Experimental Study of Contour Sources of Noise from Airland without Crew with DLE Gas Engine-30 and the Most Noise Counter Optimized by Using Method of Active Noise Control with a Variety of 45°, 90°,135°

Alfisyahrin[1], Ikhwansyah Isranuri[2], Muhammad Rafiq Yanhar[3], Syukriyadin[4], [5]Deni Sigar

[1]Departement of Electrical Engineering, University of Syiah Kuala, Banda Aceh, Indonesia
[2]Departement of Mechanical Engineering, University of Sumatera Utara, Medan, Indonesia
[3]Department of Mechanical Engineering, University of Islam Sumatera Utara, Medan, Indonesia
[4]Departement of Electrical Engineering, University of Syiah Kuala, Banda Aceh, Indonesia
[5]Departement of Mechanical Engineering, Islamic University of North Sumatra, Medan, Indonesia
Email:alfisyahrin@usk.ac.id, ikhwansyah@usu.ac.id, rafiq@ft.uisu.ac.id, syukriyadin@usk.ac.id, sigardeni@gmail.com

Abstract

Unmanned Aerial Vehicle is a flying machine aircraft that can be controlled remotely to perform its function. As with other machines, noise problems are unavoidable. One of the components contributing to noise in aircraft is the engine. To reduce the noise level produced, it is necessary to study and research further the noise factor through acoustic science by conducting experimental and simulation tests using ANSYS software which was developed in Noise Control science. In this case, simulation has the advantage because it can be used to analyze more complex systems and conditions that can be adjusted and also have more accurate results. This study aims to make comparisons and determine the optimal sound reduction angle in the experimental method and noise simulation on the DLE GAS ENGINE-30 drone engine. Based on the results of experimental tests conducted on the DLE Gas Engine-30 engine, the optimal reduction value is obtained with an engine speed of 2000 RPM on the z- axis, a distance of 0.75 m and an angle of 45° with a reduction value of 4.1 dB and at 3000 RPM engine speed is on the x- axis, a distance of 1.25 m and an angle of 135° with a reduction value of 3.5 dB. While testing based on the results of simulation testing conducted on the DLE Gas Engine-30 engine, the optimal reduction value is obtained with an engine speed of 2000 RPM on the z+ axis, 1 m distance and 45° angle with a reduction value of 9.1 dB and at 3000 RPM engine speed found on the z+ axis, a distance of 0.75m and an angle of 135° with a reduction value of 12.8 dB.

Key Word: *Unmanned aircraft, noise, DLE Gas Engine-30, noise simulation, experimental, frequency.*

I. INTRODUCTION

An unmanned aircraft (drone) is an aircraft that is controlled from a certain distance by the pilot or can control himself without a crew in the aircraft with the main propulsion source of the engine to move the propellers and use thrust (thrust) so that the aircraft can fly. The use of drones can come from inventions sourced from propellers, aircraft exhaust, or from the aircraft engine itself. USU's NVC aircraft are drones that use the DLE Gas Engine-30 engine. The DLE Gas Engine-30 engine is an identical 2 engine with upgrades so the minimum reduction required is as expected.

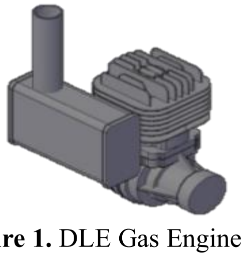

Figure 1. DLE Gas Engine -30

Figure 2. Drone

II. LITERATURE REVIEW

2.1 Unmanned Aircraft

Unmanned aircraft is an aircraft that is able to control itself or be controlled remotely by the pilot. The drone is capable of performing reconnaissance and attack missions on military requirements. Unmanned aircraft are also increasingly being used for civilian (non-military) purposes such as firefighting, non-military security, inspection of pipelines, for photo and videography purposes.

An unmanned aircraft that uses an engine will produce a louder sound compared to an electric powered drone, especially on a 2-stroke engine. Therefore, an active noise control method will be carried out to reduce the noise generated by a 2 stroke engine.

2.2 Sound

Sound is a mechanical compression or longitudinal wave that propagates through a medium or an intermediary substance in the form of liquid, solid, and gas. Theoretically pure sound can be described by the speed of oscillating vibrations or the frequency measured in units of vibration Hertz (Hz) and the amplitude or loudness of the sound by measurement in units of sound pressure decibels (dB). The normal sound frequency limit that can be received by the human ear ranges from 20 Hz to 20 kHz at various amplitudes of the response curve. Sound produced above 20 Hz is referred to as infrasound, while sound produced above 20 kHz is called ultrasonic.

2.3 Noise

Noise is an acoustic disturbance signal (sound) in the form of a signal disturbance that can interfere with the health and comfort of the environment which is expressed in decibles (dB).

2.4. Noise Level

The human ear hears sound pressure, not volume. The difference between sound pressure and volume is that the closer the listener is to the sound source, the greater the pressure will be heard. On the other hand, the farther away the listener is from the source, the less pressure will be heard, but with the same volume.

Table1. Sound Pressure Level Data [2]

Sound sources (noise) Examples with distance	Sound pressure Level Lp dB SPL
Jet aircraft, 50 m away	140
Threshold of pain	130
Threshold of discomfort	120
Chainsaw, 1 m distance	110
Disco, 1 m from speaker	100
Diesel truck, 10 m away	90
Kerbside of busy road, 5 m	80
Vacuum cleaner, distance 1 m	70
Conversational speech, 1 m	60
Average home	50
Quiet library	40
Quiet bedroom at night	30
Background in TV studio	20
Rustling leaves in the distance	10
Hearing threshold	0

2.4 Active Noise Control

Active Noise Control (Active Noise Control) is a technology that serves to reduce unwanted noise. The working principle of active noise control is to use a frequency wave of sufficient strength to neutralize the frequency wave signal from the sound source that you want to reduce the noise level. In the Active Noise Control system, there are two types of sound, namely primary sound and secondary sound. Primary sound is the type of sound that will be muffled using a secondary sound, while secondary sound is the type of sound that is used to muffle the primary sound. The secondary signal has the same amplitude as the primary signal but has an inverse shape with the amplitude of the primary sound so that it will produce a wave that has a small amplitude (residual signal), a small amplitude produces a small sound so that it can muffle the sound.

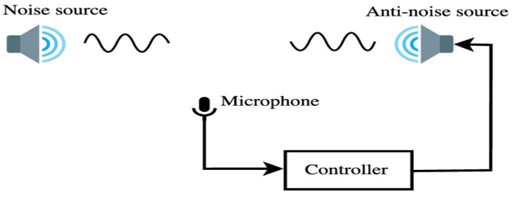

Figure 3. Active Noise Control Ilustration

2.5 Implementation of Active Noise Control System

The application of an active noise control system can be 1-dimensional or 3-dimensional, depending on what kind of zone will be protected. Periodic sounds are easier to remove than repetitive sounds.

1-dimensional protection is easier because it only uses a few microphones and speakers to activate. Some of the applications that can be applied include: noise-canceling headphones, active mufflers, and silencers in ventilation ducts. 1-dimensional protection is carried out using a straight line method between the object you want to mute and the active speaker or between the active speaker and the listener (headphones).

3-dimensional protection is more complicated because it requires more microphones and speakers than 1-dimensional protection, making it less cost-effective. Each speaker is placed in a position close to the zone that produces sound so that it inhibits the performance of the noise signal to be muted. Noise reduction is easier to do if the object to be muted does not move from the room where the object is located, but if there are several objects that are constantly moving, it will be more difficult to reduce sound.

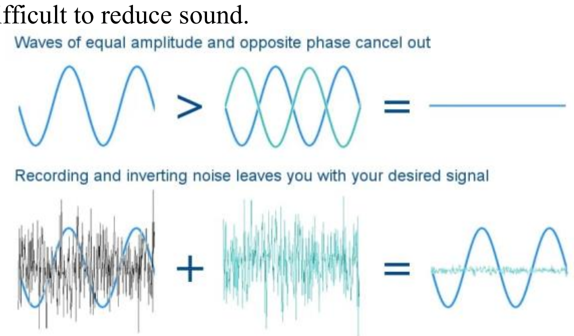

Figure 4. How Active Noise Control Works [3]

2.6 Noise Generators And Active Noise Control Instruments

A phase shifter that can produce alternating voltages at various frequencies. This phase shifter has an inverting amplifier, and a feedback filter which shifts the phase 180° of the oscillation frequency. The electronic filter shall be designed so that signals above and below the desired oscillation frequency are shifted by less or more than 180°. This results in a constructive superposition of the signal at the oscillating frequency and a destructive superposition at other frequencies

Figure 5. Instrument Active Noise Control Q7

2.7 ANSYS 2020 R1

ANSYS 2020 R1 is the most optimal software for the implementation and solution of active noise control techniques. This software can provide a solution whose goal is to get a noise analysis from the DLE Gas Engine- 30 engine in the form of a simulated contour with contour data results obtained from an active noise control instrument.

Figure 6. ANSYS 2020 R1

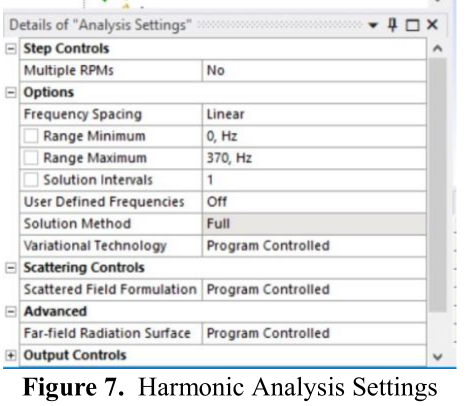

Figure 7. Harmonic Analysis Settings

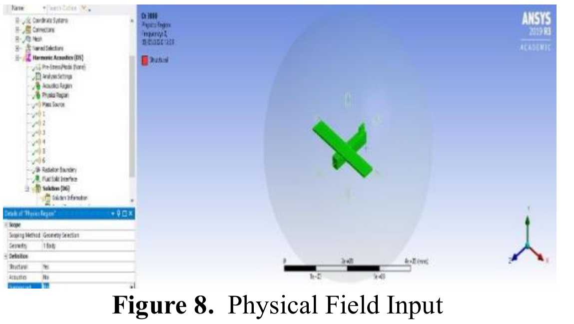

Figure 8. Physical Field Input

III. METHODOLOGY

The method used in this research is to detect the noise of the DLE Gas Engine-30 engine using numerical analysis and digital signal processing. Further analysis of this method for an active noise control system that can take advantage of the use of the DLE Gas Engine-30 drone engine.

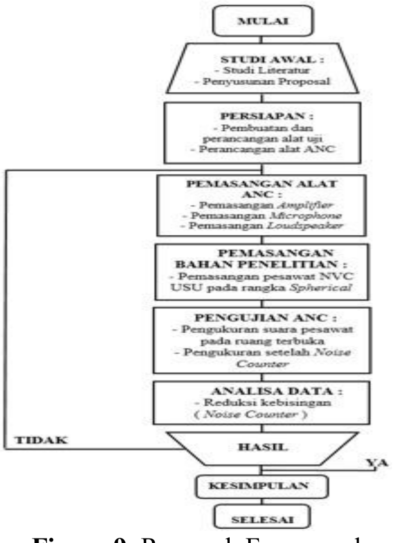

Figure 9. Research Framework

Figure 10. Unmanned Aircraft NVC USU

Figure 11. Experimental Data Retrieval Setting

A. Active Noise Control (ANC)

• Microphone

The microphone serves to capture the source of aircraft noise during testing.

Figure 12. Microphone

• Loudspeaker

The loudspeaker is used to produce sound in reverse phase from the noise source to reduce the noise.

Figure 13. Loudspeaker

• Amplifier

Amplifier serves to amplify the signal from the sound that is transmitted to the speaker for maximum output.

Figure 14. Amplifier

• Sound Level Meter

Sound Level Meter serves to measure the sound of the noise generated from the aircraft and loudspeaker.

Figure 15. Sound Pressure Level (SPL)

• Computer/Laptop

The computer/laptop functions to perform simulations and analyze results using ANSYS software.

Figure 16. Laptop

B. ANSYS

ANSYS software is used to simulate acoustic data obtained from testing in order to obtain a noise contour.

Figure 17. ANSYS Software Software

C. Spherical Frame

The Spherical frame serves to support the aircraft and 6 speakers on 6 axes, namely the X+, X-, Y+, Y-, Z+, and Z- axis for easy data retrieval during testing.

Figure 18. Spherical Frame

D. Active Noise Control Instrument

An active noise control instrument is a device that processes the sound received by the microphone and reverses its phase and will be output through the loudspeaker.

Figure 19. Active Noise Control Instrument

3.2 Setting the Noise Control Tools

The setting of an active noise control device is a combination of the tools used for data collection with the experimental test method of active noise control.

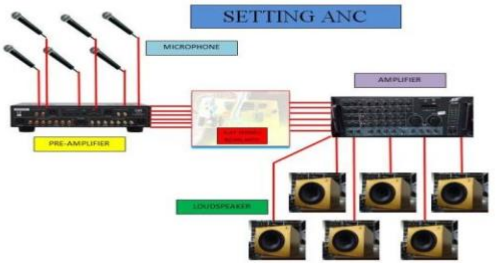

Figure 20. Pengaturan Alat Kendali Kebisingan Aktif

IV. RESULT AND DISCUSSION

The results obtained from the simulation of the DLE Gas Engine-30 engine noise test are in the form of noise contours which are indicated by colors that distinguish the amount of SPL (Sound Pressure Level). The engine speed ranges from 2000 rpm and 3000 rpm. Each engine speed has a different frequency range in the sound produced. The simulation is carried out by entering a certain frequency range and matching the results of the simulation test with the results of noise measurements measured by experimental testing.

In the process of matching the results taken as a reference for the most optimal reduction in experimental test measurements, the engine speed is 2000 RPM, z-axis with a difference in noise value of 4.1 dB at a measurement distance of 0.75m and an angle of 45º. At 3000 RPM engine speed is on the x-axis with a difference in noise value of 3.5 dB at a measurement distance of 1.25m and an angle of 135º.

In the process of matching the results taken as a reference for the most optimal reduction in the simulation test measurements, the engine speed of 2000 RPM is on the z+ axis with a difference in noise reduction value of 9.1 dB at a measurement distance of 1m, and an angle of 45º. At 3000 RPM engine speed is on the z+ axis with a difference in noise value of 12.8 dB at a measurement distance of 0.75 m, and an angle of 135º.

4.1 Tables and Graphs on Experimental Tests

Table 2. Comparison of 2000 RPM Noise Data from experimental test results before ANC and after ANC.

2000 RPM Sebelum ANC					2000 RPM Sesudah ANC				
N (rpm)	2000				N (rpm)	2000			
p (Pa)	Jarak 0,75 meter				p (Pa)	Jarak 0,75 meter			
Sudut	X+	X-	Z+	Z-	Sudut	X+	X-	Z+	Z-
45º	86.4	88.5	91.2	89.8	45º	86.20	85.50	87.80	85.70
90 °	89.8	88.7	88.7	90	90 °	90.60	89.60	93.60	88.50
135 °	91.5	90.2	93.2	90	135 °	89.60	88.20	92.30	87.60

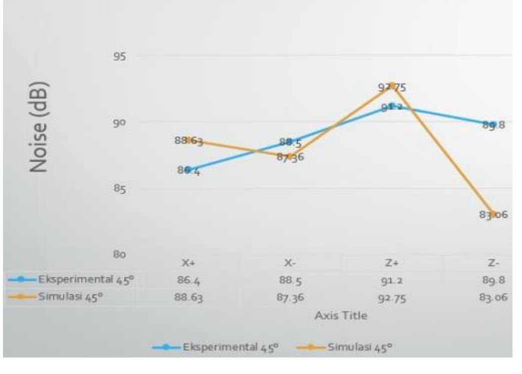

Figure 21. Graph of 2000 RPM with a distance of 0.75m and an angle of 45º before using the ANC method.

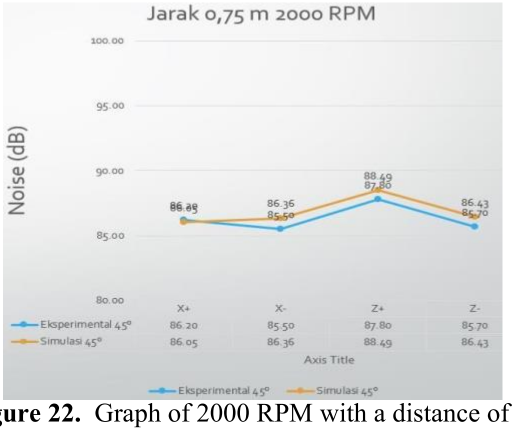

Figure 22. Graph of 2000 RPM with a distance of 0.75m and an angle of 45º after using the ANC method.

Table 3. Comparison of 3000 RPM Noise Data from experimental test results before ANC and after ANC

3000 RPM Sebelum ANC					3000 RPM Sesudah ANC				
N (rpm)	3000				N (rpm)	3000			
p (Pa)	Jarak 1,25 meter				p (Pa)	Jarak 1,25 meter			
Sudut	X+	X-	Z+	Z-	Sudut	X+	X-	Z+	Z-
45º	91.2	91.2	94.6	90.5	45º	93.5	92.4	93.2	91.3
90 °	89.3	88.5	91.7	88.1	90 °	90.2	89.6	93.4	88.7
135 °	93.5	92.4	93.2	91.3	135 °	90.8	88.9	91.3	88.3

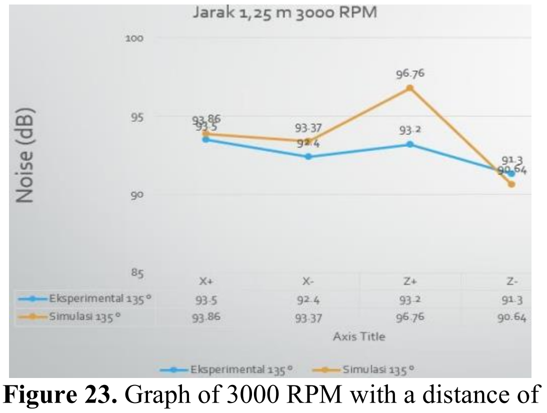

Figure 23. Graph of 3000 RPM with a distance of 1.25 m and an angle of 135º before using the ANC method.

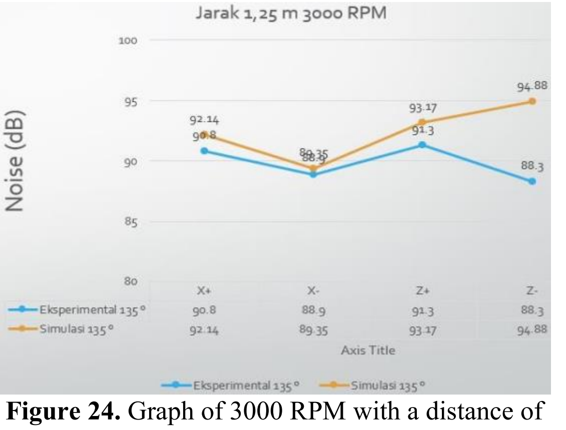

Figure 24. Graph of 3000 RPM with a distance of 1.25 m and an angle of 135º after using the ANC method.

4.2 Tables and Graphs in Simulation Testing

Table 4. Data Comparison of Noise 2000 RPM simulation test results before and after ANC.

HASIL SIMULASI SEBELUM 2000					HASIL SIMULASI SESUDAH 2000				
N (rpm)	2000				N (rpm)	2000			
p (Pa)	Jarak 1 meter				p (Pa)	Jarak 1 meter			
Sudut	X+	X-	Z+	Z-	Sudut	X+	X-	Z+	Z-
45º	86.31	86.01	90.24	81.55	45º	85.34	86.09	81.14	82.05
90 °	87.78	89.31	89.55	82.28	90 °	90.51	89.66	90.88	[illegible]
135 °	87.37	85.94	88.58	85.25	135 °	88.38	88.15	84.62	84.72

Figure 25. Graph of 2000 RPM with a distance of 1 m and an angle of 45º before using the ANC method.

Figure 26. Graph of 2000 RPM with a distance of 1 m and an angle of 45º after using the ANC method.

Table 5. Comparison of 3000 RPM Noise Data from simulation test results before ANC and after ANC.

HASIL SIMULASI SEBELUM 3000					HASIL SIMULASI SESUDAH 3000				
N (rpm)	3000				N (rpm)	3000			
p (Pa)	Jarak 0,75 meter				p (Pa)	Jarak 0,75 meter			
Sudut	X+	X-	Z+	Z-	Sudut	X+	X-	Z+	Z-
45°	94.83	95.55	99.09	93.19	45°	95.55	94.29	93.08	98.75
90 °	95.79	95.99	106.97	88.67	90 °	93.84	93.08	97.51	96.23
135 °	96.85	96.70	108.85	93.43	135 °	96.55	94.29	96.05	96.20

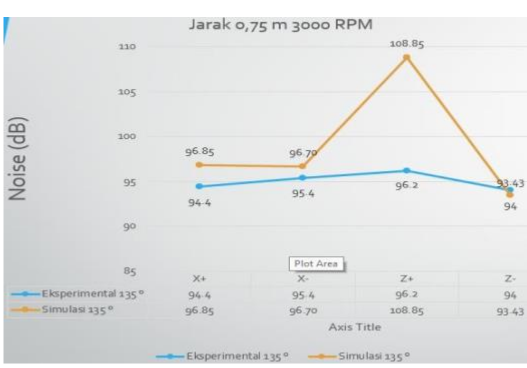

Figure 27. Graph of 3000 RPM with a distance of 0.75 m and an angle of 135º before using the ANC method

Figure 28. Graph of 3000 RPM with a distance of 0.75 m and an angle of 135º after using the ANC method.

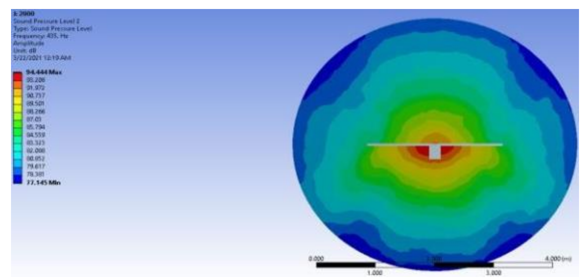

Figure 29. Measurement of the contours of the USU NVC aircraft with the DLE-Gas Engine 30 engine using the spherical method on the XY axis.

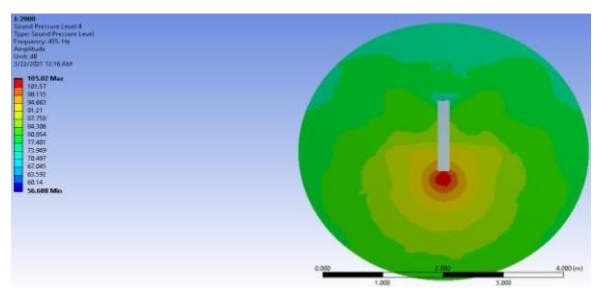

Figure 30. Measurement of the contours of the USU NVC aircraft with the DLE-Gas Engine 30 engine using the spherical method on the XZ axis.

Figure 31. Measurement of the contours of the USU NVC aircraft with the DLE-Gas Engine 30 engine using the spherical method on the YZ axis.

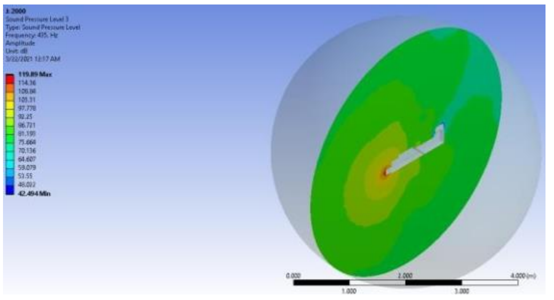

Figure 32. Measurement of the contours of the USU NVC aircraft with the DLE-Gas Engine 30 engine using the spherical method

Figure 4.8, 4.9, 4.10, 4.11 Noise contours on USU's NVC aircraft at 2000 RPM engine speed before using the active noise control method. Figure 4.8 Contour of noise on the XY axis. Figure 4.9 Contour of noise on the XZ axis. Figure 4.10 Contour of noise on the YZ axis. Figure 4.11 Contours of noise in three areas of the XYZ axis.

From the simulation results as shown in the picture, it can be seen that the red color in the contour area is the area with the highest noise level generated by the aircraft engine, with reference to red as the highest noise source to blue which is the area with the lowest noise in the surrounding area. plane.

V. CONCLUSION

The conclusion is based on the results of experimental testing and simulations on the USU NVC aircraft engine with the DLE-Gas Engine 30 engine using the active noise control method, namely:

1. From the simulations carried out on the USU NVC aircraft noise test with the DLE-Gas Engine 30 engine, it can be concluded that the higher the engine speed, the narrower the sound frequency range will be.
2. From the contours of the test results carried out in a simulation, it can be seen that the sound distribution of the USU NVC aircraft with the DLE-Gas Engine 30 engine tends to be evenly distributed in all directions.
3. From the contours of the test results carried out in a simulation, it can be seen that the engine area is the highest noise producer in the area around the aircraft.

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