Talk Outline

The third wave of aeronautics
Advanced Air Mobility (AAM)
Enabling technologies
State of the industry
Challenges and barriers
Government investment
First 50 – disruptive technologies requiring constant adaptation
Second 50 – stable evolutionary optimizations based on decreased costs
Next 50 – transformation to an emergent system described as robust, scalable, adaptive, secure, safe, affordable, convenient, efficient, and environmentally friendly
  Potential to mirror other recent on-demand market revolutions
  Bring aviation into people’s daily lives
  Will require significant technology advancement

Aviation 3.0

The Third Wave of Aviation:

- Convergence of many industries, disciplines, communities, and cultures
- Increasing frequency of technical breakthroughs
- More collaborative, more distributed and connected, increasingly democratized
Four Transformations for Sustainability, Greater Mobility, and Economic Growth

ULTRA-EFFICIENT AIRLINERS

FUTURE AIRSPACE AND SAFETY

HIGH-SPEED COMMERCIAL FLIGHT

ADVANCED AIR MOBILITY
Advanced Air Mobility
Advanced Air Mobility (AAM)

Includes “rural” and “urban” applications
Cargo transport, pax-carrying, aerial work, etc.
eVTOL, sUAS, eSTOL, eCTOL, hybrid-electric, etc.
Urban Air Mobility (UAM) is a challenging use-case with high benefit

Enabled by electrification and automation

Does not include:
Supersonic or hypersonic transport
Existing hub-and-spoke air service with large transport aircraft

Safe, sustainable, affordable, and accessible aviation for transformational local and intraregional missions

Local mission < ~75nmi, and intraregional mission < ~300nmi
Drivers for Change

Increasing commute times
Advances in technology
Cloud networks and mobile devices support fleet management and customer interactions for on-demand service
Greater public acceptance of aircraft integrity and automation, ride sharing
Goals of sustainable aviation
What does Advanced Air Mobility (AAM) look like?

This air transportation system of the future will include low-altitude passenger transport, cargo delivery, and public service capabilities.
Advanced Air Mobility Mission

Safe, sustainable, affordable, and accessible aviation for transformational local and intraregional missions
Aerial Reach

24 hr weighted average
60 minute driving commute

Any time of day
~30 minute total commute
(~40 mi radius)

Any time of day
~60 minute total commute
(~100 mi radius)
AIA/Deloitte study shows annual estimated advanced air mobility market of $115B by 2035.
How much will it cost?

For a 5-mile air taxi trip, it would cost you $31 USD. (Uber $24-37)

Having a coffee delivered from your local coffee shop: $4.20+ USD.
Enabling tech & intro to VTOLs
New Enabling Technologies

Electric Propulsion Systems
- Reduce maintenance cost
- Zero direct carbon emissions
- Reduce fuel costs
- Reduce noise

Autonomous Systems
- Enables lower operating cost
- Argued to be safer in the long run

Scalable Airspace / UAS Traffic Management
- Enables heterogeneous air traffic to scale to 10,000s of simultaneous ops in an urban setting
- Envisioned to utilize services, information framework, data exchange protocols, software, and infrastructure for coordinated operations

Vanessa Aubuchon, NASA Langley, vanessa.v.aubuchon@nasa.gov
Introduction to eVTOLs

Electric vertical take-off and landing (eVTOL)
Hovers, takes off, and lands vertically
Cruises horizontally
Utilize a distributed electric propulsion system to turn smaller rotors, generally
One size does not fit all: Various concepts take advantage of different characteristics and benefits, depending on desired mission profile

Revolutionary Vertical Lift Technology Project
NASA UAM Reference Vehicles
https://sacd.larc.nasa.gov/asab/asab-projects-2/uam-refs/

Vanessa Aubuchon, NASA Langley, vanessa.v.aubuchon@nasa.gov
eVTOL characteristics & capabilities

Top speed: 100 - 200 mph
Range: 50-300 miles (some hybrid cargo configurations can go further)
Weight: 500-4000 pounds
Size: similar to car or General Aviation aircraft
Capacity: 2-6 people; 100-1800 lbs payload
Number of rotors: 1-36
Engine Output: ~40 kW (1-125 kW)
Battery Capacity: ~70 kWh (10-320 kWh)
Cruise altitude: 500-5,000 feet
Noise: 45dB cruise, 60 dB hover

Vanessa Aubuchon, NASA Langley, vanessa.v.aubuchon@nasa.gov
State of the industry
Domestic eVTOL air taxi manufacturers

Overair

Bell

Beta

Aurora

Wisk

Joby

Jaunt

Archer Aviation

Moog

*eSTOL – electric short take off and landing

Vanessa Aubuchon, NASA Langley, vanessa.v.aubuchon@nasa.gov
Foreign eVTOL air taxi manufacturers

- Urban Aeronautics (Israel)
- Airbus (France)
- Tetra (Tokyo)
- Eve Air Mobility (Brazil)
- Volocopter (Germany)
- Lilium (Germany)
- Vertical Aerospace (UK)
- Ehang (China)
- Supernal

Credit: Urban Aeronautics https://www.urbanaero.com/
Credit: Tetra https://www.tetra-aviation.com/company
Credit: Volocopter https://www.volocopter.com/urban-air-mobility/
Credit: Lilium https://lilium.com/network
Credit: Ehang https://www.ehang.com/article/
Credit: Alex Welsh https://www.wired.com/story/supernal-sa2-passenger-evtol/

Vanessa Aubuchon, NASA Langley, vanessa.v.aubuchon@nasa.gov
eVTOL air taxi interior

Ergonomic Seat
The leather-made seat design inspired by F1 sports car provides more comfortable support for your body during flight, rest, and enjoy.

Smart Operation
The dashboard is designed with two 3.7-inch screens that enable real-time interaction and monitoring. The new multimedia system integrates a variety of assist technologies including traffic info, weather forecast, satellite navigation, and flight modes, which are displayed in different tabs for more intuitive operation. Additionally, the three-touchscreen design ensures redundancy of the human-machine interaction system to ensure flight safety.

Credit: Alex Welsh https://www.wired.com/story/supernal-sa2-passenger-evtol/
Credit: Ehang https://www.ehang.com/ehangaav/design/
Autonomous regional cargo transport

MightyFly

Elroy Air

AmeriFlight & Merlin Labs

Vanessa Aubuchon, NASA Langley, vanessa.v.aubuchon@nasa.gov
Autonomy enablers

Reliable Robotics

XWing

Near Earth Autonomy

Vanessa Aubuchon, NASA Langley, vanessa.v.aubuchon@nasa.gov
Vertiport progress

Vanessa Aubuchon, NASA Langley, vanessa.v.aubuchon@nasa.gov
Small package delivery drones

Vanessa Aubuchon, NASA Langley, vanessa.v.aubuchon@nasa.gov
Drone deliveries around the world

Given the restrictive US regulatory environment, many companies are operating in other countries:

- DoorDash and Wing announced pilot program in 2022 in **Australia**
- Amazon piloting package delivery in the **UK, Italy**
- Zipline piloting medical supply delivery in **Rwanda**
- Tesco and Manna delivered 10k items in 2020 in **Ireland**
- Meituan made 170,000 food deliveries since 2021 in **China**
- UNICEF – humanitarian UAS corridor in **Malawi**

Drones regularly deliver packages in other countries around the world.

Vanessa Aubuchon, NASA Langley, vanessa.v.aubuchon@nasa.gov
Drone deliveries in the U.S.

North American only had a 15% share in 2023.

FAA’s BEYOND Program has opened some opportunities in US for last-mile delivery. Some BVLOS waivers granted; rulemaking ongoing.

- Walmart partnering with DroneUp, Flytrex, Zipline, Wing to deliver from 36 stores in seven states (75% of DFW by end of 2024)
- Amazon Prime Air making deliveries in CA and TX
- Wing delivering for Walgreen in VA and TX
- DroneUp delivering Chick-fil-A in FL

Commercial drone deliveries are projected to exceed 1 million in 2023.

-McKinsey & Company

Vanessa Aubuchon, NASA Langley, vanessa.v.aubuchon@nasa.gov
New operating paradigms

Goal: reduce or remove pilot training requirements, thereby increasing pilot pool, increasing the scale of the system, lowering operating cost, and eventually improving safety

New operating paradigms shift human role from providing decisions to providing intent

Simplified Vehicle Operations

- Simplify the pilot’s role in higher-level decision-making associated with the total operation of flight

Multi-Vehicle (m:N) Operations

- A small group of m operators manages a large group N of aircraft

Fully Autonomous Operations

- Human provide intent only, while aircraft and associated systems performs all flight functions, including contingencies

Vanessa Aubuchon, NASA Langley, vanessa.v.aubuchon@nasa.gov
Challenges & barriers
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Government investment
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**Air Force’s Agility Prime Programs**
- “Air Force’s transformative vertical lift program that is partnering with eVTOL commercial industry to propel the third revolution in aerospace and start to field a new class of air mobility systems by 2023.”

**NASA’s Advanced Air Mobility Mission**
- “Help emerging markets to safely develop an air transportation system that moves people and cargo between places previously not served or underserved by aviation – local, regional, intraregional, urban – using revolutionary new aircraft…”

**Federal Aviation Administration (FAA)**
- including FAA and UAM in planning efforts
- collaborating with NASA on AAM National Campaign
- developed and shared UAM ConOps version 1.0

Vanessa Aubuchon, NASA Langley, vanessa.v.aubuchon@nasa.gov
NASA’s Advanced Air Mobility Work = Benefits to You

EMERGENCY RESPONSE

HEALTHCARE

AUTOMATION

VERTIPORTS

TRAVEL TIME

NOISE

INFRASTRUCTURE

FUTURE AIRSPACE

SAFETY

RIDE QUALITY

CARGO DELIVERY

ACCESSIBILITY
In closing...
Key messages

We are living through the third great revolution in aviation. The future is very exciting! Advanced Air Mobility is a key motivator for many new technologies that aim to make our lives better.

There is significant investment in AAM and a large projected economic value. Our daily lives will be impacted by these technologies within our lifetime. Your coffee, Tylenol, and Chipotle will be delivered via drone very soon!

Vanessa Aubuchon, NASA Langley, vanessa.v.aubuchon@nasa.gov
Want to Learn More?

NASA’s AAM website: nasa.gov/aam

NASA’s Advanced Air Mobility Playbook series: in both English and Spanish. Video series and corresponding web articles. Season one in English is live here: https://www.nasa.gov/feature/nasa-is-creating-an-advanced-air-mobility-playbook/

OSTEM content: Students can engage with the principles of AAM in a variety of ways — including hands-on STEM activities, coding activities, math lessons, and more. https://www.nasa.gov/aeroresearch/stem/AAM

Public events: NASA participates in various air shows, conferences, and events each year. Stay tuned to social media to learn more: https://twitter.com/nasaaero
thank you.