

Unleashing Advanced Air Mobility

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UPPER AIR MOBILITY

HANDICAPPING THE UAM RACE

► REALITY RATING RANKS LEADERS IN THE UAM MARKET
► FACTORS INCLUDE FUNDING, TEAM CERTIFICATION PROGRESS

Graham Warwick | Contributor

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Seeing Through the Hype
The UAM Reality Index

Company	Market Cap	Funding	Team	Certification
Joby Aviation	\$1.2B	\$1.2B	High	High
Archer	\$1.1B	\$1.1B	High	High
Palantir	\$1.0B	\$1.0B	High	High
Other	\$0.5B	\$0.5B	Medium	Medium

It is not until you have seen an aircraft in flight that you can truly appreciate the complexity of the task. The same is true for the UAM market. While the industry is full of hype and speculation, the reality is that the market is still in its early stages. This report provides a reality check on the UAM market, ranking the top players based on their funding, team strength, and certification progress.

Joby Aviation leads the pack with a market cap of \$1.2 billion and \$1.2 billion in funding. The company has a strong team and is making significant progress in certification. **Archer** follows with a market cap of \$1.1 billion and \$1.1 billion in funding. **Palantir** has a market cap of \$1.0 billion and \$1.0 billion in funding. Other companies in the market include **Archer**, **Joby Aviation**, and **Palantir**.

The UAM market is still in its early stages, and it is important to look beyond the hype. The reality is that the market is still in its early stages, and it is important to look beyond the hype. The reality is that the market is still in its early stages, and it is important to look beyond the hype.

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THE FRONT RUNNERS

Joby Aviation, Archer, Palantir

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VELOCIPED

Joby Aviation, Archer, Palantir

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AVIATION AND VERTICAL

Joby Aviation, Archer, Palantir

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Old Meets New | The U-2's AI Co-Pilot | Air Cargo's COVID-19 Challenge

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PICKING THE UAM WINNERS



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AAM – Advanced Air Mobility – “It’s aviation, but not as we know it”

Missions: Passenger and cargo, piloted and unmanned

Markets: Urban, suburban, rural and regional – plus military

Technologies: Electric and distributed propulsion, fly-by-wire, connectivity, autonomy

Characteristics:

It is **not** traditional aviation

- competing with cars, buses, trains

It **is** commercial aviation

- some personal & general aviation

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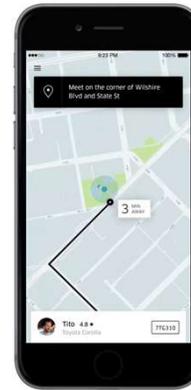


Part of a wider rethink of transportation – “mobility as a service”

Micromobility, ridesharing services and self-driving vehicles



Drone delivery, maglev, hyperloop, etc



Supersonic, hypersonic and suborbital transport



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So is it AAM or UAM...or RAM?

NASA calls it Advanced Air Mobility - AAM

AAM encompasses:

Urban air mobility – UAM = intracity

Regional air mobility – RAM = intercity

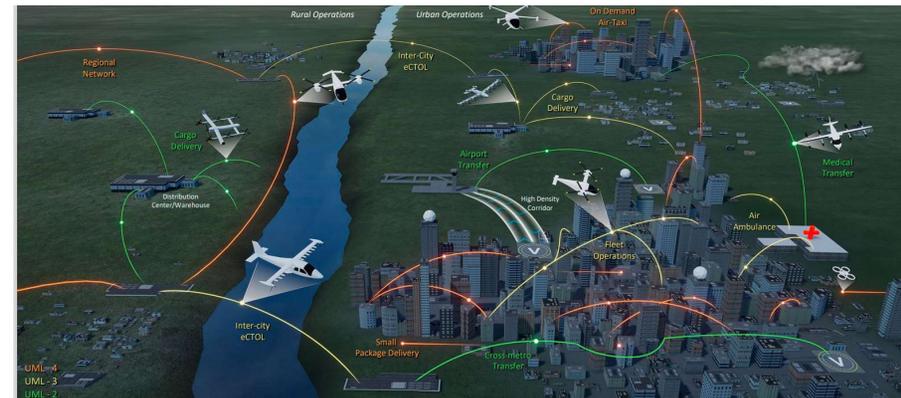
Logistics – drone delivery > regional cargo

Military – base security > personnel recovery

AAM involves:

eVTOL, eSTOL, eCTOL

where e = all-electric, hybrid-electric, hydrogen-electric



How big is the market?

How big could it be?

Roland Berger (Nov 20) - **passenger UAM** industry will generate annual revenues of \$90bn by 2050, with 160,000 commercial eVTOLs flying

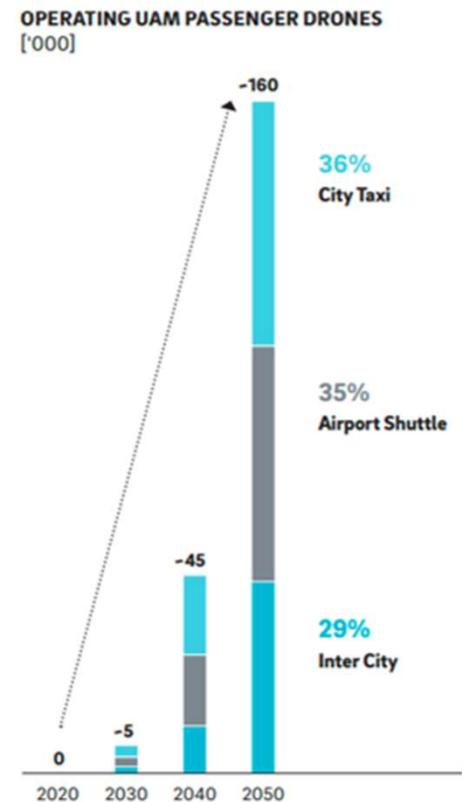
Deloitte/AIA (Jan 21) – **US AAM** market will reach \$115 billion annually by 2035, split between cargo (\$58bn) and passenger (\$57bn)

How big is that?

Global airline revenues \$840bn in 2019, taxi market \$300bn in 2030, public transport market \$1.1tn in 2030 – vs helicopter market \$48bn in 2018

How big is in now?

Zero* – but....investment in startups totaled \$907 million in first half of 2020, 20 times level in all of 2016. (* SPAC merger values Blade UAM at \$825m)



Source: Roland Berger

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Already bringing in the money

Investment:

EHang - public

Joby - \$820m (SPAC?)

Lilium - \$376m (SPAC or IPO?)

Volocopter - \$144m

Private – Archer, Kitty Hawk

US Air Force Agility Prime - \$32m – Joby, Beta, Lift, Elroy

Automotive interest:

Toyota - Joby

Daimler – Volocopter

Fiat Chrysler - Archer

Geely – Volocopter, Terrafugia

Who are the AAM players? Pick your market...

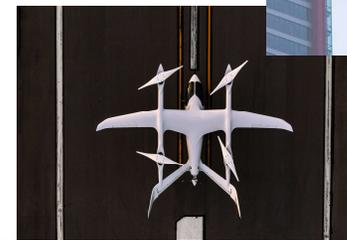
UAM (eVTOL)

EHang, Joby, Volocopter, Wisk, Hyundai, Eve, Jaunt, Vertical...



RAM (eVTOL, eSTOL)

Beta, Lilium, Electra, Dufour...



Regional (eCTOL)

Ampaire, VoltAero, ZeroAvia, Eviation...



Logistics (eVTOL, eSTOL)

Pipistrel, Elroy, Sabrewing, Airflow...



..plus many, many, many others...

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eVTOL – “It’s VTOL, but not as we know it...”

Different configurations:

Multicopter: Airbus, EHang, Volocopter

Winged: lift + cruise – Beta, Eve, Wisk

vectored thrust – Bell, Dufour, Joby, Lilium, Overair

- tiltduct, tiltwing, tiltprop, tiltfan, tiltrotor

...or a combination – Hyundai, Vertical

Different characteristics

Not hovering machines – only short periods of vertical flight

- impacts power demand, flight endurance

Distributed propulsion = redundancy. Complexity vs criticality

- influences safety and operating cost



...and it's not just eVTOL

eSTOL

Distributed propulsion and powered lift enable super-STOL capability



- operate from urban airstrips, fly regional ranges
- less demanding on batteries, easier to certificate



eCTOL

Use electrified propulsion to fly regional routes (up to 500 nm)

- lower operating costs and low/zero emissions



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How soon will we see AAM services?

What the industry is saying:

EHang – logistics 2020, passenger 2021

Elroy Air – certify, service 2022

Volocopter – certify end 2022, service 2023

Joby – certify end 2023, service by 2024

Lilium – certify end 2023, service in 2024-25

Airflow, Electra – in service c2025

Hyundai – cargo 2026, air taxi 2028, regional 2030+

Airbus, Bell – by 2030

“It’s closer than you think” – Uber Elevate (now owned by Joby)



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So, how soon will we see AAM services?

What the regulators are saying:

“Probably our first UAM/AAM aircraft to get certified will happen some time this year. [There are] probably two of three others right behind them”

“They really want to begin operations by 2023, for more testing, [and] commercial for-fee services around 2024.”

“[So] not long now.”

– *Jay Merkle, FAA, on Jan. 26 at Vertical Flight Society’s Electric VTOL Symposium*

Are we ready for AAM? The regulators

EASA

- SC-VTOL rule – July 2019
- means of compliance – May 2020

FAA

- three routes to certify AAM/UAM vehicles
 - Part 23 Amendment 64 (winged)
 - Part 27/29 (rotorcraft)
 - Part 21.17(b) (special class)
- certify operations under Part 91 or Part 135

CAAC

- JARUS SORA



**Federal Aviation
Administration**



Certification challenges - AAM vehicles are complex



◀ Volocopter VoloCity:

18 rotors, 9 battery packs, multi-redundant FCCs

▶ Joby S4:

6 tilting props, 4 battery packs, multisurface aero controls, unified flight control (F-35)



◀ Vertical VA-1X:

4 tilting props,
4 stop/stow lift rotors

▶ Lilium Jet:

36 ducted fans
On 12 tilting flaps



Advanced Air Mobility: Unleashing Technology

The level of safety question

EASA

SC-VTOL Category Enhanced
(commercial passenger transport):

- must meet requirements for
continued safe flight and landing
- probability of catastrophic failure $\leq 10^{-9}$
- commercial aviation level

FAA

“In terms of AAM, we are viewing those as the same level of safety as any other passenger aircraft, or any other manned aviation.”

“We believe the societal expectations for those aircraft are that they will operate will any other Part 21/23 aircraft with a Part 91 operation.”

– *Jay Merkle, FAA, on Jan. 26 at Vertical Flight Society’s Electric VTOL Symposium*

Are we ready for AAM? Other challenges...

Airspace

- Can begin with existing helicopter routes (eg airport shuttles)
- Can move to UAM corridors between vertiports (won't scale)

Infrastructure

- Can begin with heliports, repurposing parking garage roofs
- Need to develop dedicated vertiports (eg Lilium Orlando)

Community acceptance

- Must engage with local governments, transportation planners
- Large-scale demonstration programs will help (eg SESAR AMU-LED)

Scaling up

- The biggest challenge: across manufacturing, infrastructure, airspace, operations etc



...and risks

The market doesn't exist, at all

It exists, but stays a typical aviation market at 100s of units/year

It's huge, but is dominated by automotive, not aerospace players

It exists, but goes to China (as did drones, hence Agility Prime)

Questions?

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Presentation title

19

Backup slides

Presentation title

20

AAM, a market of opportunity, challenge...and risk

Pandora is out of the box. The convergence of automation, electrification and other commercial technologies that is enabling AAM is here to stay and will continue to disrupt aerospace

Past inflection points in aerospace technology saw the emergence and extinction of hundreds of new entrants, but new industry players did emerge (jet engine, GE; glass cockpit, Garmin)

It will happen again...

AAM demands high performance...at a low price point

Distributed propulsion, integrated flight and propulsion control, novel control architectures, simplified vehicle operation and high levels of automation/autonomy = high sensing and computing demands

eVTOLs are complex machines, but high levels of redundancy enabled by electrification reduce the criticality of individual system components - add to that the potential for large production volumes = potential cost savings

So is the AAM market an opportunity to introduce a new generation of products with higher performance capability at lower price points – with product architectures that can grow upward into more traditional aviation markets?

An emerging supplier base – but who are they?

Ones we recognize...



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And ones we don't...yet

