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Long-term Application Potential of Urban Air Mobility Complementing Public Transport: An Upper Bavaria Example

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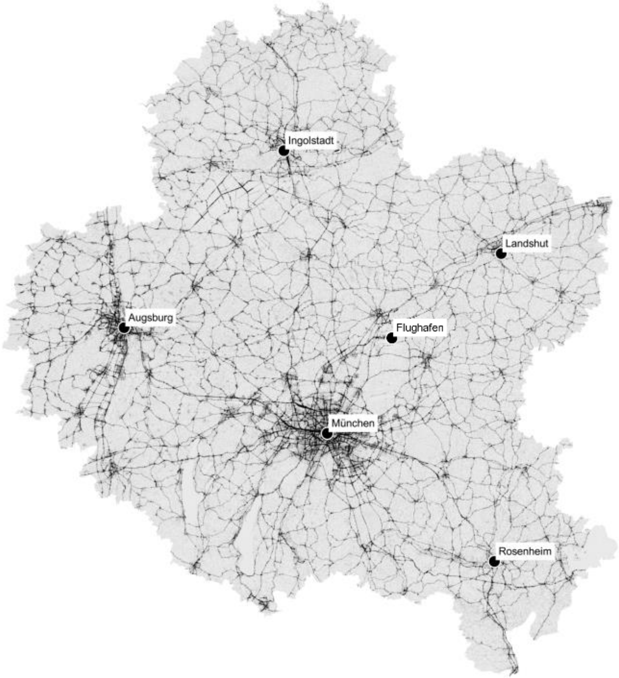
Motivation

- Urban Air Mobility is an initiative for sustainable urban mobility within the framework of the EU Innovation Partnership on Cities & Communities[1] since 2017
- Since June 2018, the City of Ingolstadt is one of the pioneering cities that Urban Air Mobility wants to establish as part of the existing transport system[2]
- Munich has the 2nd largest loss of time due to traffic jams in Germany of approx. 140h per year and driver[3]
- Constitutional goal of equal living and working conditions in the city and in the countryside throughout Bavaria



[1]https://eu-smartcities.eu/initiatives/840/description
[2]https://www.ingolstadt.de/uam
[3]http://inrix.com/press-releases/scorecard-2018-de/

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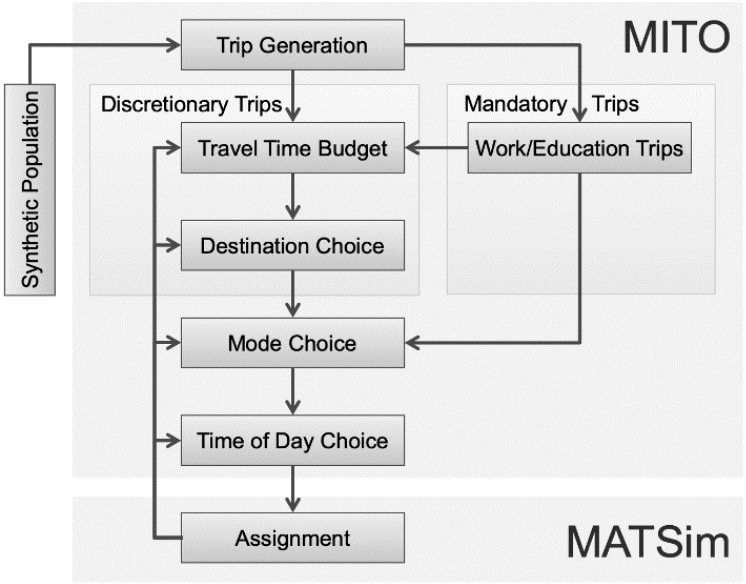
Introduction to Simulation Methodology[1,2]

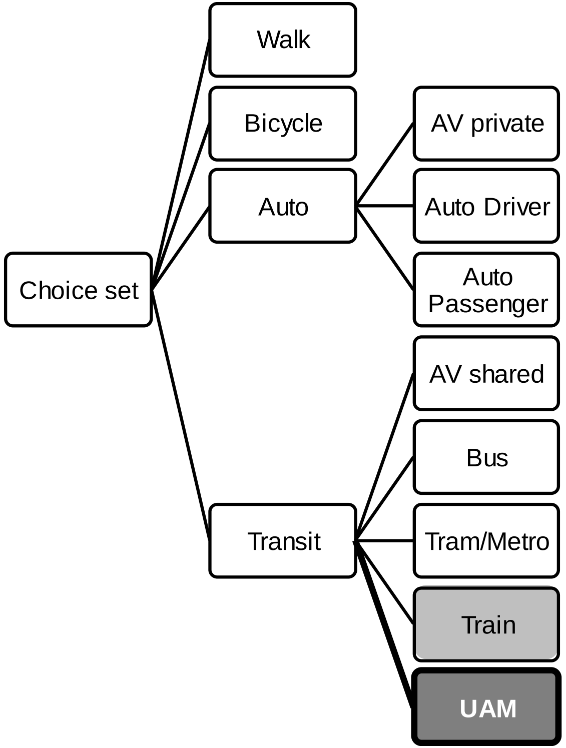
- Creation of a representative, synthetic population based on microcensus data (Mobilität in Deutschland)
- Identification of mobility needs based on travel purposes, e.g. commuting, leisure, shopping, education and destination per household
- Determination of the individual means of transport, the necessary departure and arrival times, including feedback loops e.g. due to congestion



[1]Moreno, A.T., Moeckel, R. (2018) Population Synthesis Handling Three Geographical Resolutions. ISPRS Int. J. Geo-Inf. 2018, 7(5), 174
[2]Moeckel, R., Kühnel, N., Llorca, C., Moreno, A. T., & Rayaprolu, H. (2019). Microscopic Travel Demand Modeling: Using the Agility of Agent-Based Modeling Without the Complexity of Activity-Based Models. Paper presented at the Annual Meeting of the Transportation Research Board, Washington, D.C.

Developed, Specific Mode Choice Models

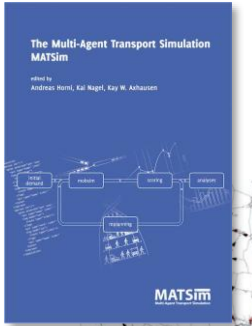
- Mode choice model based on microcensus data (Mobilität in Deutschland)
- Incremental addition of Urban Air Mobility to the public transport choice set of based on an online user survey in the Munich metropolitan area[1]
- Additional mode choice model incl. UAM for airport passengers[2]
- Additional UAM-specific access and egress mode choice model

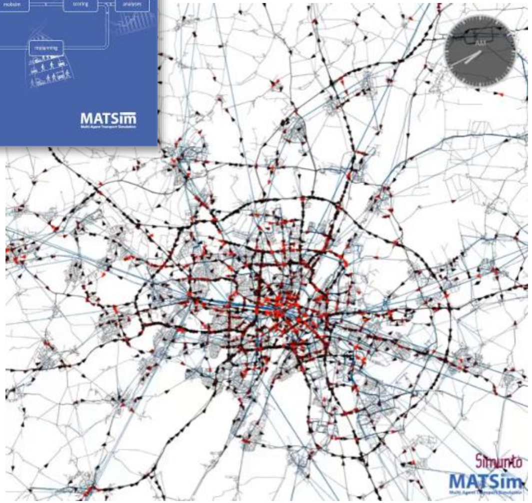


[1]M. Fu, R. Rothfeld, C. Antoniou, "Exploring Preferences for Transportation Modes in an Urban Air Mobility Environment: a Munich Case Study", Transportation Research Board Annual Meeting, Washington D.C, US, 2019.
[2]Llorca C., Zhang Q., Moreno, A.T., Moeckel, R. (2019) Airport access and egress trips in an agent-based travel demand model. Accepted for publication in 8th Symposium of the European Association for Research in Transportation (hEART 2019), Budapest.

Simulation of Urban Air Mobility

- **Use of multi-agent transport simulation MATSim[1] incl. Urban Air Mobility extension[2]**
  - Collaborative, non-commercially developed Java-based, open-source simulation environment
  - Research platform for multi-modal, intermodal and new mobility as well as infrastructure concepts
  - Modeling functions of UAM vehicles, infrastructure and network properties
  - Enables simplified passenger pooling and dynamic vehicle dispatching





[1]Horni, A., Nagel, K., & Axhausen, K. W. (Eds.). (2016). The Multi-Agent Transport Simulation MATSim. London: Ubiquity Press
[2]Rothfeld, R. et al. (2018): Agent-Based Simulation of Urban Air Mobility, AIAA Aviation, Atlanta, American Institute of Aeronautics and Astronautics

Possible Vertiport Locations[1]

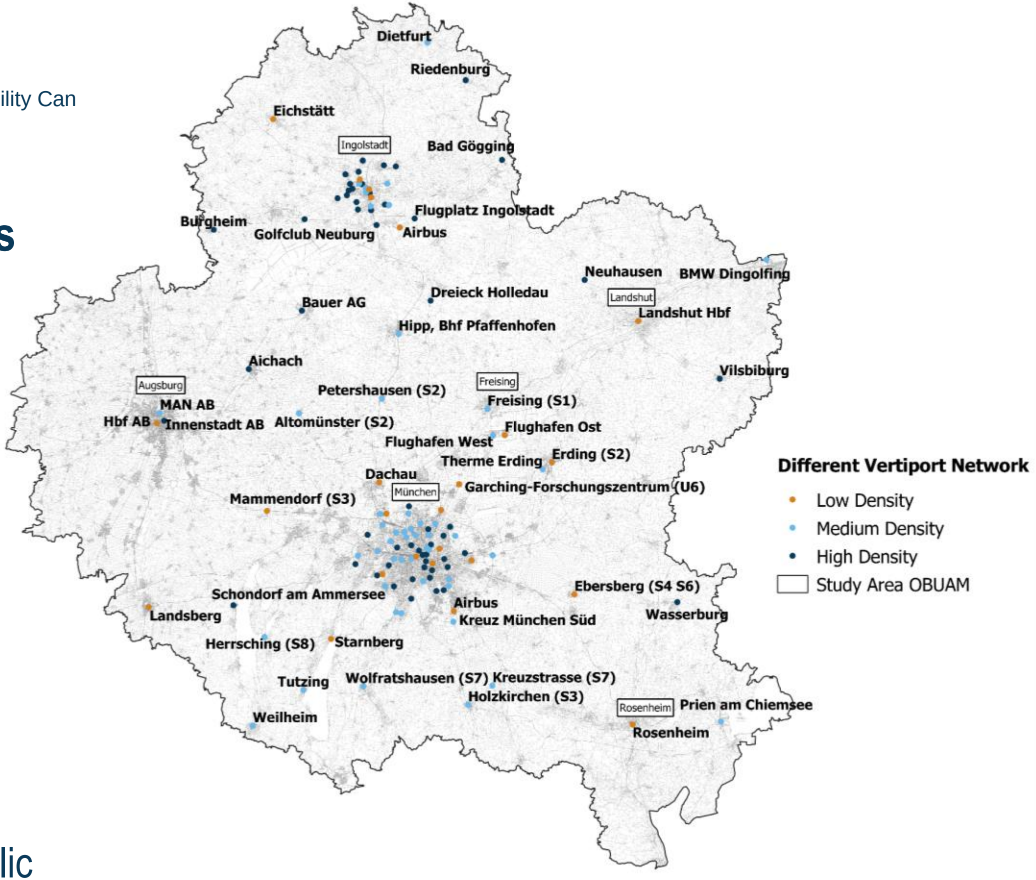
[1]A. Straubinger & M. Fu (2019) Identification of Strategies How Urban Air Mobility Can Improve Existing Public Transport Networks, Poster mobil.TUM 2019, Munich

Expert Interviews with Representatives

- City of Ingolstadt and Munich
- Munich Airport
- Chamber of Industry and Commerce Upper Bavaria

Identification of relevant locations:

- Leisure and tourist attractions
- Industrial areas and locations with high employment density
- High population density areas
- Intermodal hubs (e.g. railway stations or public transport stations)



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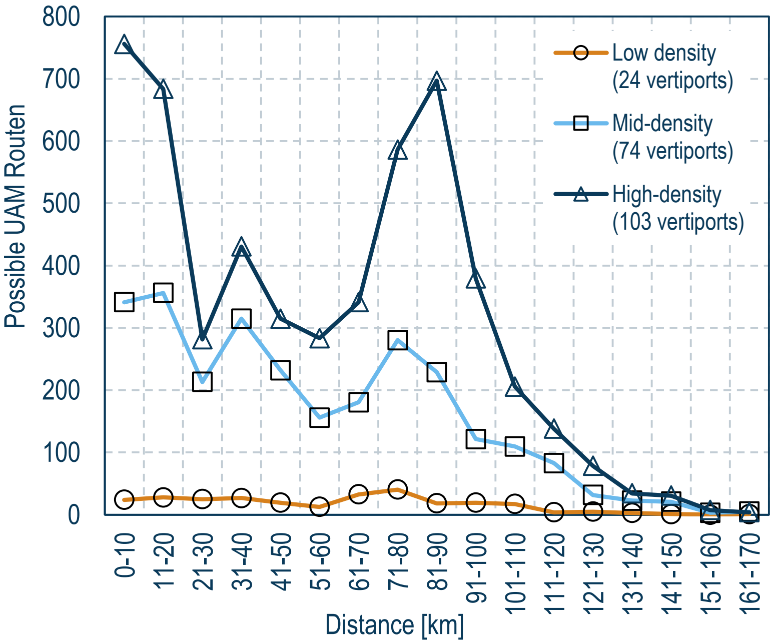
OBUAM Video: Simulation of Urban Air Mobility (3min)

Simulation of Urban Air Mobility Transport Sytems

OBUAM Vertiport Locations and Route Distances



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Simulation Results

Simulation Run A: MITO

- No capacity restrictions of UAM or feedback from ground traffic to UAM
- Fast simulation times but only aggregated simulation results

Simulation Run B: MITO-MATSim Feedback

- Capacity restrictions due to UAM vehicle availability or vertiport capacities
- Feedback of intermodal ground and UAM traffic
- High simulation times but detailed results at agent level

Ticket Price Variation

- Base fare (0€,5€,10€) plus km-dependent price (1€,2€,5€,6€,8€,10€)

Cruise Speed Variation

- 50,60,80,100,150,200,250 km/h

PAX Process Time Variation

- 10min, 20min, 30min

Netzwerk Density Variation

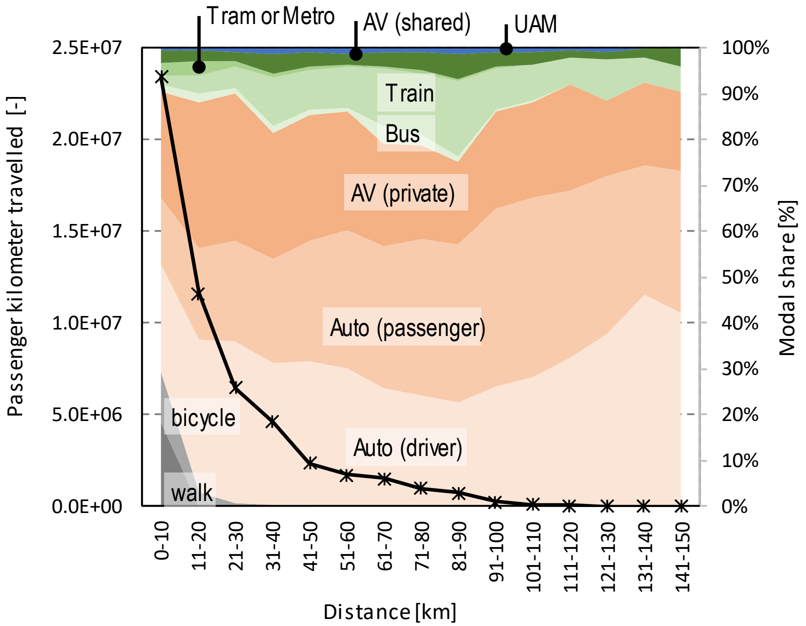
- 24, 74, 130 vertiports

OBUAM Reference Case

OBUAM UAM Reference Scenario (1/3)

Simulation parameters

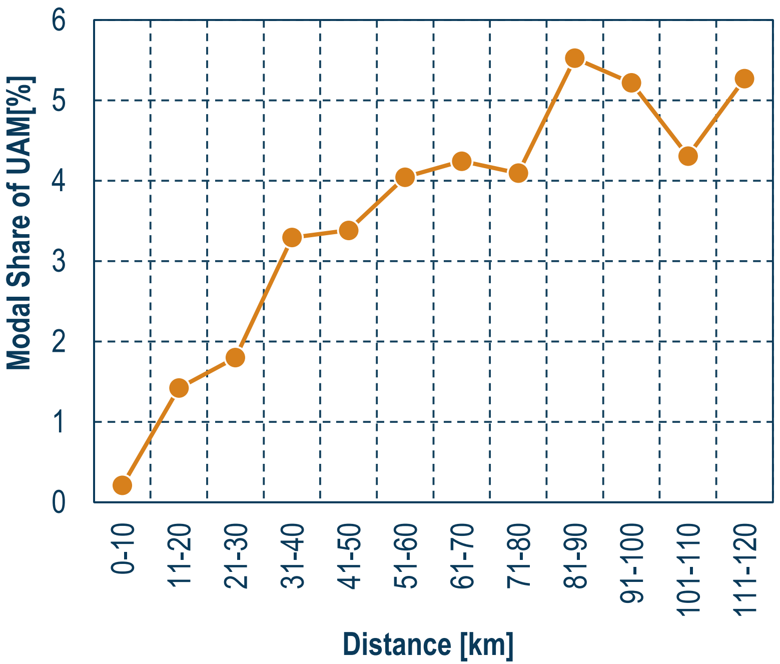
- Mobility scenario based on 2011 data
- Consideration of autonomous, privately owned (AV private) as well as autnomous vehicles integrated into public transport (AV shared)
- 74 vertiports within the study area
- Base fare of 5€ plus km-dependent price of 2€/km
- UAM vehicle cruise speed of 100km/h
- Passenger total process time at vertiports of 20min



UAM Gesamtanteil am Transport: ø0,5%

OBUAM UAM Reference Scenario (2/3)

- **Urban Air Mobility accounts for a very small share (modal split of 0.5%) of the total transport volume in the Munich metropolitan region.**
  - on short distances (<10km) UAM has a modal share of 0.2%.
  - on longer distances a share of 3%-4% (~50km)
  - on very long distances (~80km) a share of 4%-6%.

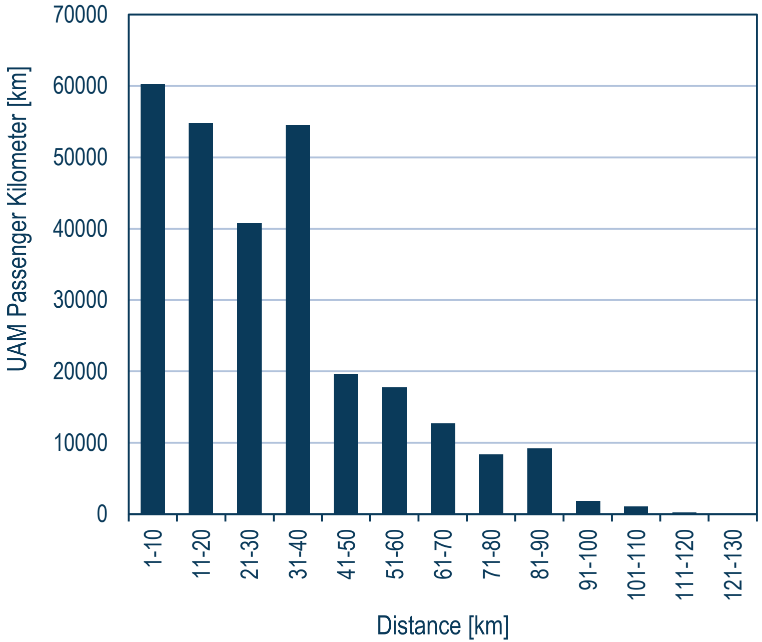


OBUAM UAM Reference Scenario (3/3)

75% of the UAM transport capacity is demanded on routes of 40km and shorter

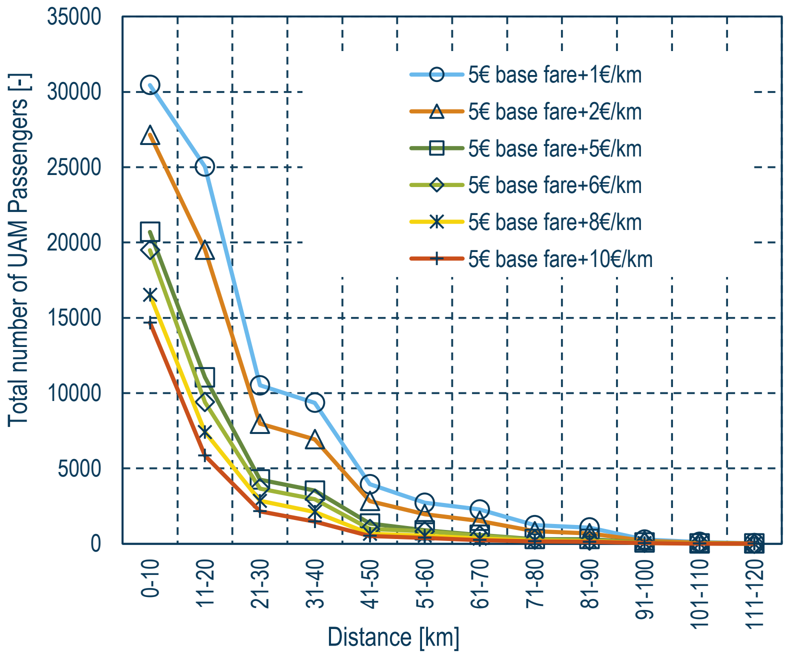
Simulation parameters

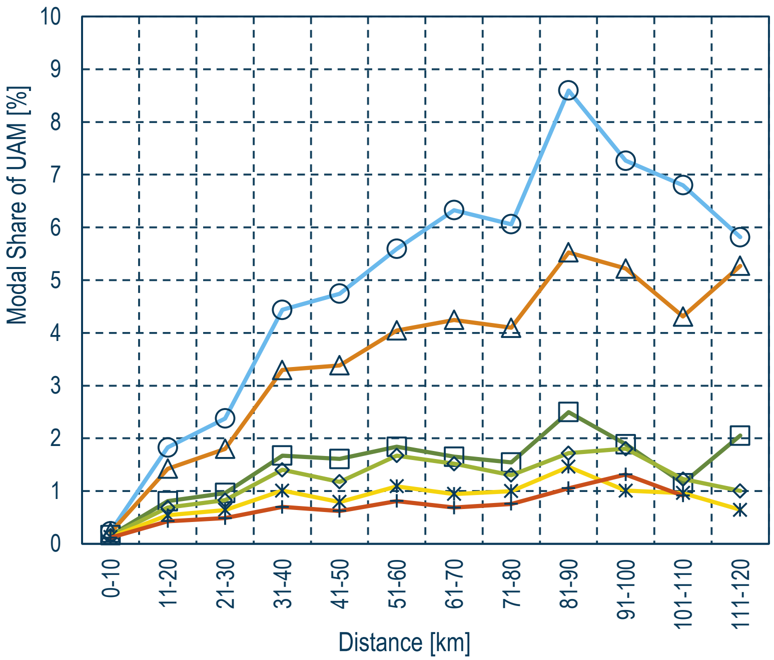
- Mobility scenario based on 2011 data
- Consideration of autonomous, privately owned (AV private) as well as autnomous vehicles integrated into public transport (AV shared)
- 74 vertiports within the study area
- Base fare of 5€ plus km-dependent price of 1€/km
- UAM vehicle cruise speed of 100km/h
- Passenger total process time at vertiports of 20min



Impact of Ticket Price on UAM Demand

- Ticket price is one of the main drivers for the UAM demand.





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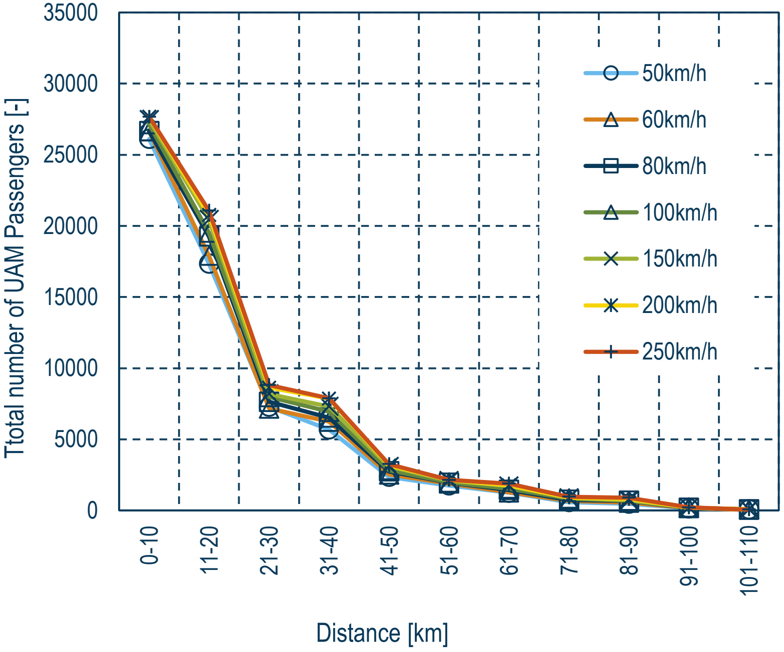
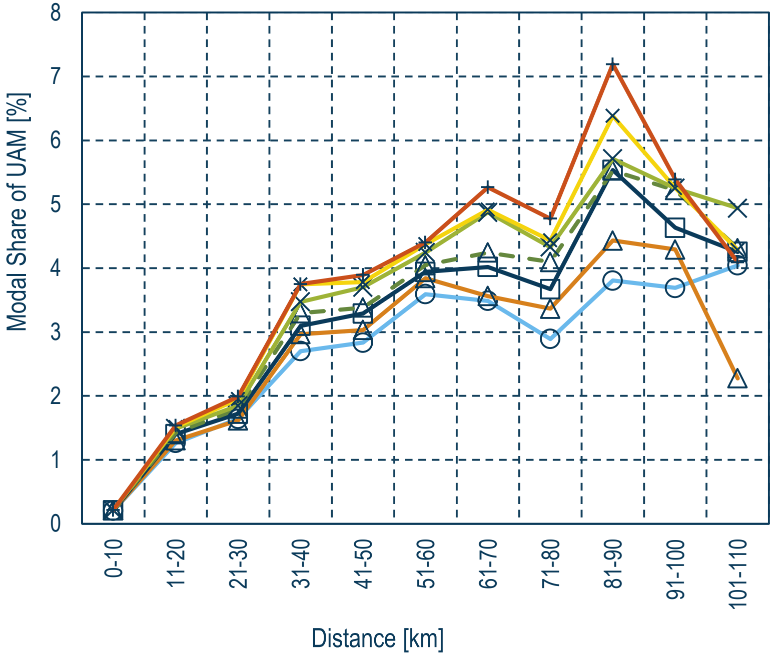
Impact of UAM Vehikel Cruise Speed

- **Only at longer distances (>30km) does the vehicle's cruise speed have a significant influence on demand.**





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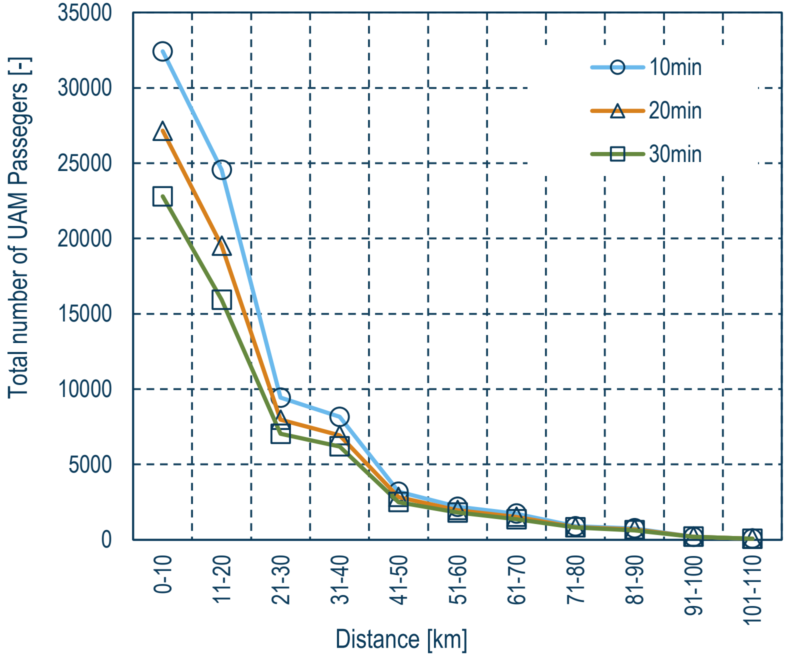
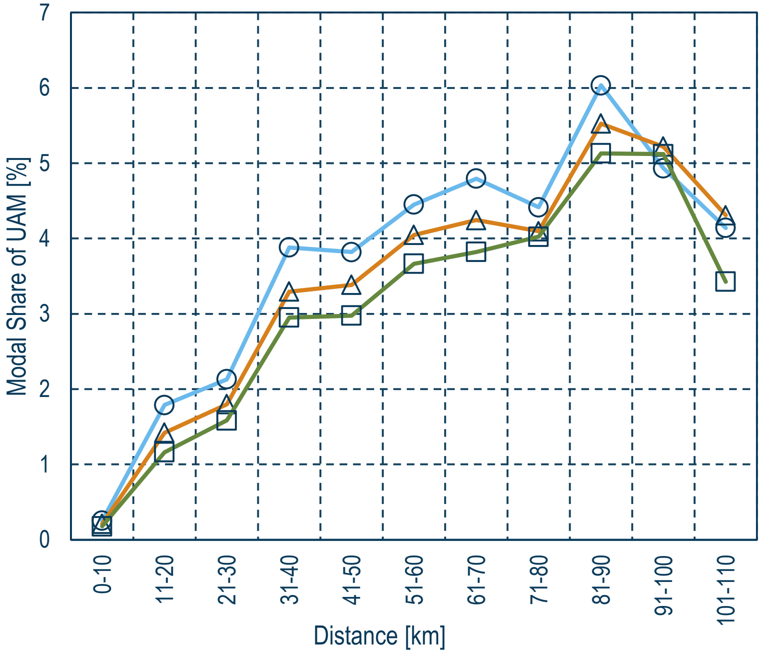
Impact of Overall Process Times for (De)- and Boarding

- **Process times at vertiports do influence demand. However, process times of 10-30 minutes do not show any massive changes in demand.**





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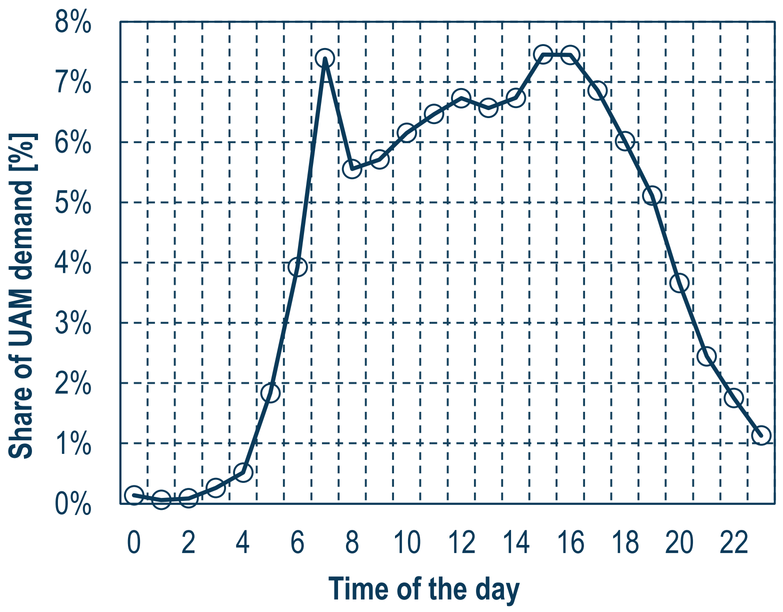
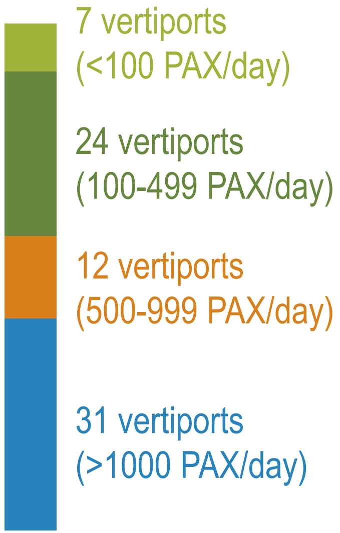
UAM Demand

- Only 4% of the UAM demand is between 10pm and 6am and concentrated demand on certain routes, very low demand at half of the routes





- UAM demand on more than 3200 routes
- 50% of the demand is on 103 routes
- 20% of the demand on only 11 routes
- >1600 routes with a daily demand of less than 4 PAX

Summary (1/5)

- **Identification of the first potentials and challenges of Urban Air Mobility for the Upper Bavaria/ Munich Metropolitan Region**
  - Modeling capability of UAM in multi- and intermodal interaction
  - Definition and UAM networks, UAM vehicle and vertiport requirements and initial operational cost estimates to be able to define the OBUAM simulation reference case
  - Variation of ticket prices, initial price structures, flight speeds and process times as well as influence of different networks

Summary (2/5)

Key Simulation Results:

- Urban Air Mobility accounts for a very small share (modal split of 0.5%) of the total transport volume in the Munich metropolitan region.
- Urban Air Mobility will therefore not significantly change the daily mobility situation in general, but the current transport offer could be complemented by a fast, flexible mode of transport.
- On short distances (<10km) UAM has a modal share of 0.2%; on longer distances a share of 3%-4% (~40km) and on very long distances (~80km) a share of 8-9% (@1€/pkm).

Summary (3/5)

Key Simulation Results:

- In absolute terms, UAM demand is concentrated on short distances under 40 km; 55% of demand is on routes <20 km, even with higher passenger processing times at the vertiports of 30 min in total.
- Process times at the vertiport do influence demand. However, process times of 10-30 minutes do not show any massive changes in demand.
- On longer distances (>40km) and at taxi-like prices (~2€/km) a UAM modal split of 4% was calculated.

Summary (4/5)

Key Simulation Results:

- The main reasons for using UAM are non-regular trips from home (e.g. leisure activities, visits to the doctor or authorities) and commuting.
- 9% of UAM demand serves Munich Airport. ~11% of original traffic could thus use UAM (~6000 daily passengers).
- Only on longer distances (>30km) does the vehicle cruise have a significant influence on demand.
- The ticket price to be paid is one of the main drivers for the UAM demand.

Summary (4/5)

- **Key Simulation Results:**
  - Only 4% of the UAM demand is between 10pm and 6am→night time operations not justified from a demand perspective
  - UAM demand is concentrated certain routes offering the possibility of pooling
  - Very low demand of less than 4 PAX per day at half of the routes→challenge of pooling & cost effective operations
- **More information during OBUAM Final Conference**
  - 19th November 2019 @TH Ingolstadt
  - Free registration: obuam@thi.de

Key Outcomes

- Urban Air Mobility accounts for a very small modal share (0.5%)
- Urban Air Mobility will therefore not significantly change the daily mobility situation in general, but the current transport offer could be complemented by a fast, flexible mode of transport.
- On longer distances (>40km) and at taxi-like prices (~2€/km) a UAM modal split of 4% was calculated.
- On very long distances (~80km) UAM has a share of 8-9% (~1€/km)
- The ticket price to be paid is one of the main drivers for the UAM demand
- Only on longer distances (>30km) does the vehicle cruise have a significant influence on demand
- Only 4% of the UAM demand is between 10pm and 6am
- OBUAM Final Conference 19th Nov.
  - Free registration: obuam@thi.de

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Background Information of the OBUAM Project

Project Goals:

- Definition and simulation of promising Urban Air Mobility mission profiles and transport networks for the Upper Bavarian region
- Quantification of UAM transport performance and feedback on the traffic situation
- Derivation of technology requirements at vehicle, infrastructure and airspace level as well as promising business and operator models
- Possible regulatory measures for the effective integration of UAM into local public transport
- Analysis of the advantages, disadvantages and possible impacts of UAM at the social, economic and ecological levels
- Identification of research needs in the areas of technology and infrastructure, operations, regulations and society

Partner

- Bauhaus Luftfahrt e.V.
  (Coordinator)
- Technische Universität München
  (Modelling Spatial Mobility)
  (Transport System Engineering)
- Technische Hochschule Ingolstadt
  (Automotive & Mobility Management)

Duration: 2019 (12 months)

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