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Aircraft noise emission management to improve sustainable airport environmental development

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Abstract

This article concludes that a holistic strategy, encompassing technological innovation, regulatory measures, operational procedures, community engagement, land use planning, infrastructure investment, and global collaboration, is necessary for sustainable airport environment development. By implementing the measures, airports can mitigate the environmental impact of aircraft noise while supporting the growth of the aviation industry in a socially responsible manner. As global air traffic continues to rise, the environmental impact of aircraft noise has become a significant concern for airports and surrounding communities. This abstract explores strategies for managing aircraft noise emissions to enhance the sustainability of airport environments. The focus is on a comprehensive and integrated approach that encompasses technological advancements, regulatory measures, community engagement, and strategic planning. The objective is to balance practice between managing aircraft noise effectively and improving overall airport efficiency. This integration is essential for sustainable aviation development in the face of growing air traffic demand.

Keywords: Aircraft Noise, Airport Operations, Sustainable Airport Environmental.

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Introduction

Aircraft noise has been one of the most important sources of excessive noise generated by airport operations. Sources of aircraft noise emission are the engines of an aircraft are jet engines or piston engines, and the aircraft structure (O'brien, 2006). As aircraft characteristic and performance, aircraft produces more noise during take-off or landing (Janić, 2011) airports are considered to be important contributors to the problem of excessive noise, and from a community's perspective, one of the most obvious environmental problems of airport activities is noise pollution (Thomas, 2011) Furthermore, ground access systems of vehicles in the airport landside area also noise generated and adds to the existing problem of excessive noise in airports operations.

Noise emission can be defined as any unwanted sound, cause profound negative effects on humans' health and their physical, psychological and social wellbeing and quality of life (Griefahn et al., 2004). The sustainable and environmental development concerns with the operation of airports such as noise issues, emissions, energy consumption, land use by airports and energy consumption.

Aircraft noise levels are significant environmental factor associated with airport operations. The noise generated by aircraft can impact both the immediate airport vicinity and the surrounding communities. Aircraft noise can disrupt the daily lives of people living near airports. Continuous exposure to high levels of noise can lead to annoyance, sleep disturbance, and adverse health effects. Furthermore, noise pollution can affect local wildlife and ecosystems, potentially disrupting habitats and migration patterns.

The various components of an aircraft contribute to the overall noise generated during its operations. The key components that produce noise such as aircraft powerplant main gear, nose gear, brake system and airframe system (Isermann and Bertsch 2019) The primary source of noise in aircraft is often the jet engines. High-speed exhaust gases, turbulence, and the mechanical components within the engine can generate significant noise during takeoff, climb, cruise, descent, and landing. Also, propeller engines in propeller-driven aircraft, noise can be generated by the rotation of the propellers and the combustion process in the engine (Bertsch et al. 2019) In addition, aircraft brake systems

such as main gear brake system. During the landing phase, the main gear brake system is engaged to slow down the aircraft. Friction between the brake pads and the landing gear components can produce noise, especially during heavy braking. Together with nose gear brake system, similar to the main gear, the nose gear brake system contributes to noise when braking actions are performed during landing.

Also, aerodynamic noise of the airframe, which included the wings, fuselage, and other surfaces, can produce noise due to aerodynamic interactions with the air during various flight phases. This can include noise generated by airflow over surfaces and turbulent air movements.

Other aircraft systems may be Auxiliary Power Unit (APU), which provides power to the aircraft when the main engines are not operating during aircraft parking on the ground, this can contribute to noise. Together with aircraft noise may be generated by hydraulic systems during certain aircraft maneuvers or operations.

On the other hand, airports congestion brings the need to manage airport environment more efficiently in order to increasing sustainability for aviation industry environmental management system. Regulatory frameworks, such as emissions trading schemes and environmental impacts assessments, may be used to encourage environmentally friendly employment practices. The environmental impact of increased air traffic is a growing concern, managing this impact involves adopting sustainable practices, such as investing in fuel-efficient aircraft, exploring alternative fuels, and implementing noise reduction measures.

The aviation industry concerned is to solve a balanced approach for maximizing the capacity of airports potentials for future growth with the accompanying negative environmental impacts of aviation industry by modernizing infrastructure, improving technology and optimizing air traffic management systems which can contribute to increased efficiency and capacity utilization (Jeeradist, 2023). Also, the consideration in establish time-based restrictions or curfews on certain noisy aircraft operations during sensitive hours to reduce noise exposure during nighttime and early morning hours. Together with the method of optimize ground operations, such as taxiing and engine testing, to minimize unnecessary noise emissions of aircraft on the ground at the airport.

Objective

The purpose of this academic article is to integrated aviation industry strategy and manage significant emission level of aircraft noise to improved sustainability airport environment. Together with airports congestion brings the need to manage airport environment more efficiently in order to increasing sustainability for aviation industry management.

Aircraft noise emissions and strategies to mitigate their environmental effects

The global nature of air travel, international cooperation is crucial. Coordination among countries, airlines, and regulatory bodies can help develop standardized practices and ensure a harmonized approach to managing air traffic and airport capacity. The environmental impact of increased air traffic is a growing concern. Managing this impact involves adopting sustainable practices, such as investing in fuel-efficient aircraft, exploring alternative fuels, and implementing noise reduction measures. Regulatory frameworks, such as emissions trading schemes and environmental impact assessments, may be used to encourage environmentally friendly practices.

Addressing the challenges associated with airport capacity and air traffic growth requires a multifaceted approach that involves collaboration among governments, regulatory bodies, airports, airlines, and the broader aviation industry (Jeeradist, 2023). Balancing economic interests with environmental sustainability is a key consideration in developing effective and responsible solutions. Absolutely, managing airport congestion and promoting sustainability in the aviation industry go hand in hand.

Here are some strategies and considerations for efficiently handling airport environments to enhance sustainability:

- 1) Infrastructure development and optimization by invest in modern, energy-efficient airport infrastructure to accommodate increasing passenger numbers without compromising environmental standards. Implement green building practices and technologies to reduce the carbon footprint of airport facilities.

2) Alternative energy sources by explore and adopt alternative energy sources to power airport operations. This can include solar, wind, or other renewable energy options to reduce dependence on traditional fossil fuels.

3) Electric Ground Support Equipment (GSE) by transitioning to electric GSE, such as electric baggage vehicles and aircraft tugs, can significantly reduce emissions on the ground.

4) Sustainable ground transportation by improve access to airports through sustainable ground transportation options, such as electric shuttles, public transportation, and cycling infrastructure.

5) Waste management and recycling by implement robust waste management and recycling programs to minimize the environmental impact of airport operations. This includes recycling waste generated by passengers and airport facilities.

6) Water conservation by implement water conservation measures, such as efficient irrigation systems and the use of recycled water, to reduce the airport's overall water consumption.

7) Noise reduction measures by implement noise reduction technologies and operational procedures to minimize the impact of airport activities on local communities.

8) Collaboration with airlines to promote the use of fuel-efficient and low-emission aircraft. Encourage the adoption of sustainable aviation fuels (SAFs) to reduce the carbon footprint of flights.

9) Set and work towards emission reduction targets for the entire airport ecosystem, including both direct and indirect emissions. This may involve participation in international initiatives like CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation).

10) Green certifications and standards by pursue and adhere to environmental certifications and standards, such as ISO 14001, to demonstrate a commitment to sustainable practices and continuous improvement in environmental performance.

11) Engage with local communities to address concerns related to environmental impact. This can involve regular communication, public forums, and collaboration on sustainable initiatives.

12) Invest in research and innovation to identify and implement new technologies and practices that further enhance the sustainability of airport operations.

Aviation industry technological and innovation trend to improve noise emission

With technological advances, modernizing infrastructure, improving technology, and optimizing air traffic management systems can contribute to increased efficiency and capacity utilization. In addition, aircraft landing detail and aircraft wheel configuration are effective parameters in noise production (Shafabakhsh et al. 2018) these components are more efficient in terms of reducing noise generation.

Also, it is observed that aircraft and engine manufacturers made significant improvements in noise in the production of new generation aircraft engines to prevent noise emission caused by aircraft. Especially in areas close to airports, people are disturbed by the noise generated by aircrafts during landing, takeoff and ground operations. It is observed that many of the existing airports in the world are mostly located near city centers and dense settlements (AIRBUS 2016).

In term of environment affects, how impacts of population experience aircraft noise.

The distance between aircraft flying over population density plays a role in how they perceive aircraft noise, and the noise abatement procedures are designed to keep the airplanes as high as possible, for as long as possible, without compromising the safety of passengers in the aircrafts or the communities below them.

In case of environmental factors, atmospheric or environmental conditions have a major impact on aircraft noise. The reverberation of sound waves caused by weather may actually make noises seem louder, or quieter, than they are. This is due to the physics behind how aircraft noise travels to our ears, and why aircraft flying at altitudes that normally produce no noise may seem louder. On a gusty day, aircraft noise is moved around in the air. More people hear it but it's not as intense because it's being redistributed to a wider area. Like wind, fog can absorb or reflect noise. This can either increase or decrease the perceived noise level. Including cloud coverage, depending on the thickness of a cloud, aircraft noise will bounce off the ground back up into the sky

and bounce off the cloud right back down. It won't be as intense the second time around, but it may amplify the original sound, depending on the cloud height.

Noise, like heat, is energy, and energy sources are drawn to each other. During the day, when the air is warmer than the ground, noise energy from an aircraft staying in the air, so while population experience still hears it, it seems quieter. Conversely, at night, when the ground is warmer than the air, the noise is drawn down, making it seem louder.

In term of topography, rich greenery absorbs sound, which means less of it gets to population experience ears. In the middle of a forest as an aircraft flew over, it would seem quieter. Direction of noise will bounce off hard surfaces, essentially amplifying it. This is also the case when an aircraft flies over water. Population is more sensitive to aircraft noise depending on what they're doing, and that has a lot to do with when the noise is being experienced. Most of the aircraft noise experienced by people on the ground is unavoidable. These noise levels can change from day to day based on the air traffic at the airport or the weather-dictated operation planes are following (Pearson, 2023).

Enhancing sustainability airport noise emission improvement

The managing of airport noise improvement and enhancing sustainability in aviation industry are interconnected goals. The specific strategies that can help increase the efficiency and sustainability of airport environments are as follow.

1) Optimized airport design by plan and design airports with sustainability in mind, incorporating energy-efficient buildings, green spaces, and environmentally friendly infrastructure.

2) Implement smart technologies to optimize the use of resources. This includes using sensor networks for efficient lighting, heating, and cooling systems, as well as advanced data analytics for operational efficiency. Electric Ground Support Equipment (GSE) utilize with transition to electric-powered ground support equipment, such as baggage tugs and passenger buses.

3) Encourage and support sustainable transportation options to and from the airport, such as electric shuttles, public transit, and cycling infrastructure. This reduces air

and noise pollution on the ground measures by integrate noise reduction technologies and procedures to minimize the impact of airport activities on nearby communities.

4) Flight Planning with preferential runway use and optimized flight paths together with engage local communities to understand their concerns and incorporate feedback into sustainability initiatives. This can foster a positive relationship between the airport and the community.

5) Continuous monitoring and improvement by regularly monitor environmental performance and seek continuous improvement. This involves conducting regular environmental assessments and audits to identify areas for enhancement.

By adopting these strategies, airports can contribute to the overall sustainability of the aviation industry while effectively managing congestion and ensuring a positive impact on the environment and surrounding communities.

Discussion and Conclusion

To promote the improve sustainable airport environmental development. This study investigates noise environmental impact, noise emission of aircraft by implement comprehensive noise monitoring systems to track and analyze aircraft noise levels. This information can be used to assess the effectiveness of noise reduction measures.

In concerned with regulatory frameworks, noise regulations are adhered to and enforce noise regulations set by aviation authorities. These regulations often include noise certification standards for aircraft and guidelines for noise management at airports. The operational procedures implement noise abatement operational procedures, such as preferential runway use and optimized departure and arrival routes, to minimize the impact of aircraft noise on surrounding communities. Regulatory bodies work with local authorities to establish zoning regulations that control land use around airports. Zoning may restrict certain developments in areas prone to high levels of aircraft noise.

Aircraft are categorized based on their noise levels, usually expressed in terms of Effective Perceived Noise Level (EPNL) or other standardized metrics. These categories help regulators and airports classify aircraft according to their noise impact. International Civil Aviation Organization (ICAO) sets global standards for aircraft noise certification

through Annex 16 to the Convention on International Civil Aviation. These standards are adopted by many countries worldwide (ICAO Annex 16).

Technology advancements by encourage the use of quieter aircraft technologies. Modern aircraft are often designed with noise reduction features, including quieter engines and aerodynamic improvements. Also, implement comprehensive noise monitoring systems to track and analyze aircraft noise levels (Shafabakhsh et al. 2018). This information can be used to assess the effectiveness of noise reduction measures.

In order to community outreach by considered engage with local communities to raise awareness about aircraft noise, share information about ongoing noise reduction efforts, and address concerns. Involve local communities in the development and review of airport noise management plans. This can foster collaboration and help address specific concerns. Airports are often required to create noise contour maps, indicating the areas around the airport with varying levels of noise exposure. These maps can influence land use planning decisions.

Addressing aircraft noise emissions requires a combination of technological advancements, operational adjustments, and community engagement. As the aviation industry evolves, ongoing efforts to minimize the environmental impact of aircraft noise remain a crucial aspect of sustainable airport management.

In conclusion, a holistic and collaborative approach that combines technological innovation, regulatory measures, operational adjustments, community engagement, land use planning, infrastructure investment, and global cooperation is necessary to achieve sustainable airport operations and minimize the environmental impact of aircraft noise. By addressing these aspects comprehensively, airports can contribute to both the aviation industry's growth and the well-being of surrounding communities.

Suggestion

Improving sustainable airport operations by managing aircraft noise emissions requires a multi-faceted approach. Here are some specific suggestions for aircraft noise emission management to enhance the sustainability of airports:

Invest in Quieter Aircraft Technology by encourage and incentivize airlines to invest in and operate aircraft equipped with quieter engine technologies and collaborate with aircraft manufacturers to support the development and adoption of next-generation, low-noise propulsion systems.

Implement Noise-Based Landing Fees by introduce landing fees that are based on the noise level produced during aircraft operations. Higher fees for noisier aircraft can incentivize airlines to upgrade their fleets to quieter models.

Promote Continuous Descent Approaches by encourage the implementation of Continuous Descent Approaches (CDAs) during aircraft landings, which reduce noise by allowing planes to descend gradually instead of using a series of level segments.

Optimize Flight Paths and Procedures to work with aviation authorities to optimize flight paths and procedures to minimize noise impact on residential areas. And implement precision navigation technologies to allow for more predictable and controlled flight paths.

Deploy Noise Barriers and Landscaping by install physical noise barriers and utilize landscaping strategies to create natural sound buffers between airports and neighboring communities. Develop green spaces and vegetation that act as effective noise absorbers and provide aesthetic benefits.

Establish Community Noise Monitoring Programs by implement community noise monitoring programs to actively involve residents in reporting noise concerns. Use data from these programs to identify specific noise hotspots and tailor mitigation strategies accordingly.

Engage in Collaborative Planning with foster collaboration between airport authorities, airlines, local governments, and community representatives in the planning process. Establish advisory committees to ensure that community concerns are considered in decision-making related to airport expansion or operational changes.

Implement Time-of-Day Restrictions by introduce restrictions on the operation of noisier aircraft during specific hours, especially during nighttime, to minimize the impact on sleep and overall well-being of residents.

Encourage Sustainable Aviation Practices by promote the use of sustainable aviation fuels (SAFs) to reduce the overall environmental impact of aviation, including noise emissions. Explore and support research into alternative, quieter propulsion technologies, such as electric or hydrogen-powered aircraft.

Educate and Raise Awareness by conduct educational campaigns to increase public awareness about the efforts being made to manage aircraft noise. Provide information on the importance of sustainable aviation practices and the role communities can play in supporting noise reduction initiatives.

Utilize Technology for Noise Modeling by leverage advanced noise modeling technologies to predict and assess the potential impact of airport operations. Use these models to proactively plan and implement noise mitigation measures.

Regularly Review and Update Noise Abatement Policies by periodically review and update noise abatement policies to incorporate the latest technologies and best practices. Ensure that policies remain aligned with evolving aviation industry standards and environmental goals.

By implementing these suggestions, airports can work towards creating a balance between economic growth and environmental sustainability, ensuring that noise emissions are effectively managed for the benefit of both the aviation industry and the surrounding communities.

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