Vertidrome Design: State of the Art and Current Research
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Agenda

1. Vision of Urban Air Mobility 
   *then vs. now*

2. Why do we need UAM tailored Ground Infrastructure?

3. Regulatory Framework

4. Challenges of Terminologies

5. „Vertidrome-in-the-lab“ 
   Performance Assessment of a Vertidrome's Airside Operation

6. Summary and Outlook
1. Vision of Urban Air Mobility
1. Vision of Urban Air Mobility  
then vs. now

Central London Helidrome proposed by Norman Dodds (1951)


Gannett Fleming’s proposal for the Uber Elevate Skyport Challenge (2018)
2. Why do we need UAM tailored Ground Infrastructure?

**Airport**
- High performance and affordable fixed-wing operations
- ICAO Standard: ICAO AN 14-1

**Heliport**
- Low frequency and less affordable rotorcraft operations
- ICAO Standard: ICAO AN 14-2

**UAM Ground Infrastructure**
- On-demand but affordable
- High dispatch frequencies
- Complex obstacle scenery
- Ground taxi
- Simultaneous, automatic operations
- Steep approaches/ departures
2. Why do we need UAM tailored Ground Infrastructure?

<table>
<thead>
<tr>
<th>Demand</th>
<th>(On-demand) Request</th>
<th>Complex (Obstacle) Scenery</th>
<th>New Aircraft Technologies</th>
<th>(Unknown) Weather Dependency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variation of demand densities</td>
<td>Minutes to hours before actual flight</td>
<td>Urban environment, often in controlled airspace</td>
<td>New propulsion systems, no long-term experience</td>
<td>Urban Heat Islands, operation of lightweight aircrafts</td>
</tr>
</tbody>
</table>
3. Regulatory Framework

- **Part 21 Light**
  - **Drastic Simplification** of the airworthiness system (General Aviation)

- **SC-VTOL-01**
  - **New Category** Airworthiness Standards for VTOL Aircraft

- **MOC-SC-VTOL**
  - **Means of Compliance** for VTOL Aircraft
  - **Flexible & Fair** Cooperation with Industry
  - **& NEW DRAFTS!**

- **SC E-19**
  - **Filling the gap!** Certification specification for "modern" propulsion systems

- **Vertiport Design Manual**
  - **Vertiport Task Force (VTF)** Design Manual under development

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**EASA**

- Certified for small commercial flights
- New certification system for transport aircraft
- Simplified rules for small aircraft
4. Challenges due to Missing Terminologies

**UAM Ground Infrastructure**

- Aerodrome
- Airparks
- Vertiplaces
- Vertistation
- Vertihub
- VTOL-ports
- UAM Aerodrome
- Drone Terminal

**Vertidrome**

- Opportunity Hub
- pocket Airport
- sky node

**UAM Vertiport**

- Vertiport
- Vertibase
- greenfield mobility hub

**Vertipad**

- VTOL
- Vertiports
- Vertistop
4. Challenges due to Missing Terminologies

On-demand

ICAO [3]:

“On-demand, non-scheduled flights on short notice for the carriage by air of passengers, freight or mail, or any combination thereof for remuneration usually performed with smaller aircraft including helicopters (typically no more than 30 seats). Also includes any positioning flights required for the provision of the service”

Transportation Science [4]:

„Mobility-on-demand-System (MODS):
• Operates without schedule
• Is bookable by an app
• Offers a real-time dispatching based on a routing algorithm
• Anticipates ride-pooling
• Conducted by a driver with a special license for the transport of passengers“


https://www.researchgate.net/publication/324064594_Der_tatsächliche_Bedarf_hinter_bedarfsgesteuerten_Angaben_Analyse_des_Nutzenbeitrags_von_Eigenschaften_des_Bedienkonzepts_von_Mobility-on-demand_Systemen
5. „Vertidrome-in-the-lab“
Performance Assessment of a Vertidrome’s Airside Operation

How do we decide if a vertidrome satisfies our requirements from an operational perspective?

Level of Service Concept


5. „Vertidrome-in-the-lab“
Performance Assessment of a Vertidrome’s Airside Operation

Who?  What?  How?

[Vertidrome Design: State of the Art and Current Research] > [Karolin Schweiger]  •  HorizonUAM Virtual Symposium > 22 – 23 September 2021

Stakeholder Requirements

<table>
<thead>
<tr>
<th>Reference</th>
<th>Passenger</th>
<th>VTOL Vehicle</th>
<th>Vertidrome</th>
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<td>Ø (d_{PAX})</td>
<td>(t_{AFT} - t_{NFT})</td>
<td>≥ 95 % Flights ≤ (d_{TF})</td>
<td>Metric</td>
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<tr>
<td>≤ 2 Minutes</td>
<td>≤ 5 Minutes</td>
<td>(d_{TF} = 2.5) Minutes</td>
<td>Objective</td>
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<tr>
<td>Ø (d_{PAX})</td>
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<td>&lt; 95 % Flights ≤ (d_{TF})</td>
<td>Metric</td>
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<tr>
<td>&gt; 2 Minutes</td>
<td>&gt; 5 Minutes</td>
<td>(d_{TF} = 2.5) Minutes</td>
<td>Objective</td>
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</table>

Vertidrome Airside Level of Service (VALoS)

Flow

[Processed Operations per Time Interval]

Nomenclature

\(d\) = delay
\(t\) = time (duration)
\(AFT\) = actual flight time
\(NFT\) = nominal flight time
\(TF\) = total flight
\(PAX\) = passenger

5. „Vertidrome-in-the-lab“
Performance Assessment of a Vertidrome‘s Airside Operation

**Basis?**

Discrete Event Based Simulation (DES)

Demand Distribution

Vertidrome Layout and Operational Concept


Animation by T. Dreyzehner, T. Stephani (FL-PAS), 3D Vehicle Model provided by P. Weiand (FT-HUB)
5. „Vertidrome-in-the-lab“ Performance Assessment of a Vertidrome’s Airside Operation

Example: Vertiport @ Munich Trade Fair

### VALoS: Vertiport at Munich Trade Fair - Volatile Demand Distribution

<table>
<thead>
<tr>
<th>Flow</th>
<th>Occurrence</th>
<th>PAX</th>
<th>VTOL</th>
<th>Vertidrome</th>
<th>Occurrence</th>
<th>PAX</th>
<th>VTOL</th>
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Example: Vertiport @ Munich Trade Fair

### Setting 4 (4 Gates)

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### Setting 5 (3 Gates)

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6. Summary and Outlook

**Summary:**

1. Vertiport State of the Art
2. Regulatory Framework
3. Evaluation of a Vertidrome's airside capability to process a specific demand forecast

**Insights about:**

- Lack of terminologies and regulations regarding the development of UAM ground infrastructure
- **Complexity of the interaction** between different stakeholders and a vertidrome's infrastructure components
- **VALoS** = Vertidrome Airside Level of Service Framework
  - Maximum/ critical **flow rates achieved** during an operational day
  - **Utilization** of each infrastructure **component** (Heat map)
  - **Potential bottlenecks**
  - **Capability** of the vertidrome design and its corresponding operational concept

**Outlook:**

1. A Vertidrome’s Airside Level of Service (VALoS) under **weather constraints**
2. Analysis of **Sequencing** and **Scheduling** approaches
3. **Interface** to other HorizonUAM research groups (UAM network, vehicle design, demand analysis, etc.)
Thank you for your attention!

“The U.S. and Western Europe often view airports as nuisances and environmental threats rather than as critical infrastructure to compete and prosper. This has resulted in their maligning and neglecting airports while Asia and the Middle East invest heavily to leverage them. Such malign neglect comes at the long-term economic peril of the West.” John D. Kasarda