiveness of noise monitoring and management, minimizing the negative impact of noise pollution on humans and the environment.

Keywords: *simulation model; air transport; noise; acoustic pollution*

МОДЕЛЮВАННЯ ПОШИРЕННЯ АВІАЦІЙНОГО ШУМУ З УРАХУВАННЯМ СПРЯМОВАНОСТІ ЙОГО АКУСТИЧНОГО ВИПРОМІНЮВАННЯ

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Анотація. ***Постановка проблеми.*** Зростаючий рівень шумового забруднення внаслідок розвитку інфраструктури та збільшення інтенсивності транспортних потоків, зокрема авіаційного транспорту, стає серйозною екологічною та соціальною проблемою. Надмірний рівень шуму негативно впливає на здоров'я людей, спричиняючи фізіологічні та психологічні розлади, знижуючи якість життя населення. У цьому контексті дослідження шумового режиму на об'єктах, що потребують захисту від акустичних впливів, набуває особливої актуальності. ***Методи дослідження.*** У представленій роботі розглянуто методологію прогнозування та оцінки шумового забруднення з використанням сучасних інструментів комп'ютерного моделювання. Зокрема, використано програмний комплекс «AcousticLab», який ґрунтується на положеннях прикладної акустики та дозволяє проводити аналіз процесів поширення звукових хвиль у різних середовищах. Основна увага приділяється моделюванню авіаційного шуму, як одного з найпоширеніших джерел шумового впливу в урбанізованих зонах і поблизу аеропортів. ***Результати*** дослідження демонструють можливість створення детальних моделей розповсюдження шуму, що враховують геометричні та фізичні особливості місцевості, типи джерел шуму та їх характеристики. Це дозволяє здійснювати точні розрахунки рівнів акустичного впливу, прогнозувати їх просторовий розподіл і оцінювати ризики для здоров'я населення. ***Наукова новизна.*** Запропонований підхід забезпечує інструментальну підтримку для розробки стратегій шумозахисту, включаючи проєктування екранів, бар'єрів та оптимізацію просторового планування територій. Таким чином, використання програмного комплексу «AcousticLab» сприяє підвищенню ефективності моніторингу та управління шумовим середовищем, дозволяючи мінімізувати негативний вплив шумового забруднення на людину та довкілля.

Ключові слова: *імітаційна модель; авіаційний транспорт; шум; акустичне забруднення*

Introduction. When developing a master plan for a populated area [1] and at subsequent stages of design and construction, a study is made of the impact on the population of various types of industrial, transport, household and other sources of external noise pollution, an assessment of the sanitary and ecological state of the territory and objects located on it is carried out, development and implementation of practical recommendations for its improvement [2−5].

Carrying out a detailed survey of the noise regime of different types of buildings (industrial, public, residential, etc.), determining the acoustic characteristics of the sources of noise pollution affecting them, checking the acoustic efficiency of the applied architectural and planning, construction and acoustic, engineering and construction, organizational and other means and noise protection methods begins with an assessment of the current state of the acoustic regime of the territory, which is usually carried out by means of one-time (less often long-term multipoint) full-scale instrumental measurements of the actual values of source noise levels at the protected objects under study [6].

The software package for calculating, evaluating, analyzing, predicting and visualizing the acoustic regime of urban development and the adjacent territory "AcousticLab" implements the developed theoretical calculation that provides a qualitative analysis of the noise regime of the objects of study and results that have equal errors in the acoustic assessment of the compared solutions. This theoretical calculation, using the known provisions of applied acoustics, is the basis for making a noise mode forecast regarding existing or expected sound levels in protected objects.

Acoustic indicators of noise impact are calculated near the external surfaces (at a distance of 2 meters from facades, roofs and other fencing elements) of buildings and structures, as well as on the territory adjacent to them and at a selected distance from the ground level, which allows you to set indicators on the facade at the selected building height. These indicators can be used to assess the degree of negative acoustic impact on the development, or as initial data for further calculation of acoustic indicators in the premises of protected buildings and structures. These calculations can also be used to compare the acoustic performance of alternative options for architectural planning, structural engineering and other decisions made at various stages of design and construction.

The software package is intended for modelling and quantitative calculation of sound levels at given points in free and built-up areas, as well as for constructing and subsequent visualization of sound fields of various sources of external adverse noise impact, such as: aircraft on aircraft routes, motor vehicles on urban road network, water and rail transport, as well as equipment for industrial, energy, storage and other enterprises. Intra-quarter sources can be taken into account: boiler houses, pumping stations, transformer substations, energy centres, ventilation, pumping and other equipment located near protection facilities; children's and sports games, discos, loading and unloading operations at trade and public catering enterprises, and others.

The software package allows you to simulate point, linear, planar and spatial (arbitrary shape) noise sources, their other acoustic, spatial and temporal parameters, taking into account the direction of the acoustic radiation of sources, their spectral parameters, the nature of sound emission, apply various scales of acoustic and temporal correction, take into account geometric shapes, sizes of sources and obstacles in the way of sound propagation.

The results of calculations can be presented in the form of noise maps built on the basis of flat, three-dimensional (3D) models of the objects under study, for equivalent, maximum, octave (1/3 octave) sound frequencies, linear, or corrected by “A” sound levels (sound pressure).

The software package consists of five modules that take into account the specifics of the operation of simulation models of sound sources. The “Model” module is the main functional module that uses the algorithm of the computer program “AcousticLab” [7], designed to form a model, visualize sound fields that occur on the external surfaces of buildings and structures, as well as in the adjacent territory. Modules “Point and linear non-directional noise sources” are designed to form a model taking into account the action of stationary (fans, pumps, compressors, other technological, technical and auxiliary equipment) and moving (cars, trains, etc.) noise sources and perform calculation, evaluation, analysis and visualization of the acoustic regime of protected objects. Two more modules “Point and linear directional noise sources” are designed to solve the same problems, taking into account the directionality of noise sources. The directionality of the aircraft noise source is most pronounced. In order to evaluate it, the module “Linear Directional Noise Sources” uses the algorithm of the computer program for calculating the contours of aircraft noise during the operation of aircraft “AcousticLab” [8].

All five subsystems interact with the application server and the “AcousticLab” database, the software product of the automated workspace for the study of the noise regime (AW SNR) and other functional modules of the system.

Below is a fragment of the user manual for the “AcousticLab” software package, which provides a detailed description of the physical meaning of acoustic calculation based on the basic provisions of applied acoustics, demonstrates the sequence of its implementation and presentation of the results.

Accounting for the directivity of the sound fields of the noise source. Acoustic calculation often requires taking into account external sources with a pronounced directionality of the sound field, for example, an aircraft noise source [9]. With the external action of other point, linear and spatial transport sources, it should be taken into account that they can have a pronounced directivity of sound radiation (directivity factor $\Phi \neq 1$).

Let us consider in more detail the accounting of external sources using the example of the operation of aircraft engines. Due to the specifics of their functional, technical and design features, aircraft engines radiate sound energy into three-dimensional space, the surface front of which is an ellipsoid of revolution, aligned with the rotation axis of the fan and engine turbine. At the same time, energy is emitted from the side of the fan and the nozzle of the turbojet engine, having sound levels significantly higher than that emitted in the lateral directions.

The noise regime of the study area is determined by the simultaneous and separate action of point emitters that make up an aviation source, which in turn is an element of aircraft systems and mechanisms with linear dimensions that are quite comparable with the length of the sound waves emitted by them. A distinctive feature of an aircraft noise source from known ground-based sources is that the aircraft source moves at high speed in the air along a trajectory with varying altitude.

Since in the process of movement the aircraft can change the direction of its movement vector in accordance with the route of movement and the flight profile, the direction of sound radiation can significantly affect the noise mode of the objects being examined. Accounting for this parameter by the AcousticLab software product is carried out as follows:

At the beginning of the XYZ Cartesian coordinate system, a single point directional acoustic emitter is placed, having the shape of the front of the acoustic radiation surface in the form of an ellipsoid of rotation in general position ($\Phi \neq 1$). The source can freely move in three-dimensional space. The relations that allow taking into account the shape of such a front of the sound radiation surface in the acoustic calculation are made taking into account the following geometric transformations in three-dimensional space.

The transition from one rectilinear coordinate system in three-dimensional space to another is described in the general case as follows:

$$[x"y"z"1] = [x\ y\ z\ 1][A].$$

Consider the matrices corresponding to the following basic geometric transformations:

1. Sound source turns:

- around the X axis at an angle α

$$[\sigma_x] = \begin{vmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\alpha & \sin\alpha & 0 \\ 0 & -\sin\alpha & \cos\alpha & 0 \\ 0 & 0 & 0 & 1 \end{vmatrix};$$

- around the Y axis at an angle γ

$$[\sigma_y] = \begin{vmatrix} \cos\gamma & 0 & -\sin\gamma & 0 \\ 0 & 1 & 0 & 0 \\ \sin\gamma & 0 & \cos\gamma & 0 \\ 0 & 0 & 0 & 1 \end{vmatrix};$$

- around the Z axis by an angle β

$$[\sigma_z] = \begin{vmatrix} \cos\beta & \sin\beta & 0 & 0 \\ -\sin\beta & \cos\beta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{vmatrix};$$

2. Transfer (shift, displacement) to a vector (x_2, y_2, z_2)

$$[T] = \begin{vmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ x_2 & y_2 & z_2 & 1 \end{vmatrix};$$

3. Reflection

- relative to the plane $z = 0$

$$[M_z] = \begin{vmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 \end{vmatrix};$$

- relative to the plane $y = 0$

$$[M_y] = \begin{vmatrix} 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{vmatrix}.$$

In the general case, the rotation of the direction vector of acoustic radiation of a single point source around an arbitrary point is implemented by moving the origin of the coordinate system to it, performing the required rotation, and then returning to the original coordinate system XYZ (Fig. 1).

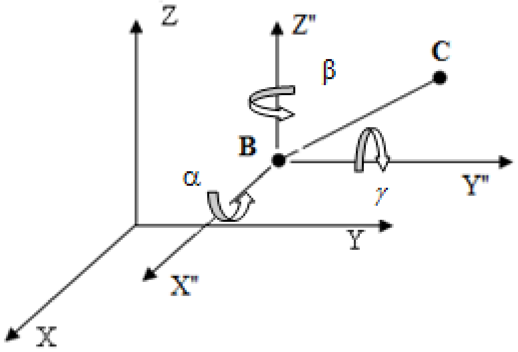

Fig. 1. Geometric scheme for describing the front of the sound radiation surface of a moving directional point noise source along the aircraft trajectory in three-dimensional space

The resulting matrix that specifies the required sequence of transformations (shift to point B (x_2, y_2, z_2), rotation through an angle α around the OX axis, rotation through an angle β around the OZ axis, rotation through an angle γ around the OY axis and then recalculating the result relative to the original coordinate system) has the following form:

$$[A] = [T]^{-1}[\sigma_y][\sigma_z][\sigma_x][T].$$

Thus, successive rotations of the vector $[x_1, y_1, z_1, 1]$ about the centre at a point (x_2, y_2, z_2) at certain angles are performed as follows:

$$[x'' \quad y'' \quad z'' \quad 1] =$$

$$= [x_1 \quad y_1 \quad z_1 \quad 1] \cdot \begin{vmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ -x_2 & -y_2 & -z_2 & 1 \end{vmatrix} \cdot$$

$$\cdot \begin{vmatrix} \cos\gamma & 0 & -\sin\gamma & 0 \\ 0 & 1 & 0 & 0 \\ \sin\gamma & 0 & \cos\gamma & 0 \\ 0 & 0 & 0 & 1 \end{vmatrix} \cdot \begin{vmatrix} \cos\beta & \sin\beta & 0 & 0 \\ -\sin\beta & \cos\beta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{vmatrix} \cdot$$

$$\cdot \begin{vmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\alpha & \sin\alpha & 0 \\ 0 & -\sin\alpha & \cos\alpha & 0 \\ 0 & 0 & 0 & 1 \end{vmatrix} \cdot \begin{vmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ x_2 & y_2 & z_2 & 1 \end{vmatrix}$$

After performing the product of matrices, we get:

$$x'' = ((x_1 - x_2)\cdot\cos(\gamma) + (z_1 - z_2)\cdot\sin(\gamma))\cdot\cos(\beta) - (y_1 - y_2)\cdot\sin(\beta) + x_2$$

$$y'' = (((x_1 - x_2)\cdot\cos(\gamma) + (z_1 - z_2)\cdot\sin(\gamma))\cdot\sin(\beta) + (y_1 - y_2)\cdot\cos(\beta))\cdot\cos(\alpha) - (-(x_1 - x_2)\cdot\sin(\gamma) + (z_1 - z_2)\cdot\cos(\gamma))\cdot\sin(\alpha) + y_2$$

$$z'' = (((x_1 - x_2)\cdot\cos(\gamma) + (z_1 - z_2)\cdot\sin(\gamma))\cdot\sin(\beta) + (y_1 - y_2)\cdot\cos(\beta))\cdot\sin(\alpha) + (-(x_1 - x_2)\cdot\sin(\gamma) + (z_1 - z_2)\cdot\cos(\gamma))\cdot\cos(\alpha) + z_2$$

It should be noted that when the vector moves in the opposite direction, i.e. when $y_2 > y_1$, to the above transformations, you need to add reflection relative to planes $y = 0$ and $z = 0$ (turn BC to 180^0 and its subsequent movement in the opposite direction):

$$[A] = [T]^{-1}[\sigma_y][\sigma_z][\sigma_x][M_z][M_y][T],$$

where:

$$[x'' \quad y'' \quad z'' \quad 1] =$$

$$= [x_1 \quad y_1 \quad z_1 \quad 1] \cdot \begin{vmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ -x_2 & -y_2 & -z_2 & 1 \end{vmatrix} \cdot$$

$$\cdot \begin{vmatrix} \cos\gamma & 0 & -\sin\gamma & 0 \\ 0 & 1 & 0 & 0 \\ \sin\gamma & 0 & \cos\gamma & 0 \\ 0 & 0 & 0 & 1 \end{vmatrix} \cdot \begin{vmatrix} \cos\beta & \sin\beta & 0 & 0 \\ -\sin\beta & \cos\beta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{vmatrix} \cdot$$

$$\cdot \begin{vmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\alpha & \sin\alpha & 0 \\ 0 & -\sin\alpha & \cos\alpha & 0 \\ 0 & 0 & 0 & 1 \end{vmatrix} \cdot \begin{vmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 \end{vmatrix} \cdot$$

$$\cdot \begin{vmatrix} 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{vmatrix} \cdot \begin{vmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ x_2 & y_2 & z_2 & 1 \end{vmatrix}$$

Thus, the resulting vector coordinates have the form:

$$x''=((x_1-x_2)\cdot\cos(\gamma)+(z_1-z_2)\cdot\sin(\gamma))\cdot\cos(\beta)-(y_1-y_2)\cdot\sin(\beta)+x_2$$

$$y''=-((((x_1-x_2)\cdot\cos(\gamma)+(z_1-z_2)\cdot\sin(\gamma))\cdot\sin(\beta)+(y_1-y_2)\cdot\cos(\beta))\cdot\cos(\alpha)-(-(x_1-x_2)\cdot\sin(\gamma)+(z_1-z_2)\cdot\cos(\gamma))\cdot\sin(\alpha))+y_2$$

$$z''=-((((x_1-x_2)\cdot\cos(\gamma)+(z_1-z_2)\cdot\sin(\gamma))\cdot\sin(\beta)+(y_1-y_2)\cdot\cos(\beta))\cdot\sin(\alpha)+(-(x_1-x_2)\cdot\sin(\gamma)+(z_1-z_2)\cdot\cos(\gamma))\cdot\cos(\alpha))+z_2$$

For that part of the AcousticLab software product, where the methods of acoustic calculation of sound fields of noise sources are implemented, presented in the form of motion trajectories BC (sections of general position lines on which single directional point emitters are located), finding the angles through the coordinates of the origin $B(x_2,y_2,z_2)$ and end $C(x_1,y_1,z_1)$ segment, performed by the following transformations. First, we move the origin of the coordinate system to the point $B(x_2,y_2,z_2)$. Next, we rotate the coordinate axes so that the direction of the OY axis corresponds to the direction of the vector $(x_1-x_2,y_1-y_2,z_1-z_2)$. In this case, the vector OY will go to OY″, where the coordinates of the latter are calculated as follows:

$$[xy''\ yy''\ zy''\ 1]=[0\quad y\quad 0\quad 1][\sigma_y][\sigma_z][\sigma_x].$$

Substituting rotation matrices:

$$[xy''\quad yy''\quad zy''\quad 1]=$$

$$=[0\quad y\quad 0\quad 1]\cdot\begin{vmatrix}\cos\gamma & 0 & -\sin\gamma & 0\\ 0 & 1 & 0 & 0\\ \sin\gamma & 0 & \cos\gamma & 0\\ 0 & 0 & 0 & 1\end{vmatrix}\cdot$$

$$\cdot\begin{vmatrix}\cos\beta & \sin\beta & 0 & 0\\ -\sin\beta & \cos\beta & 0 & 0\\ 0 & 0 & 1 & 0\\ 0 & 0 & 0 & 1\end{vmatrix}\cdot\begin{vmatrix}1 & 0 & 0 & 0\\ 0 & \cos\alpha & \sin\alpha & 0\\ 0 & -\sin\alpha & \cos\alpha & 0\\ 0 & 0 & 0 & 1\end{vmatrix}.$$

Doing the multiplication, we get:

$$\begin{cases} xy''=-y\cdot\sin(\beta) & (1)\\ yy''=y\cdot\cos(\beta)\cdot\cos(\alpha) & (2)\\ zy''=y\cdot\cos(\beta)\cdot\sin(\alpha) & (3)\end{cases}.$$

Further, from the resulting system of equations, we find the angles α and β. First, dividing (3) by (2) we find the angle α:

$$\frac{zy''}{yy''}=\frac{\cancel{y\cdot\cos(\beta)}\cdot\sin(\alpha)}{\cancel{y\cdot\cos(\beta)}\cdot\cos(\alpha)}=tg(\alpha)\Rightarrow\alpha=arctg\left(\frac{zy''}{yy''}\right).$$

And, since the vectors OY″ and $(x_1-x_2,y_1-y_2,z_1-z_2)$ are collinear, then the ratio of their respective coordinates are equal, i.e.:

$$\frac{xy''}{x_1-x_2}=\frac{yy''}{y_1-y_2}=\frac{zy''}{z_1-z_2},$$

where:

$$\frac{zy''}{yy''}=\frac{z_1-z_2}{y_1-y_2}.$$

With this in mind, we finally get that

$$\alpha=arctg\left(\frac{z_1-z_2}{y_1-y_2}\right).$$

Further dividing (2) by (1) we find the angle β:

$$\frac{yy''}{xy''}=\frac{\cancel{y}\cdot\cos(\beta)\cdot\cos(\alpha)}{-\cancel{y}\cdot\sin(\beta)}=-ctg(\beta)\cdot\cos(\alpha).$$

Using the known relation:

$$\cos(\mathrm{arctg}(x))=\frac{1}{\sqrt{1+x^2}}$$

and the previously found angle α:

$$\cos(\alpha)=\frac{1}{\sqrt{1+\left(\frac{zy''}{yy''}\right)^2}}=\frac{yy''}{\sqrt{yy''^2+zy''^2}}$$

we get

$$ctg(\beta)=-\frac{yy''}{xy''\cdot\cos(\alpha)}=-\frac{\cancel{yy''}\cdot\sqrt{yy''^2+zy''^2}}{xy''\cdot\cancel{yy''}}\Rightarrow$$

$$tg(\beta)=\frac{1}{ctg(\beta)}=-\frac{xy''}{\sqrt{yy''^2+zy''^2}}.$$

And taking into account the collinearity of the vectors, we finally have:

$$\beta=-arctg\left(\frac{x_1-x_2}{\sqrt{(y_1-y_2)^2+(z_1-z_2)^2}}\right).$$

The third angle γ is found from the condition of the coplanarity of the vectors OY″ OZ″ OZ. To do this, we find the mixed product of these three vectors and equate it to 0.

$$OY''\cdot OZ''\cdot OZ=\begin{vmatrix} xy'' & yy'' & zy'' \\ xz'' & yz'' & zz'' \\ 0 & 0 & z \end{vmatrix}=$$

$$=-y\cdot sin(\beta)^2\cdot z^2\cdot sin(\gamma)\cdot cos(\alpha)+$$
$$+y\cdot sin(\beta)\cdot z^2\cdot cos(\gamma)\cdot sin(\alpha)-$$
$$-z^2\cdot sin(\gamma)\cdot cos(\beta)^2\cdot y\cdot cos(\alpha)=$$
$$=y\cdot z^2\cdot(-sin(\gamma)\cdot cos(\alpha)+$$
$$+sin(\beta)\cdot cos(\gamma)\cdot sin(\alpha))=0$$

where:

$$tg(\gamma)=tg(\alpha)\sin(\beta).$$

Substituting the previously found values of the angles α and β, we obtain:

$$\gamma=-arctg\left(\frac{(z1-z2)\cdot(x1-x2)}{(y1-y2)\cdot\sqrt{(x1-x2)^2+(y1-y2)^2+(z1-z2)^2}}\right)$$

With the help of the relations obtained, an acoustic calculation of the sound fields of noise sources with a pronounced directionality of their sound fields is implemented. The initial data on the direction of acoustic radiation of noise sources should be taken from the results of full-scale instrumental measurements, passport characteristics, and from reliable reference sources [6].

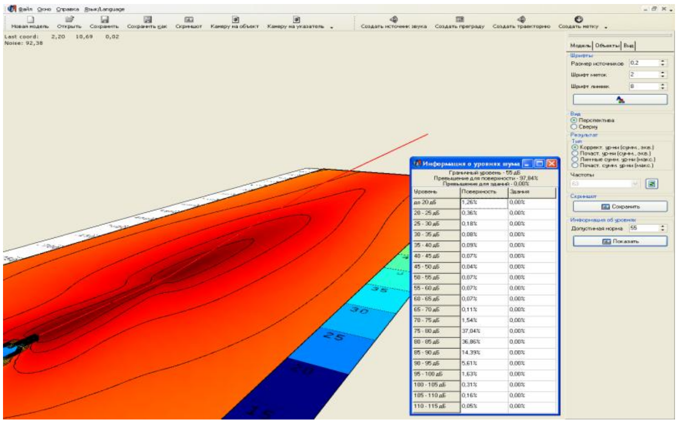

Fig. 2. An example of a 3D model rendering sound fields capturing sound levels in the runway area on the ground from a linear directional aircraft noise source during takeoff

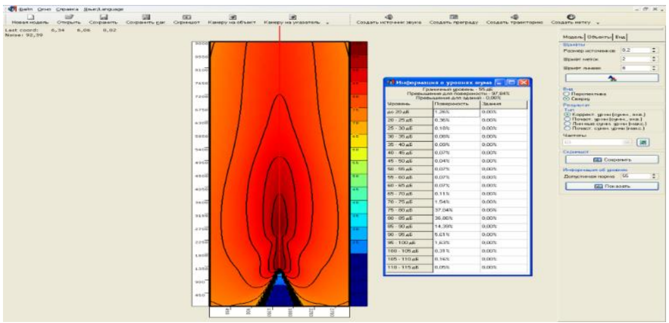

Fig. 3. An example of a 2D model visualizing sound fields capturing sound levels in the runway area on the ground from a linear directional aircraft noise source during takeoff

An example of building a simulation model of the protected object. The numerical values of the coordinates of the location of the noise source in the Cartesian coordinate system, to which the selected area is linked, appear in the corresponding windows (“X”, “Y”, “Z”). The numerical values of the acoustic parameters of each noise source are entered in the appropriate cells opposite each “Frequency” value of the spectral components of sound pressure levels in dB, or equivalent (in terms of energy) corrected sound levels in dBA (Fig. 2, 3).

Conclusions. This development improves the simulation method used to assess, analyze and predict the levels of aircraft noise in urban areas. The improvement of the hardware-software complex "AcousticLab" was carried out to create a special manual and its certification in order to use it to solve the problems of noise protection in Ukraine.

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