What is The Vertical Flight Society?

- The international professional society for those working to advance vertical flight
  - Founded in 1943 as the American Helicopter Society (AHS)
  - Everything from VTOL MAVs/UAS to helicopters, eVTOL, etc.
- 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
- Brings together the community — industry, academia and government agencies — to tackle the toughest challenges

Join us today: www.vtol.org
A 75+ Year Legacy

- **VFS has a long history of advocacy and leadership**
  - Helped establish NASA-Army Joint Office, Nat’l Rotorcraft Technology Center (NRTC), Centers of Excellence, RITA/VLC
  - Worked with NASA and DoD to save the NFAC wind tunnel

- **Provided major support to transformative initiatives**
  - Joint Strike Fighter/F-35B STOVL Lightning II
  - 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)

**VFS Works to Advance Vertical Flight!**
Forecast International’s global Platinum Forecast database:

**Civil rotorcraft production** is expected to dip again near term, but longer-term growth expected:
- 2019: $5.6B / 1,100 aircraft
- 2030: $8.6B / 1,400 aircraft
- +53% in production value
- +25% in units (more expensive civil rotorcraft)

**Military rotorcraft production** expected to continue slow decline:
- 2019: $14.8B / 615 aircraft
- 2030: $12.3B / 448 aircraft
- -17% in production value
- +27% in units (more expensive military rotorcraft)
Aging U.S. Military Fleet

- V-22 only new U.S. military rotorcraft design fielded in past 30 years; CH-53K in service in 2023-2024
- All other deployed designs are 30-50 years old
  - UH-1 Huey first flight 1956; Chinook 1961; Black Hawk 1975; Apache 1976
  - Many 1960s airframes are still flying!
  - CH-53K only new design in acquisition process
  - OH-58 Kiowas in service from 1969 to 2017
Future Vertical Lift (FVL)

- **5 Capability Sets from Light to Ultra Heavy**
  - Plus advanced unmanned programs
- **Joint Multi-Role (JMR) Technology**
  - Demonstrations – 30,000 lb-class (13.6 t)
    - Bell V-280 Valor and Sikorsky-Boeing SB>1 Defiant
    - *US industry has invested ~$1B in JMR at 4:1 government spending*
- **Currently 3 Capability Sets in planning**
  - **CS1** (Light): Army’s Future Attack Reconnaissance Aircraft (FARA) to replace Kiowa Warriors
  - **CS2** (Medium): Navy to replace Seahawks/Fire Scouts with **FVL Maritime Strike**
  - **CS3** (Medium heavy): Army’s Future Long-Range Assault Aircraft (FLRAA) to replace Black Hawks; Attack/Utility Replacement Aircraft (AURA)
Sikorsky Boeing SB>1 Defiant
JMR Demonstrator
Future Attack Reconnaissance Aircraft (FARA)

- Bell 360 Invictus
- Sikorsky Raider X
- AVX/L3Harris CCH
- Boeing

www.vtol.org/FVL
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Sikorsky S-97 Raider for FARA
Compounds & Tiltrotors

- **Sikorsky-Boeing SB>1 Defiant™ (2019)**
  - 30,000 lb (13.6 t) class

- **Sikorsky S-97 Raider™ (2015)**
  - 11,000 lb (5 t)

- **Sikorsky X2 Technology™ Demonstrator (2008)**
  - 5,500 lb (2.5 t)

- **Bell Helicopter V-280 Valor (2017)**
  - 30,000 lb (13.6 t) class

- **Leonardo (with Bell) AW609 (2003)**
  - 16,800 lb (7.6 t)

- **Bell Boeing V-22 Osprey (1989)**
  - 52,600 lb (23.8 t)
Clean Sky 2: Leonardo NGCTR Demonstrator

- New Wing (no dihedral and no swept) Integration (T-WING)
- Advanced empennage configuration (LIFTT)
- Innovate fuel system (DigiFuel & DEFENDER)
- Mast tilt for control improvement (LH)
- Distributed FCS system (LH)
- Flow through engine
- Splitted gearbox architecture to support non tilting engine (LH)
- New control laws (LH)
Clean Sky 2: Airbus RACER
Vertiflite Covers Advanced VTOL (including eVTOL)
The Electric VTOL Revolution

- Electric & hybrid electric propulsion enable new possibilities for:
  - Regional/Rural Air Mobility (RAM)
  - Urban Air Mobility (UAM)/Air Taxis
  - Urban Cargo Delivery/Disaster Relief
  - Personal Air Vehicles
  - Ultralights
  - Personal Flying Devices
  - Urban Package Delivery
eVTOL Ultralights Are Flying
In the US/Canada

- Flight experience offerings
- Ultralights under FAR Part 103 do not require certification
- Less than 254 lb (115 kg) plus 30 lb per float plus parachutes, etc.
- Restricted in speed, overflights, etc.
- Opener and Kitty Hawk have made 20,000+ flight each!

*Like flying jet skis!*

Kitty Hawk Flyer (<254 lb)

Hoversurf Scorpion (<254 lb)

Opener BlackFly (310 lb)

LIFT Aircraft Hexa (462 lb)
Jan 2020 Unveilings

- Bell unveils all-electric Nexus 4EX at CES
- Hyundai unveils S-A1 concept at CES and pledges billions for advanced tech like UAM
- Joby Aviation’s Series C investment led by Toyota with $394M. Total = $720M.
Uber Elevate & VFS
- Unveiled at eVTOL Workshop in Sep 2016
- Summits April 2017, May 2018, June 2019

Developing an “Ecosystem”
- Partnerships with cities, real estate companies, aircraft manufacturers, and EV charger companies
- Connecting innovators, investors, regulators, technical experts, media

Small aircraft, but high barriers
- Technical, regulatory, environmental, economic, infrastructural and cultural

Uber plans test flights in 2020 and operational service in 2023!
**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

- Sikorsky “Firefly” Project (2010)
  - Conversion of S-300C to electric power
Why Now?

- Advancements in electric motors
- Advancements in batteries
- Advancements in computer modeling and simulation
- Advancements in composites
- Low cost manufacturing
- Movement to performance regs
- Tech innovations
- Tech investments > $2B

= Enabling new configurations and new innovations
Will the eVTOL Revolution Succeed?

- eVTOL must have low direct operating costs and seat mile costs to be successful
- Batteries will continue to improve
  - Drones: As of January 2019, 1.3M drones registered in US and 116,000+ registered drone operators.
  - EVs: Tesla Model S started in 2012 now all car companies have electric cars. Much lower operating costs vs. fuel-burning cars.
  - Look at your laptop or cell phone today compared to 10 & 20 years ago
- Cost: eVTOL aircraft will be much cheaper/easier to manufacture, for much higher production rates/reduced costs
- Noise: much lower, allowing more operations in higher density locations
- Potential for step-change in utilization by improved cost, noise & speed
5 Key Challenges for eVTOL for UAM

1. **Technology**: batteries, motors, etc. for larger sizes, e.g. pilot + 4 pax
2. **Infrastructure**: physical and ATM/UTM
3. **Flying**: Pilot shortage vs. autonomy
4. **Standards & Regulations**: in development
5. **Public acceptance**: safety, noise, NIMBY

* + a rush for first mover advantage!

Airbus 1-seat Vahana (unmanned)
Boeing 2-seat Passenger Air Vehicle (unmanned)
Airbus 4-seat CityAirbus (unmanned)
The Electric VTOL News
www.eVTOL.news

- World eVTOL Aircraft Directory
  - Everything from the silly to the serious
- 252 aircraft (as of 26 Jan 2020)
  - 96 Vectored Thrust
  - 37 Lift + Cruise
  - 54 Wingless (multicopters)
  - 46 Hover Bikes/Flying Devices
  - 19 eHelos & eGyros
- 230+ VFS articles on eVTOL
- Timeline, maps, company directory, educational videos, etc.
eVTOL Online Resources

- Electric VTOL News
  - www.eVTOL.news
  - www.facebook.com/electricVTOL
  - www.twitter.com/electricVTOL
  - www.youtube.com/VTOLsociety
  - www.instagram.com/VTOLsociety
  - www.vimeo.com/VTOLsociety

- Also
  - Electric VTOL eNewsletter
  - eVTOL News videos
  - eVTOL video proceedings (100+ hours)
  - eVTOL short course videos (20 hours)
1st Annual Panel (2018)
The Electric VTOL Revolution

- **Mike Hirschberg**, Executive Director, AHS International (moderator)
- **Michael Thacker**, EVP Technology & Innovation, Bell Helicopter
- **Mark Moore**, Director of Aviation Engineering, Uber Technologies
- **Greg Bowles**, VP for Global Innovation & Policy, General Aviation Manufacturers Association (GAMA)
- **Dr. Mike Romanowski**, FAA Aircraft Certification Service’s (AIR) Director of the Policy & Innovation Division (AIR-600)
2nd Annual Panel (2019)
The Electric VTOL Revolution

Moderated by Elan Head, Vertical Magazine

- Mike Hirschberg, Executive Director, Vertical Flight Society
- Scott Drennan, VP Innovation, Bell
- Zach Lovering, VP of Urban Air Mobility Systems, Airbus UAM
- Thierry Grison, VP Business Development Hybrid New Market, Safran
- Danny Sitnam, President/CEO, Helijet International
- Rex Alexander, President, 5 Alpha
- Michael Dyment, Managing Partner, NEXA Capital Partners
HAI Urban Air Mobility Forum

Tuesday afternoon, Jan. 28 @ 1-3 pm, Ballroom CDE

Moderated by Jim Viola, HAI president and CEO

- **Airbus**: Travis Mason, vice president for certification and regulatory affairs
- **Bell**: Carey Cannon, chief engineer of technology and innovation
- **FAA**: Jay Merkle, executive director, Unmanned Aircraft Systems Integration Office
- **Uber**: Nikhil Goel, head of product for aviation
- **NEXA Capital Partners**: Michael Dyment, founder and managing partner
3\textsuperscript{nd} Annual Panel (2020)
The ((Quiet)) Electric VTOL Revolution

Wednesday, March 6 @ 9:00-11:00 am Room B310

Moderated by Elan Head, Vertical Magazine

- Jim Sherman, Vertical Flight Society
- Juliet Page, Volpe — HAI Fly Neighborly Working Group Chair
- Ben Goldman, Joby Aviation
- Pamela Cohn, Hyundai Motor Group, UAM Division
- Mark Moore, Uber Technologies
VFS eVTOL Events

- **Transformative Vertical Flight 2020 @ San Jose, California, Jan. 21–23, 2020**
  - Technical Specialists' Meeting on Aeromechanics for Advanced Vertical Flight
  - 7th Annual Electric VTOL Symposium
  - International Powered Lift Conference (IPLC) joint with AIAA, SAE and Royal Aero Society
  - Short Course on eVTOL Fundamentals
  - 500 attendees, 17 exhibitors, 11 sponsors, NASA tour

- **2nd Workshop on Electric VTOL Infrastructure**
  - Glassboro, NJ, March 17-19, 2020
  - Supporting FAA Tech Center, Atlantic City
  - City planners, architectural firms, utilities, etc.
  - Expecting 100-200 attendees
  - [www.vtol.org/infrastructure](http://www.vtol.org/infrastructure)
Final Fly Off
Feb 27-29th @ Moffett Federal Airfield
NASA Ames Research Center
Moffett Field, CA, USA
www.GoFlyPrize.com
76th Annual Forum
www.vtol.org/forum

- Annual Forum attracts 1,400 engineers, scientists and leaders from industry, academia and governments
- VTOL aircraft CEOs/VPs-engineers, military leaders, researchers, etc
- ~250 technical papers
- ~75 panelists
- ~75 exhibitors
- Grand Awards Banquet
- eVTOL short course & Bell Canada tour

Forum 76 is May 19-21, 2020 @ Montreal
VTOL Innovators – Then and Now
Where We Are Now

First hover
2011 e-Volo VC1
(Karlsruhe, Germany)

First public demos
2019 Volocopter 2X
Mercedes-Benz Museum (Stuttgart)

Capable product
2019 Concept Volocopter VoloCity

Advanced product
TBD

1907 Cornu (Lisieux, France)
1938 Fw 61 Deutschlandhalle (Bremen)
1967 Bo 105 first flight (Ottobrun)
2015 H160 (Marignane)
Summary

- **VFS is the global Vertical Flight Society**
  - We are helping to shape the future of vertical flight!
  - $Billions going into new military & civil high-speed/long range rotorcraft
  - 76th Annual Forum is May 2020 in Montreal, Quebec, Canada
  - Find out more at www.vtol.org

- **Significant funds being invested in electric VTOL (>2.5B)**
  - 2nd Infrastructure Workshop: March 17-19 near Philly
  - 250+ concepts — significant work in hybrid/electric VTOL aircraft
  - The explosive interest in drones is being repeated with manned eVTOL
  - The Electric VTOL Revolution is transformative like the turbine engine
  - Find out more at www.eVTOL.news