Traffic Management Challenges in Advanced Air Mobility

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The emerging demand for Advanced Air Mobility is expected to pose new challenges that cannot be addressed by existing air traffic management approaches. Key among these challenges are the large number of operations, the increased levels of competition, and the dynamic nature of the demand. In this talk, we discuss how protocol-based approaches can be used to balance efficiency (both operational and economic) and fairness, in a scalable manner with limited information-sharing.

Key Words : Advanced Air Mobility (AAM), Congestion, Traffic Management, Efficiency, Fairness

Advanced Air Mobility (AAM) operations – characterized by electric and hybrid aircraft, and short-range and highly automated operations – are expected to transform the way that people and goods are transported.[7] Recent market analyses suggest that the scale of AAM operations will far exceed that of conventional aviation operations.[1,2,4] The emergence of AAM demand has necessitated the development of new concepts of operations (ConOps) for UAS Traffic Management (UTM) and more pertinently, Urban Air Mobility (UAM).[5,6] It is generally expected that the scale and density of UAM operations will be such that traditional air traffic management (ATM) paradigms will no longer be sufficient. A further change from current operations is that the traditional Air Navigation Service Providers (ANSPs) will no longer be responsible for managing AAM traffic; for example, it is expected that (private) Provider of Services for UAM (PSUs) will be responsible for managing UAM traffic.[6] AAM operations are also likely to support on-demand applications in highly-competitive environments, as a result of which fleet operators may be unable or unwilling to share flight plans far in advance for planning purposes.

Motivated by the above challenges, this talk will discuss some of our recent work on developing distributed, protocol-based (i.e., "rules-of-the-road") approaches to airspace congestion management.[3,8] Our underlying protocol centers on the construction of priority queues to determine access to each congested volume of airspace. We leverage the concepts of backpressure (a measure of queue build-up) and cycle detection (vehicles that block each other from proceeding) to promote efficiency, and present several flight- and operator-level prioritization schemes. We also extend our protocol to accommodate varying delay costs for flights. Using realistic simulation scenarios of random origin-destination missions, cross-flow traffic patterns, and simulated hub-based package delivery operations, we evaluate our protocols in terms of their efficiency (both operational and economic) and fairness.

References

1) K. Balakrishnan, J. Polastre, J. Mooberry, R. Golding, and P. Sachs. Blueprint for the Sky: The roadmap for the safe integration of autonomous aircraft. Technical report, Airbus UTM, 2018.

2) Booz Allen Hamilton. Urban Air Mobility (UAM) Market Survey. Technical report, NASA, November 2018. https://ntrs.nasa.gov/citations/20190001472.

3) Christopher Chin, Karthik Gopalakrishnan, Hamsa Balakrishnan, Maxim Egorov, and Antony Evans. Protocol-based Congestion Management for Advanced Air Mobility. In *USA/Europe ATM R&D Seminar*, 2021.

4) Crown Consulting. Urban Air Mobility (UAM) Market Survey. Technical report, NASA, November 2018. https://ntrs.nasa.gov/citations/20190002046.

5) FAA and NASA. UTM ConOps v2.0. Technical report, NASA, 2020.

6) Federal Aviation Administration. Urban Air Mobility: Concept of Operations v1.0. Technical report, FAA, 2020.

7) National Academies of Sciences, Engineering, and Medicine. *Advancing Aerial Mobility: A National Blueprint*. The National Academies Press, Washington, DC, 2020.

8) Victor Qin and Hamsa Balakrishnan. Cost-Aware Congestion Management Protocols for Advanced Air Mobility. In *International Conference on Research in Air Transportation*, 2022.