Sample Report

eVTOL Landscape, Opportunities, and the Road Ahead

Jun-24

FutureBridge

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01 Introduction

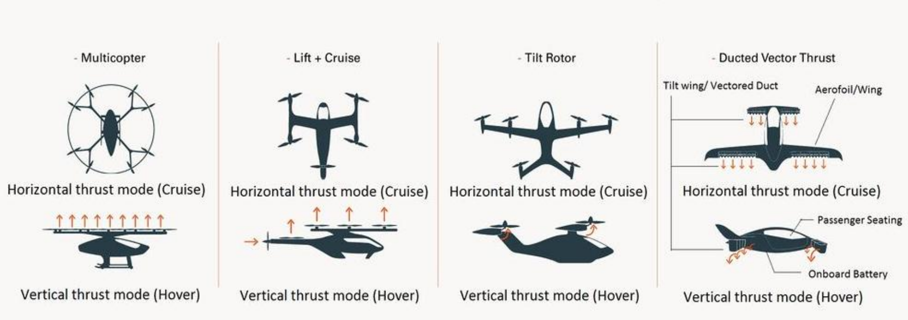
eVTOL refers to ‘Air Taxi’ or ‘Passenger Air Vehicle (PAV)’

What are eVTOLs?

Electric vertical take-off and landing (eVTOL) is the class of aircraft that use electric power to take off, hover, and land vertically.

- Designed for urban air mobility, they are ideal for intra- and inter-city travel.
- They are essentially personalized helicopter taxis for one or more passengers.

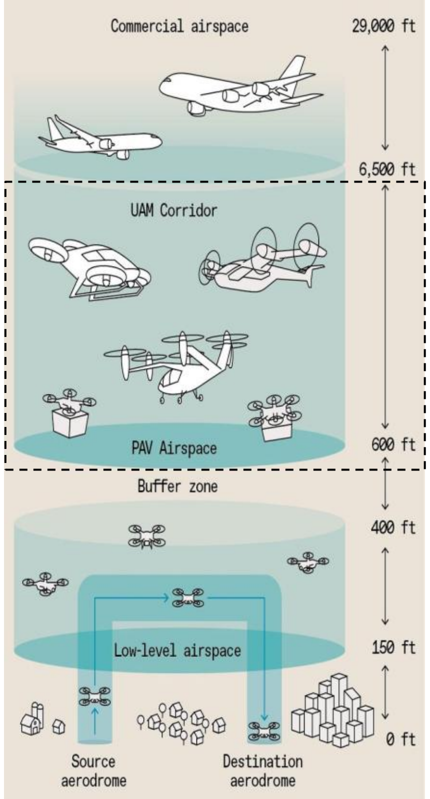
Types of eVTOL



Efficient in take off, landing and hovering	Can fly short and long distances	Can fly short and long distances	Efficient in flying
Inefficient in flying long distances	Very noisy	Reduced payload	Inefficient in hovering

Major Applications and Use cases

- On-demand Passenger Services/Air Taxi
- Emergency Medical Service
- Cargo Transportation
- Search and Rescue
- Remote Supply
- Surveillance and Reconnaissance



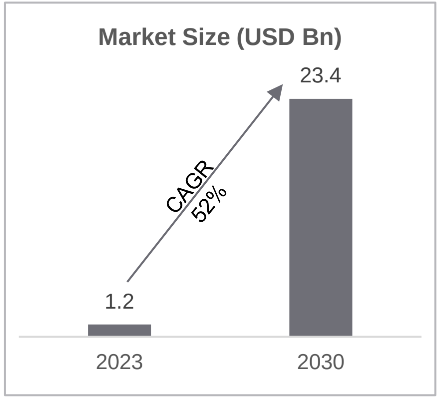
eVTOLs stand out in comparison charts for sustainability in short-distance transportation

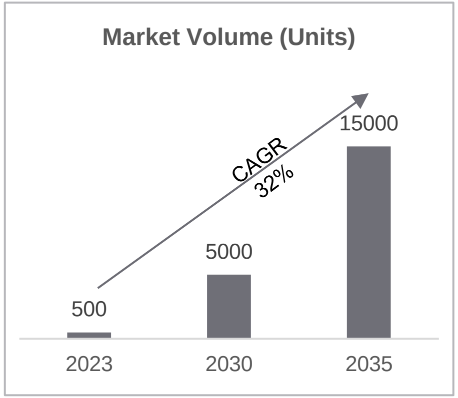
Comparing eVTOLs with traditional transportation modes

Parameter	Road Transport	Short-Distance Air Transport	eVTOL
Emissions (CO_2)	271 g/km per vehicle (average car)	255 g/km per passenger (regional jets)	0 g/km (if using renewable energy)
Energy Efficiency	30-35% (internal combustion engine)	15-20% (turboprop aircraft)	70-90% (electric motors)
Noise Pollution	70-80 dB (urban areas)	85-100 dB (takeoff/landing)	60-70 dB (estimated for eVTOL)
Land Use	High (extensive road networks)	Moderate (airports and airspace)	Low (vertiports require less space)
Operational Costs	Standard Taxi - ~$1.5/vehicle mile Premium Taxi -~$4/vehicle mile	$0.60/airline mile	2025 - ~$2.7/airline mile 2030 - ~$2.5/airline mile
Travel Time (to cover 200-mile trip)	258 mins	236 mins	82 mins
Infrastructure Needs	Extensive roads, bridges, parking	Airports, runways, air traffic control	Vertiports, charging stations
Average Speed	40-50 km/h (urban traffic)	500-800 km/h (short flights)	150-250 km/h (cruise speed)
Passenger Capacity	1-5 (average car)	50-100 (regional aircraft)	2-5 (typical eVTOL design)

02 Drivers and Challenges

Global eVTOL sales is expected to register a CAGR of 52% between 2023 - 2030





North America is anticipated to dominate the global market due to:

- Presence of key manufacturers like Joby Aviation, Bell Textron, Kitty Hawk, etc.
- Rising investments by the government

Europe is expected to witness significant growth as several cities have joined the Urban Air Mobility (UAM) initiative, as part of EIP-SCC.

APAC is expected to grow at a higher CAGR owing to the increased investments by eVTOL manufacturers such as Ehang.

Growth Drivers

- ***Stringent government regulations*** aimed at reducing carbon emissions in the transportation sector
- ***Increasing urbanization*** and population growth leading to city congestion
- Growing demand for ***sustainable transportation solutions*** offering cleaner and efficient alternatives
- ***Improvements in battery life, propulsion systems***, and ***autonomous systems***
- eVTOLs require ***minimal infrastructure investments*** and area for vertiports
- ***Rising investment across sectors in eVTOL*** is set to drive market growth.
- ***Growing collaboration*** between companies, governments, and research institutions is driving innovation and investments in the eVTOL market
- The ***time-saving advantage of eVTOLs***, capable of traveling up to 10 times faster than traditional road transport—is a key driver of their adoption.

Key Developmental Challenges for eVTOL Aircrafts

Battery Thermal Management	eVTOLs require high energy density batteries, but compact designs and safety concerns challenge effective heat dissipation, risking performance degradation and thermal runaway under varying flight conditions.
Flight Range Duration	These aircraft have a short range of approximately 100 miles due to high power needs for vertical takeoff, and less efficient aerodynamics compared to helicopters, which can typically fly around 500 miles.
Propulsion Efficiency	They face challenges in achieving high power-to-weight ratio, aerodynamic efficiency during cruise, and efficient hovering due to design compromises for vertical flight capabilities.
Payload Capacity	They prioritize batteries for electric motors, limiting payload due to their weight and low energy density compared to conventional fuels, compounded by structural and power requirements.
Drag Reduction	eVTOL aircrafts face constraints of weight and size. Adding drag reduction tech like special aerodynamic surfaces increase complexity, impacting efficiency during transition to wing-borne flight.
Noise Control	eVTOL aircraft in urban areas raise concerns due to multiple propellers generating higher noise levels compared to traditional aircraft, potentially leading to community opposition and operational restrictions.
Air Traffic Management	eVTOL aircraft operating alongside traditional planes in urban areas may lead to congestion and conflicts, requiring dedicated infrastructure like vertiports and specialized air traffic management systems.
Anti Collision System	Developing reliable anti-collision systems for eVTOL aircraft involves integrating robust sensors, managing weight and power constraints, and ensuring effective obstacle detection in complex urban environments.
Flight Transition Stability	Transition stability in eVTOL aircrafts are hindered by aerodynamic changes, thrust-induced shifts in center of gravity, stall risks, control surface limitations, and heightened sensitivity to gusts.
Communication and Navigation System	Reliable communication in urban eVTOL operations is critical for safety and efficiency, navigating obstacles, managing air traffic, and safeguarding against cybersecurity threats and GPS signal issues.

Challenges – Municipal, Regulatory, Consumer and Technical

Municipal Challenges

Challenge	Description
Infrastructure Development	▪ Design and construction of vertiports and charging stations ▪ Management of increased air traffic in urban areas.
Zoning and Land Use	▪ Updating zoning laws to accommodate vertiports and associated facilities ▪ Ensuring compliance with local regulations and land use plans
Public Acceptance	▪ Overcoming psychological barriers to the adoption of eVTOL aircraft including concerns about safety, noise, and environmental impact
Power Infrastructure	▪ Ensuring that the power infrastructure can support the high-power demands of eVTOL charging and operations. ▪ Investments in power grid upgrades and infrastructure

Consumer Challenges

Challenge	Description
Safety	▪ Safety is a major concern for consumers, as eVTOLs are a new and untested technology. The risk of accidents and the potential of harm to passengers and bystanders is a significant concern
Noise	▪ The noise emitted by eVTOLs in urban areas is a significant issue
Accessibility	▪ eVTOLs are not yet widely available and may not be accessible to all populations, especially those with disabilities
Cost	▪ The cost of eVTOLs are a significant challenge for consumers, as they are still a relatively new and expensive technology.

Regulatory Challenges

Challenge	Description
Certification Process	▪ The certification process for eVTOLs is complex and challenging due to the unique characteristics of these aircraft
Lack of rules	▪ Current regulatory frameworks lack comprehensive rules on various aspects including product certification, airmen, operations, and safety
AI Algorithms	▪ AI algorithms have difficulties in keeping a comprehensive description of the intended function as they lack predictability and interpretability
Pilot Training and Licensing	▪ The need for a new eVTOL pilot's license and the training requirements for pilots are significant regulatory challenges. ▪ The industry needs to work with governments to establish clear training and licensing standards

Operational Challenges

Challenge	Description
Vertiports	▪ Management of vertiports operations inclusive of site selection, zoning, operational efficiency, security measures, etc.
Service Model	▪ Setting up ride scheduling and sharing network for users.
Charging station	▪ Managing various operational aspects of charging stations like Power Supply and Grid Capacity, standardization, charging technologies, etc.
Partner services	▪ Multimodal transportation – Integration with existing air and ground transportation systems

03 Key Players

Player Landscape (1/2) – As of 2024, the eVTOL market has amassed over $8 billion+ in combined funding among key players

Vertical Aerospace

VX4
(Total Funding - USD 265.1 Mn)

Volocopter

VoloCity
(Total Funding - USD 780.6 Mn)

Joby Aviation

S-4
(Total Funding – USD 2 Bn)

Eve Air Mobility

EVE
(Total Funding – USD 372 Mn)

Lilium

Lilium Jet
(Total Funding – USD 1.4 Bn)

Wisk Aero

Cora
(Total Funding – USD 450 Mn)

Archer Aviation

Midnight
(Total Funding – USD 1.1 Bn)

Beta Technologies

ALIA
(Total Funding – USD 1.1 Bn)

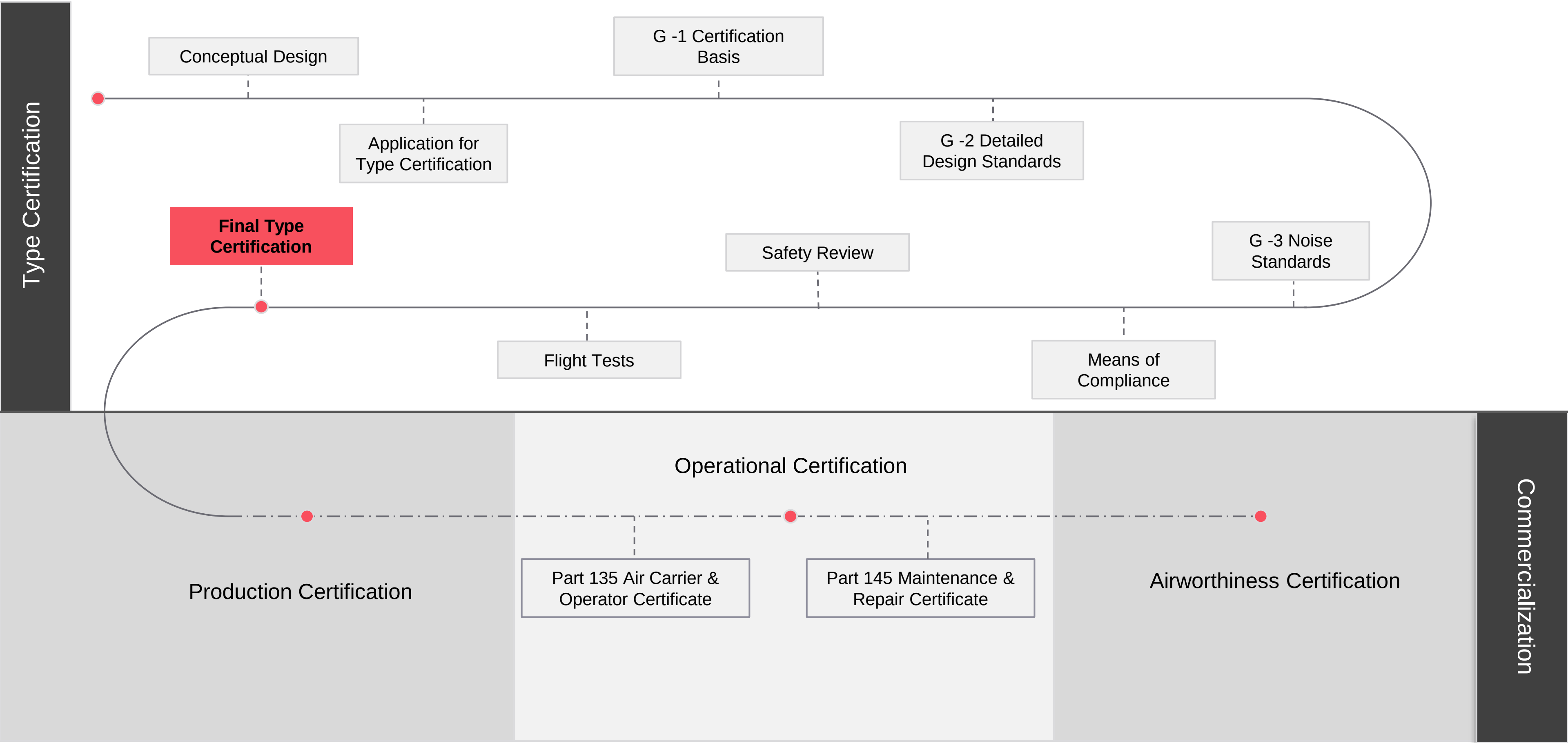
Player Landscape (2/2) – Current eVTOLs typically have a range of under 200 miles and can seat at least 4 passengers plus a pilot for non-autonomous flights

Pilot Passengers

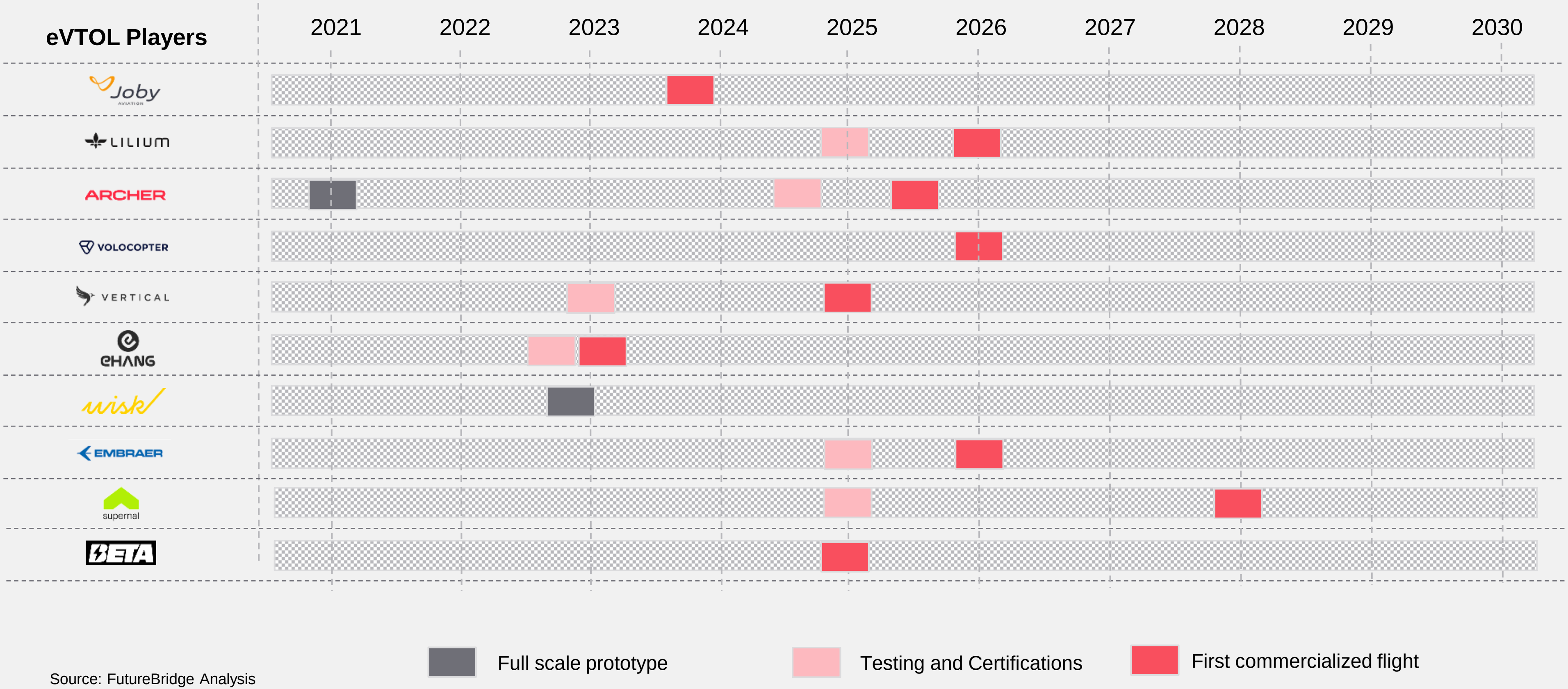
Company	Origin	Region	eVTOL	Power	Speed (mph)	Seating capacity	Range (Miles)	Recent Development
VERTICAL	2017	US	VX4	8 Electric battery-powered propulsors	150		100	March 2024: Second VX4 assembled for flight testing September 2022: First flew its full-scale demonstrator model, the VX4
VOLOCOPTER	2011	Germany	VoloCity	9 lithium-ion battery packs, brushless DC electric motor, 18 rotors	68		22	March 2024: Gets clearance from Germany's LBA civil aviation authority to start early serial production of VoloCity
Joby AVIATION	2009	US	S-4	6 Electric motors	200		150	June 2024: Acquires Autonomous Flight Tech developer Xwing
EVE MOBILITY REIMAGINED	2017	US	EVE	8 VTOL-only propellers, 2 pusher propellers powered by Electric motor			60	May 2024: Eve Air Mobility and Saudia Technic Sign MOA to explore MRO activities and eVTOL reassembly in Saudi Arabia May 2022: Goes Public with IPO in NYSE
LILIUM	2015	Germany	Lilium Jet	36 Electric motors and 1 MW lithium-ion battery	186		186	February 2024: Assembly of Lilium Jet Propulsion Systems Begins at Wessling, Germany
wisk	2019	US, New Zealand	Cora	12 Electric battery-powered lifting propellers	25		25	June 2023: Boeing takes full control of Wisk Aero
ARCHER	2018	US	Midnight	Battery-electric tilt rotor	150		60	June 2024: Receives Part 135 Operating Certificate permitting to begin on-demand commercial air taxi operations
BETA	2017	US	ALIA VTOL	4 vertical lift and 1 pusher propeller with electric motors	140		250	April 2024: Achieves first piloted transition flight with a prototype of its Alia 250 eVTOL aircraft prototype

04 Road to Adoption

Journey to Adoption – Necessary Certifications and Compliance



Commitments from eVTOL players on commercialization of their aircrafts



Source: FutureBridge Analysis

05 Industry Outlook

New markets are emerging as potential hotspots for eVTOLs

eVTOL aircraft are expected to have significant opportunities with high per capita income cities in specific countries that have severe traffic congestion

- Urban air mobility could become a reality well before 2030, especially where technology and regulations are advanced
- This would include cities like in New York, Los Angeles, Chicago, Montreal, etc.
- Residents of Saudi Arabia, UAE, Malaysia, and South Korea are also expected to be early adopters of eVTOLs once they are approved for use

Major countries with eVTOL developments

Saudi Arabia

NEOM and Volocopter Joint Venture (2023)

- To integrate with NEOM's multi-modal, zero-emission public transit system.
- Initial order of 15 Volocopter aircraft to start operations within 2-3 years.

Eve Air Mobility and flynas MoU

- Exploring eVTOL operations in Saudi Arabia, focusing on Riyadh and Jeddah by 2026.

UAE

Archer Aviation in Abu Dhabi

- Partnership with Abu Dhabi Investment Office (ADIO) to launch all-electric air taxi service in the UAE by 2026

Joby Aviation in Dubai

- Signed agreement with Dubai's Road and Transport Authority (RTA) to launch air taxi services by 2026
- Partnership with Skyports to develop vertiport infrastructure at Dubai International Airport, Palm Jumeirah, etc.

Malaysia

Feasibility study for vertiports deployment (2021)

- Collaboration between Malaysia Airports, Skyports, and Volocopter
- Focused on implementing air taxi services as part of the Sultan Abdul Aziz Shah Airport (LTSAAS) regeneration plan

AirAsia and Vertical Aerospace

- Plans to lease 100 Vertical's VX4 eVTOLs for urban air mobility service

South Korea

South Korea's first crewed air taxi test flight (2021)

- Conducted by Volocopter in Seoul as part of the comprehensive K-UAM roadmap

Vertical Aerospace and Kakao Mobility (2024)

- Pre-ordered 50 VX4 eVTOL aircraft for integrating it with its existing Mobility-as-a-Service platform

Eve Air Mobility and Jeju Air (2023)

- Released a concept of operations whitepaper for eVTOL flights on Jeju Island

Opportunities for Tier-1s/2s

The eVTOL (electric vertical take-off and landing) market is a rapidly emerging sector with numerous opportunities across various domains.

Partnerships and Collaborations

The eVTOL market is expected to see increased partnerships and collaborations between **battery manufacturers, eVTOL manufacturers**, and other stakeholders to develop and commercialize new battery technologies and solutions

Material development

The opportunities in material development arise from the unique requirements and challenges of eVTOL aircraft, which demand innovative materials for performance, safety, and efficiency. Few example areas for material development include **lightweight materials for body, advanced battery materials, high-strength alloys, acoustic dampening materials**, etc.

Scaling up

Given the current **limitations of aircraft Original Equipment Manufacturers (OEMs) in producing high volumes** of eVTOLs and their components, there are significant opportunities for other suppliers to scale up and meet the demands of this emerging market.

Aggregation Software

Aggregation software can serve several critical functions in eVTOLs by pulling together data from various systems, devices, and sources. The software can serve functions like **fleet management, ride-sharing platforms, customer service and booking, infrastructure coordination**, etc.

Thank you

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