Restructuring of the Urban Airspace for the Implementation of Urban Air Mobility

Bachelor's Thesis of Eray Özal

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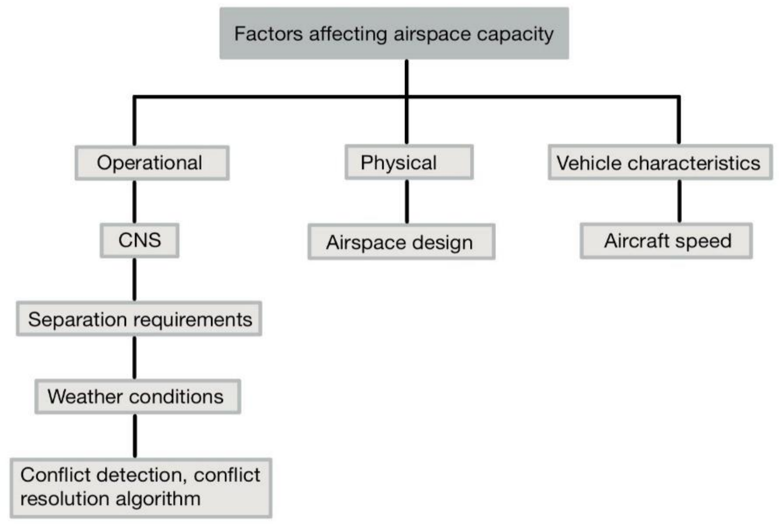


Factors affecting airspace capacity can be divided into operational, physical, and vehicle related factors.

Operational factors: CNS infrastructure must be highly reliable to enable high density UAM operations, as flight responsibilities will be predominantly delegated to the individual aircraft. The capacity of airspace decreases with increasing separation requirements. Weather conditions can impact all flight operations. In UAM this impact is exacerbated by the smaller size and lighter weight of the vehicles, as well as lower operating altitudes. Finally, conflict detection and conflict resolution will be performed by the involved aircraft (=decentralized).

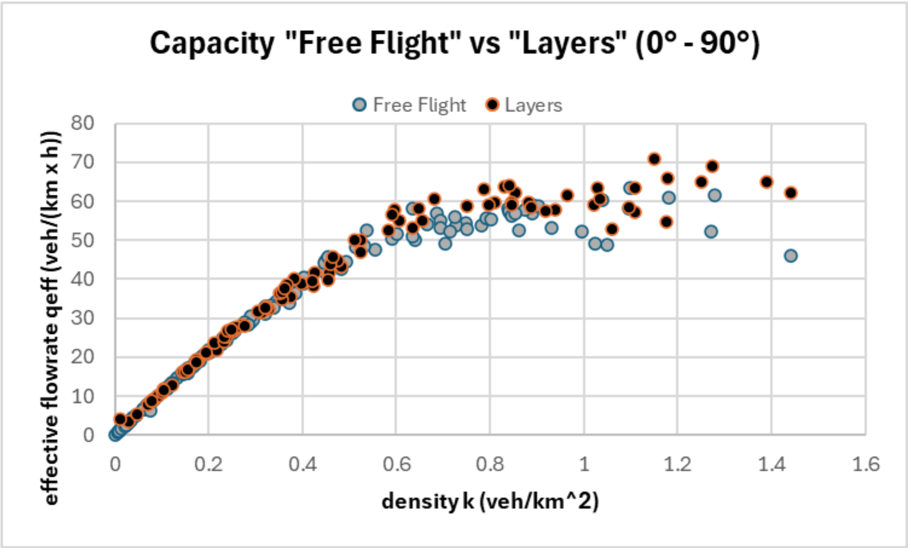
Physical factors: Four proposed airspace designs were reviewed. The “Free Flight”, “Layers”, “Zones”, and “Tubes” model. The first two were identified as having the highest maximum capacity and were chosen for a deeper review.

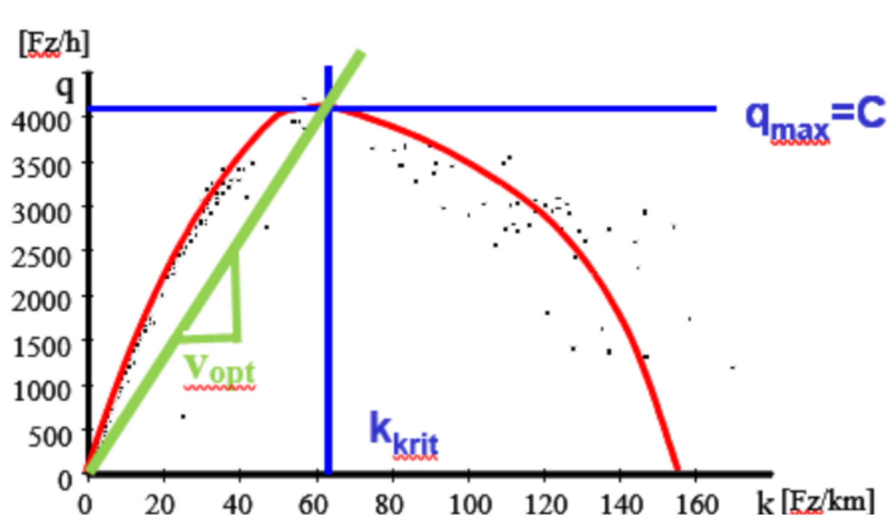
Vehicle characteristics: Lower aircraft speeds effectuate higher critical densities. Therefore, operators should consider lowering aircraft speeds in high density situations.

Simulation environment: The “Free Flight” and “Layers” designs were analyzed in the TUDelft BlueSky simulator regarding their capacity. The simulation environment was circular shaped and composed of 24 vertiports, of which 16 were positioned on the edge of the circle and 8 within the circle.

Capacity of designs: In the figure on the right a graphical comparison of the “Free Flight” and 0° - 90° “Layers” Layer is depicted. The “Layers” design performed better then the “Free Flight” design in maximizing airspace capacity, by better minimizing conflict numbers. This finding is coherent with reviewed literature.

Separation requirements & aircraft speeds: Reducing separation requirements from 0.3 nm to 0.1 nm increases airspace capacity by more than 100 %. Regarding aircraft speeds, operator should consider lowering speeds in high density situations to enhance network stability.





Connection between road network and air network capacity: Road networks and air networks behave similarly, as can be implied by the resemblance of their fundamental diagrams (diagram of autobahn observations on the left). The capacity increases until the point of critical density. If the critical density is surpassed, capacity starts to decline. Calculations of the optimal speed (slope of the green line) for the critical density imply that aircraft move faster than cars at that density.

Conclusion: It can be stated that air networks and road networks, more specifically highways or autobahns, behave similarly regarding capacity. It must be noted that the “Layers” and “Free Flight” concepts are less akin to a road network, in terms of the structure, then a “Tubes” network.

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