Electric VTOL Aircraft: Transformative Vertical Flight

Mike Hirschberg, Executive Director
AHS International — The Vertical Flight Technical Society
www.vtol.org
The global **Vertical Flight Technical Society**
- Founded in 1943 as the **American Helicopter Society**
- Everything from VTOL MAVs/UAS to rotorcraft and eVTOL to STOVL

**Expands knowledge** about vertical flight technology and promotes its application around the world

**Advances safety and acceptability**

**Advocates for vertical flight R&D funding**

**Helps educate and support** today’s and tomorrow’s vertical flight engineers and leaders
AHS Legacy and Opportunities

- AHS has a proud history of advocacy and support
  - Worked with NASA, Army and Air Force to save the NFAC wind tunnel
  - Helped in establishment of NASA-Army joint office, VLRCOEs, NRTC, RITA/VLC
- Provided major foundational support to transformative initiatives
  - Joint Strike Fighter/F-35B STOVL
  - V-22 Osprey tiltrotor
- Providing major foundational support to new transformative initiatives
  - Future Vertical Lift (FVL)/Joint Multi-Role (JMR)
  - Electric and hybrid-electric VTOL (eVTOL)

We exist to advance vertical flight!
AHS Electric VTOL Efforts

- **Transformative Vertical Flight Workshops**
  - Building community & developing industry roadmap
  - [https://nari.arc.nasa.gov/wghome](https://nari.arc.nasa.gov/wghome)

- **Since 2014, annual series with NASA, etc.**
  2. Aug 2015, NASA Ames, California
  4. Jun 2017, Denver, Colorado
  5. **Jan 2018, San Francisco, California**
  6. **Jan 2019, Phoenix, Arizona**
  7. **Jan 2020, Mountain View, California**

- Presentations, videos and links at
  - [http://www.vtol.org/transformative](http://www.vtol.org/transformative)

- **Significant funding in electric VTOL ($>500M?)**
  - >50 companies developing electric and hybrid/electric VTOL aircraft

---

**Uber Elevate**

- Unveiled at 4th Workshop in Sep 2016
- White Paper in Oct 2016 / Summit in April 2017

**Developing an “Ecosystem”**

- Partnerships with cities, real estate companies, aircraft OEMs, EV charger manufacturers & cities
- Connecting innovators, investors, regulators, technical experts, standards organizations
The 20th Century proved that vertical flight was possible with combustion engines and drive systems. ASTOVL/JAST/JSF proved that the engine location could be decoupled from the center of gravity.

Mechanical complexity led to high failure rate and fatal accidents for a “Wheel of Misfortune.”
## Electric VTOL Air Mobility

### Tilt Thrust
1. A³ Vahana
2. AirspaceX MOBi
3. Aurora Flight Sciences LightningStrike
4. Autonomous Flight Y6S
5. Bartini Flying Car
6. Bell Helicopter (Air Taxi)
7. Carter Aviation CarterCopter
8. DeLorean Aerospace DR-7
9. Digi Robotics Droxi
10. Digi Robotics DroFire
11. Embraer unnamed
12. EVA X01
13. HopFlyt (unnamed)
14. JAXA Hornisse 2B
15. Joby Aviation S4

### Lift + Cruise
1. Aurora Flight Sciences eVTOL
2. Flexcraft (unnamed)
3. HoverSurf Formula
4. Napoleon Aero VTOL
5. SKYLYS Aircraft AO
6. Zee Aero Z-P1

### Wingless
1. Airbus Helicopters CityAirbus
2. Avianovations Hepard
3. Cartivator SkyDrive
4. Dekatone (unnamed)
5. EHang 184
6. Jetpack Aviation (unnamed)
7. Volocopter VC200 / 2X
8. Workhorse SureFly
9. Passenger Drone
10. PAV-X PAVX
11. PAV-X PAV-UL Ultralight

### Hover Bikes/Hover Seats
1. Alauda Airspeeder
2. Davinci ZeroG (Prototype)
3. Flike
4. Flyt Aerospace FlytCycle
5. HoverSurf Drone Taxi R-1
6. HoverSurf Scorpion
7. Kalashnikov (unnamed)
8. Kitty Hawk Flyer
10. Malloy Hoverbike
11. Neva Aerospace AirQuadOne
| Aircraft | Classification | Alt/addl propulsion info | Maturity | Date | Design Firm | Country | Additional Co(s) | Total lift fans | Total cruise fans |有用 | Max speed (kph) | Max speed (mph) | Max range | Max cruising altitude | C/L range | C/L endurance | C/L cruising speed | Fuel Volume | Fuel Type | Max payload | Load capacity | Max take-off weight | Max payload weight ratio | Max take-off weight/Max payload | Overall length (m) | Tip-to-tip distance (m) | Cruising altitude (m) | Full charging | Full scale manned flights | Full scale non-eVTOL UAS flown | Maturity Notes |
|----------|----------------|--------------------------|----------|------|-------------|---------|-----------------|----------------|-----------------|-------|----------------|----------------|------------|-------------------|----------|--------------|-----------------|-------------|-----------|-------------|--------------|-----------------|-------------------------|----------------------|----------------------|---------------------|----------------|---------------------|---------------------|---------------|
Electric Helicopters?

- Eliminate complex rotors!
  - Cyclic, collective, swashplate
  - Transmissions, gearboxes, shafting, hydraulics, etc.
- Distributed Electric Propulsion
  - Replace single complex system with multiple simple thrusters
- Get on a wing for efficiency
  - Higher speed, longer range
- Environment
  - Noise, noise, noise!
  - “Tailpipe” emissions

- Not this!
- Cars were not buggies with mechanical horses
Pre-Historic eVTOL


e-volo Volocopter VC1 Demonstrator (2010)
Multi-“Rotor” Configurations

NASA GL-10 Greased Lightning
(2014 tethered, 2015 transition)

e-volo Volocopter VC200
(2013 tethered, 2016 manned)
e-volo 2x Multicopter
Now in pre-production

Photos courtesy of e-volo GmbH
Aurora eVTOL

Full Scale eVTOL concept
800 kg, all electric

- 8 VTOL electric props
- 1 pusher electric prop
- 97 kt (180 km/h)
- First Flight 2018

¼-scale demonstrator
12.5 kg, all electric

Graphics courtesy of Aurora
Manassas, Virginia, USA

www.eVTOL.news
Aurora XV-24A LightningStrike

Full Scale XV-24A
5.9 t, hybrid electric

- 18 + 6 electric fans
- 3x 1 MW Generators
- 1 RR Liberty engine
  - 6k shp (4.5 MW)
- 300 kt (555 km/h)
- First Flight 2018

Subscale Vehicle Demonstrator (SVD)
150 kg, all electric, 20% scale

Graphics courtesy of Aurora Flight Sciences
Manassas, Virginia, USA

In This Issue:
- Aurora’s LightningStrike
- Forum 72 Highlights
- Seeing through DVE
- Hearing without Wires
- Tribute to Glid Doman

July/August 2016

www.vtol.org

www.eVTOL.news
2-seat “Eagle” LiliumJet prototype
640 kg, all electric

- 36 electric fans
  - 24 on wings
  - 12 on canards
- 160 kt (300 km/h)
- “Eagle” first flight April 2017

Graphics courtesy of Lilium Aviation
Garching, Germany

www.eVTOL.news
XTI Aircraft: TriFan 600

Hybrid-electric concept

www.eVTOL.news
A³ by Airbus: Vahana

Graphics courtesy of A³
Please don’t call it a ‘flying car’!
Unless it’s a flying car!

Terrafugia Transition

Aerombil
Today’s Agenda: The Promise

- **Welcome**
  - Chris Silva, NASA (Technical Chair)

- **eVTOL: Promise & Progress**
  - Mike Hirschberg, AHS International (Program Chair)

- **Uber Elevate Common Reference eVTOL**
  - Mark Moore, Uber Technologies

- **Electric & Hybrid-Electric VTOL**
  - Francesco Giannini, Aurora Flight Sciences

- **Transformative VTOL**
  - John Piasecki, Piasecki Aircraft

- **Four Ways for On-Demand Mobility**
  - Mathias Thomsen, Airbus Group

- **Networking Reception**
# Friday’s Agenda: The Challenges

<table>
<thead>
<tr>
<th>Topic</th>
<th>Speaker(s)</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overview of NASA eVTOL Studies</td>
<td>Chris Silva</td>
<td>NASA Ames</td>
</tr>
<tr>
<td>eVTOL Analysis Tools &amp; Frameworks</td>
<td>Dr. Rob MacDonald</td>
<td>Uber Technologies</td>
</tr>
<tr>
<td>Panel: Challenges of Urban Air Mobility Airspace</td>
<td>Dr. Parimal Kopardekar</td>
<td>NASA Ames</td>
</tr>
<tr>
<td>Skyport, Cabin &amp; User Experience</td>
<td>John Badalamenti</td>
<td>Uber Technologies</td>
</tr>
<tr>
<td>Get Involved and Shape the Future!</td>
<td>Mike Hirschberg</td>
<td>AHS International</td>
</tr>
<tr>
<td>Challenges of eVTOL Standards &amp; Certification</td>
<td>Tom Gunnarson (Zee Aero) &amp; Greg Bowles (GAMA)</td>
<td></td>
</tr>
<tr>
<td>Panel: Challenges of Urban Aviation Ground Infrastructure</td>
<td>Stan Swaintek</td>
<td>Uber Technologies</td>
</tr>
<tr>
<td>Panel: Challenges of Acoustics</td>
<td>David Josephson</td>
<td>Josephson Engineering</td>
</tr>
<tr>
<td>Panel: Challenges of Hybrid-Electric VTOL Propulsion</td>
<td>Jason Schug</td>
<td>Ricardo</td>
</tr>
<tr>
<td>Panel: Perspectives on Prospective Markets</td>
<td>Jason Schug</td>
<td>Ricardo</td>
</tr>
<tr>
<td>Closing Remarks &amp; What's Next</td>
<td>Chris Silva</td>
<td>NASA Ames</td>
</tr>
</tbody>
</table>
eVTOL Resources

- **eVTOL News:**
  - www.vtol.org/electricVTOL
  - www.facebook.com/electricVTOL
  - www.twitter.com/electricVTOL
  - www.eVTOL.news

- **Uber Elevate white paper and Summit**
  - www.uber.com/elevate/whitepaper or www.vtol.org/uber

- **Transformative VTOL**
  - www.vtol.org/transformative

- **Roadmap — Four Working Groups**
  - Private Intra-city (Short range ~ 5 – 50 miles)
  - Commercial Intra-city (Short range ~ 5 – 50 miles)
  - Commercial Inter-city (Longer range ~ 50 – 150 miles)
  - Public Services (Medical, fire, disaster, enforcement)