

Advanced Air Mobility Human factors Considerations for Current eVTOL Pilot Interfaces

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Advanced Air Mobility: A Survey of Current eVTOL Vehicles and Simulation Testbed

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Presentation Overview

- Introduction
- Background
- Purpose
- Methods
- Results
- Discussion



Source: NASA



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Introduction

- What is advanced air mobility (AAM)?
- Principle drivers:
 - Distributed electric propulsion system
 - Traffic congestion/travel time
 - Noise pollution
 - Safety considerations
- Numerous emerging eVTOL aircraft configurations.



Source: Vertical Magazine



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Background



Traditional Six-pack, Analog Pilot Interface



Glass Cockpit Pilot Interface



Proposed eVTOL Pilot Interface

Purpose

- Identify and describe the range of eVTOL aircraft configurations.
- Provide insight into proposed eVTOL pilot interface and control concepts.
- Identify commercial-off-the-shelf eVTOL simulation testbeds available to conduct human factors research related to eVTOL pilot interfaces.



Methods

- **Step 1:** Surveyed from a catalogue of 350 eVTOL aircraft manufacturers and 600 aircraft; shortlisted 15 based on funding, operation type, enter in service year (EIS)
- **Step 2:** From shortlist, categorized aircraft based on propulsion type and payload
- **Step 3:** Ranked aircraft concepts based on current stage of development (e.g., piloted v/s. autonomous, flight test, certification); identified leading 10 vehicles
- **Step 4:** Extracted data associated with pilot interfaces and available simulation testbeds from industry and company websites, press releases, and social media



Results: Categories of eVTOL Aircraft



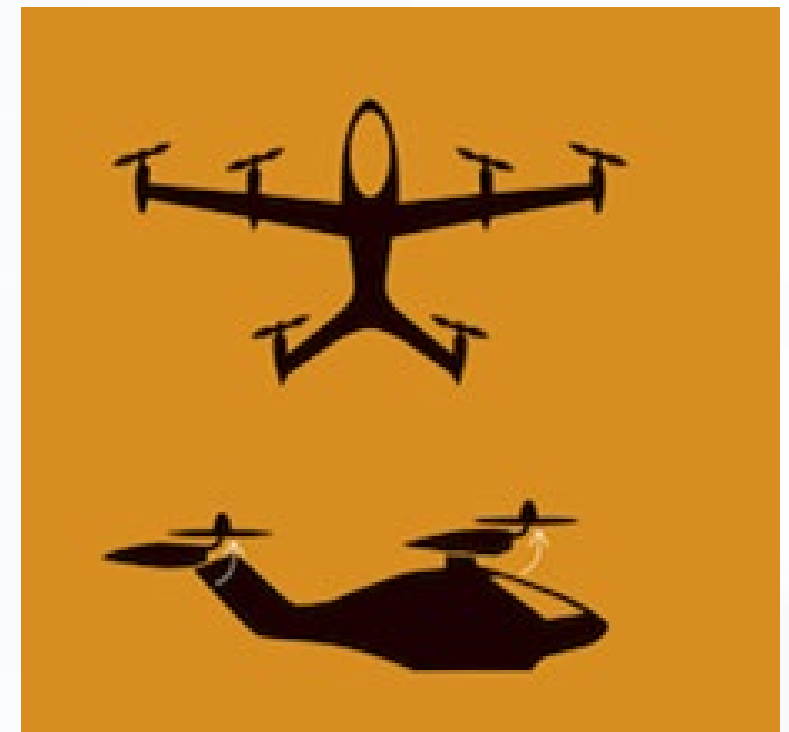
Multicopter

199 aircraft concepts



Lift + Cruise

126 aircraft concepts



Vectored Thrust

241 aircraft concepts

Results: Top 15 eVTOL Manufacturers

OEM, eVTOL Aircraft	Multicopter	Lift+cruise	Vecrored Thrust	Payload	EIS
Joby Aviation, S4			x	Air taxi	2024
Volocopter, Volocity Air Taxi	x			Air taxi	2024/2026
Beta Technology, Alia		x		Cargo, Air taxi	2024
Eve Air Mobility, Eve		x		Air taxi	2026
Lilium, Lilium Jet			x	Cargo, Air taxi	2025
Wisk, Cora		x		Air taxi	N/A
Archer, Maker/Midnight			x	Air taxi	2025
EHang, EH-216	x			Air taxi	2022/-
Elroy Air, Chaparral C1		x		Cargo	2023
Kitty Hawk, Heaviside		x		Air taxi	N/A
Pipistrel, Nuuva V300				Cargo	2023
Vertical Aerospace, VX4			x	Air taxi, Cargo, EMS	2025
Airbus, CityAirbus		x		Air taxi, EMS	2025
Supernal, S-A1			x	Air taxi	2028
Overair, Butterfly			x	Air taxi	2026

Note: Rows highlighted in gray were excluded from further analysis based on the current aircraft automation capability and payload

Results: Top 10 eVTOL Aircraft

eVTOL Aircraft	Preliminary design (1)	Prototype build (2)	Flight testing (3)	Certification (4)	Commercially Operating (5)
Joby Aviation, S4				x	
Volocopter, Volocity Air Taxi			x		
Beta Technologies, Alia			x		
Eve Holding, Eve		x			
Lilium, Lilium Jet				x	
Archer, Maker			x		
Vertical Aerospace, VX-4		x			
Airbus, CityAirbus	x				
Supernal, SA-1	x				
Overair, Butterfly		x			

Results: Pilot Interface Database

- Pilot interface trend include:

- Number of displays: 1 - 3 displays with customizability
- Conventional flight information:
 - Airspeed
 - Altitude
 - Heading
 - Horizontal situation indicator (HSI)
 - GPS
- Information on shortlisted eVTOL pilot interface included:
 - Electric battery information (power, temperature, system checklist)
 - RPM
 - Torque
 - Landing precision
 - Rotor tilt angle
 - Estimated time to destination and en-route

Company & Vehicle Name		Joby Aviation	Vertical Aerospace	Archer	Lilium	Beta Technologies	Bell	Volocopter
		S4	VA-1X	Maker/Midnight	Lilium Jet	ALIA	Nexus 6HX, 4EX	Volocity Air Taxi
Displays	1							X
	2	X	X					
	3						X	
	3+			X	X			
	Customizable	X				X		
Information on Displays	Altimeter	X	X	X	X	X	X	X
	HSI	X	X	X	X	X	X	X
	Heading	X	X	X	X	X	X	X
	Landing Precision	X	X	X		X		X
	GPS	X	X	X	X	X	X	X
	Airspeed	X	X	X	X	X	X	X
	ETE	X	X	X		X	X	X
	Battery Power	X	X	X		X	X	X
	Battery Time	X	X	X		X		X
	Battery Temperature	X	X	X		X		X
	Rotor Tilt/Angle	X	X	X	X			
	Torque	X		X		X		

Results: eVTOL Pilot Interface Trends

Pilot Interface trends

- Larger glass, touch with customizable displays.
- Single and dual set-ups.
- Reduced information redundancy.
- Integration of battery information.
- Inceptors – to fly the aircraft.
- Single pilot operations (SPO interface).
- Use of emerging technologies, like synthetic vision, advanced sensors information display.



Bell Nexus Pilot Interface

Results: X Plane 11/12 Simulation Testbed



Range of third-party eVTOL aircraft available to fly in the testbed, including AeroG Aviation aG-4 Liberty eVTOL aircraft



Aircraft cockpit customization functionality can be utilized for future human factors research using X-Plane maker.

Results: Microsoft Flight Simulator Testbed



Volocopter Velocity Air Taxi in Microsoft Flight Simulator



Equipped with Garmin pilot interface

Current & Future Research

- **Current Research:**
 - Conducting preliminary research with available eVTOL pilot interface information to identify human factors research questions.
 - Using available simulation testbed to study cockpit modifications in line with proposed eVTOL pilot interface information made available to public.
- **Future Research:**
 - Conduct experimental research studies to investigate the influence of various pilot interface configurations on pilot situation awareness, workload, and performance.
 - Investigate pilot training requirements for eVTOL operation

References

IEEE Spectrum. (2022, February 25). *EVTOL companies are worth billions—Who are the key players?* IEEE Spectrum. <https://spectrum.ieee.org/evtol-air-taxi-industry>

NASA. (2018, May 7). *Taking air travel to the streets, or just above them.* <https://www.nasa.gov/aero/taking-air-travel-to-the-streets-or-just-above-them>

SMG Consulting. (n.d.). *Advanced Air Mobility Reality Index.* Advanced Air Mobility Reality Index. <https://aamrealityindex.com/>

VFS eVTOL directory hits 600 concepts. (2022, January 24). Vertical Mag. <https://verticalmag.com/press-releases/vfs-evtol-directory-hits-600-concepts/>