Infrastructure to Support Advanced Autonomous Aircraft Technologies in Ohio

An Economic Impact Analysis
Draft Report | May 26, 2021
Project Team

Project Lead & Project Manager

• Experts in advanced air mobility and intermodal transportation, air traffic management, advanced aerospace
• Three decades of experience working with aviation innovators

Geospatial Mapping & Impact Analysis

• Boutique investment bank and corporate advisory firm with 14 years project financing experience serving the aerospace and UAM industries

Supply Chain Insights & Stakeholder Outreach

• Intimately involved advancing small UAS and AAM technologies in the United States
• Leading UAS and artificial intelligence initiatives for the state of Ohio

KEY VALUE ADD

National leader in integrating and implementing AAM technologies

KEY VALUE ADD

Geospatial Mapping, Business Case Opportunity Analysis, and Economic Impact Assessment

KEY VALUE ADD

Technology insight and subject matter expertise in aerospace supply chains
The Challenge
A transportation system that is sustainable, efficient, affordable

• Surface traffic operations costs: $12 billion/year*
  o Urban traffic congestion costs: $4.6 billion/year
  o Safety costs: $3.9 billion/year
• Vehicle traffic increasing (8% since 2000 vs. population up 3%)

* Modernizing Ohio’s Transportation System: Progress and Challenges in Providing Safe, Efficient and Well-Maintained Roads, Highways and Bridges, TRIP, June 2018
The Opportunity

Advanced Air Mobility (AAM)

• Moves people and cargo between places not conveniently served by surface transportation and underserved by aviation.

• Enables smart multimodal transportation connecting urban areas and regions
The Opportunity

Small Unmanned Aircraft Systems (sUAS)

- Increase operating efficiencies
- Increase safety
- Decrease environmental impacts
- Open new markets and lines of business
The Project
Assess the Economic Impact of a Robust AAM Landscape Serving Ohio

• Forecast potential benefits of AAM systems and services through 2045
• Advise Ohio how it can capitalize on this market opportunity
Methodology

- Interview and survey key stakeholders
- Assess and inventory demographics and existing infrastructure
- Develop highest potential AAM and sUAS use cases
- Model operating and capital expenditures and revenues
- Forecast potential economic impacts of AAM: GDP growth, added jobs and tax revenues
Robust Assets Developing an AAM/sUAS-Ready Ohio

Ohio Department of Transportation – funder/regulator
  • Drive Ohio/Ohio UAS Center – one-stop shop for AAM
  • Remote Tower Project – implementing cost-effective alternative to rural-to-urban AAM air traffic control
  • Vertiport Planning Project – with NASA Ames, to identify locations within Ohio’s largest cities
  • Ohio UAS Traffic Management (UTM) – developing framework for managing lower-altitude airspace
  • Skyvision – with Air Force Research Laboratory, providing ground-based detect-and-avoid capabilities
  • 33 Smart Mobility Corridor – real-world proving ground for autonomous transportation
  • Combined Aircraft Sensor Network Project – detecting and tracking lower-altitude aircraft
  • NASA AAM National Campaign – one of five U.S. entities to address community integration for AAM
  • JobsOhio – economic development/workforce agency
Four Supply Chains Required for AAM

- **Tier 0/OEM**: AAM Ground Infrastructure Operators, Tier 0/OEM
- **Tier 1**: Heliport Contractors, Infrastructure Funds, Composites, Etc.
  - PSU - Traffic System Operators
  - Assembly Modules, Motors, Batteries, Avionics, Etc.
  - ATC Systems Integrators, Radars, RFID, Etc.
  - PSU Subsystems, Beacons, Comms and Components, Etc.
- **Tier 2**: Airspace Designers, Structural Engineering, Transport Planners Etc.
  - eVTOL Developers and Manufacturers
  - eVTOL Operators and Governments
- **PSU**: PSU Subsystems, Beacons, Comms and Components, Etc.
  - Electronic Components, Software Programs, Etc.
  - Maintenance Services and Capabilities, Pilots, Etc.
  - Training Facilities, Etc.
Geospatial Mapping of the State of Ohio

- Geographic Boundaries
- Waterways
- Bridges
- Property Boundaries
- Roads
- Logistic Corridors
- Surface Logistics Centers
- Water Ports
- Public Lands
- Hospitals
- Blood Banks
- Clinics
- Airports
- High Resolution Airport Facilities Maps
- Heliports
- Military Bases
- Government Buildings
- Transmission Lines
- Electrical Sub Stations
- Traffic Congestion
- NASA Facilities
- Sports Venues
- F1000 Corporations
- Major Manufacturing Facilities
- Part 91 Facilities and Aircraft
- Part 135 Facilities and Aircraft
- Universities and Colleges
- Shopping Centers
- Music Venues
- Zoning Districts (Limited)
- Etc.
Logistics Corridor Analysis
Supporting Cargo Movement and “Last-Mile” Deliveries

- **I-75** – Toledo to Cincinnati though Dayton
- **I-80** – Northwest (Edon) to Northeast (Hubbard) though Toledo and Cleveland
- **I-71** – Cleveland to Cincinnati though Columbus
- **I-70** – Southwest (New Paris) to Southeast (Brideport) through Dayton and Columbus
- **US-33** – Central West to South Central through Columbus
Most Likely AAM Uses
Moving Cargo and People

- On-Demand Air Taxi
- Regional Air Mobility
- Airport Shuttle
- Emergency Services
  Medical Air Ambulance
- Corporate/Business Aviation
- Cargo & Freight Delivery
Most Likely sUAS Uses
Efficient, safe, affordable deliveries and operations

- Transportation Infrastructure Inspection
- Agriculture & Livestock
- Airport Infrastructure Inspection
- Package Delivery
- Utility Infrastructure Inspection
- Medical Non-Passenger Transport
- Law Enforcement & Public Safety
Passenger Economic Modeling

**Inputs**
- City Demographics
  - Population and Density
  - GDP per Capita
  - Age Distribution
  - Airline Enplanements
  - Congestion
  - Taxi Fleets and On-Demand
  - Public Transport
  - Emergency Facilities
  - Airports and Heliports
  - Corporate HQs
  - Business Aviation Fleets
- Infrastructure Costs
  - Nominal Heliport or needed vertiport Facilities
  - Passenger Handling
  - PSU Systems
  - ANSP Interfaces
- Vehicle & Supply Chain
  - OEM Fleets
  - Electric/Hybrid/Hydrogen
  - Battery and Charging
  - Power Grid
  - Supply Chain and MRO
- Demand Assumptions
  - Phasing
  - Pricing
- Regulatory and Community Constraints
  - Noise
  - Safety
  - Public Perception

**Assumptions/Drivers**
- Ground Infrastructure Inputs
  - Heliports/Vertiports
  - Airport Terminals
  - Vehicle Charging Systems
- AAM Service Demand Elasticity
  - Emergency
  - Airport Shuttle
  - Air Taxi
  - Campus
  - Regional
  - Cargo
  - Personal
- eVTOL Manufacturing Supply Chain
  - 7 Vehicle Types
    - Piloted
    - Autonomous
  - Comm/Nav/Surveillance
  - NOCI
  - Automation Systems
- PSU Infrastructure Inputs
  - Revenue/P/L Model
  - Balance Sheet
  - Cash Flows
  - CAPEX
  - Investment
  - Service Model

**Modeling and Analysis**
- City PPP Model
  - Revenue/P/L Model
  - Balance Sheet
  - Cash Flows
  - CAPEX
  - Investment
- UAM P135/121 Operator Model
  - Revenue/P/L Model
  - Balance Sheet
  - Cash Flows
  - CAPEX
  - Investment
  - Service Model
- PSU Service Model
  - Revenue/P/L Model
  - Balance Sheet
  - Cash Flows
  - CAPEX
  - Investment
  - PSU Infrastructure

**Outputs**
- Business Case Dashboard
  - City PPP Model
  - AAM Ops Model
  - PSU Model
- Economic Impact
  - Direct
  - Indirect
  - Induced
  - Catalytic
- Tax Revenues
  - Federal
  - State/Provincial
  - Local
  - Sales Taxes

**Findings**
- Business Viability
- Private Investment Likelihood
- Affordability
- Public Acceptance
- What is the outlook for 84 of the most significant metropolitan areas globally, and what policy, technology, and financial issues will individually define their success?
- What will be the plan, and the minimum investment to move these urban areas to the tipping point of success?
- What is the expected size of AAM markets over the next 25 years, but especially the next 5?

**Emergency Services**
- Medevac
- Facility to Facility
- Search and Rescue
- Surveillance and Traffic

**Business Aviation**
- Mobility Configurations
- Utilization Strategies
- Benefits
- Shareholder Value

AAM Financial/Economic Tools

A NEXA Capital Company
Assumptions

Vehicle Assumptions
• Max Payload - 1 Ton
• Min Payload – 50 lbs
• Operational Cost per F/H - $717.19
• Annual Trips/Vehicle – 1,825
• Vehicle Lifespan – 5 years

Commodity Assumptions
• Only Time-Sensitive Goods
• Only High-Value Goods
• Commodity Weight Class between 50-1,000 lbs

Inputs

Ohio Actual Air Freight Totals
4.9 M Tons of goods over 25 years valued at over $464B

Ohio Actual Truck Freight Totals
8.9 B Tons of goods over 25 years valued at over $10.2T

Filters

Time Sensitive Commodities
• Pharmaceuticals
• Precision Instruments
• Machinery
• Electronics
• Perishables

Commodity Weight Classes
• 0-50 lbs
• 50-250 lbs
• 250-500 lbs
• 500-1,000 lbs
• 1,000+ lbs

Commodity Value Classes
• Low Value <$1K
• Medium Value $1-5K
• High Value $5-20K
• Very High Value $20K+

Constraints

Exogenous Factor Constraints
• Infrastructure Availability
• Industry Adoption
• Variable Modes
• Vehicle Supply
• Emerging Technology

Findings

• $2.1B in Revenue over 25 years
• 1.2M Tons of Cargo
• $5.5B Value of Goods Transported
• 2.5M eVTOL Cargo Trips
What can Ohio expect to gain over 25 years if you invest in AAM?
AAM Economic Forecast by Five-Year Phase
$13 Billion of Economic Activity Generated Over 25 Years

2020-2024: $0.4B
- Passenger Revenues: $0.1B
- Vehicle Purchases: $0.08B
- Cargo Revenues: $0.11B
- Ground Infrastructure (CAPEX/OPEX)
- PSU Infrastructure (CAPEX/OPEX)
- Emergency Services Revenues

2025-2029: $1.4B
- Passenger Revenues: $1.3B
- Vehicle Purchases: $0.1B
- Cargo Revenues: $0.08B
- Ground Infrastructure (CAPEX/OPEX)
- PSU Infrastructure (CAPEX/OPEX)
- Emergency Services Revenues

2030-2034: $2.2B
- Passenger Revenues: $1.9B
- Vehicle Purchases: $0.3B
- Cargo Revenues: $0.08B
- Ground Infrastructure (CAPEX/OPEX)
- PSU Infrastructure (CAPEX/OPEX)
- Emergency Services Revenues

2035-2040: $3.9B
- Passenger Revenues: $3.7B
- Vehicle Purchases: $0.2B
- Cargo Revenues: $0.08B
- Ground Infrastructure (CAPEX/OPEX)
- PSU Infrastructure (CAPEX/OPEX)
- Emergency Services Revenues

2041-2045: $5.1B
- Passenger Revenues: $4.8B
- Vehicle Purchases: $0.3B
- Cargo Revenues: $0.08B
- Ground Infrastructure (CAPEX/OPEX)
- PSU Infrastructure (CAPEX/OPEX)
- Emergency Services Revenues
Projected Operator Revenues by CSA
$7.1 Billion Over 25 Years
Passenger Traffic by CSA
7.2 million total Ohio passenger trips by 2045
AAM Cargo Revenues by Logistics Corridor
$2.1 Billion over 25 years
Ohio AAM Will Require 81 Vertiports Over 25 Years

**Vertiport by Type**

- Remediation
- Unserviced Vertipad
- Serviced Vertiports
- Airport Multiport

**Vertiport by CSA and Phase**

- Phase 1 (2020-2024)
  - Akron: 14
  - Cincinnati: 16
  - Cleveland: 16
  - Columbus: 22
  - Dayton: 9
  - Toledo: 4

- Phase 2 (2025-2029)
- Phase 3 (2030-2034)
- Phase 4 (2035-2040)
# Ohio sUAS Use Cases – Efficiency Benefits Eclipse Economic Returns

## Use Cases Table

<table>
<thead>
<tr>
<th>Use case</th>
<th>Description</th>
<th>Key Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructure – Bridges, Highways, Tunnels</td>
<td>• Mapping and visual inspections for structural integrity</td>
<td>• Less traffic congestion</td>
</tr>
<tr>
<td>Infrastructure – Airports</td>
<td>• Runway debris and perimeter inspections</td>
<td>• Lower risk of aircraft accidents</td>
</tr>
<tr>
<td>Infrastructure – Powerlines, Tower, Pipelines</td>
<td>• Visual and thermal inspections for leaks, incursions, damage</td>
<td>• Improved worker safety</td>
</tr>
<tr>
<td>Law Enforcement &amp; Public Safety</td>
<td>• Crowd control, event monitoring, fire fighting, search &amp; rescue, reconnaissance</td>
<td>• Increased safety for the general public</td>
</tr>
<tr>
<td>Agriculture &amp; Livestock</td>
<td>• Crop &amp; herd monitoring, seeding, fertilization</td>
<td>• Enhanced food security</td>
</tr>
<tr>
<td>Package Delivery</td>
<td>• Movement of consumer packages</td>
<td>• Less road traffic</td>
</tr>
<tr>
<td>Medical Non-Patient Delivery</td>
<td>• Transport of organs, blood, lab specimens, pharmaceuticals</td>
<td>• More lives saved more quickly</td>
</tr>
</tbody>
</table>

## Observations:
- Benefits include:
  - Efficiency
  - Productivity
  - Cost savings
  - Enhanced data quality
  - Work-safety mitigation
  - Improved environment

**Observations:**

**- Benefits include:**
  - Efficiency
  - Productivity
  - Cost savings
  - Enhanced data quality
  - Work-safety mitigation
  - Improved environment
Robust Economic Forecast Developed Using IMPLAN

**4 AAM CAPEX and OPEX Supply Chains**

**Example Components**
- Vertiports
- Battery Charging Stations
- Security
- Shelter
- Amenities

- ATC Towers
- ANSPs
- Beacon & Radar
- Surveillance
- Counter-UAS
- Detect & Avoid Systems
- GPS
- Weather Sensors

- Helicopter Operators
- Medical Services
- Airport Shuttle
- Regional Transport
- Cargo Delivery
- Tourism
- Heli Skiing

- Vehicle Manufacturers
- Battery Technology
- Hydrogen Power
- Propulsion

**Direct Industry Impact**
- Air Transportation
- Other Transit
- Travel Services
- Taxi & Limo Services

- Air Transportation
- Other Transit
- Architectural, Engineering, & Related services (AE&R)

- Air Transportation
- Other Transit
- B2B Electronic Markets
- Taxi & Limo Services
- Ambulatory Services
- Travel Services
- AE&R

**Indirect Industry Impact**
- Data processing, hosting, and related service
- Telecommunications
- Energy production and transmission
- Real estate services
- Computer systems design & related services
- Financial investment services, funds and other financial vehicles

**Catalytic Impacts**
- Accelerated demand for alternative power sources such as Hydrogen
- Improved labor market efficiencies
- Acceleration in STEM funding and educational opportunities
- Suburban/rural access

**Induced Industry Impact**
- Miscellaneous Spending of direct and indirect employee wages
  - Logistics
  - Hospitality
  - Tourism
  - Etc. Etc.
Ohio’s GDP can grow by $11.4 billion
1.63% increase by 2045

Figures are additive
New and existing AAM-related businesses can create 15,000 new jobs by 2045

Top 10 Occupations *(Not in order)*
- AAM Operational Support (Maintenance, etc.)
- AAM Operators (Pilots, etc.)
- Business and Financial Operations
- Engineering, Intelligent
- Hospitality
- Transportation Systems
- Medical and Supporting Services
- Services
- Travel Support Quality Control and Safety Engineering
- Vehicle Design and Manufacturing
- Other
Beneficial Catalytic Impacts of AAM and sUAS

**Improved Labor Market Efficiencies**
Improving the mobility of the labor market will better match employees to employers.

**Improved Suburban/Rural Connectivity**
AAM will link rural and urban areas, better integrating Ohio’s economy and improving opportunities.

**Accelerated STEM Funding and Educational Opportunities**
New academic programs built around the AAM industry will support its growth and understanding.

**Accelerated Demand for Alternative Power Sources such as Hydrogen**
The growth of AAM will spur growth in energy R&D alternative sources to power AAM.
Potential AAM Challenges and Barriers

Challenges/Barriers

• Interoperability standards
• Capital and venture investment
• Infrastructure investment
• Market demand
• Public acceptance
• Privacy
• Environmental impacts such as noise
• Property rights

Noise Recommendations

• Create a center of excellence for conducting field acoustic measurements
• Incentivize companies to fly their sUAS and AAM systems at the center to generate data
• Advocate for state-funded research on AAM noise
• Advocate for/support noise surveys along key transportation arteries
• Guide noise policy making and outreach to local communities
• Conduct community noise annoyance surveys and pilot programs
Recommendations
How Ohio Can Capitalize on AAM

1. Develop a policy, infrastructure, and R&D roadmap for **statewide AAM** implementation.

2. Launch a robust, **targeted program** of studies, demonstrations, pilot programs and local AAM planning initiatives.

3. Demonstrate Ohio’s **national leadership** in AAM leveraging projects underway and starting.

4. Position Ohio to **attract participants** within each of the four supply chains for the AAM industry.
AAM Market Opportunity Over 25 Years

$13B
Economic Activity

15,000
Additional Jobs

$2.5 Billion
Tax Revenues
Questions?