Identification and Analysis of Constraints for Urban Air Mobility Transportation Systems

Master‘s Thesis of David Schmidt

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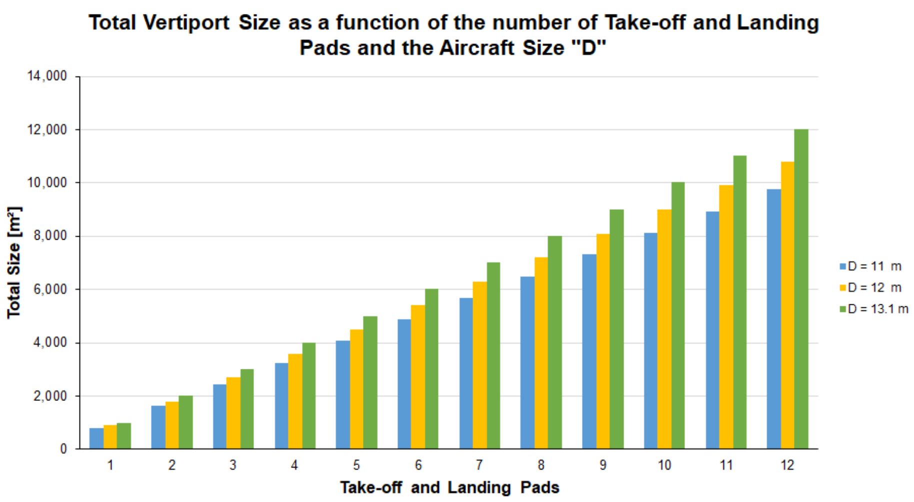

Figure 1: Vertiports sizes as a function of the number of take-off and landing pads and three aircraft sizes: 11 m, 12 m and 13.1 m

The rapid population growth is a huge problem for existing transportation systems. The increasing demand for transportation will soon overburden the street networks. Urban Air Mobility (UAM) is an opportunity to relieve the streets from the rising number of vehicles, by utilizing eVTOL (electric Vertical Take-off and Landing) aircraft, which operate over congested highways. However, the implementation of a UAM transport system in cities is currently a huge challenge for transport planners since recommendations for the effective implementation are not available. The goal of this thesis was to provide transport planners with recommendations for how to successfully implement a UAM system. The first step was to identify and evaluate the most critical UAM-related constraints. Based on the constraint analysis, UAM implementation guidelines were developed to support transport planners effectively design a UAM system. In the final step, these guidelines were used to demonstrate the UAM implementation in two case study areas (San Francisco and Melbourne) and recommendations for transport planners were provided.

The constraint analysis revealed three critical UAM-related constraints: aircraft operations, aircraft choice and the design of the UAM infrastructure. Aircraft operations and specifically, the community noise exposure due to UAM aircraft was identified as the most significant challenge and was therefore an important part of this thesis. The Community Noise Equivalent Level (CNEL) was used to estimate the noise exposure level for the community averaged over 24 hours. Based on the information, such as requirements and calculations from the three investigated constraints, the UAM implementation guidelines were developed. Using the information from the guidelines, the implementation process of a UAM system in two case study areas was demonstrated. The implementation process was based on four scenarios, two for each case study area, to generate different implementation alternatives for transport planners. The final step was to conduct two trade-off analyses, which focused on the relationship between the CNEL, passenger volumes and land use required for the take-off and landing site. In the first trade-off analyses, a strict CNEL limit and a low passenger demand were assessed. The second one focused on high passenger volumes in the future and resulting increase of the take-off and landing site.

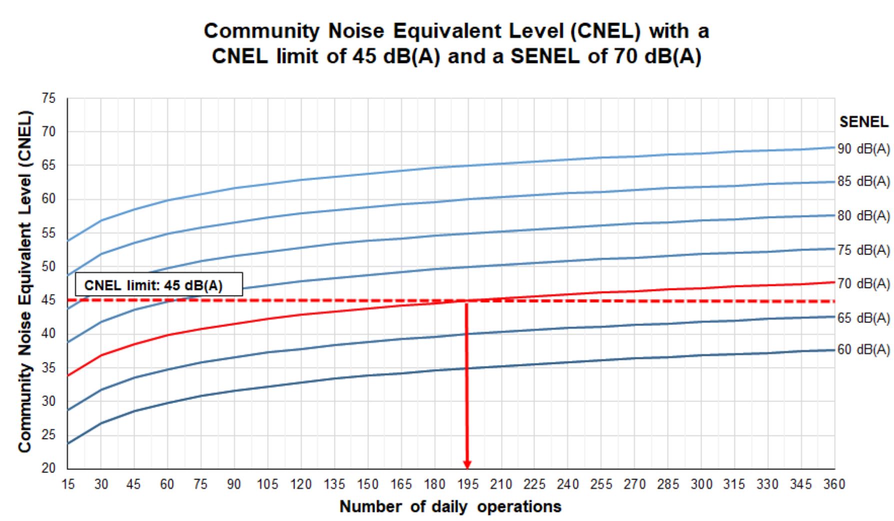

Figure 2: CNEL Limit: 45 dB(A) and SENEL: 70 dB(A)

Based on the two trade-off analyses, recommendations for transport planners for the most effective implementation were provided: For high-density urban areas, a CNEL limit of 50 dB(A) is recommended. This ensures that a high number of daily UAM operations with an aircraft noise level (abbreviated as SENEL = Single Event Noise Exposure Level) of 70 dB(A) can be achieved possible (Figure 3). According to Figure 2, a CNEL limit of 45 dB(A) and an aircraft SENEL of 70 dB(A) is not recommended because the total number of daily UAM operations would be reduced to 195. Ultimately, this would result in a decline of passenger volumes. The results from the second trade-off analysis revealed that the required vertiport size increases with rising passenger volumes and by utilizing larger aircraft (Figure 1). It is recommended to choose the smallest possible aircraft to reduce the required plot size of the vertiport while simultaneously achieving high passenger volumes. For high-density urban areas, a maximum of four take-off and landing pads is recommended to reduce the land use and ultimately, to promote the community acceptance of the UAM system.

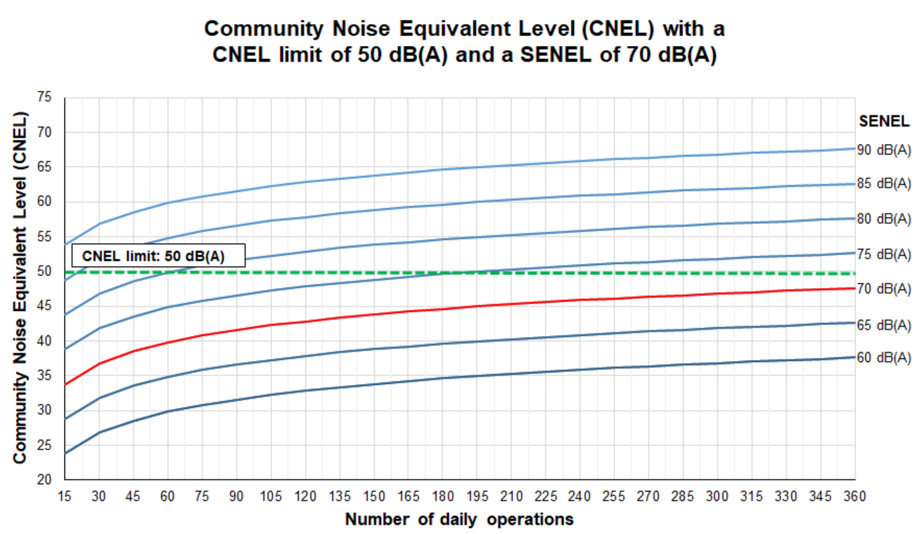

Figure 3: CNEL Limit: 50 dB(A) and SENEL: 70 dB(A)