Urban Air Mobility - Trends & Challenges

Dr. Jochen Kaiser
Head of Visionary Aircraft Concepts
The Bauhaus Luftfahrt Approach

>> Founded in November 2005 by
  > The Bavarian Ministry of Economic Affairs, Infrastructure, Transport and Technology
  > Airbus
  > IABG
  > Liebherr Aerospace
  > MTU Aero Engines

>> A non-profit research institution with long-term time horizon
  > Strengthening the cooperation between industry, science and politics
  > Developing new approaches for the future of aviation with a high level of technical creativity
  > Optimizing through a holistic approach in science, economics, engineering and design
  > Added value due to interdisciplinary teams
    • Aeronautical engineering
    • Economy & ecology
    • Geography
    • Informatics & knowledge management
    • Materials science
    • Physics & chemistry
    • Social sciences

>> Going “New Ways“ for the mobility of tomorrow
The Idea of Aviation in Urban Mobility is not new.....
...and existed and still exists....
**Mobility within and between cities**

**Year 1970**
30% urban : 70% rural

**Year 2014**
54% urban : 46% rural

**Year 2030**
60% urban : 40% rural

Source: ESA World Urbanization prospects 2014
Commuting Times in Large Metropolitan Areas
Data according to TomTom

<table>
<thead>
<tr>
<th>City Name</th>
<th>Metropolitan size</th>
<th>Average Extra Time</th>
<th>Extra Time at Morning Peak</th>
<th>Extra Time at Evening Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mexico City</td>
<td>21 Mio.</td>
<td>58%</td>
<td>+63%</td>
<td>+81%</td>
</tr>
<tr>
<td>Jakarta</td>
<td>30 Mio.</td>
<td>58%</td>
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<td>+88%</td>
</tr>
<tr>
<td>Rio de Janeiro</td>
<td>14 Mio.</td>
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</tr>
<tr>
<td>Santiago de Chile</td>
<td>7 Mio.</td>
<td>43%</td>
<td>+73%</td>
<td>+96%</td>
</tr>
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<td>15 Mio.</td>
<td>45%</td>
<td>+101%</td>
<td>+84%</td>
</tr>
<tr>
<td>New York</td>
<td>24 Mio.</td>
<td>35%</td>
<td>+52%</td>
<td>+62%</td>
</tr>
<tr>
<td>Beijing</td>
<td>25 Mio.</td>
<td>46%</td>
<td>+95%</td>
<td>+63%</td>
</tr>
<tr>
<td>Istanbul</td>
<td>15 Mio.</td>
<td>49%</td>
<td>+71%</td>
<td>+91%</td>
</tr>
<tr>
<td>Moscow</td>
<td>17 Mio.</td>
<td>44%</td>
<td>+94%</td>
<td>+81%</td>
</tr>
<tr>
<td>London</td>
<td>17 Mio.</td>
<td>40%</td>
<td>+91%</td>
<td>+86%</td>
</tr>
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</tr>
<tr>
<td>Sydney</td>
<td>5 Mio.</td>
<td>39%</td>
<td>+75%</td>
<td>+87%</td>
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22nd International Forum on Advanced Microsystems for Automotive Applications (AMAA 2018)
12.09.2018
UAM Initiatives worldwide

- Conventional and Short TOL
  - Fixed-Wing
  - Autogyro
  - Rotor-based
  - Fan-based

- Extremely Short or Vertical TOL
  - Tilt-Wing/Prop.
  - Hybrid-Wing
  - Tailsitter

Percentage of Programs:
- Rotor-based: 34%
- Fan-based: 8%
- Tilt-Wing/Prop.: 29%
- Hybrid-Wing: 26%
- Tailsitter: 3%

Energy Source:
- Electric: 31
- Hybrid-Electric: 14
- Fuel: 9
  - Unknown: 3
  - 90% Fuel Cell: 2

Concept Types/Purpose:
- Urban Air Mobility: 33
  - Inter-City: 11
  - Unknown: 11

22nd International Forum on Advanced Microsystems for Automotive Applications (AMAA 2018)
1. Rotary-Wing & Fan-based Concepts

2. Tilt-/ Hybrid-Wing Configurations

3. Fixed-Wing „Flying Cars“
Hybrid-Electric Power Train

Main Differences between Automotive & Aviation Applications:

>> Mission Profile

> Recuperation is part of energy management

> Constant energy demand over a large part of the mission
Electric Aircraft History & Future Concepts

MB-E1 on October 21, 1973

--- Battery powered
----- Fuel cell-battery hybrid
------ Engine-battery hybrid


List is not exhaustive

--- Electric

- MB-E1
- Antares 20E
- Silent 2
- AE-1 Silent

Fuel cell-battery hybrid

- HK36 FCD
- Flight Design Hybrid Motor
- Silent 2 Electro
- Electric
- Antares DLR-H2
- Electric Viva
- SkySpark
- Waiex
- Yuneeq eX30
- Airbus E-Fan 2.0
- ENFICA-FC
- Taurus
- Alatus ME
- eGenius
- eViva
- Electraflyer-ULS
- Evinta EVO
- Taurus G4
- FlyNano
- ASS 71
- DA36 E-Star

Engine-battery hybrid

- NASA "LEAPTech"
- Joby Aviation "Joby S2"
- Volocopter 2X
- Airbus E-Fan 2.0
- Aurora eVTOL
- Bauhaus Luftfahrt "Ce-Liner"

Source: NASA.gov
Source: Jobyaviation.com
Source: Airbusgroup.com
Source: Bauhaus-Luftfahrt.net

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Urban Air Mobility Infrastructure Concepts
(Visualisations taken from NASA, Uber, Volocopter, Lilium)
Integration of UAM into urban mobility

Sioux Falls MATSim Baseline Scenario: UAM covering 4% of trips
What are the implications on cities?

Example: Los Angeles

- Population
  - City: approx. 4 Million
  - Metropolitan Area: approx. 13 Million
- LA International Airport
  - Aircraft Operations per day: around 2000 A/C
What are the implications on cities?

Assumption:

- Average number of rides per day
  - 3 by every resident

- PAV share on transport capacity similar to taxi:
  - 1% of passenger traffic

- PAV flights / hour
  - 5,000 in LA city
  - 16,000 in LA metropolitan area
What are the implications on cities?

**Automation / Autonomy**
- Pilotless Operation
- Air Traffic Management
- Databases

**Infrastructure**
- PAV-Ports
- Power Supply
- Communication

**Reliability of Service**
- Capacity
- Time for Waiting & Travel
- Interoperability with other Modes of Transportation

**Safety & Regulations**

**Acceptance**
Future Prospects of Aviation in Urban Mobility

>> Multiple aspects are still being discussed:

- Vehicle characteristics regarding take-off and landing capabilities, travel speed, capacity,...
- Operational concepts as on-demand vs. scheduled, commercial vehicles vs. personal vehicles, inter- vs. intra-city,...
- Possible market structures, ownership models and business models
- Level of system costs
- Infrastructure set-up
- Air traffic management, routing and scheduling, UTM/ATM integration
- Regulatory framework

>> What we know today...

- High level of activities on research and industry side with focus on vehicle demonstrator and ATM/UTM concepts
- Commercial, piloted operations targeted in 2023 onwards
- Full-scale, autonomous operations decades away
- Operation from (heli)pad type area
- Various studies show an UAM market share of <10%, more around 4-6%
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