

COMPARATIVE INVESTIGATION OF AIRCRAFT INTERIOR NOISE PROPERTIES

D. Miljković
HEP Zagreb, Vukovarska 37
dmiljkovic@hep.hr,

M. Maletić
FER Zagreb, Unska 3
mmaletic@fer.hr,

M. Obad
STORM Zagreb, Begovićeveva 14
mobad@storm.hr

Abstract: Investigation and comparison of aircraft interior noise is presented for different aircraft propulsion systems. Interior noise of four airplanes (piston, turboprop, turbojet and turbofan) and two helicopters (piston and turbine) is analyzed. Spectral and temporal properties of interior noise are given with reference to aircraft flight phase using flight simulator sound generator with recorded interior noise. A mathematical description of interior noise spectrum related to engine, propeller and rotor rotation speed and noise of relative wind is presented. Based on the analyzed interior noise properties proposals for suitable noise reduction methods are given.

Key words: aircraft, noise, propulsion, noise reduction

1. INTRODUCTION

Noise can be defined as an unwanted sound. It has negative impact on health, particularly on psychological health. High levels of noise negatively influence concentration, communication and ability to effectively perform cognitive tasks. Decreasing noise levels in an aircraft beside crew and passenger comfort provides potential for increased safety. The noise level and spectrum depends on the aircraft, propulsion system and flight phase. In this paper we have analyzed aircraft interior noise of six aircrafts (four airplanes and two helicopters). As a source of noise we have used Microsoft F2004 flight simulator sampling sound generator that made the whole experiment financially affordable, yet quality noise recordings enable us to note most important noise properties of aircraft interior noise for various propulsion types (combination of engine and propeller).

2. AIRCRAFT NOISE

Aircraft noise contains the following main components: engine noise, propeller noise, airframe noise and structure borne noise (as a particular kind of airframe noise), [1, 2]. Aircraft interior noise is combination of all mentioned components that, with various degrees, penetrate into the aircraft cabin. The sources and paths of airborne and structure-borne noise resulting in interior noise in an

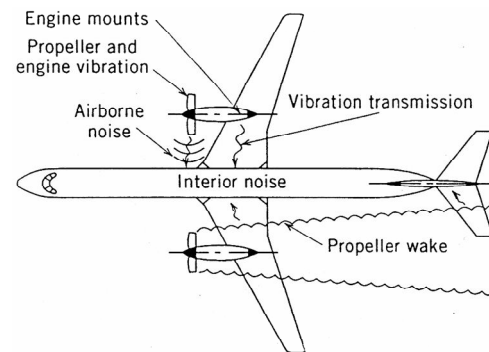


Fig. 1. Sources and paths of airborne and structure-borne noise resulting in interior noise in an airplane cabin, according to [1]

airplane cabin are illustrated in Fig. 1 from [1].

2.1. Engine noise

There exist various types of aircraft engines. The main types are piston, turboprop, turbojet, and turbofan. Engine noise is highly dependent on propulsion type. Piston engines exist as gasoline and diesel engines. Piston engine noise is the result of pressure pulses on intake and exhaust during engine four cycles, Fig.2. In the case of piston engine, noise spectrum is dependent on rotational speed (*RPM*) and number of cylinders.

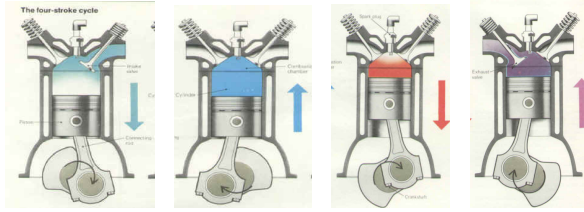


Fig. 2. Four cycles of piston engine

Cylinder firing rate (*CFR*) is dependent on rotational speed:

$$CFR = \frac{RPM}{60} \quad (1)$$

Engine firing rate (*EFR*) is dependent on *CFR* and number of cylinders (*N*):

$$EFR = N \cdot CFR \quad (2)$$

Discrete frequency components related to *CFR* and *EFR* are illustrated in Fig. 3.

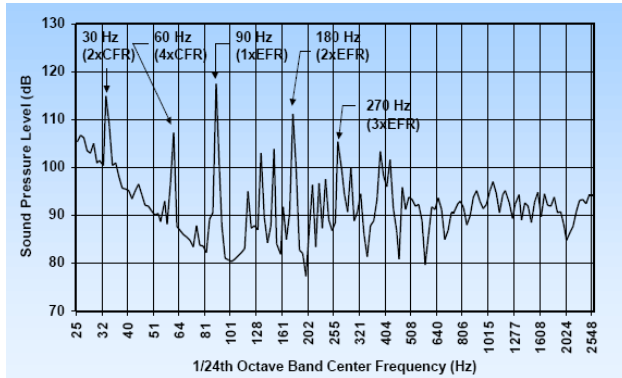


Fig. 3. Piston engine frequency components

In turbine engines noise spectrum is again dependent on rotational speed (*RPM*), but is less discrete and together with harmonics (due to turbine blades) has a strong broadband component, particularly with turbojet engines. Noise components of turbojet engine are illustrated in Fig. 4 from [3], the dominant component is jet exhaust noise. There exists a basic tonal component dependent on rotational speed and number of turbine blades, but it is mixed with broadband turbulent airflow. In case of turbofan engine noise (with noise components illustrated in Fig. 5, [3]) there are more pronounced harmonics due to fan blades, particularly with high bypass ratio engines. Broadband jet noise contribution is lower than on turbojet engine.

2.2. Propeller noise

Propeller noise is composed of tonal and broadband components. Tonal component contains basic frequency and harmonics. The basic frequency f_1 or *BPF* (blade pass frequency) is the product of propeller rotation speed and number of propeller blades:

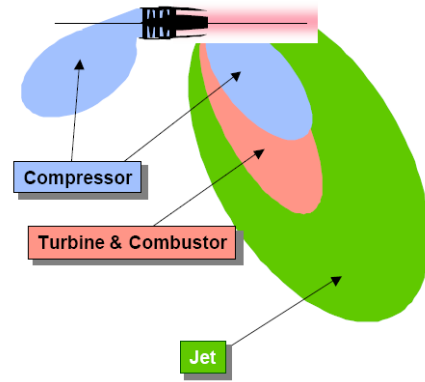


Fig. 4. Turbojet engine noise components (note dominant turbulent jet exhaust gas noise)

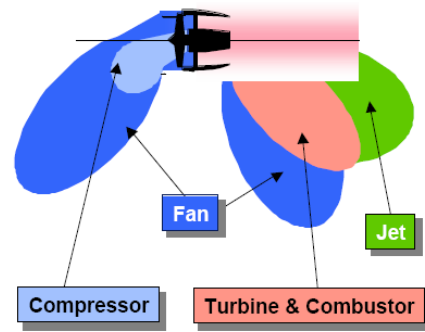


Fig. 5. Turbofan engine noise components

$$BPF = \frac{N_R N_B}{60} \quad (3)$$

where is:

BPF basic frequency of tonal propeller component
 N_R propeller rotation speed (rotations per minute)
 N_B number of propeller blades

Beside base frequency also appear harmonic components:

$$f_n = f_1 N \quad (4)$$

where is

f_n frequency of n -th harmonic
 f_1 basic tonal frequency
 N number of particular harmonic

Similar consideration can be applied to fan noise of turbofan engines where the fan is a type of propeller with a large number of blades.

In a single engine aircraft propeller noise enters the cabin through front window in the form of pressure pulses. The main disturbance is radiated outside aircraft in open space. With multiengine aircrafts propeller noise is more pronounced because the pilot and passengers are often in line with the propeller blades.

2.3. Airframe noise

Airframe noise is the result of air flow (wind around airframe). It is of the broadband flow mixing type except where a resonant cavity is formed (e.g. at control surface gaps). Its main characteristic is a great dependence on aircraft speed. Noise intensity is related to aircraft speed (Fig. 6) with the following equation:

$$I = kv^n \quad (5)$$

where v is the speed of an aircraft and the exponent n varies between 5 and 6 and is dependent on the shape of fuselage.

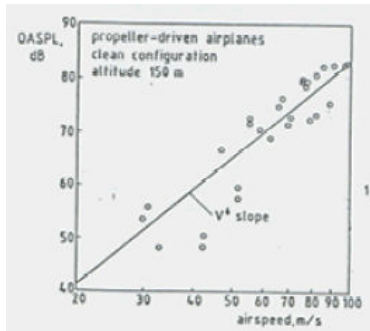


Fig. 6. Airframe noise dependency on speed

2.4. Structure borne noise

Structure borne noise results from airframe vibrations. Various vibration modes excite structural modes. Acoustic space again has its acoustic modes that are excited by structural modes. This noise is quite complex and difficult to suppress, hence the best method is to prevent vibration entering the cabin.

2.5. Interior noise levels

It depends a lot on the aircraft, but on average the values are 80 dB and above, up to 110 dB in case of some piston (eg. Cessna 210) and turboprop aircraft for some phases of flight (takeoff). There is quite a lot of variation between various aircraft of the same model. Aircraft interior noise is also position dependent (Fig. 7, example of King Air cabin), ie. noise level and spectrum change a little when moving through a cabin (there may exist small spots with a difference in the noise level of about 10 dB from average). Aircraft interior noise is generated predominantly by the engine and the slipstream. Propeller noise is not so dominant when the pilot is not in line with the blades.

2.6. Propulsion noise

Propulsion is dependent on engine-propeller combination. Piston aircraft use piston engine with propeller. Turboprop aircraft combine turbine engine and propeller. In the case of turbojet and turbofan engines there is clearly no need for propeller as the engine does all

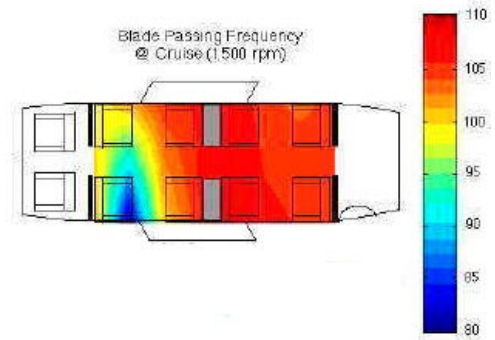


Fig. 7. Interior noise level is position dependent

the job of generating forward thrust. Waveform and spectrum of engine noise signal for various propulsions are given in Fig. 1-8. Following measurements are based on stored waveforms from simulator's sampling sound generator.

2.7. Piston engine

In the case of piston engine and propeller we have a clear periodic component shown in noise waveform and spectrum (Fig. 8 and 9).

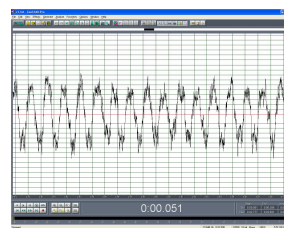


Fig. 8. Waveform

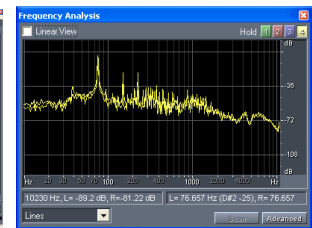


Fig. 9. Spectrum

2.8. Turboprop engine

With the turboprop propulsion again we have a periodic waveform and spectrum, but this time there is a more pronounced broadband noise from turbine engine. The base frequency and harmonics are higher due to higher number of propeller blades (Fig. 10 and 11).

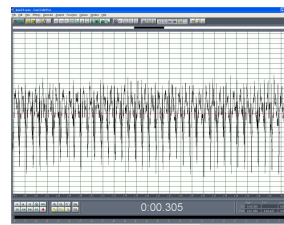


Fig. 10. Waveform

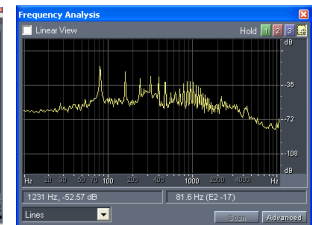


Fig. 11. Spectrum

2.9. Turbojet engine

Analyzing the sound of a turbojet engine we found a noisy waveform and broadband noise spectrum (Fig. 12 and 13). Besides basic tonal component, rest is broadband noise.

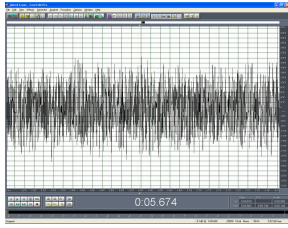


Fig. 12. Waveform

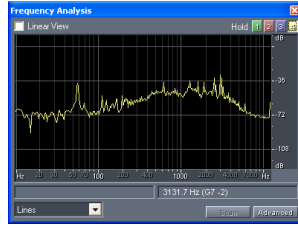


Fig. 13. Spectrum

2.10. Turbofan engine

With turbofan engines, again we find a noticeable periodicity in noise waveform and tonal components in the noise spectrum (due to fan blades, a kind of enclosed propeller with many blades), shown in Fig. 14 and 15.

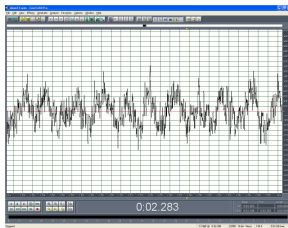


Fig. 14. Waveform

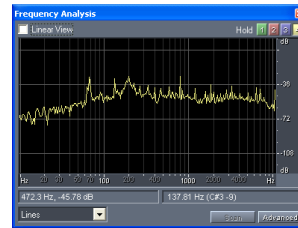


Fig. 15. Spectrum

3. EXPERIMENT SETUP

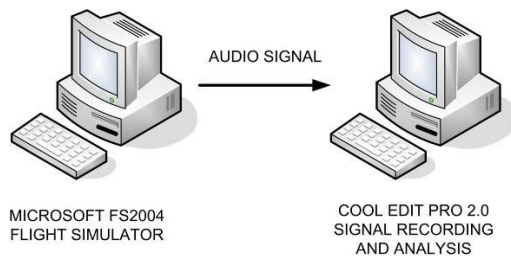


Fig. 16. Experiment setup using two PC computers

We have used two separate computers. One was running an instance of FS2004 flight simulator with various aircraft models (default, RealAir C172, FFX/SGA B737 and HSJ DC8). The other is recording and analyzing noise using CoolEdit Pro 2.0. As a noise source we have used quality recordings for Microsoft FS2004 flight simulator sampling sound generator. The simulator uses carefully chosen mix of numerous cockpit noise recordings for a particular flight phase. Mixture of recordings is adjusted for pitch and amplitude (in sound configuration file for a particular aircraft) in the simulator sound generator to preserve correct amplitude and spectral information, [4].

4. AIRPLANE NOISE

Noise in the following flight phases has been analyzed: idle, takeoff, climb, cruise, descent, approach and landing.

During the idle phase engine is running at idle speed and the airplane is not moving. The idle phase includes noise from aircraft systems (avionics fans, air condition etc.). In the takeoff phase the aircraft is speeding up on the runway (with noises from wheels and airframe) and leaves the runway. The climb phase includes climb to a cruise altitude with the initial thrust reduction after takeoff. The cruise phase is horizontal flight. The descent is a flight phase between cruise and final approach. Approach phase contains last few minutes of flight (for airplanes down the ILS glideslope with gear and flaps extended) and speed reduced for landing. Landing phase includes touchdown with braking using reverse thrust that is activated on turboprop, turbojet and turbofan aircraft. Airplanes have been flown with thrust, indicated and vertical speeds, gears and flaps selected according to available checklists.

4.1. Piston aircraft

Cessna 172 is a four-seat, single-engine (piston), high-wing aircraft. The engine is a four-cylinder, fuel-injection Lycoming IO-360 with two-blade propeller (Fig. 17). Waveforms and spectra of interior noise are shown in Fig. 18-31. Tonal components are present in all flight phases. At higher speed comes influence of aerodynamic noise and greater relative importance of broadband noise in noise spectrum. More on Cessna single piston engine interior noise can be found in [5].

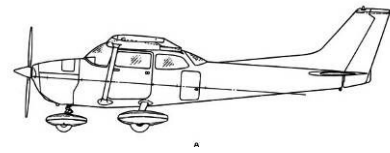


Fig. 17. Cessna 172 piston engine aircraft

- Idle (stationary aircraft, engine 700 RPM)

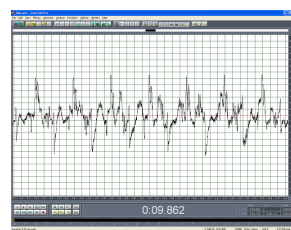


Fig. 18. Waveform

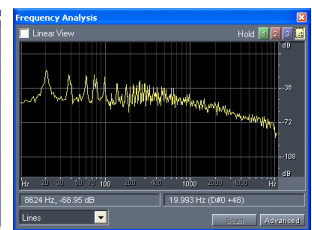


Fig. 19. Spectrum

- Takeoff (50 knots, Full power, 2300 RPM)

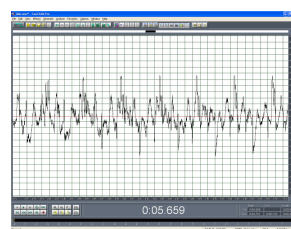


Fig. 20. Waveform

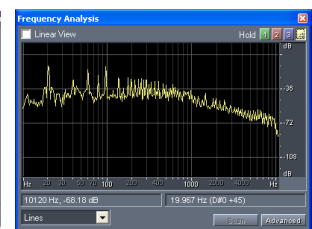


Fig. 21. Spectrum

- Climb (80 knots, 700 ft/min, 2300 RPM)

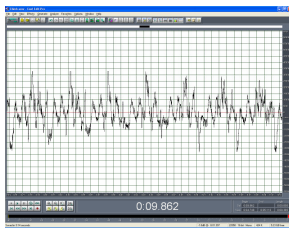


Fig. 22. Waveform

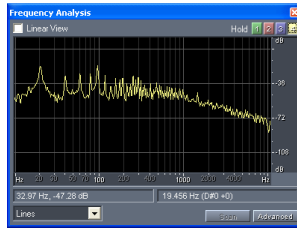


Fig. 23. Spectrum

- Cruise (110 knots, 2500 RPM)

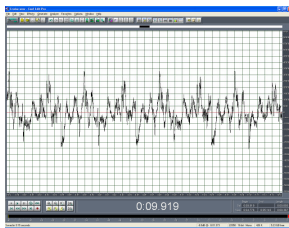


Fig. 24. Waveform

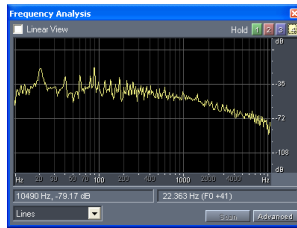


Fig. 25. Spectrum

- Descent (100 knots, -700 ft/min, 2000 RPM)

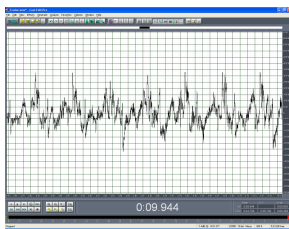


Fig. 26. Waveform

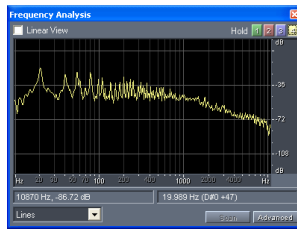


Fig. 27. Spectrum

- Approach (75 knots, -400 ft/min, 2100 RPM, flaps 20)

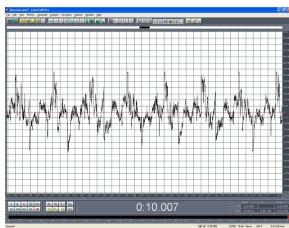


Fig. 28. Waveform

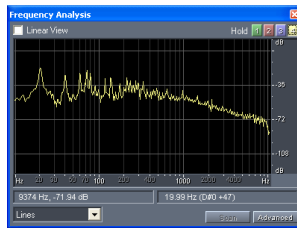


Fig. 29. Spectrum

- Landing (<65 knots, 700 RPM)

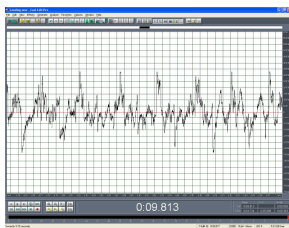


Fig. 30. Waveform

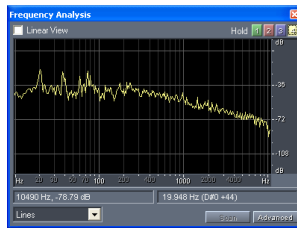


Fig. 31. Spectrum

4.2. Turboprop aircraft

The Beechcraft King Air B350 (Fig. 32) is a twin-turboprop business and utility aircraft. The aircraft is equipped with PT-6A-60 engines and four-blade propellers. Waveforms and spectra of interior noise are shown in Fig. 33-46. Similar to Cessna, tonal components are present in all phases of flight. At higher speeds there is significant relative contribution of broadband noise, as well as a combination of tonal and broadband noise roar during braking with reverse. More about turboprop aircraft noise and active noise control for twin turboprop aircraft can be found in [6].

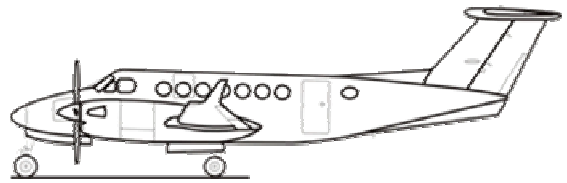


Fig. 32. King Air 350 turboprop aircraft

- Idle (stationary aircraft, 1700 RPM)

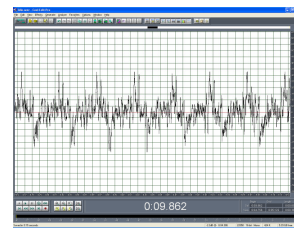


Fig. 33. Waveform

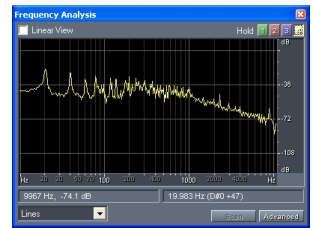


Fig. 34. Spectrum

- Takeoff (<110 knots, full power)

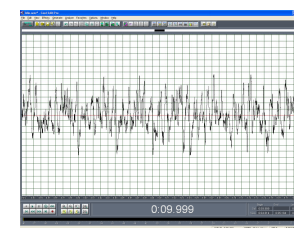


Fig. 35. Waveform

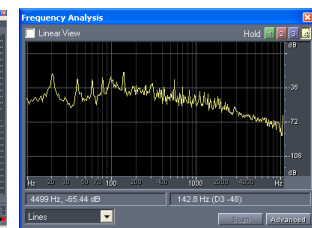


Fig. 36. Spectrum

- Climb (160 knots, 1800 ft/min, 2000 RPM)

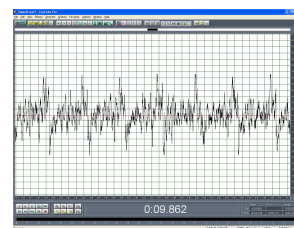


Fig. 37. Waveform

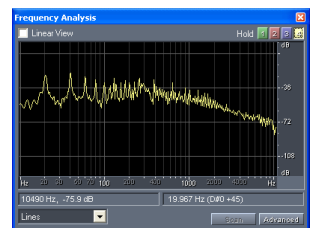


Fig. 38. Spectrum

- Cruise (220 knots, torque 80)

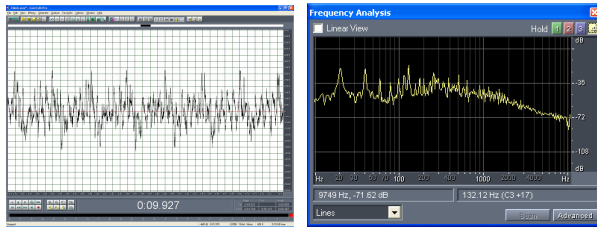


Fig. 39. Waveform

Fig. 40. Spectrum

- Idle (stationary aircraft)

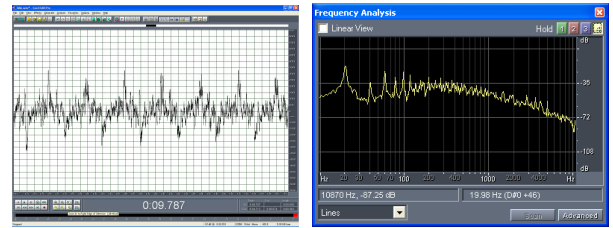


Fig. 48. Waveform

Fig. 49. Spectrum

- Descent (180 knots, -1800 ft/min, torque 10)

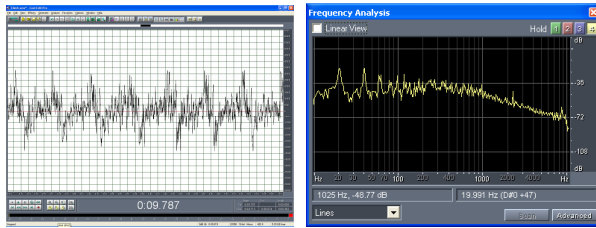


Fig. 41. Waveform

Fig. 42. Spectrum

- Takeoff

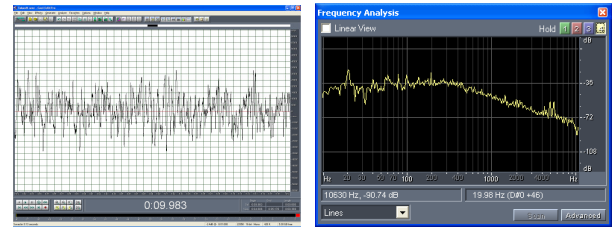


Fig. 50. Waveform

Fig. 51. Spectrum

- Approach (110 knots, torque 25)

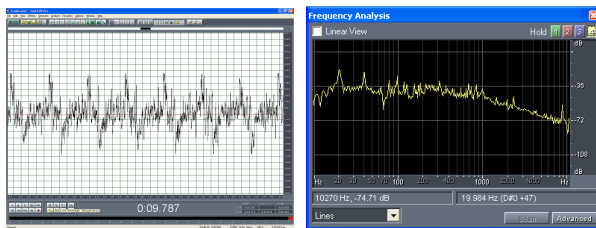


Fig. 43. Waveform

Fig. 44. Spectrum

- Climb (1800 ft/min)

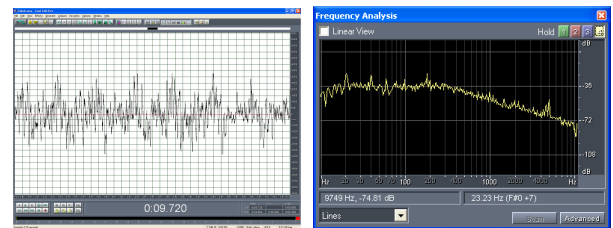


Fig. 52. Waveform

Fig. 53. Spectrum

- Landing (braking with reverse thrust)

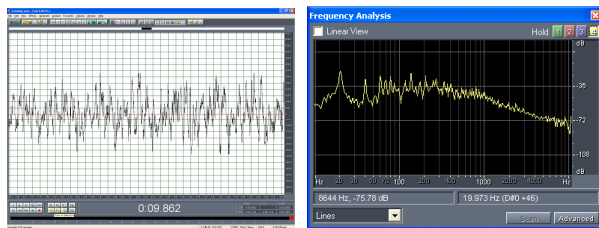


Fig. 45. Waveform

Fig. 46. Spectrum

- Cruise (FL 240, Mach 0.76 - 335 knots)

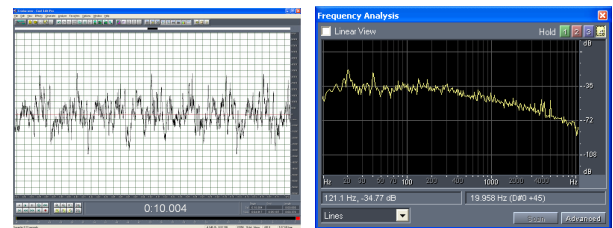


Fig. 54. Waveform

Fig. 55. Spectrum

4.3. Turbojet aircraft

DC-8-30 is a historic jetliner, Fig. 47. Today it is mainly used for cargo and parcel post transport. It is equipped with four turbojet engines with reverses P&W JT4A.



Fig. 47. DC-8-30 four turbojet engine jetliner

- Descent (330 knots, -1800 ft/min)

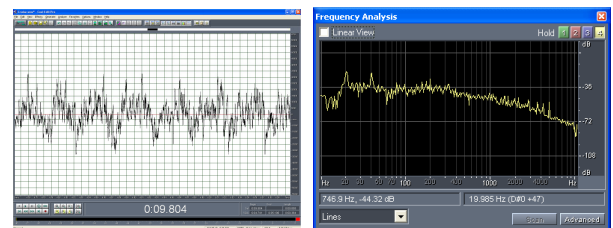


Fig. 56. Waveform

Fig. 57. Spectrum

- Approach (150 knots)

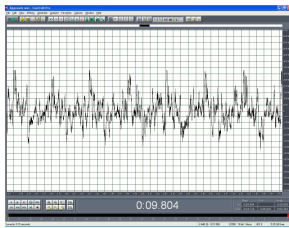


Fig. 58. Waveform

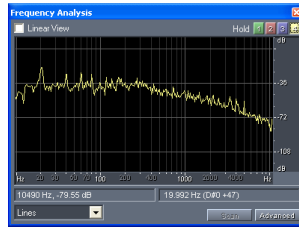


Fig. 59. Spectrum

- Takeoff

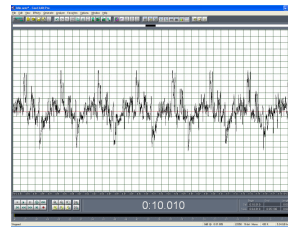


Fig. 65. Waveform

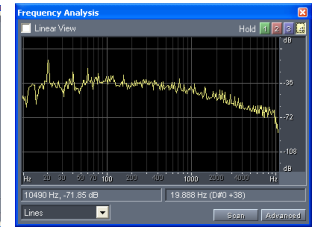


Fig. 66. Spectrum

- Landing (braking with reverse thrust)

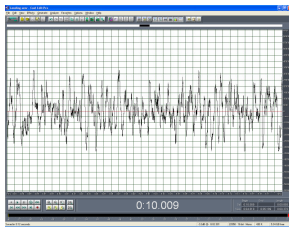


Fig. 60. Waveform

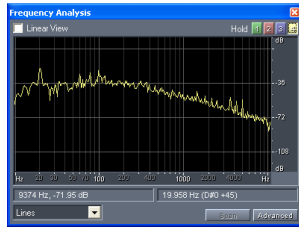


Fig. 61. Spectrum

- Climb (250 knots, 1800 ft/min)

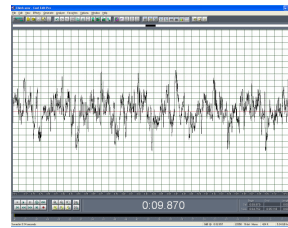


Fig. 67. Waveform

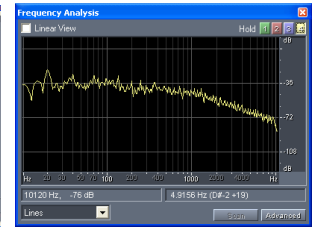


Fig. 68. Spectrum

Waveforms and spectra of interior noise are shown in Fig. 48-61. Tonal component is clearly noticeable only in idle phase. All other flight phases consist of broadband noise. Broadband noise comes both from engines and relative wind around airframe.

4.4. Turbofan aircraft

Boeing 737-800 (Fig. 62) is a new version of Boeing 737, the world's most popular short to medium range airliner equipped with quiet CFM 56-7B27 turbofan engines.



Fig. 62. Boeing 737-800 - twin turbofan engines airplane

Waveforms and spectra of interior noise are shown in Fig. 63-76. Tonal components are present at idle (mostly cockpit and aircondition noise), takeoff, climb, approach (low speed) and landing (low speed + reverse). In other phases, lot of broadband aerodynamic noise is present.

- Idle (stationary aircraft)

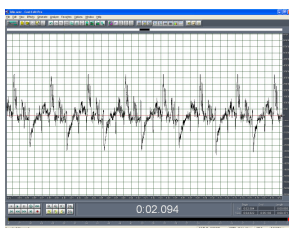


Fig. 63. Waveform

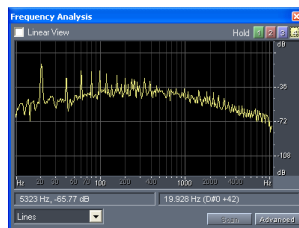


Fig. 64. Spectrum

- Approach (150 knots, flaps 30, gear down)

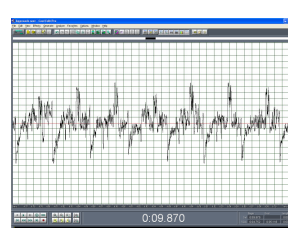


Fig. 73. Waveform

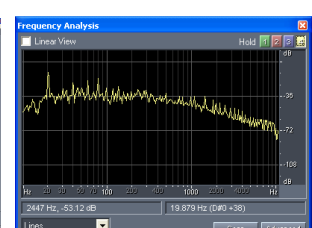


Fig. 74. Spectrum

- Cruise (FL 280, Mach 0.80 - 325 knots)

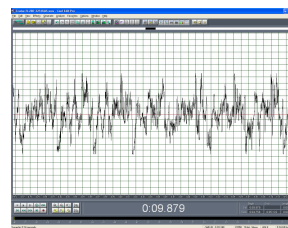


Fig. 69. Waveform

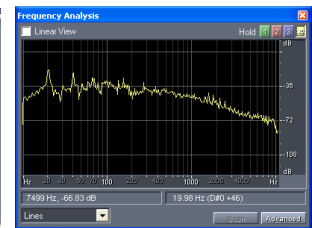


Fig. 70. Spectrum

- Descent (Mach 0.75 to FL240, -1800 ft/min)

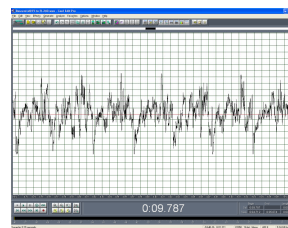


Fig. 71. Waveform

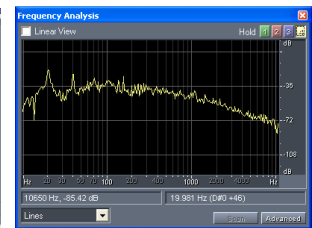


Fig. 72. Spectrum

- Landing (braking with reverse thrust)

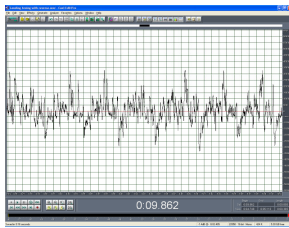


Fig. 75. Waveform

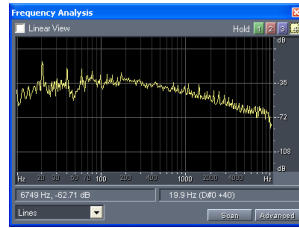


Fig. 76. Spectrum

- Climb (20 MP, 50 knots)

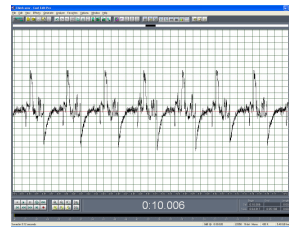


Fig. 82. Waveform

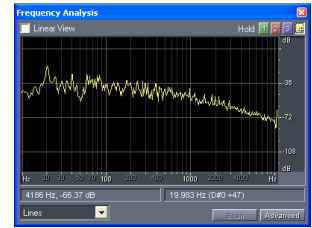


Fig. 83. Spectrum

5. HELICOPTER NOISE

The main sources of helicopter noise are: rotor, engine and transmission noise. We have analyzed noise of two helicopters: piston and turbine in seven flight phases.

5.1 Piston helicopter

Robinson R-22 Beta II (Fig. 77) is a small, light two-person helicopter with Lycoming O-320 four-cylinder, air-cooled, normally aspirated, carburetor-equipped piston engine with a two-bladed main rotor and conventional two-bladed tail rotor.



Fig. 77. Robinson R-22 Beta II

Waveforms and spectra of interior noise are shown in Fig. 78-91 (MP stands for manifold pressure).

- Idle (stationary, MP 11-12)

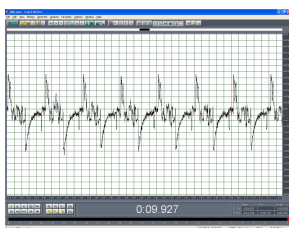


Fig. 78. Waveform

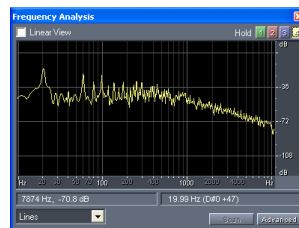


Fig. 79. Spectrum

- Cruise (20 MP, 90 knots)

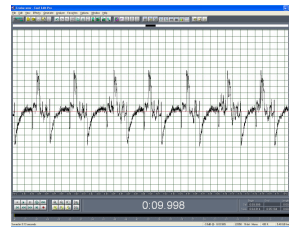


Fig. 84. Waveform

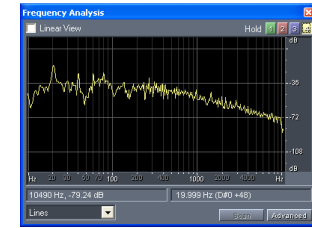


Fig. 85. Spectrum

- Descent (15 MP, 60 knots)

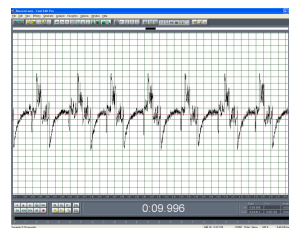


Fig. 86. Waveform

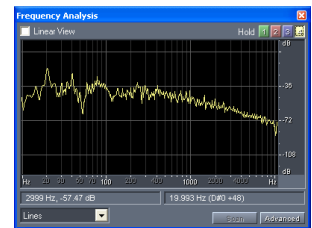


Fig. 87. Spectrum

- Approach (14 MP, 30 knots)

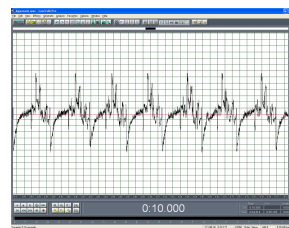


Fig. 88. Waveform

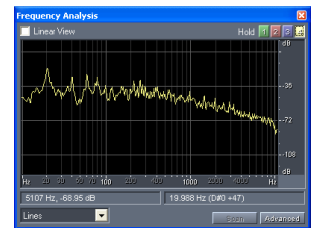


Fig. 89. Spectrum

- Takeoff - hover (15 MP)

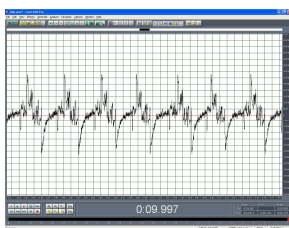


Fig. 80. Waveform

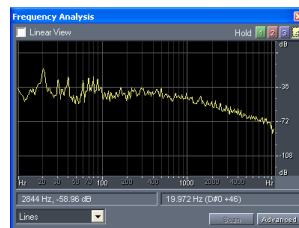


Fig. 81. Spectrum

- Landing (14 MP)

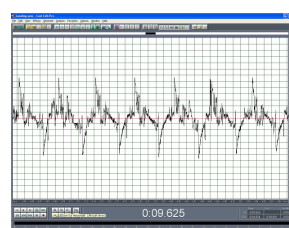


Fig. 90. Waveform

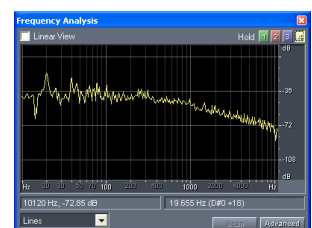


Fig. 91. Spectrum

Tonal component from engine dominates all flight phases. Little broadband noise could be heard during cruise and descent. Noise is quite similar regardless flight phase with exception of idle phase.

5.2 Turbine helicopter

Bell 206 Jet ranger is a two-bladed main rotor, turbine powered helicopter with a conventional, two-bladed tail rotor (Fig. 92). Turbine engine is Allison 250-C20J.

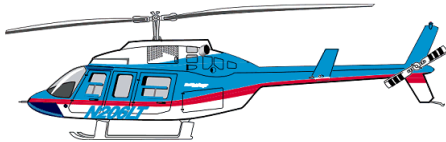


Fig. 92. Bell 206 Jet Ranger III

Waveforms and spectra of interior noise are shown in Fig. 93-106. Tonal component from the engine dominates all flight phases with a small broadband noise contribution when helicopter achieves progressive speed. With the exception of idle phase, noise is very similar (engine and rotor work within narrow RPM range).

- Idle (stationary, torque 30)

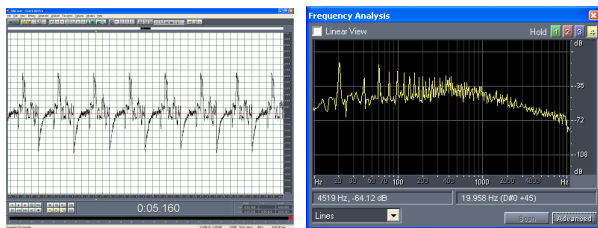


Fig. 93. Waveform

Fig. 94. Spectrum

- Takeoff- hover (torue 70)

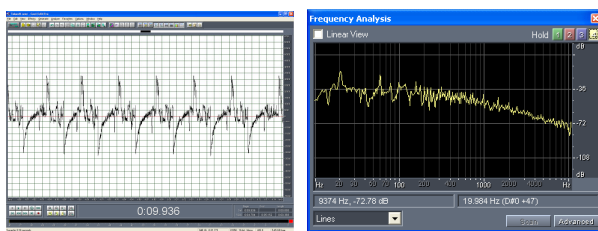


Fig. 95. Waveform

Fig. 96. Spectrum

- Climb (torque 85, 52 knots)

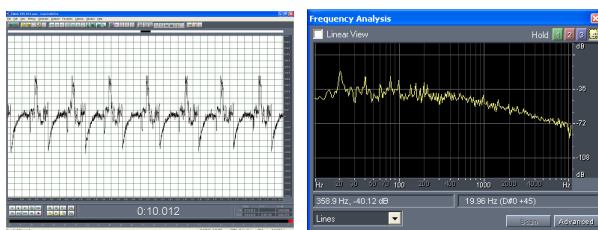


Fig. 97. Waveform

Fig. 98. Spectrum

- Cruise (torque 85, 100 knots)

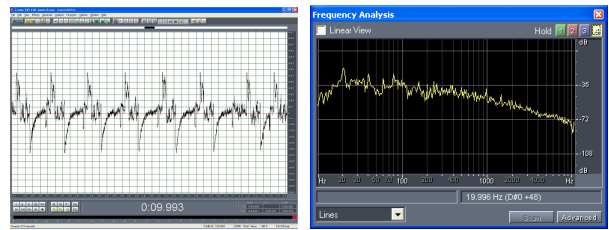


Fig. 99. Waveform

Fig. 100. Spectrum

- Descent (torque 70, 90 knots)

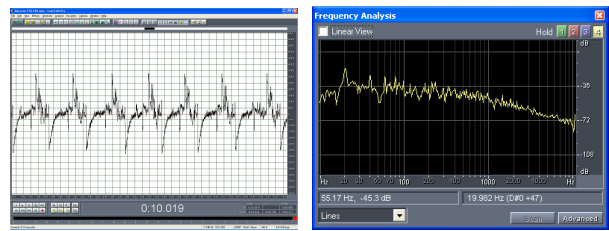


Fig. 101. Waveform

Fig. 102. Spectrum

- Approach (torque 65, 60 knots)

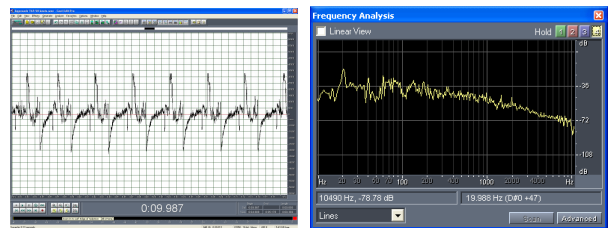


Fig. 103. Waveform

Fig. 104. Spectrum

- Landing (torque 60)

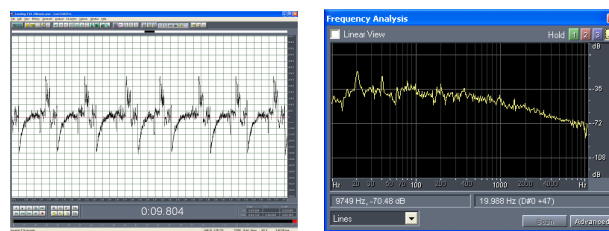


Fig. 105. Waveform

Fig. 106. Spectrum

6. COMPARISON OF NOISES

Noise is propulsion related and flight phase related. On the basis of previous experiments we may present the main interior noise properties in table 1.

Tonal components are most dominant during idle, takeoff and approach phases. Broadband component is dominant during climb, cruise and descent (when the aircraft travels with higher airspeed).

	idle	takeoff	climb	cruise	descent	approach	landing
PLANE							
piston	T	T	T+B	T+B	T+B	T	T
turboprop	T	T	T+B	T+B	T+B	T	T+B
turbojet	T+B	T+B	T+B	T+B	T+B	T+B	T+B
turbofan	T+B	T	T+B	T+B	T+B	T	T+B
HELI							
piston	T	T	T	T+B	T+B	T	T
turbine	T	T	T	T+B	T+B	T	T

T – Tonal B – Broadband

Table 1. Comparison of noises (aircraft/flight phase)

7. NOISE REDUCTION

There exist passive, active and hybrid noise reduction methods for aircrafts [7]. Frequency range for application is shown in Fig. 107.

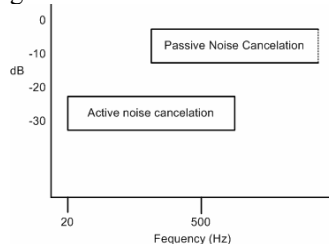


Fig. 107. Frequency range for passive and active methods

- Passive noise cancellation, suitable for higher frequency noise, like airframe wind noise.
- Active noise cancellation is achieved by destructive interference [8,9,10]. Suitable for low frequencies, like propeller tones, engine and helicopter transmission.
- Passive vibration cancellation, vibration isolators and vibration dampers tuned to particular frequency.
- Active vibration cancellation, achieved by destructive interference in a similar way as an active noise cancellation with vibration shakers.

Suitability of noise reduction methods is shown in table 2.

Aircraft	Noise reduction		Vibration reduction	
	Active	Passive	Active	Passive
Airplane				
Piston	+++	+		++
turboprop	+++	+	++	++
Turbojet		++	+	+
Turbofan	++	++	+	+
Helicopter				
Piston	+++	+	+	++
Turbine	+++	+	+++	++

Table 2. Suitability of noise reduction method

8. CONCLUSION

With low expenses, we have analyzed noise properties of six aircrafts (airplanes and helicopters) with different propulsion systems. We have gained insights into main noise properties of each propulsion system in various

phases of flight. At low speeds, noise is dominated by tonal components of piston and turboprop engine. Turbofan and turbojet engine generate a lot of broadband spectrum noise (jet whine) even with stationary airplane. With higher airspeeds aerodynamic noise become increasingly important contributing to the mixture of tonal and broadband noise. Takeoff run of airplanes contains additional noises, mainly from airplane undercarriage. Climb noise is a mixture of tonal and broadband noise. During cruise phase, due to higher aircraft speed, broadband noise component becomes more pronounced. Again, during descent broadband component is in relative contribution more pronounced because engines that normally have tonal components are running on low or idle power setting. Approach phase, with lower speed and engine power setting, has overall lower mixture of tonal and broadband noise, contaminated with the noise from the extended gear and flaps. Landing with turboprop, turbojet or turbofan engines is dominated with roar of reverse thrust activation during braking. Tonal components, particularly at lower frequencies are suitable for active noise cancellation. Broadband noise components should be reduced with classical passive methods. Complicated structure borne sound should be reduced by isolating cabin from vibration influence of engines and propellers.

REFERENCES

- [1] M.J.Crocker, *The Generation of Noise in Machinery, its control, and the identification of noise sources*, Encyclopedia of Acoustics, John Wiley, 1997, Vol. II, pp. 991-1024
- [2] D. Miljkovic, *Active noise control in light aircraft cabin using multichannel coherent method*, Ph.D. Thesis, University of Zagreb, 2006
- [3] Ira Ruschwald, *Continuing Work on Aircraft Noise Reduction, Summary of the Aircraft Noise Technology Workshop*, Sao Paulo, Dec. 2001, Boeing CAEP WG1
- [4] E. Struzynski, *FS SoundStudio*, www.fssoundstudio.com
- [5] J. F. Unruh and P. D. Till, *General Aviation Interior Noise: Part I-III – Source/Path Identification Technology*, NASA/CR-2002-21165, Southwest Research Institute, San Antonio, Texas, May 2002
- [6] S. Johansson and I. Claesson, *Active Noise Control in Propeller Aircraft*, Proceedings of ISMA 23, pp. 13-25, 1998, Leuven (Belgium), September 16-18, 1998
- [7] L.R.Miller, D.J.Rossetti and M.A.Norris, *Passive, Active and Hybrid Solutions for Aircraft Interior Noise Problems*, LL-6007, Lord Corporation, November 1995
- [8] S.M. Kuo and D. R. Morgan, *Active Noise Control : A Tutorial Review*, Proceedings of the IEEE, Vol. 87, No. 6, June 1999
- [9] H. G. Leventhall and L. Wong, *A Review of Active Attenuation And Development of an Active Attenuator 'Open Refuge'*, HSE Contract Research Report No. 4/1988, W S Atkins Engineering Sciences, 1988
- [10] D. Miljkovic, M. Maletic and B. Somek, *Active Noise Control*, MIPRO 2007, Opatija, Croatia, May 2007