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Technology for Reduction of Annoyance Caused by Aircraft in Cities

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Abstract

The communities living in cities are the most affected by noise produced by aircraft flying over in approach procedure of after taking off. On the other hand, in cities, the population density is high and for this reason a large number of citizens are affected.

The noise generated by aircraft is multiple reflected by buildings and absorption of this noise is low due to absence of vegetation which is specific to the most of modern cities.

This presentation shows several possibilities to reduce the level of annoyance produced by aircraft on communities living in cities through psychoacoustics methods and tries to anticipate the evolution of cities design for facing to the future challenges related by development of aerial traveling.

Outline

1. Introduction
2. A brief review of Psychoacoustics
3. Underlying of productive directions
4. Experiments on annoyance done in COMOTI
5. The first technology proposed by COMOTI: Emitting of a masking sequence of sounds by aircraft (not recommended)
6. The second technology proposed by COMOTI: Using of sound machines or loudspeakers placed at ground level
7. Possible evolution of city architecture for reduction of annoyance produced by aircraft noise
8. Conclusions

1. Introduction

- In our days, the communities which are the most affected by aircraft noise are living in cities.
- The most of airports are located in the vicinity of cities now because in time cities extended to airports.
- In this way, the citizens living in cities became to be much affected by the noise generated by aircraft flying over in approaching procedure of after taking off.
- The noise generated by aircraft is multiple reflected by buildings being channeled along streets. Absorption of this noise is low due to absence of vegetation (which is a specific feature of the most of the modern cities) and because during design of buildings the problem of noise absorption was not taken into account.
- For this reason, reduction of the annoyance level produced by aircraft on communities living in cities through methods related by psychoacoustics and anticipation of cities design evolution for facing the future challenges related by development of aerial traveling is important.

2. A brief review of Psychoacoustics
[1]

- **Psychoacoustics is a branch of physics which studies the connection between physical characteristics of sound and listener's perception.**

- **It deals with:**

-thresholds

-localization of sound

-hearing adaption at sound loudness

-frequency selectivity

-timbre and loudness

-analysis of auditory

-influence of noise to health

-masking of sound

- **Psychophysical experiments involve listeners as test subjects**

3. Underlying of productive directions

[1]

The most important for annoyance level reduction are:

▪ **Thresholds**

▪ **Frequency selectivity: The probability of detecting a sound from a certain source decreases dramatically if the listener is also exposed to other sounds at the same time. This phenomenon is called “masking”.**

▪ **Masking:**

-type 1 of masking: Low volume sound can not be heard in the presence of a loud sound

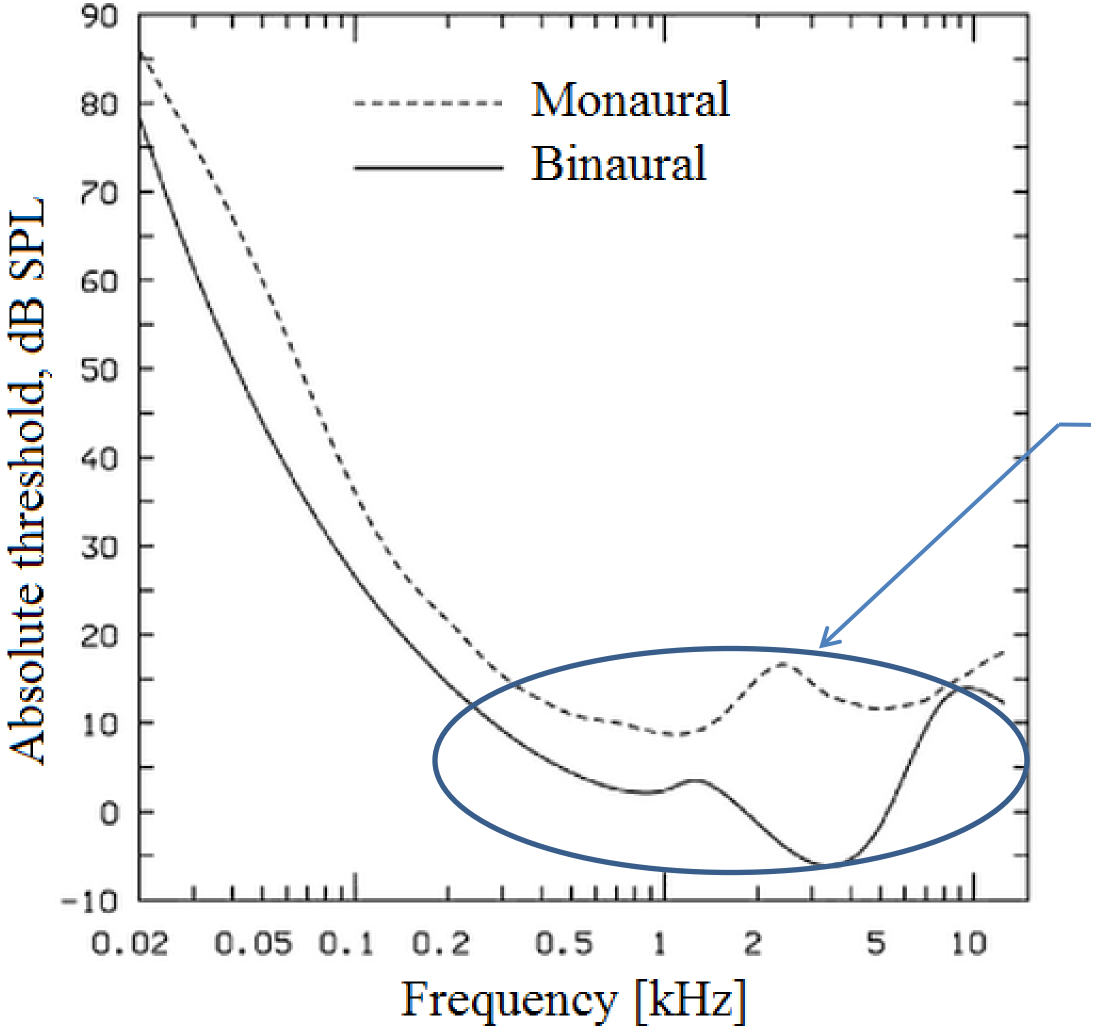
-type 2 of masking: It appears when two sound signals have similar frequency components

[1]-Nejc Rosenstein, Psychoacoustics, 8.1.2014, Univerza v Ljubljani

3. Underlying of productive directions

[1]

The importance of thresholds:



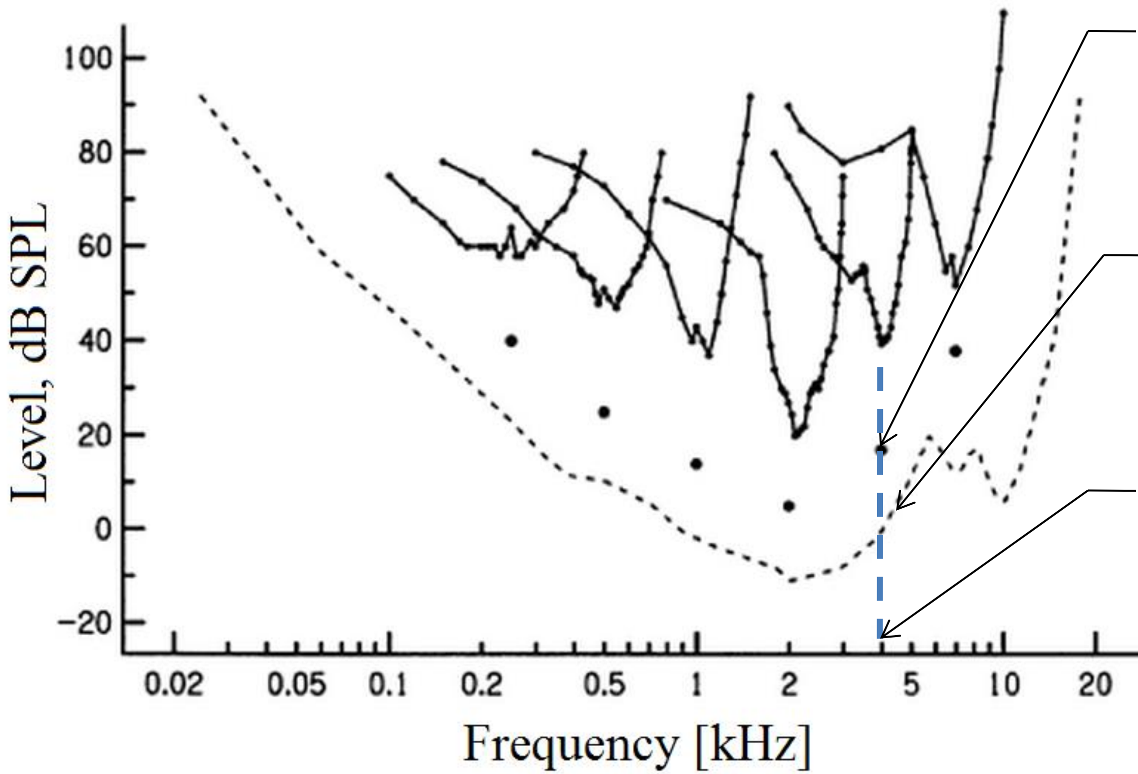
Effort for annoyance reduction should be done for this area because here the thresholds have minimum values

Fig.1-Measurements of absolute thresholds for binaural (both-ears) and monaural (one-ear) [1]

3. Underlying of productive directions

[1]

-Type 1 of masking: Low volume sound can not be heard in the presence of a loud sound



Level of masker signal >10…20dB than the sound to be masked

The absolute threshold of a signal at a given frequency

Minimum level of masker signal is reached when its frequency ≈ frequency of masked signal

Fig.2-Measurements of psychophysical tuning curves showing the level of masker signal which is needed to successfully mask a signal of a given frequency [1]

[1]-Nejc Rosenstein, Psychoacoustics, 8.1.2014, Univerza v Ljubljani

3. Underlying of productive directions [1]

-Type 2 of masking: it appears when two sound signals have similar frequency components

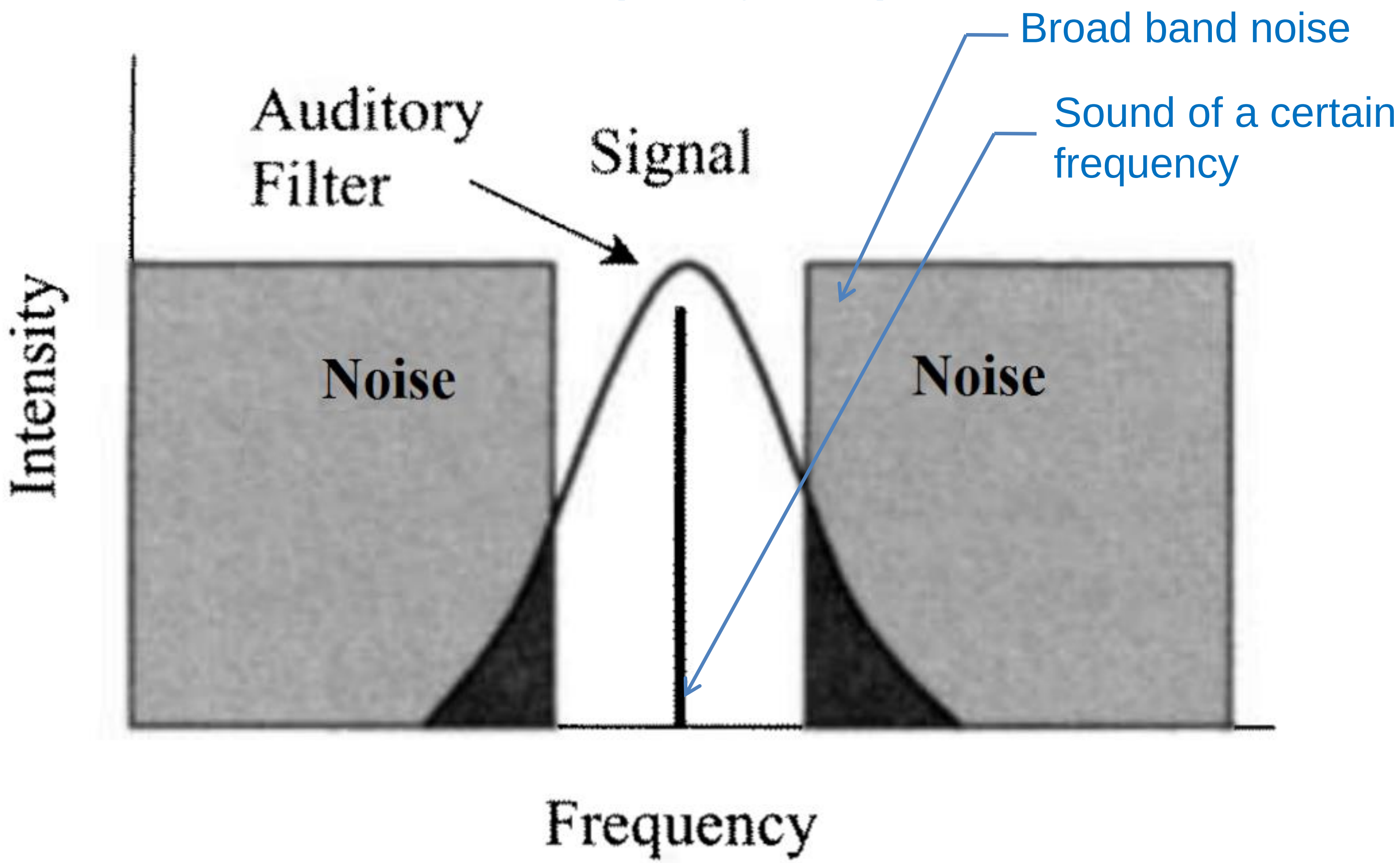


Fig.3- Noise masked by a sound [1]

4. Experiments on annoyance done in COMOTI

https://www.youtube.com/watch?v=vITtgWpJfZ0

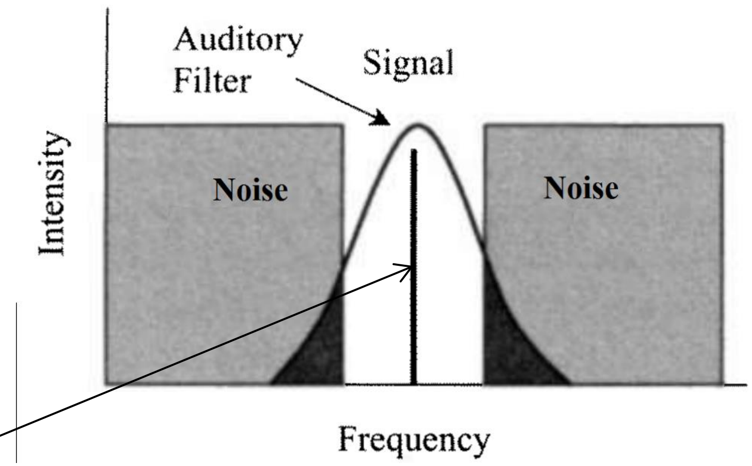
Fig.4- Noise simulator

http://www.szynalski.com/tone-generator/

Fig.5- Signal generator

▪**Combinations of masking effect type 1 and 2 were experimented in COMOTI:**

- **First combination:** Signals of various frequencies with 10…20 dB louder than the corresponding frequency of broad band noise were emitted simultaneous with the aircraft noise



- **Results:** No notable effect was registered i.e. a unique frequency can not mask the whole broadband noise →

- **Conclusion:** Using <u>of a single frequency has no effect</u> on reduction of annoyance level

4. Experiments on annoyance done in COMOTI

https://www.youtube.com/watch?v=vITtgWpJfZ0

Fig.6- Aircraft noise simulator

https://www.youtube.com/watch?v=m2uTFF_3MaA

Fig.7- Emitting of an harmonic sequence of sounds (melody)

• **Second combination:** A melody and an aircraft broad band noise were simultaneously emitted. The broad band noise was emitted by an aircraft noise simulator and the melody was with 10 dB louder than the broad band

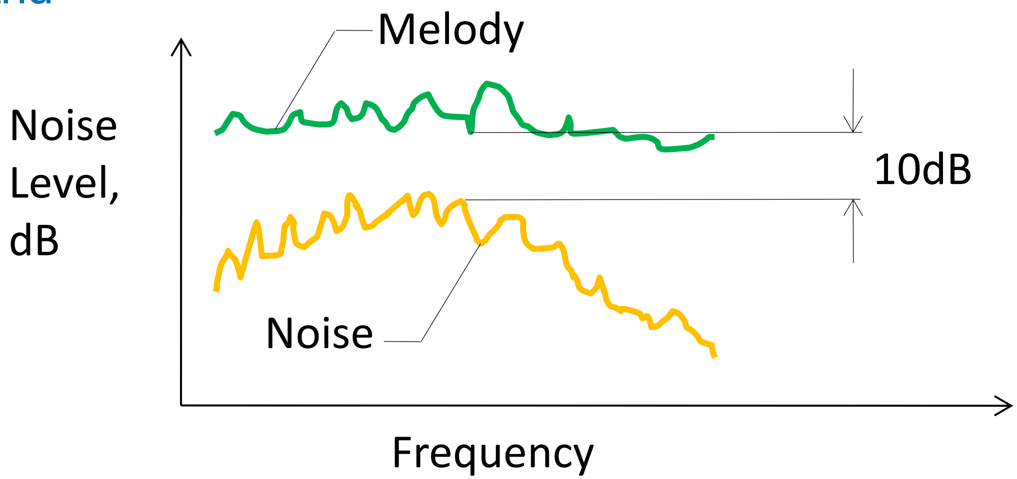


Fig.8- Scheme showing how emitting of a melody can mask the broad band noise

•Masking of broadband noise was observed →

•Using of <u>a melody superposed over the broadband noise</u> is a good direction for reduction of annoyance level

4. Experiments on annoyance done in COMOTI

▪**Images of experiments done in COMOTI-Computer + sonometer in a small anechoic room**

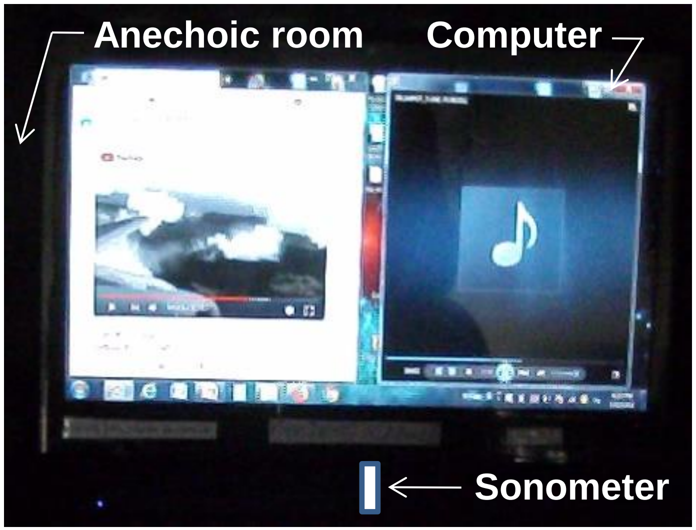


Fig.9- Emitting of masking melody (Trumpet _Tune-Purcell) by computer (69…74 dB)*

Fig.10- Emitting of aircraft noise by noise simulator (60…62 dB)*

Fig.11- Simultaneously emitting of aircraft noise (60…62 dB) and a melody (69…74 dB) leads to masking of broadband noise*

***Note: Available registrations will be presented during the Workshop**

5. The first technology proposed by COMOTI: Emitting of a masking sequence of sounds by aircraft (not recommended)

- **Emitting of a masking sequence of sounds by multiple loudspeakers placed on aircraft. This technology is not productive because:**
  - **- High power is necessary**
  - **- It is difficult to be accepted by the whole ground auditory**
  - **- It is difficult to be accepted by passengers**

Loudspeakers

Fig.12- Emitting of an harmonic sequence of sounds by aircraft

6. The second technology proposed by COMOTI: Using of sound machines or loudspeakers placed at ground level

Fig.13- Using of sound machines or loudspeakers around airports

6. The second technology proposed by COMOTI: Using of sound machines or loudspeakers placed at ground level

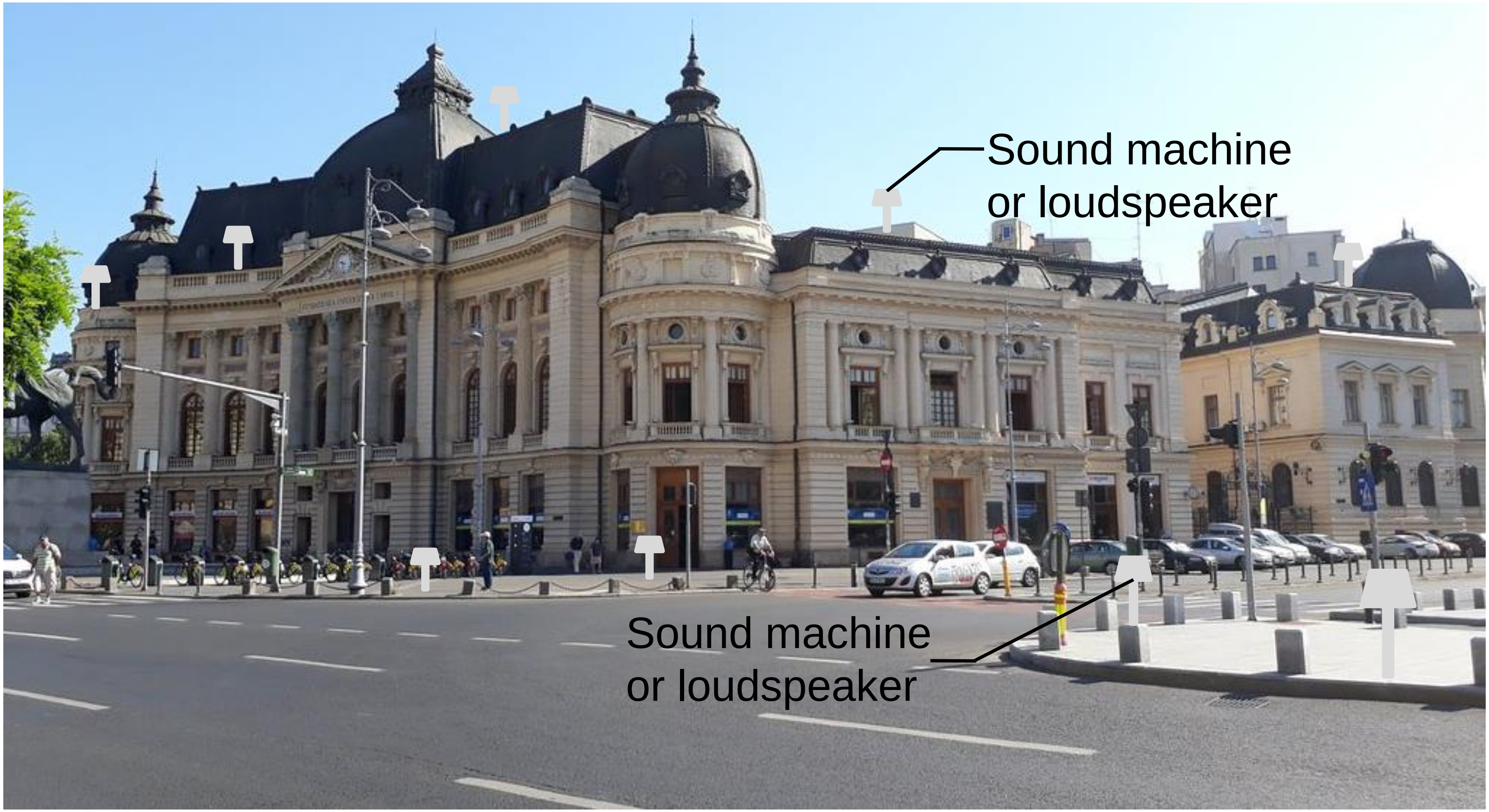


Fig.14- Sound machine placed in adequate points in city instead of first proposed technology (point 5)-<u>Analysis of auditory is needed for selection of musical sequence (melody)</u>

7. Possible evolution of city architecture for reduction of annoyance produced by aircraft noise[2]

- **Introduction of Airbus flying taxies will ask installing of landing platforms over buildings**
- **The multiple landing platforms will protect the community by the direct aircraft noise**

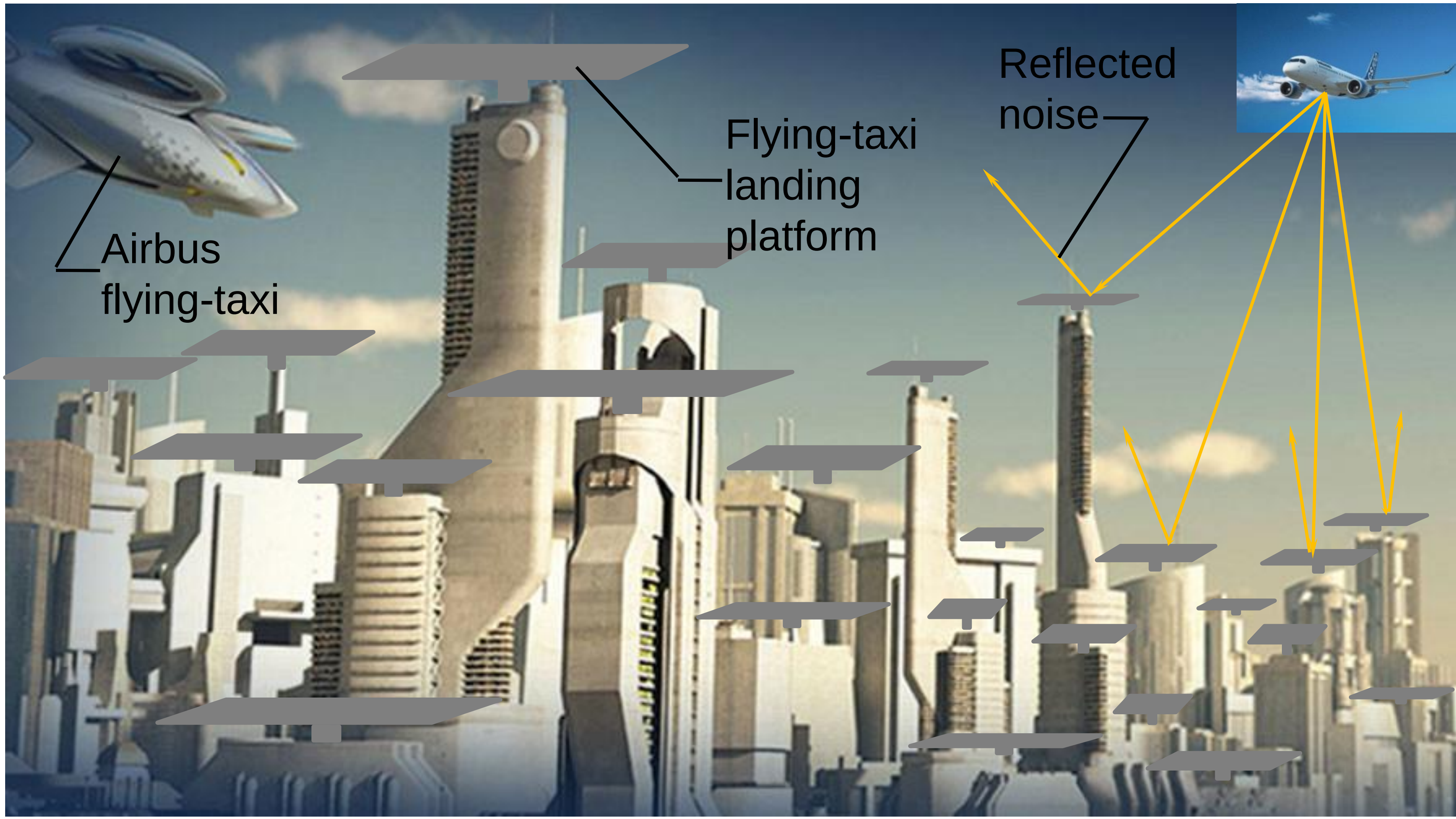


Fig.15- Airbus flying taxi service

2-http://www.cartavern.com/airbus-developing-autonomous-flying-taxi-service/

8. Conclusions

- **Masking is a good methodology for reduction of annoyance produced by aircraft. Two types of masking can be used:**
  - **-Type 1 of masking: Low volume sound can not be heard in the presence of a loud sound**
  - **-Type 2 of masking: It appears when two sound signals have similar frequency components**

- **Emitting of an harmonic sequence of sounds by multiple loudspeakers placed on aircraft seems is not productive technology**

- **Using of sound machines or loudspeakers in conjunction with analysis of auditory is a productive technology-It can be the objective of a future European Project**

- **Future evolution of city architecture could be connected to introduction of Airbus flying taxies → the multiple landing platforms used for flying taxis can act as a shield against noise produced by aircraft and by flying taxies**

Reference:

1- Nejc Rosenstein, Psyhoacoustics, Doctoral Thesis, 8.1.2014, Univerza v Liubliani, Fakulteta za matematiko I fiziko

2-http://www.cartavern.com/airbus-developing-autonomous-flying-taxi-service/