An Analysis of Select Weather Parameters and Aircraft Noise Levels in Dearborn Heights, Michigan

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Table of Contents

Abstract:

Noise pollution from an **aircraft** is an often-overlooked component of quality of life in urban and suburban areas. Understanding this is crucial when trying to minimize **health effects**. These health effects include high blood pressure, anxiety, inner ear degradation, and psychological stress (EPA 2023). Crestwood High School hosts many outdoor activities, such as cross country, track, soccer, baseball, football, etc. Crestwood High School is affected by noise pollution because it is an area airplanes visit many times daily en route to the airport for flights coming in. This research was conducted during the fall and winter seasons of 2023/24. Researchers used a **Sound Level meter** and various devices to measure aircraft noise in decibels over four months. Data on **air temperature**, noise pollution, **dew point**, **relative humidity**, and the **cloud cover**, was collected using **GLOBE protocols**. The environmental factors listed above were collected with the **Vernier Go Direct Weather.** The researchers took cloud observations and uploaded their data through the **GLOBE Cloud Observer app**. While further research on this topic is warranted, adjusting outdoor activities to coexist with periods minimal noise could reduce health risks associated with aircraft noise. One objective of this research is to find out when aircraft-caused noise pollution is at its peak so that its adverse effects on students participating in outdoor activities may be avoided or minimized.

Key Words: Noise pollution, Aircraft, Health Effects, Sound Level meter, GLOBE protocols, Dew Point, Relative Humidity, Cloud Cover, Vernier Go Direct Weather device, GLOBE Cloud Observer app

Research Questions

1. To what extent do airplanes cause noise levels in suburban areas?
2. What atmospheric factors possibly affect noise levels caused by airplanes?
3. What noise levels (in decibels) are produced by aircrafts in the process of descending to a local regional airport?

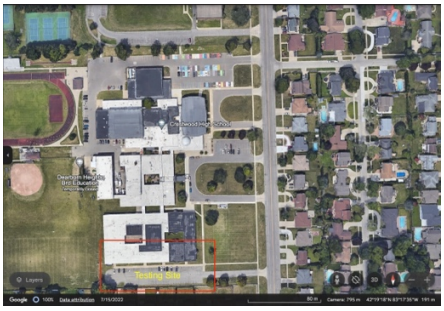
Null Hypotheses:

1. Air temperature and humidity have no correlation with noise pollution.
2. Cloud coverage has no effect on noise pollution.

Introduction and Review of Literature:

Noise pollution from landing aircraft has the potential to adversely affect the quality of life for many species, including humans. Noise pollution comes in multiple forms, including transport, industrial, and neighborhood noise. A Vernier Sound meter is used to measure the sound levels of the aircraft in the process of landing and wind speed. The sound levels were measured in decibels (dB); a normal sound level is 70 dB, and anything higher can create adverse effects on human health over time. Prolonged exposure to high noise levels can lead to "auditory system deterioration, hearing loss, sleep disturbance, cardiovascular disease, and diminished learning capacity" (Elliff et. al 11). Noise pollution not only has consequences for humans but also for the environment. As noise pollution continues to rise from industrial machinery, such as aircraft, harmful effects are seen globally on the environment through disruption of wildlife and decrease of biodiversity as "noise alters species richness, abundance, and community composition…" (Senzaki 1). In this study, student researchers collected data on aircraft noise, air temperature, barometric pressure, cloud coverage, dew point, and relative humidity. Upon this, students

examined the roles each played in aircraft noise pollution. Noise pollution seems to be particularly dependent on factors such as air temperature, dew point, and cloud coverage. Cloud coverage has been found to have a positive correlation with aircraft noise. Hence, as cloud coverage increases, so does the noise caused by aircraft. In specific, further cloud coverage leads to sound waves deflecting toward the ground, enhancing the receiver's ability to hear sound. On the other hand, air temperature has been found to have an inverse relationship with aircraft noise, as colder temperatures cause an increase in noise produced and heard by these aircraft. This research is essential to document sound levels students on the ground are exposed to meet ideal environmental factors and times, minimizing the risks to individual's health.



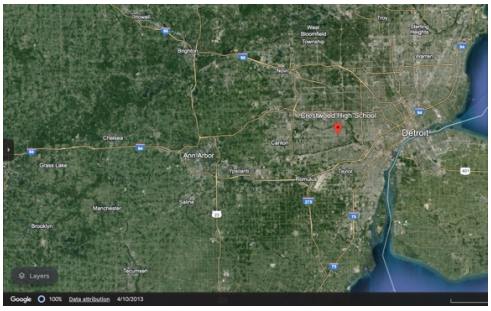


Figure 1 (left) and 2 (right). Site visualization. The image on the left shows Crestwood High School's teacher parking lot. The image on the right displays Crestwood High School (42.3221° N, 83.2932°W) on a larger scale map to provide an idea where the research site is located in. Southeastern Michigan.

Methodology:

Beginning in early November of 2023 and ending in late February 2024 the researchers collected 16 days of data. A Vernier Sound Level meter, Vernier Go Direct Weather meter, Flight Radar 24 app, and the GLOBE Observer app were used to collect data. The GLOBE Observer app was

essential for recording and achieving the site's cloud data. The Flight radar app was used to track when and where planes were arriving from and other factors such as plane type, barometric altitude, ground speed, wind speed, and direction. As a plane approached the testing site, a researcher used the Sound Level Meter to record the noise levels in decibels. This would be input into the datasheet for that day. At the same time, another researcher used the Vernier Go Direct Weather meter to measure the surface wind speed in m/s and to obtain the air temperature, dew point, relative humidity, barometric pressure, and wind direction. This information was then carefully recorded on a data form for that day. This was repeated until data collection for the days tested was done. An average of 5 planes were recorded each day from noon to 3 pm.

Figure 3 and 4. Vernier Sound level meter. Image to the left is an up-close picture of the Vernier Sound Level Meter that was used to measure noise levels. The image to the right shows a researcher using the Sound Level Meter.

Figures 5 and 6. Vernier Go Direct Weather device. The image on the left shows the Vernier Go Direct Weather Device that was used to measure the wind speed. The image on the right shows a researcher taking data using the device.

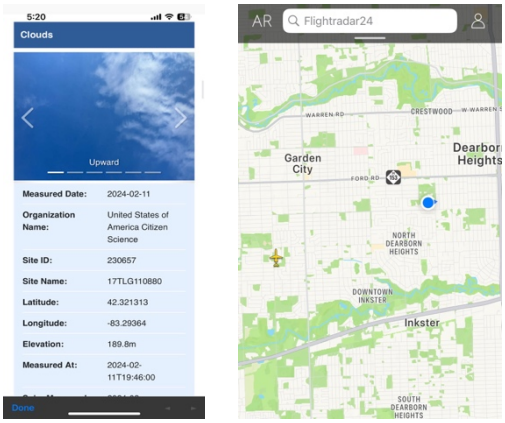


Figure 7 and 8. Apps used. The image to the left shows the GLOBE Cloud Observer app that was used to identify clouds, cloud cover, and upload the researchers data to GLOBE. The image to the right is a screenshot of the Flight Radar 24 app that was used to track airplanes near the test site.

Results:

While examining the results obtained from the Vernier Sound Level meter and the Vernier Go

Direct Weather device, discoveries were made. Air temperature, relative humidity, and the dew

point had an inverse relationship with the noise produced by the aircrafts. Temperature and relative humidity were the two factors that the researchers could visibly see had a relationship with noise pollution. This was due to other factors such as surface wind speed and barometric pressure being relatively consistent in Southeast Michigan.

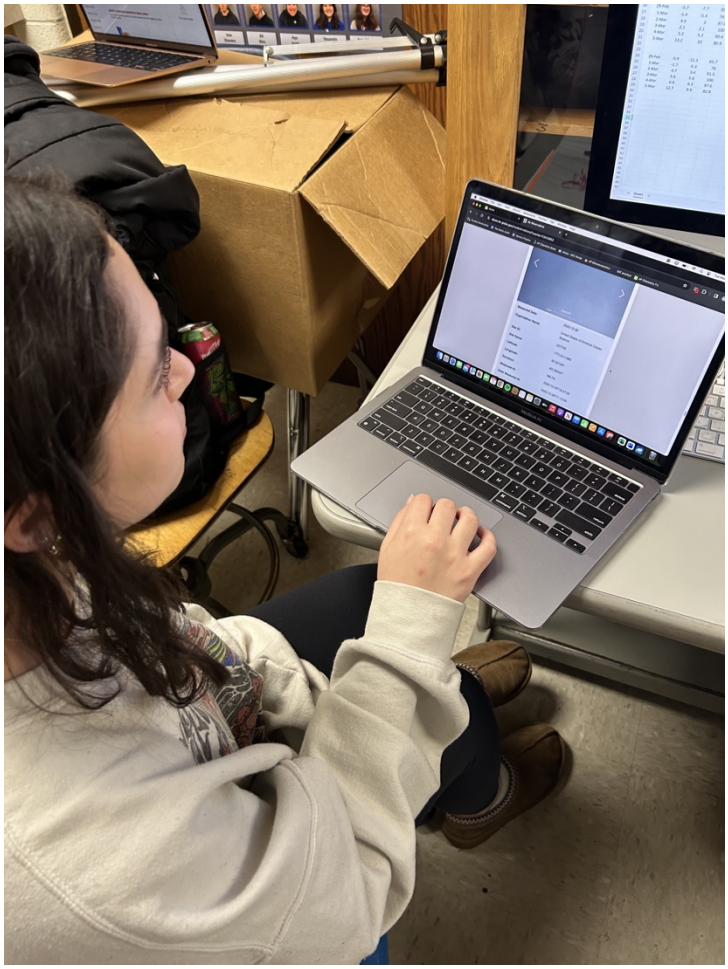


Figure 9. Data entry. This image shows a Dearborn Heights researcher inputting the data into the GLOBE Cloud Observer app.

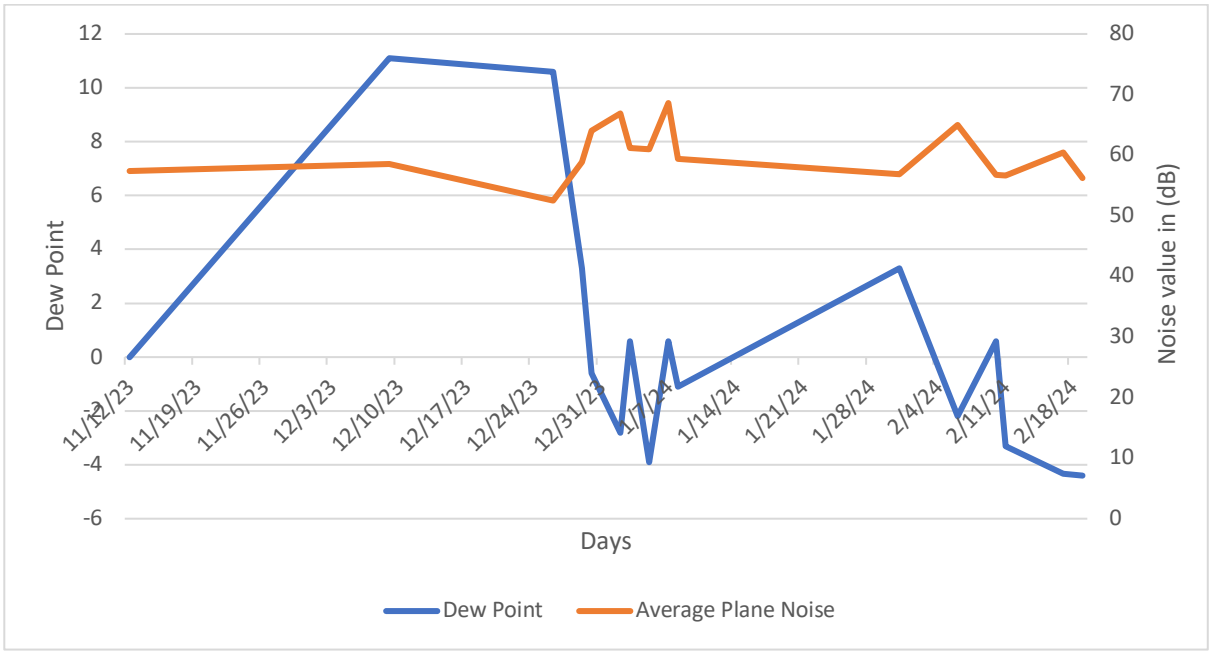


Figure 10. A comparison of dew point and average plane noise. The graph shows little correlation between dew point and the average plane noise collected during the collection period, demonstrating an inverse relationship.

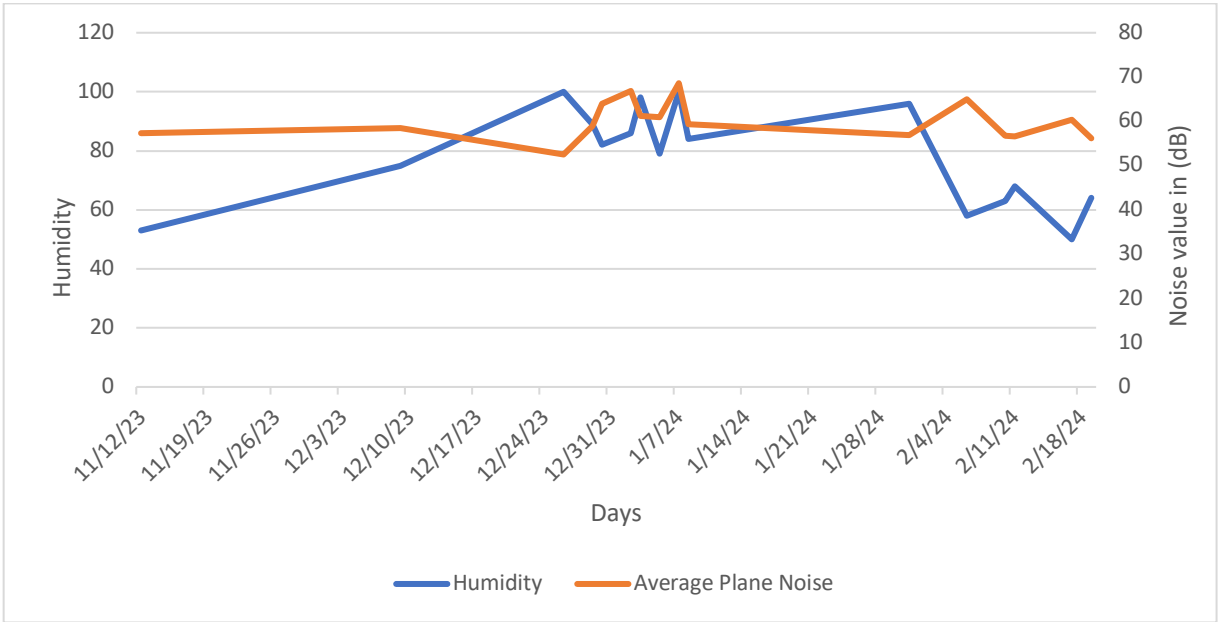


Figure 11. A comparison of relative humidity and average plane noise. The graph shows an inverse relationship between relative humidity and the average plane noise. When humidity is high the plane noise in decibels is lower than that on days with higher humidity.

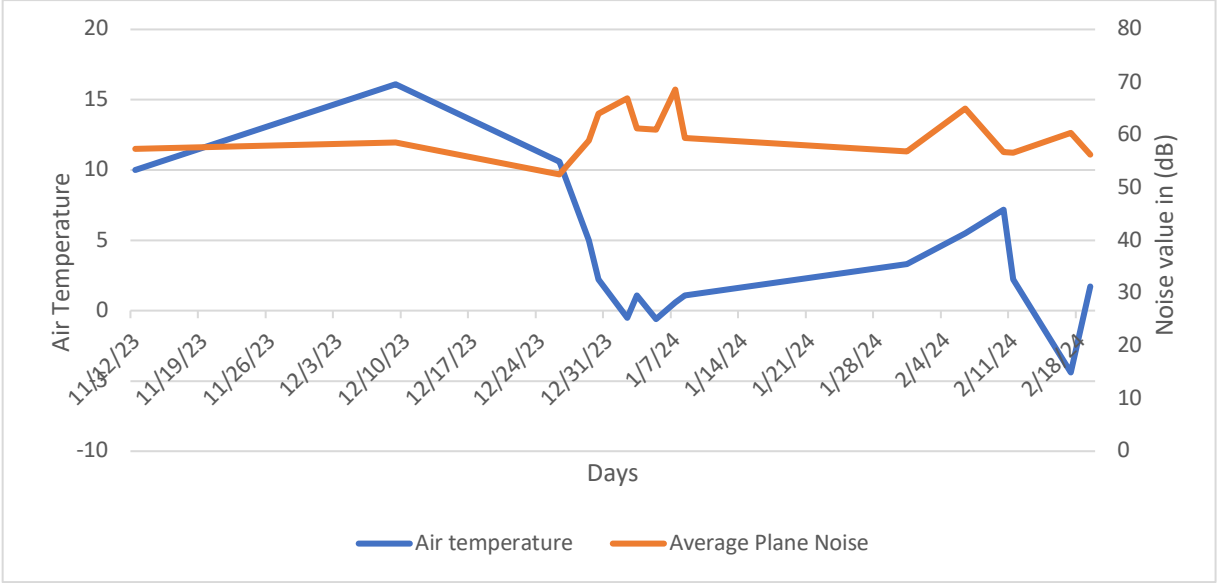


Figure 12. A comparison of air temperature and average plane noise. The graph shows a slight inverse relationship between air temperature and average plane noise collected during the collection period. When the temperature in degrees Celsius is high the plane noise is lower than that of days with lower temperatures**.**

Discussion:

The null hypothesis that cloud coverage does not affect noise pollution was accepted. The researchers found that when cloud coverage varied, there was no significant difference in aircraft noise levels measured in decibels. This was because not all aircraft were flying directly overhead the Sound Level meter, and most aircraft were flying into the Metro Detroit Airport and over the researchers' school from the northeast direction. Due to the aircraft flying slightly further than ideal when trying to observe the effect of cloud cover on aircraft noise, the researchers couldn't pick up on a relationship between cloud cover and aircraft noise in decibels.

The null hypothesis that air temperature and humidity have no correlation with noise pollution was rejected because the researchers found that air temperature and humidity are inversely related to aircraft noise. Air temperature and humidity influence airplane noise due to their impact on atmospheric absorption. Gases in the atmosphere, such as water vapor, carbon dioxide, and ozone, absorb frequencies. The degree of atmospheric absorption differs across different regions of the electromagnetic spectrum and is the presence of absorbing gases and particles in the atmosphere (NASA 1999). The degree of absorption also varies depending on humidity and temperature. When both humidity and temperature are high, the degree of atmospheric absorption is high, and the frequencies are lower. Dew point and relative humidity are directly related, meaning the dew point also affects the degree of atmospheric absorption. A result is the absorption of more of the sound waves and lowering the noise, in decibels, airplanes were producing (Oakland International Airport 2006). The relationship between air temperature, humidity, dewpoint, and atmospheric absorption underscores the significance of managing airplane noise with higher air temperature and humidity levels contributing to reduced aircraft noise levels, highlighting the importance of looking at weather variables when trying to manage aircraft noise efforts.

There are other factors that contribute to aircraft noise that the researchers couldn't account for. Barometric altitude was one of those factors. Barometric altitude is often difficult to test for accurately and safely. To test for barometric altitude, the researchers would have to point a laser at an aircraft in the sky to measure the distance between the ground and aircraft. Pointing a laser at an aircraft is a federal crime, ultimately preventing the researchers from looking more at barometric altitude. There is also the fact that there are various airlines, different types of

airplanes, and all come with different engine types and varying times of engine creation. Newer engines tend to have a sleeker design, emitting less noise than older engines.

The researchers noticed these relationships but proceeded to collect data as the weather got colder and humidity continued to fluctuate. However, while the researchers did all they could, perfect results are close to impossible to achieve. One possible source of error would be the direction the airplanes were coming in from. The researchers tested data from the same spot throughout the data collection process and the Sound Level meter could have picked up on airplanes flying directly overhead rather than in a different direction. In favor of the researcher's data, most of the aircrafts were flying in from the northeast direction, lessening the potential skew of the researchers results. Another possible source of error may be the cars passing by on the nearest road. While the researchers conducted research when the road was nearly empty, there were sometimes cars that would be passing by, potentially making the results the sound meter was producing greater than they should have been.

While perfect results remain elusive, the researchers did everything possible to eliminate possible sources of error. The researchers ensured they tested around the exact times per day, in the same area, and stayed in the same spot in that given area. The researchers made these decisions based on when outdoor activity was conducted and near where the outdoor activity was being conducted so the researchers could see the magnitude of the noise the students partaking in said activities were being exposed to.

Understanding how atmospheric conditions impact noise levels is crucial for lessening the impact of aircraft noise on communities so that it is possible to prevent health degradation in those communities.

Conclusion:

Using the Vernier Sound Level Meter, there was a notable difference between air temperature and humidity compared to sound produced by aircraft in decibels. The results indicated an inverse relationship between air temperature and humidity when compared with noise produced by aircraft. Hence, as noise levels produced by aircraft increase, air temperature decreases, implying that colder weather has a more significant impact making noise levels louder. However, there was also noted that barometric pressure and surface wind speed did not appear to influence the overall noise produced by aircraft. Some other factors researchers did not consider in this project included the type of engines within the aircraft, the altitude of the aircraft, and the type of airplane. Considering all these factors, it is possible that prolonged exposure to aircraft noise can be potentially unsafe depending on how long and how frequently one is exposed to the noise. Students attending the school near the study site should consider adjusting after-school activities to coincide with times when aircraft noise is minimal which could reduce possible health risks to students. Further research should be conducted to more fully understand the impact of aircraft noise on student health. This research could be improved by expanding our study period and taking data multiple times throughout the day rather than just one specific time.

Citations/Bibliography:

Aircraft Noise (Excerpt from the Oakland International Airport Master Plan Update -2006) Background. 2006, flyquietoak.com/wp-content/uploads/2022/04/aircraft_noise_fundamentals.pdf.

Elliff, Ted, et al. *Impact of Aircraft Noise Pollution on Residents of Large Cities STUDY Requested by the PETI Committee Policy Department for Citizens' Rights and Constitutional Affairs Directorate-General for Internal Policies PE 650.787-September 2020*. 2021, www.europarl.europa.eu/RegData/etudes/STUD/2020/650787/IPOL_STU(2020)650787_EN.pd

"Remote Sensing." *Earthobservatory.nasa.gov*, 17 Sept. 1999, earthobservatory.nasa.gov/features/RemoteSensing/remote_04.php.

Senzaki, Masayuki, et al. "Direct and Indirect Effects of Noise Pollution Alter Biological Communities in and near Noise-Exposed Environments." *Proceedings of the Royal Society B: Biological Sciences*, vol. 287, no. 1923, Mar. 2020, p. 20200176, https://doi.org/10.1098/rspb.2020.0176.

US EPA, OAR. "Clean Air Act Title IV - Noise Pollution." *Www.epa.gov*, 3 June 2015 www.epa.gov/clean-air-act-overview/clean-air-act-title-iv-noise-pollution#:~:text=Health%20Effects.

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Badges:

I am a Data Scientist:

The researchers hope to receive the "I am a data scientist" badge for their efforts in collecting and organizing data using the Vernier Sound Level Meter, Vernier Go Direct Weather device, and the Flight Radar 24 app. The researchers collected 16 days of data from the Crestwood High School teacher parking lot. All the data was carefully input into an Excel spreadsheet where the researchers were then able to create graphs. These graphs were then analyzed by the researchers to determine their relationships with one another. However, the researchers did find some

limitations to their research. One limitation being that the testing site is located next to a busy intersection. While the researchers tried to conduct research when the road was empty, there were sometimes cars passing by. This could have potentially skewed the results obtained from the sound meter making the noise recorded higher than it was.

I Make an Impact:

The researchers hope to receive the "I make an impact" badge as their research can be extremely beneficial to their school and community. This research can bring light to an issue that many may not think about. Many activities held at the school can lead to students and staff being exposed to high noise levels while outside. Students attending school activities near the testing site should be aware of high noise levels to protect them from the various potential health risks. After-school activities could be scheduled to take into account the times when noise produced by aircrafts is at maximum to help reduce health risks. This research can also be used to help other schools close to an airport or an area where loud aircraft noise is common.

I am a Stem Storyteller:

The researchers hope to receive the "I am a stem storyteller" badge for their efforts to spread the word about the negative effects of noise pollution. The 3 researchers created an Instagram page to help spread the word to their community about the negative health effects from noise pollution. The username to their account is @decibelsdetectives. The researchers hope that their account will help inform their fellow classmates of the possible health issues they may be

exposed to when in an area with high noise levels. They plan to use the account to also bring light to possible improvements to aircrafts to make them emit less noise.