Extended Abstract: Using Evolutionary Algorithms for eVTOL Design Optimization based on Multi-agent Simulations

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When investigating Urban Air Mobility (UAM) from a fleet operator's perspective, one interesting question is how to find the vehicle specifications that best suit a specific market and its requirements. The UAM vehicle design will influence the efficiency of the offered service and, therefore, will determine the operator's profitability depending on the demand profile. Consequently, it is mandatory to know the transportation demand early on and adapt the UAM vehicle characteristics, e.g., the number of passengers or range.

We present a framework to close the gap by finding optimal UAM specifications based on large-scale traffic simulations. We show how to derive optimal design specifications of electric vertical take-off and landing vehicles (eVTOLs) by utilizing a Genetic Algorithm (GA) in combination with the Multi-Agent Traffic Simulation (MATSim) [1], including UAM services [2]. Similar approaches with different optimization and demand predictions have been proposed to address problems related to the design of eVTOL vehicles [3, 4].

Our framework aims to derive an optimal specification for UAM vehicles based on regionally specific traffic patterns. This task is divided into several steps. First, during an initialization step, a design space is generated based on publicly available eVTOL design data sets [1] that are post-processed to derive upper and lower bounds for the vehicle specifications speed, range, cruise height, and passenger capacity. Then, the UAM vertiport network and vertiport processing characteristics have to be decided on, and the vehicle specification is required to prepare the UAM system. The network is generated by clustering the agents' home locations into a specific number. Then the center of the agents' homes in each cluster is chosen for a vertiport position. For this study we investigated a network with 5 vertiports (Fig. 1 (a)) for the region of Corsica. A description of how such scenarios are derived can be found in [5] and the model itself and the extension are publicly available [2]. The simulation of Corsica consists of 1.1×10^4 individual trips.

The effect of the vehicle design on the operational performance is directly apparent from Fig. 1 (b). The specifications vary strongly, whereas the best design shows, e.g., a minimal capacity and cruise height, and the poorest individual display larger values. The cruise speed and range do not vary between the best and the poorest individual. It indicates a smaller vehicle capacity suits the demand profile of the investigated scenario better.

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[1] https://evtol.news/aircraft
[2] https://github.com/BauhausLuftfahrt/MATSim-UAM

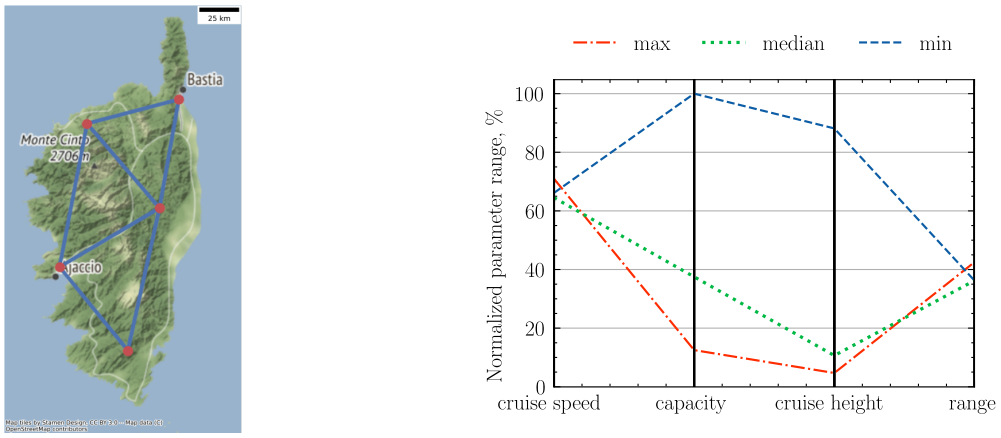

Figure 1: (a) Showing the UAM network with 5 vertiports for the Corsica region. (b) Showing for each network size the max, median and min set of vehicle parameters from all explored solutions. The corresponding normalized parameter ranges in %, are for cruise speed $0 - 600\,\mathrm{km/h}$, capacity $1 - 8\,\mathrm{PAX}$, cruise height $0 - 10\,\mathrm{km}$ and range $0 - 1000\,\mathrm{km}$.

This shall give a first idea of how an integrated framework consisting of a multi-agent traffic simulation, open eVTOL design databases, and an operational profit scheme can be used for identifying optimal vehicle concepts for Urban Air Mobility (UAM) specifications. The quality of the optimal specifications depends strongly on the accuracy of the implemented traffic simulation, which is challenging for new traffic modes as UAM and the quality of the profit parameterization. With the increasing availability of operational and vehicle specification data, the quality of the framework will increase further. Thanks to the generic character of the proposed methodology, it can be considered a universal approach for determining the optimal configurations of different products and services based on simulations of large-scale systems for addressing the needs of specific markets.

References

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