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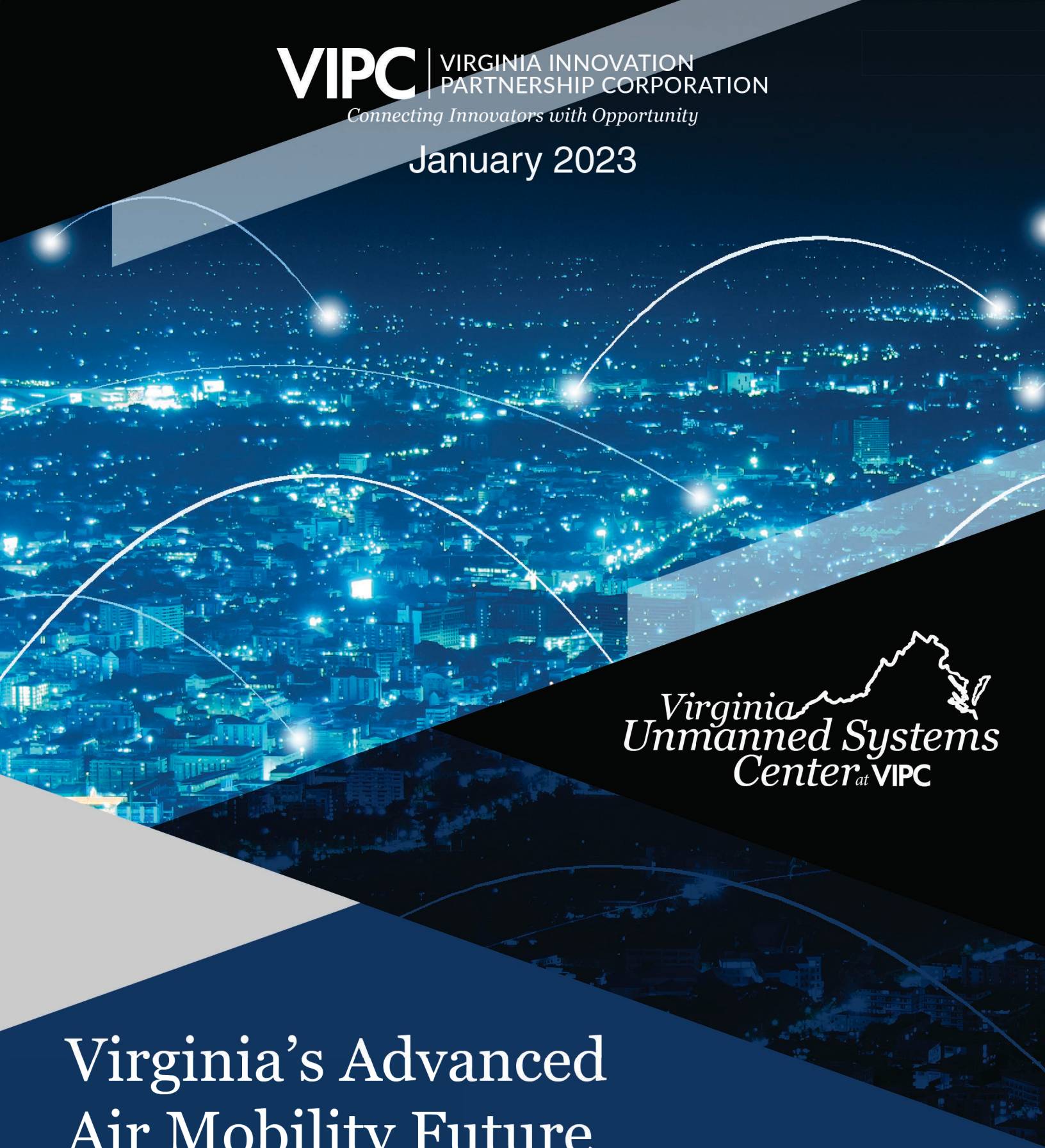

Virginia Unmanned Systems Center at VIPC

Virginia's Advanced Air Mobility Future

AAM's economic benefit for the Commonwealth

This AAM white paper was commissioned by the Virginia Innovation Partnership Corporation (VIPC) and The Office of the Secretary of Commerce and Trade

Norfolk, Virginia

Preface

This is an economic impact study focused on new air transportation and technology options called Advanced Air Mobility (AAM), which will have transformative societal and economic benefits. Additionally, it is an exploration of how the Commonwealth of Virginia may become a leader of AAM in North America, with the opportunities and challenges involved in being among the first.

Audiences are legislators, municipal and government agencies, transportation and social policy experts, the aviation and tech industries, research organizations, the media, universities, community leaders and, most significantly, residents of the Commonwealth of Virginia.

SPONSORS

This paper was commissioned by the Virginia Innovation Partnership Corporation (VIPC) and the Office of the Secretary of Commerce and Trade. VIPC creates technology-based economic development strategies to accelerate innovation, imagination, and the next generation of technology and technology companies. VIPC, a non-profit corporation, bridges gaps at the earliest stages of the innovation continuum.

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We also wish to thank the many, companies and agencies throughout the Commonwealth of Virginia who contributed information and perspectives to this project.

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Executive Summary

A new form of mobility will soon transform the lives of Virginia residents, businesses, educators, agencies, and public safety personnel. Advanced Air Mobility (AAM) uses electric Vertical Takeoff and Landing (eVTOL) aircraft, electric Short Takeoff and Landing aircraft (eSTOL), hybrid electric and hydrogen Regional Air Mobility (RAM) vehicles, and small uncrewed aerial systems (sUAS), often known as drones, to perform countless tasks not traditionally performed by existing aircraft and in airspace not traditionally used.

Within a few years, passengers will take short, quiet, carbon-free flights within cities and suburbs, and between rural airports and urban centers. They will also fly between city pairs and rural airports at awkward distances currently not served by airlines, hopping on quick flights from Winchester, Blacksburg, Charlottesville, and Chesapeake to places like Washington Dulles Airport, the Capitol at Richmond, or downtown Washington, DC.

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Further down the road, the public will be able to order an air taxi using a phone “app” to fly them to their desired local airport destinations much like today’s road-based Uber.

AAM will also save lives by quickly and efficiently transporting critically ill patients to hospitals, and drones will support Commonwealth Public Safety and quickly deliver organs, blood, and medical supplies. Fire and police departments will use it to support incident awareness and dispatch the proper ground response. AAM will bridge the rural-urban divide, allowing individuals who live at greater distances from metropolitan areas to commute more easily for better-paying jobs and to have new AAM jobs within their own communities.

The new technology will enhance tourism and efficiently ship high-priority cargo. And AAM will energize businesses, universities, and students in technical fields. With diligent preparation, Virginia will become a center for multi-dimensional mobility, boosting its current aerospace and drone industry and attracting manufacturers and investment from around the country.

This comprehensive study illuminates the opportunities and challenges the AAM industry presents as it continues to rapidly evolve. In addition to exploring the social, business, and economic benefits, we also investigate the various uses of these aircraft to transport people and cargo, and perform a variety of functions for police, fire, forestry, agriculture, package delivery, and inspections.

In 2022, the Virginia Unmanned Systems Center at VIPC established the Virginia AAM Alliance (VAAMA), a collaboration between VIPC and the Virginia Department of Aviation, which has brought together nearly 100 stakeholders from across the Commonwealth. VAAMA members are experts in aerospace, business, government, transportation, economic development, real estate, logistics, academia, and healthcare, individually and focus groups. These leaders are contributing their expertise and vision for AAM, with its many benefits to government, businesses, universities, and residents. This study utilizes VAAMA members' insights, and details the methods used to arrive at its findings for jobs, revenues, and overall economic impact.

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Systems Center at VIPC is dedicated to stakeholder
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capabilities and fostering collaboration among the abundant industry, academic and government resources
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Tracy Tynan,
Director,
Virginia Unmanned Systems Center at VIPC

We estimate in the next 23 years some 66 million passengers in Virginia are expected to have traveled using new eVTOL services since their introduction. About 7.7 million passengers per year, or over 21,000 passengers per day, are forecasted by the 2041-2045 time period.

According to our findings the economic impact and benefits to the Commonwealth of Virginia by the AAM industry (through 2045) will:

- Generate $16 billion in new business activity and related stimulus, in part by integrating AAM vehicle and related manufacturing into the state.
- Add 10% or more to the growth of Virginia's existing aerospace sector.
- Produce $2.8 billion in local, state, and federal tax revenues.
- Create over 17,000 new full-time aerospace industry and other jobs in the Commonwealth.
- Bring employment and educational opportunities to all regions of the Commonwealth. including underserved and economically challenged areas.

In addition to the economic benefits outlined in this study, we have recommended eight (8) specific actions and follow-on steps. These steps will support the promising job number as well as accelerate AAM adoption and opportunity growth:

- The Commonwealth of Virginia should promptly appoint a Virginia AAM Executive Director to oversee, coordinate, and drive programs and policies to benefit the state's emerging AAM industry.
- Plan, implement, and operate an MVI (Minimum Viable Infrastructure for air traffic management), enabling the approval of BVLOS (Beyond Visual Line of Sight) operations in opportune Virginia regions. This MVI would be funded utilizing a PPP (Public Private Partnership) structure that demonstrates limited, targeted capital investment that can demonstrate near-term benefits and therefore be supported by affordable user fees in the future. Currently, FAA regulations require drones to operate within Visual Line of Sight (VLOS).
- Invest resources in multiple AAM/sUAS development regions as test environments, tapping local facilities (airports, heliports, test ranges), companies, and agencies currently active in each sector.
- Attract and facilitate OEMs (Original Equipment Manufacturers) of AAM aircraft along with supporting supply chains.
- Organize Virginia's public use airports to ready themselves for the advent of Regional Air Mobility and to support MVI services for AAM in their respective regions, as well as to serve as community engagement resources.
- Continue to expand statewide STEM programs to promulgate future AAM/sUAS workforce development.
- Incorporate Washington, DC as part of Virginia's overall AAM business case, exploring partnerships to add catalytic benefits to Virginia state economic totals.
- Introduce a Digital Twins and Immersive Technologies "living laboratory" to accelerate AAM evolution and benefits, covering key Virginia jurisdictions such as NOVA, DC, Hampton Roads, Southside, Eastern Shore, Shenandoah Valley, etc.

Each of these recommendations will have strong and direct positive impacts on job creation, driving overall sector sustainability, improved public service and healthcare outcomes for residents, a shrinking rural-urban divide, and in many cases, equitable statewide benefits.

Figure 2- NASA is helping set the stage for rapid introduction of electric aircraft into XUEDQ DQG UHJLRQDO PDUNHWV

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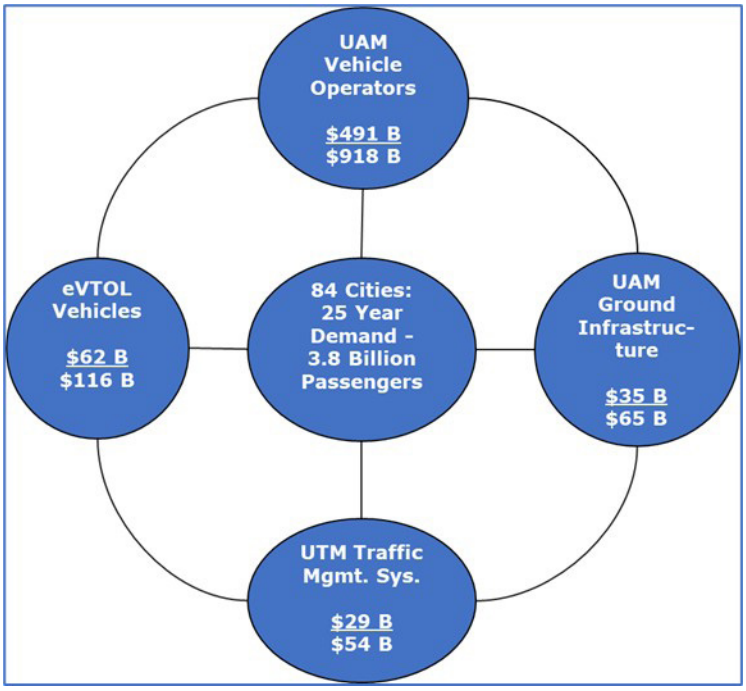
Advanced Air Mobility is a new concept of air transportation that moves people and cargo between places not conveniently served by surface transportation or underserved by aviation—local, regional, intra-regional, urban—using revolutionary new aircraft that are only just now becoming possible. AAM covers manned and unmanned aircraft including electric Vertical Takeoff and Landing (eVTOL) aircraft and electric Short Takeoff and Landing aircraft (eSTOL), and Small Uncrewed Aircraft Systems (sUAS), also known as drones.

The new AAM aircraft are possible due to state-of-the-art technologies—from lithium-ion batteries to light-weight electric motors, advanced composites, aircraft flight automation processes, and safety systems. According to industry, lithium-ion batteries may fly these aircraft for 200 miles before a recharge. Some of the first aircraft may be hybrid, propelled by a combination of batteries and fuel for longer-range trips. At some point further in the future, hydrogen fuel cells will be an alternative.

AAM will make use of unused airspace. Unlike commercial aircraft, which operate at higher altitudes, it is likely that AAM aircraft will fly below 4,000 feet, and sUAS will fly below 1,000 feet.

Market analysis performed by Morgan Stanley, Goldman Sachs, and others forecast a global opportunity worth more than $1 trillion through 2045. UAM Geomatics estimates over $11 trillion globally (see figure below) with much of this business flowing into the regions most eager to adopt this new technology.[1] With considerable direct AAM industry support from NASA and billions of dollars currently committed by the aerospace sector, the stage is being set for AAM at the local and state levels across the US.



Many metropolitan regions are planning to introduce AAM pilots in the next few years—including Singapore, Munich, Paris, Dubai, Vancouver, Los Angeles, Orlando, and Dallas—as a strategic solution to mitigating sprawl and congestion. For this reason, these new mobility options were originally called Urban Air Mobility. However, the new technology will also bring numerous benefits to rural areas: new jobs, revenues, economic opportunities, short local flights across the state, improved access to quality healthcare, and expanded Medevac rescue, to name a few. Given its many uses in both urban and rural areas, the name has evolved to become Advanced Air Mobility.

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[1] www.nexa-uam.com

AAM and NASA National Campaign

The NASA Advanced Air Mobility National Campaign, announced in 2020 and going strong today, is designed to promote public confidence and accelerate the realization of emerging aviation markets for passenger and cargo transportation in urban, suburban, rural, and regional environments. NASA defines the term "Advanced Air Mobility" as the development and deployment of aviation in transformative and innovative manners to provide aerial mobility in ways not typically seen today. NASA's vision for AAM is that it:

- Is safe, sustainable, accessible, and affordable aviation for transformational local and intra-regional missions.
- Includes the transportation of passengers and cargo as well as aerial work missions, such as infrastructure inspection, disaster response, or search and rescue operations using sUAS.
- Includes local missions of about a 50-mile radius in rural or urban areas, and intra-regional missions of up to a few hundred miles that occur between urban areas, between rural areas, or between rural and urban areas.

Important to the future success of NASA's AAM National Campaign is the close collaboration and involvement of the Federal Aviation Administration (FAA). Much of what is happening today throughout the Commonwealth of Virginia is influenced heavily by NASA and FAA programs, which give the industry an improved technical as well as policy framework as AAM concepts become reality.

"Advanced Air Mobility is an emerging industry WKDW ZLOO EHQH¿W RI WKH &RPPRQZHD creating opportunities for innovation leadership, regional connectivity and job FUHDWLRQ ´

Bob Stolle,
President & CEO, Virginia Innovative Partnership Corporation

The Leading Virginia Advanced Air Mobility Use Cases

This section discusses AAM applications that will provide the most significant benefits to Virginia residents, businesses, and other stakeholders. AAM for Virginia must be properly scaled, tailored, designed, and cost justified with a solid business case in mind.

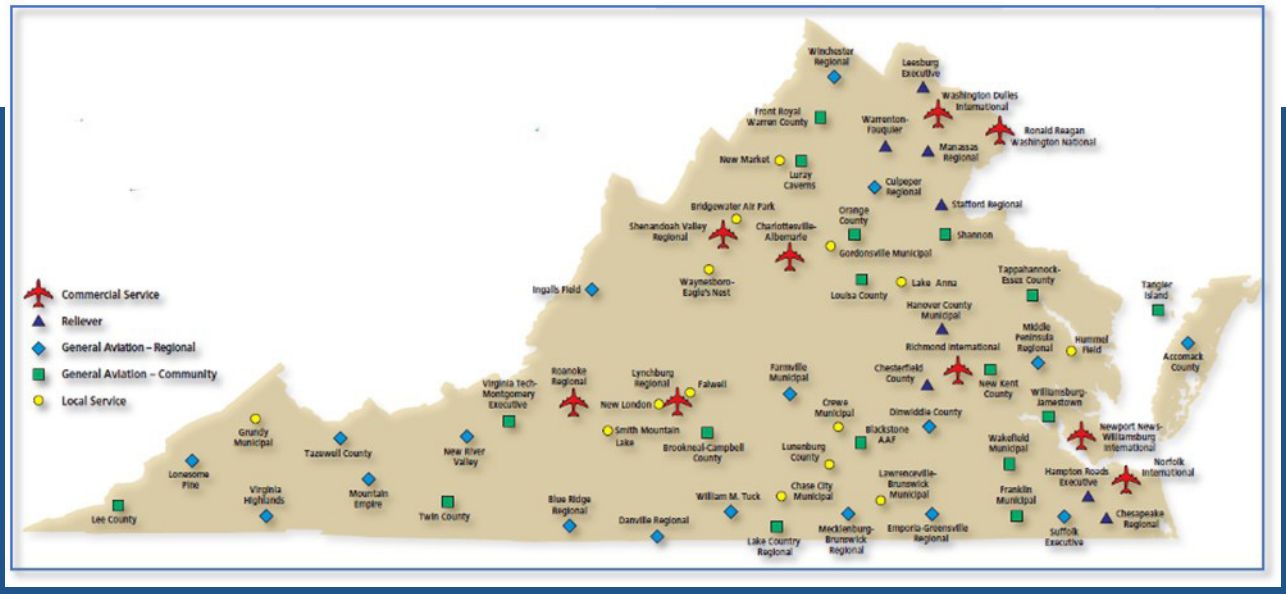
For all use cases, we must bear in mind that Virginia has a wide range of weather: severe thunderstorms, hurricanes, snowstorms, high winds, and ice storms are possible. While these meteorological phenomena affect all transportation modes, the initial AAM aircraft and operations will be more sensitive to operational disruption than existing ground, aircraft, and helicopter operations. Business cases developed for such AAM operations, including the one this report will present for Virginia, will need to factor in these weather patterns as well to account for a reasonable financial impact of this reality. The industry will need to collaborate with companies

such as Tru Weather, headquartered in Reston, Virginia, a micro-weather data and analytics company which collects and translates diverse weather data sets, and through an analytics engine, translates weather data into targeted insights and actionable decisions for weather sensitive industries such as AAM.

Regional Air Mobility

Many cities in Virginia find themselves at awkward travel distances from each other. Flights of less than 150 miles are often hard to come by and expensive as they are often not viable for current commercial carriers. If they are available, travelers ask if it is worthwhile to drive to the airport, park, take the bus to the terminal, go through security, wait, and hope the flight takes off on time. Travelers from Northern Virginia to Virginia Beach, for instance—a 200-mile distance with inconvenient air service—resign themselves to a three-and-a-half-hour drive with no traffic, and four or five hours if there is road work or an accident. The same can be said for military officials and defense contractors shuttling between the Norfolk-Hampton Roads area and the Pentagon. Regional Air Mobility—scheduled short flights on eVTOL and eSTOL aircraft—would offer a convenient new option for such journeys. Imagine hopping on a flight from Tysons Corner to downtown Richmond, or Hampton Roads to Roanoke, or Newport News to the Pentagon, and arriving in a fraction of the time it would take to drive.

Virginia has 66 public use airports (see figure below), of which only nine are used by commercial airlines. The two largest are in Northern Virginia: Dulles International Airport with 24.8 million passengers in 2019 and Ronald Reagan National Airport with 23.9 million. The other 57 airports are GA (General Aviation) facilities, used for a variety of purposes such as agricultural operations, medical services, flight schools, and business aviation. The traditional business model of airlines is to avoid short flights and smaller cities, but many airlines, such as Delta, Virgin, United, American, and others have placed orders for small, less expensive AAM aircraft to expand their markets from the inconvenient and ubiquitous hub and spoke system.



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Airports are economic drivers. Together, Dulles and Reagan airports brought $9 billion to area businesses in 2017 alone. In 2016, Virginia's 57 GA airports directly or indirectly supported more than 6,100 jobs, with earnings (including sole proprietorships) of roughly $360 million, total gross domestic product of nearly $560 million, and total economic output of nearly $1.1 billion. Despite these figures, only a few of these GA airports, such as Manassas Regional Airport (HEF), 40 miles from Washington, DC, are functioning at high capacity. Most others are greatly or somewhat underutilized.

According to the 2015 Virginia Air Transportation System Plan Update, nearly 95 percent of Virginia's population live within a 30-minute drive of one of the Commonwealth's public use airports. By developing a network of RAM services at underutilized GA airports, the state could provide public convenience as well as significant regional economic development in terms of new jobs, improved workforce mobility, taxes, and overall economic productivity.

Examples of public use airport initiatives in AAM are evident throughout the state. In the southeast corner of the state, Hampton Roads Executive Airport (KPVG), a privately-owned public use facility, covers 664 acres and has 600,000 square feet of existing and "under construction" buildings, with another 300,000-400,000 buildable square feet approved by federal and state environmental agencies. In addition, the aviation and warehousing/storage complex contains surplus land for another 1.2 million square feet of aircraft testing and manufacturing facilities. Some 100 federal facilities are located within thirty miles of the airport as well as a major port complex ten miles to the east. Leading private employers such as Amazon's new 3.5 million square-foot distribution facility, Target's cross-dock facilities, and Towne Bank's headquarters are located just 3-10 miles to the north. The airport sits at the intersection of four major highways and one major rail line.

Hampton Roads Executive Airport (see figure below) already embraces the future of AAM and is currently planning for a dedicated passenger vertiport (eVTOL landing and takeoff area), electric charging stations, and a hydrogen fuel depot, as well as BVLOS radar surveillance capabilities, in addition to the building infrastructure. "Our mission is to be at the cutting edge of the transition to new AAM vehicles, as a Research, Testing and Training Complex (RTTC)," according to Steve Fox, General Manager. "We then see our airport as an all-inclusive hub, using these new eVTOL aircraft for three things: passengers, cargo, and medical supplies. We want to become a Regional Air Mobility hub for flights to DC by 2025, servicing the many Department of Defense (DoD) facilities in Hampton Roads. So many people take the arduous drive to the Pentagon and back… A safe, clean and fuel efficient AAM flight could be 30 minutes."

Figure 5- Hampton Roads Executive Airport is located next to WKH DFUH *UHDW 'LVPDO 6ZDPS DQ H[DLUFUDIW WHVW ÀLJKWV

Another example of a forward-looking regional airport is Winchester Regional Airport (OKV), 80 miles west of Washington, DC (see figure below).

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Management have taken several steps to reposition this 375-acre facility for Advanced Air Mobility by:

- Creating meaningful partnerships. The OKV Airport Authority board of directors and staff are represented on several state-level working groups and committees and have also fostered direct relationships with entities involved in policy discussions around AAM, including NASA Langley Research Center, National Renewable Energy Lab (NREL), Rappahannock Electric Cooperative, George Mason University, and Laurel Ridge Community College.
- Leveraging industry expertise. According to General Manager Nick Sabo: OKV has sought guidance from an AAM manufacturer to help inform the design of a replacement terminal building, referred to as the “Airport Terminal of the Future.” The building will be ready to accommodate Regional Air Mobility operations, including eVTOL and CTOL (Conventional Takeoff and Landing) aircraft used for myriad applications (e.g., passenger, cargo, air ambulance) as well as host MVI for AAM.
- Incorporating AAM concepts into capital planning processes. OKV is considering AAM implications at the design phase for all capital projects, for instance, installing spare conduit

wherever an electric aircraft is likely to park in the future and data communications for AAM vehicles. OKV is also drafting a policy document that describes how the Airport Authority will address AAM in the next 10 years including sustainable fuels, alternative fuels (e.g., hydrogen), sUAS integration, and aerospace workforce development.

- Becoming a knowledge resource for the community. In terms of community integration, OKV intends to step into a leadership role in the Winchester regional community to become not only advocates for the new technology, but also to become a resource to educate leaders on new economic development opportunities and aeronautical capabilities.

Regional Air Mobility will generate significant benefits to these and other airports and their surrounding communities. Those that prepare for AAM as early adopters will further optimize the payback and speed returns.

Airport Shuttle

Major commercial airports in Virginia such as Washington Dulles International, Washington DC Ronald Reagan National Airport, Richmond International Airport, and Norfolk International Airport currently serve over 50 million passengers annually. These airports and their major airlines will be among the first users of AAM as they already have most of the infrastructure required. Departing passengers will board an eVTOL shuttle at a downtown vertiport or at carefully chosen locations throughout the region and arrive at the airport quickly, without the hassle of parking or taking a long taxi ride. Similarly, arriving passengers will take a shuttle from the airport to downtown or to a vertiport close to their home or office.

Shuttles could depart at scheduled times or could be on-demand. Airlines such as United, Delta, Virgin Atlantic, and many others are already in the early planning stages for eVTOL airport shuttles to serve large metropolitan areas. Some airlines are already ordering prospective aircraft and making investments in those companies.

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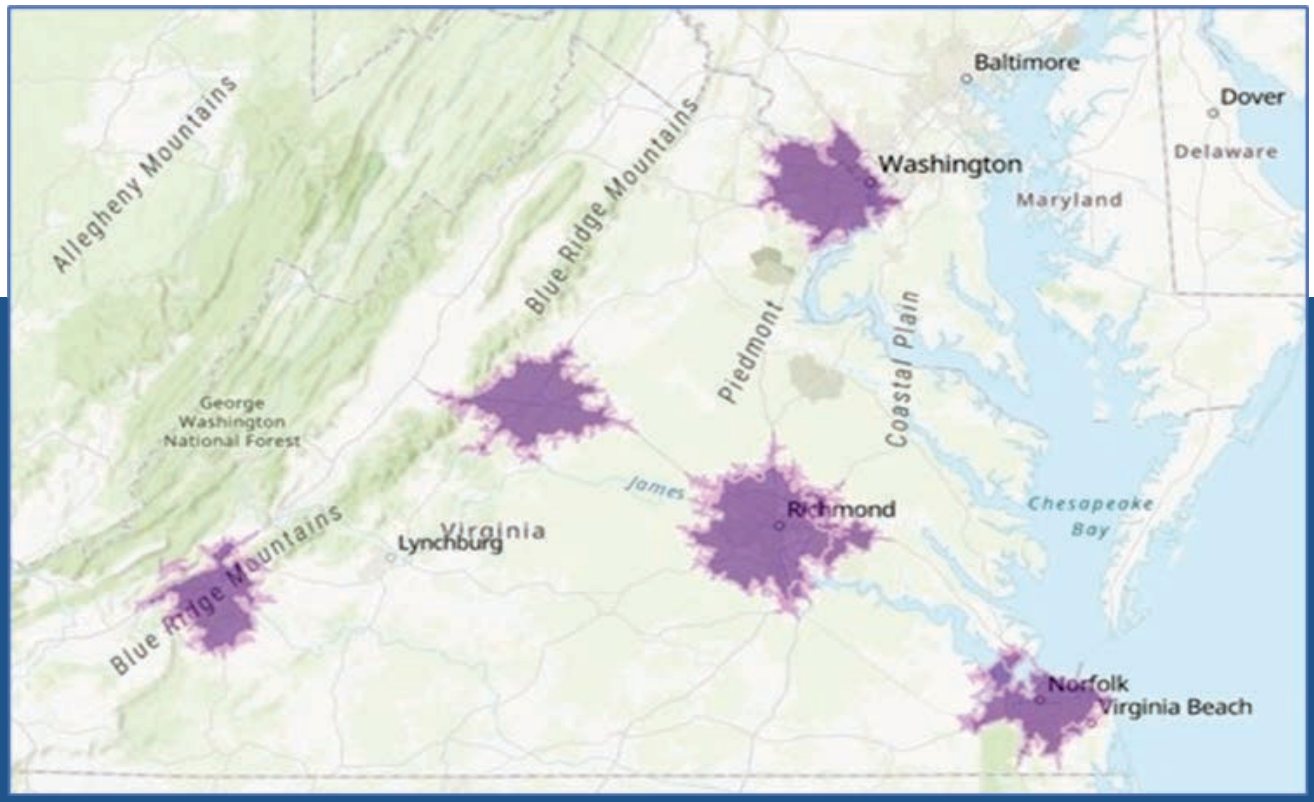
Medevac and Healthcare Missions

AAM—in the form of passenger-carrying eVTOL aircraft—will improve healthcare outcomes and efficiencies across the Commonwealth. eVTOLs will transport critically ill or injured patients to Level 1 trauma centers, of which Virginia has only six out of 102 hospitals: two in Norfolk, the others in Charlottesville, Richmond, Roanoke, and Fairfax (see figure below). While Medevac helicopters save countless lives, they are expensive (the average cost in the US is between $25,000 and $30,000 per trip, which insurance often does not cover) and noisy, which limits their use in hospitals located in residential neighborhoods. Given their limited number, Medevac helicopters might not always be available or, if they are, might take too long to reach seriously ill patients in rural parts of the state. It is likely that eVTOL aircraft—much quieter and less expensive than helicopters—will expand Medevac use, saving lives and the Virginia hospital system as well as patients a great deal of money.

AAM Medevac will meet an even greater need if rural Virginia hospitals close down, as predicted by national policy experts at the Center for Healthcare Quality and Payment Reform (CHQPR). Of the state's 28 rural hospitals, most of them in the south or southwest, CHQPR found that thirteen are continually in the red with too few patients to remain profitable. Five are at risk of immediate closure.[2]



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[2] "Study: Up to a Third of Rural Hospitals Are at Risk of Closure." Richmond Times-Dispatch, January 7, 2023.
[3] Business Aviation Embraces Electric Flight - How Urban Air Mobility Creates Enterprise Value, NEXA Advisors 2021

Corporate and Business Aviation

Companies across the nation have long benefited from business aviation. Increased mobility satisfies management's need for greater organizational agility, knowledge integration, and transaction speed. Profitable companies create jobs, stimulating the regional economy. The business aviation community is actively discussing adding Advanced Air Mobility options to their corporate flight departments.[3]

Virginia has hundreds of private aircraft located mostly at executive and regional airports across the state, particularly in Northern Virginia and the Hampton Roads-Norfolk area. eVTOL aircraft will solve the "middle mile" or "door-to-door" challenge, complementing a corporate flight department's existing aircraft with electric or hybrid aircraft capable of moving a team of key people quickly from the home office to a meeting in the city center, or to an outlying airport to depart on a business aircraft or scheduled airline flight. In addition to last mile trips, companies that have numerous business locations within Virginia—trips within the limited range of eVTOLs—could use AAM aircraft between facilities, allowing greater coverage and more frequent visitation at reduced cost.

On-Demand Air Taxi Services

Given the stress drivers put on Virginia's roads, it is not surprising that despite the state's best efforts some roads are deteriorated and congested, costing Virginia drivers a total of $9.5 billion each year. The Virginia Department of Transportation (VDOT) has calculated the additional vehicle operating costs (VOC) to the average motorist in the state's largest urban areas as a result of driving on rough roads, the cost of lost time and wasted fuel due to congestion, and the financial cost of traffic accidents. The chart below details the cost of deficient roads statewide for the average driver in the state's largest urban areas.

Location	VOC	Safety	Congestion	Total
Hampton Roads	$684	$317	$758	$1,759
Northern Virginia	$485	$83	$2,015	$2,583
Richmond	$512	$349	$641	$1,502
Roanoke	$361	$457	$510	$1,328
VA Statewide	$2.8 Billion	$2.1 Billion	$4.6 Billion	$9.5 Billion

While large cities have traditional public transportation systems such as metro, bus, taxi, and Uber/Lyft, AAM would provide similar services but with faster response and transportation time. Travelers could order an aircraft on their phone, go to the nearest vertiport, and fly over city traffic to their destination in a few minutes.

One intriguing concept is the deployment of air taxis in a particular urban area of demand. Rather than being town or county specific, an AAM-based air taxi service could cover a 60-mile radius in a selected region and fly anywhere in that radius in less 30 minutes for pickup. These can be in rural areas, perhaps at the county seat, or suburban areas around the larger cities.

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Some eVTOL OEMs are projecting that on-demand, electric air taxis could be flying short hops over major cities as soon as 2026. According to company executives, investor materials, and a NASA study, for short hops each eVTOL passenger might pay from $2.25 per mile to as much as $11 per mile, depending on several factors. For example, using the lower range of cost, a flight from Tysons Corner, VA to Baltimore-Washington International (BWI) Airport could cost $75.

Tourism Services

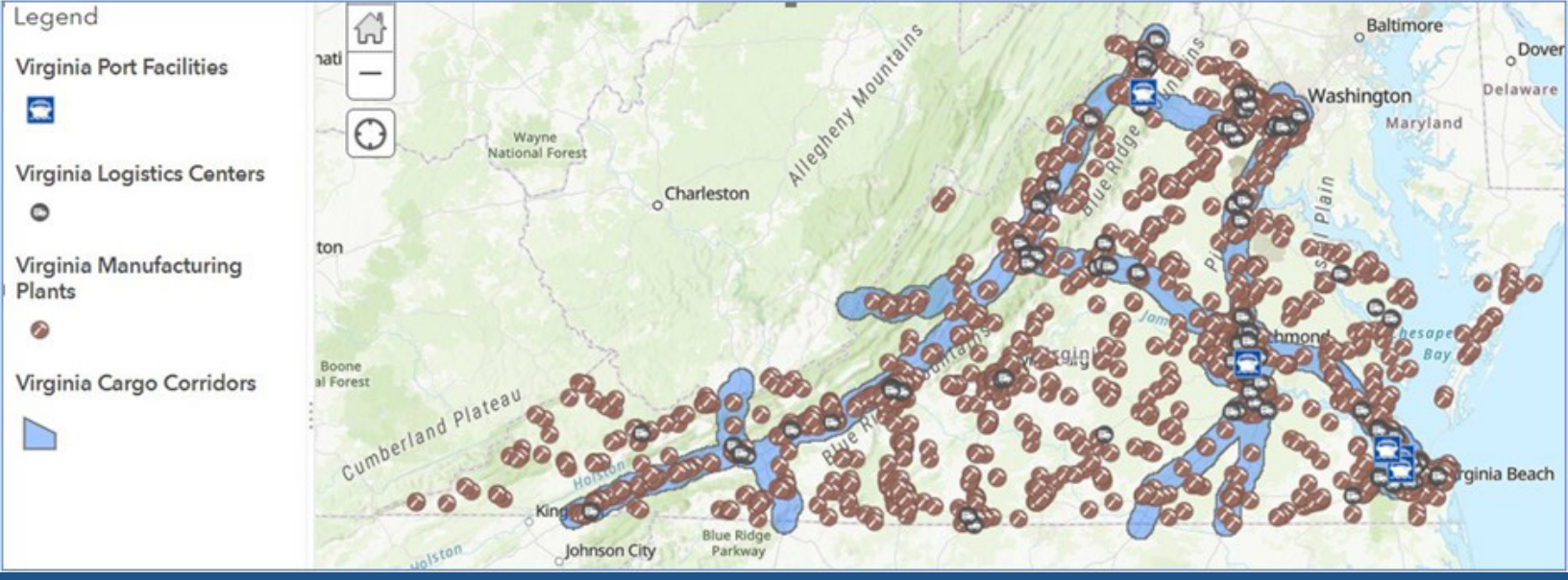
In 2019, Virginia's tourism industry generated $27 billion in visitor spending, supported 237,000 jobs, and contributed $1.8 billion in state and local revenue. Tourists spent an average of $73 million a day in the state.

The use of eVTOL aircraft for tourism will bring more visitors and their dollars to the state which is already a national tourism magnet for its colonial, Revolutionary War, and Civil War history, its 22 national parks and 42 state parks, the Blue Ridge Mountains, and popular Atlantic beaches. Using Regional Air Mobility, tourists could easily visit top attractions across the state in a few days, flying from Virginia Beach, to Washington, DC, to the Shenandoah.

Transport, Logistics, and Cargo

Virginia enjoys an excellent cargo transportation infrastructure with a good highway system with truck terminals, multiple railroads with yards, and intermodal facilities, river ports, and many airports. The proximity to distribution centers such as Walmart, UPS, USPS, FedEx, and others is also advantageous.

Virginia has already invested in major logistics hubs such as the Port of Virginia and the Virginia Inland Port along major logistics routes. AAM can provide a wide swath of cost-effective benefits covering consumers and businesses, and the many supply chains dependent upon logistics, and extend and leverage these investments, driving additional return on existing Commonwealth investment. Virginia has several prominent cargo logistics corridors, generally along freeways and rail lines, that support industries uniquely dependent upon efficient cargo delivery. The state's industries will continue to build out infrastructure along its main logistics corridors such as I-81, I-95, I-64, and I-77. These routes will see a high demand for time-sensitive cargo to be flown to many destinations between cities or factories. The map in the figure below identifies one dimension of this—manufacturers and their proximity to the cargo corridors, which can be a challenge for delivery of time-sensitive materials.



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The Leading Virginia Small Uncrewed Aerial Systems Use Cases

Virginia has already developed a national reputation for sUAS testing and applications, as it is home to the Virginia Tech Mid-Atlantic Aviation Partnership, one of seven FAA test sites across the country and many of the leading industry providers. sUAS use cases will create thousands of new permanent full-time jobs as well as provide safety, convenience, and efficiencies in the years ahead.

Small Package and Medical Delivery

Small packages are already being delivered within Visual Line of Sight (VLOS). Headquartered in Virginia Beach, DroneUp is a leading drone delivery platform and drone services provider currently working with Walmart to create 34 drone hubs in six states at selected stores. As of December 2022, delivery services were operating in Arkansas, Florida, Arizona, and Texas, with Virginia and Utah to come online soon. Drones deliver more than 10,000 items up to ten pounds in as little as 30 minutes for a delivery fee of $3.99. Naturally, this initial market will break wide open as soon as the FAA permits BVLOS.

DroneUp is also active in the medical delivery market. According to the company's Practice Director for Medical Services, "We are really excited to be working with multiple health systems, emergency services, and medical partners to stand up drone delivery services for critical medical applications throughout the US. Those use cases include the transport of urgent lab specimens, medications, and supplies across hospital campuses, clinical lab networks and even direct to patients in home health programs or emergency situations.

"DroneUp has seen an increased demand to adopt consumer-driven models within healthcare even before the pandemic, but with the advent of major supply chain issues caused by COVID-19, there was an acceleration across the industry to adopt new transportation solutions. Drone delivery will allow hospitals to optimize staff resources, expand their courier service and ultimately improve patient outcomes through faster, more accessible care. Families will be able to leverage the convenience of 30-minute secure, contactless prescription delivery. And when seconds count, emergency services can rapidly deploy lifesaving medications and equipment to individuals in need. There is an incredible

opportunity before us to put in place the Advanced Air Mobility infrastructure and regulatory framework that will unlock these essential services for our communities and the public. These applications have in common small packages of under 5 or 10 pounds, relatively short “last mile” distribution and time-sensitive delivery. Today, roughly 85 percent of retail deliveries are under 5 pounds. We expect package delivery to make up a large segment of future drone missions, with retailers such as our partner Walmart, expanding drone delivery as a service nationwide. Other major retailers and quick service restaurants are in the process of evaluating drone delivery as well. Express package companies including FedEx and UPS are well along in their plans. Because package delivery in Virginia numbers over 1 million items per day, drone delivery promises to cut costs while increasing customer desires for such conveniences.”

The Commonwealth of Virginia has the opportunity to further support the growth of sUAS delivery, and companies like DroneUp, through limited, targeted investment in MVI that produces focused public data services that allow operators to scale services more efficiently and more cost-effectively. For example, additional micro-weather services would allow operators to make more informed flight decisions, expansion of advisory services in the Virginia Flight Information Exchange to assist in planning and ground compliance, and provision of targeted situational awareness services to support FAA BVLOS approvals.

Richmond, Virginia

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Dave Bowles,
Executive Director, Virginia institute for
Spaceflight & Autonomy

Infrastructure Inspections

sUAS are ideally suited to inspect bridges, highways, tunnels, telephone lines and poles, electric transmission wires, substations, utility poles, pipelines, cell phone towers, smokestacks, and wind turbines. Drone inspection causes less traffic congestion and manpower than workers in a truck taking up a lane, while also improving worker safety.

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Virginia has 21,241 bridges that need to be inspected regularly by qualified VDOT personnel, as well as 40,000 towers for high voltage power, and 44 million feet of high-power transmission lines, equivalent to over 8,333 miles[4]. These lines are constantly in the weather and should be inspected at least once every three years[5]. Currently, they are inspected by crews of three using a cherry picker to lift the workers up. The three-man crew spends one to three hours doing each inspection. Those companies using drones for such inspections report that each tower can be imaged within one hour. We estimate approximately 13,000 operations a year for this segment only, not counting the inspection of transmission lines, which is done by airplanes or helicopters.

sUAS are also quite efficient at inspecting airports for security purposes and locating debris on runway' perimeters that might cause an accident. Workers are no longer required to venture out onto the runway in between flights to search for debris.

Agriculture, Forestry and Timber Management, and Waterway Inspections

sUAS are already used to inspect the health of agriculture, forests, and waterways. Virginia has more than 43,000 farms, which cover more than 8 million acres, and some 16 million acres of forest. In 2018, the state's agriculture and forestry exports were valued at nearly $3 billion. The lower half of the Chesapeake Bay separates mainland Virginia from its Eastern Shore and is source of ecological importance and economic activity.

For agricultural use, sUAS aircraft will detect and pinpoint wildfires—which can quickly consume entire fields. They will monitor soil moisture, pests, and herds, and deliver pesticides to keep weeds and pests from destroying crops. In forests, they will monitor for fires, tree health, illegal logging, harvest, clear-cut inspections, and pests, and will drop "dragon eggs" to safely initiate controlled burns and create a containment line in the event of a wildfire.

[4] ESRI GIS database
[5] Interviews with utility companies

Drones will monitor the Chesapeake Bay for pollution, fish die-offs, illegal fishing, algae blooms, wildlife, and floods.

Public Safety, Law Enforcement, and First Responder Support

The application of sUAS for local, state, and federal public safety applications is obvious and presents many potential advantages that helicopters and airplanes do not. They are far less costly and complex, can be launched much faster—in as little as a minute or two—are less conspicuous with lower noise levels, and have a much smaller environmental impact. The city of Chula Vista, CA has one of the longest standing “drone as a first responder” programs and has clearly demonstrated value in reduced dispatch, shorter response time, and lives saved. Virginia has already made early investments in these kind of capabilities with funded “state asset” public safety UAS programs through York County Fire Department and Harrisonburg Fire Department.

There are currently 339 law enforcement agencies, 556 registered fire departments, and 7 regional emergency management offices in Virginia[6]. Some of the local public safety agencies currently don’t use drones while others have multiple drones. These drones have EO/IR cameras mounted beneath them and are flown by trained operators[7]. They are used to provide vital overwatch for fire, hazmat, and rescue operations; support wide area search and rescue; support vehicle accident response; track suspects, and assist with crowd control. Such an aircraft covers more ground than an officer at greatly reduced risk to both the officers and the public.

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“Drones offer significant emergency responder advantages at a very low cost,” said Chris Sadler, Director, Public Safety Innovation Center, Virginia Innovation Partnership Corporation. “They help find missing persons such as runaway juveniles, lost toddlers, and wandering Alzheimer’s patients. They have assisted police in murder cases by looking at areas of suspicion to find a potential burial site. In cases of drownings, they work with the Coast Guard to find bodies in areas such as under piers, boat houses, duck blinds, and other covered areas where personnel in a helicopter cannot see. Additionally, the rotor wash of helicopters sometimes disturbs water too much at low altitude to see what’s in the water.”

Chris Sadler explained that sUAS assist with armed barricade situations and SWAT warrant serving. In terms of a fire, ladder truck crews often just point the hose to the roof without really being able to tell where the flames are through the smoke. A drone flying overhead could send the live footage to the firefighter’s cell phone to assist with better placement of water streams. The use of a thermal imaging sensor on a drone offers a great tactical advantage, as well as firefighter overwatch due to its ability to see personnel and critical situations during night and/or through heavy smoke environments. For example, the drone can easily detect hazards such as fuel storage tanks so that these hazards can be identified and classified while minimizing risk of life to firefighters.

“It has been said that emergency response use of drones will become standard in the next few years, and anyone not using them may be considered negligent,” he added. “Right now, BVLOS rules are holding up more expanded and advantageous emergency/life-saving use. I want to see automatic drone response. For rescue use, I want to see drones located at strategically located places around the community, at fire and police stations and hospitals. When a 911 call comes in, and you live in a rural community where it would take an ambulance too long to drive there, they would send you a drone with defibrillators or NARCAN. A 911 operator or other emergency response personnel will then instruct the person who reported the emergency what to do with the life-saving equipment that arrived while the EMS first responders are still en route.”

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[6]U.S. Department of Justice Office of Justice Programs Bureau of Justice Statistics, U.S. Fire Administration National Fire Department Registry

[7]EO/IR refers to the electromagnetic (EO) spectrum (what we can see, and IR refers to thermal (heat Imaging).

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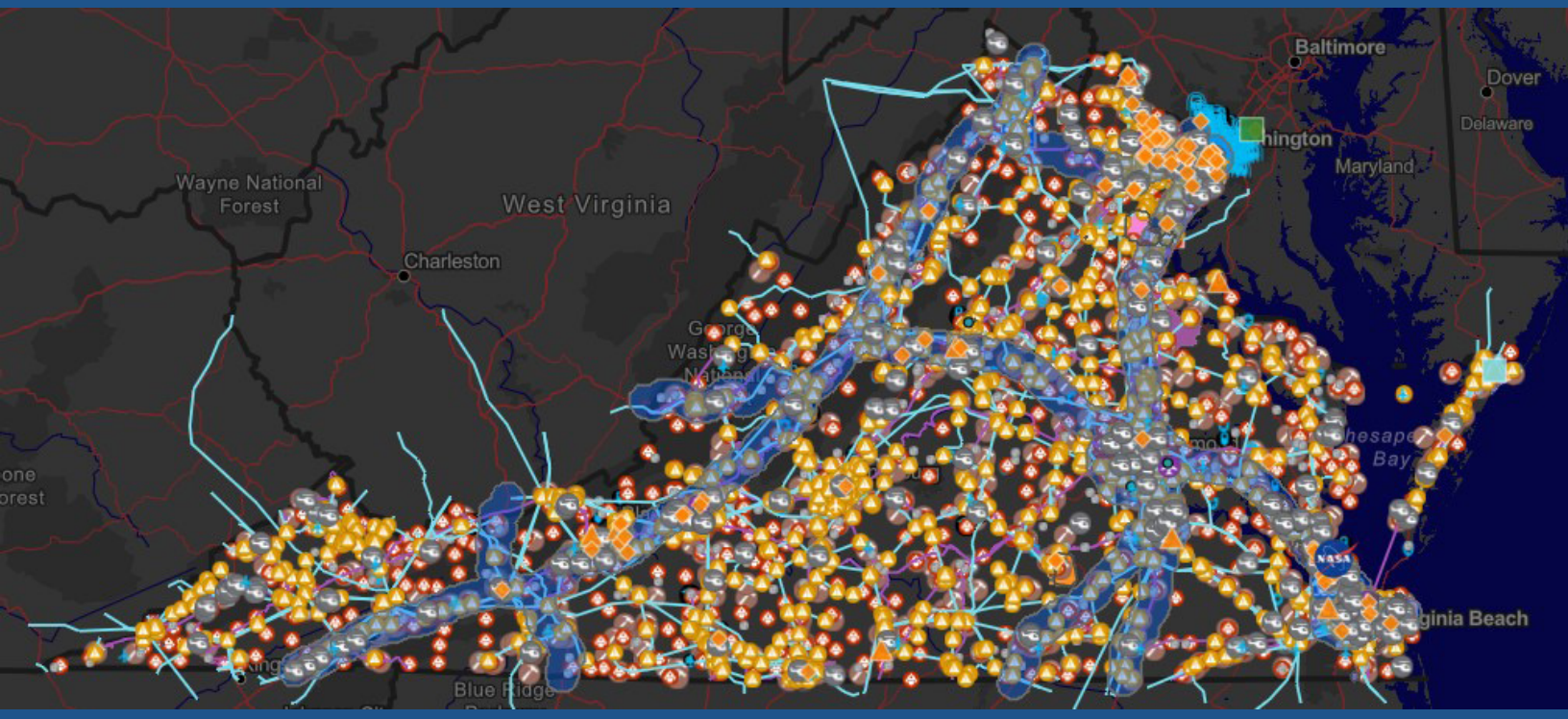
The NEXA team inventoried existing transportation infrastructure available throughout the Commonwealth of Virginia using ArcGIS, combined with geocoded features added to complete the basic asset library. This geospatial mapping and physical inventorying tool provides unique capabilities for applying location-based analytics. Contextual tools are also able to visualize and analyze geospatial data via maps, datasets, algorithms, and reports. The team documented more than 60 layers of information that will become indispensable when designing and operating new airborne systems within the Commonwealth. These layers, some shown in the figure below, were researched, compiled, and loaded into the ArcGIS software to be mapped onto the state.

With those layers, the ArcGIS analysis tools provide insight into critical infrastructure within given parameters. For example, we can determine how many helipads are within an urban area's Metropolitan Statistical Area (MSA) or how many manufacturing and logistics centers are within five miles of a key cargo logistics corridor. The tool provides myriad analysis options that offer the most accurate inputs for the business case model. ArcGIS is heavily used today by multiple Virginia agencies.



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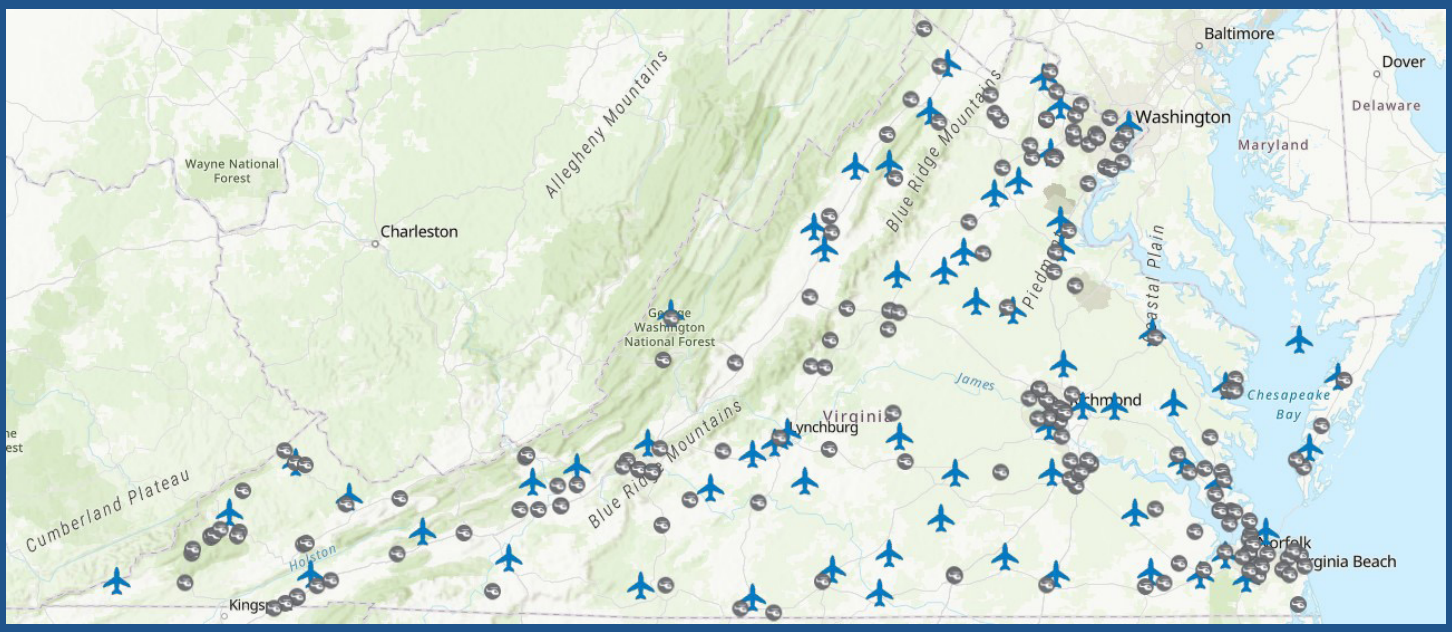
The figure above shows major roads, logistics corridors, transmission lines, hospitals, airports, heliports, public transit nodes, police and fire stations, and many more layers, so many, in fact, that it is difficult to decipher. However, in ArcGIS, the user can turn layers on and off for a clearer picture of desired attributes. For instance, the figure below shows only airports and heliports.



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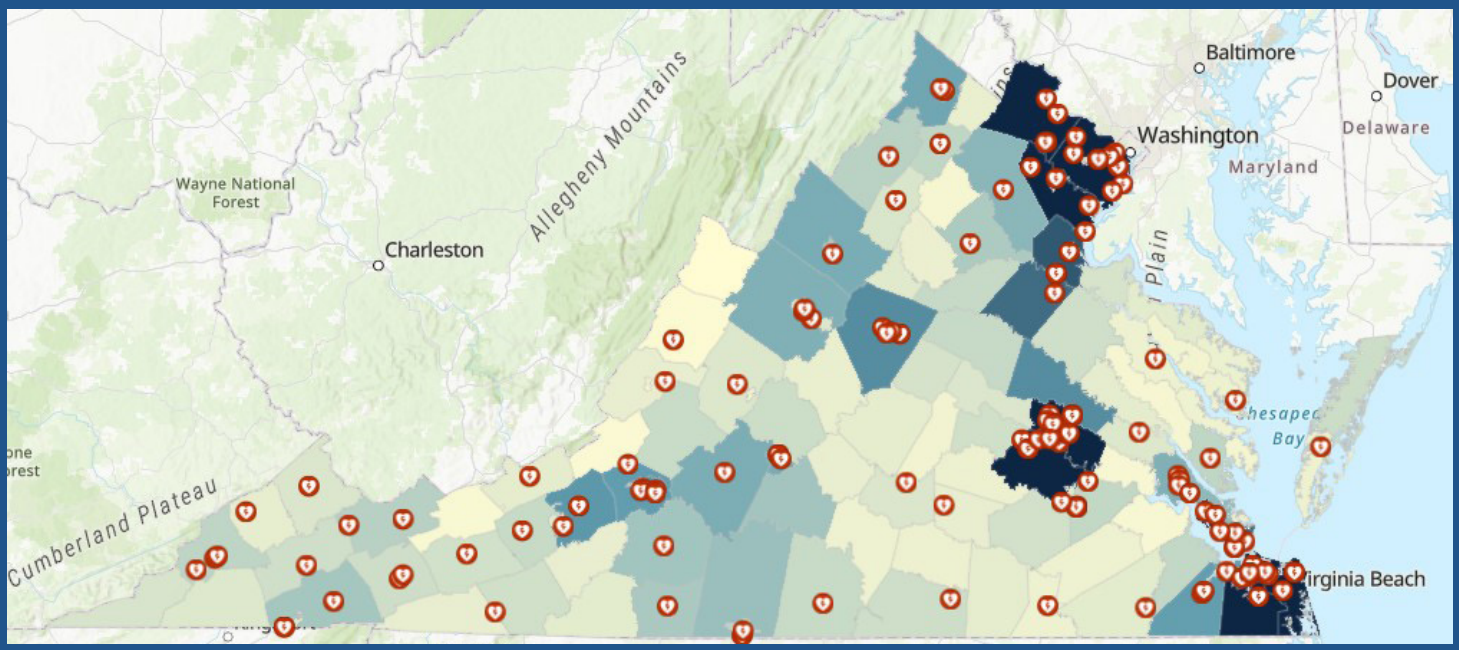
And the next figure shows hospitals and counties, dark blue correlating to higher population density.



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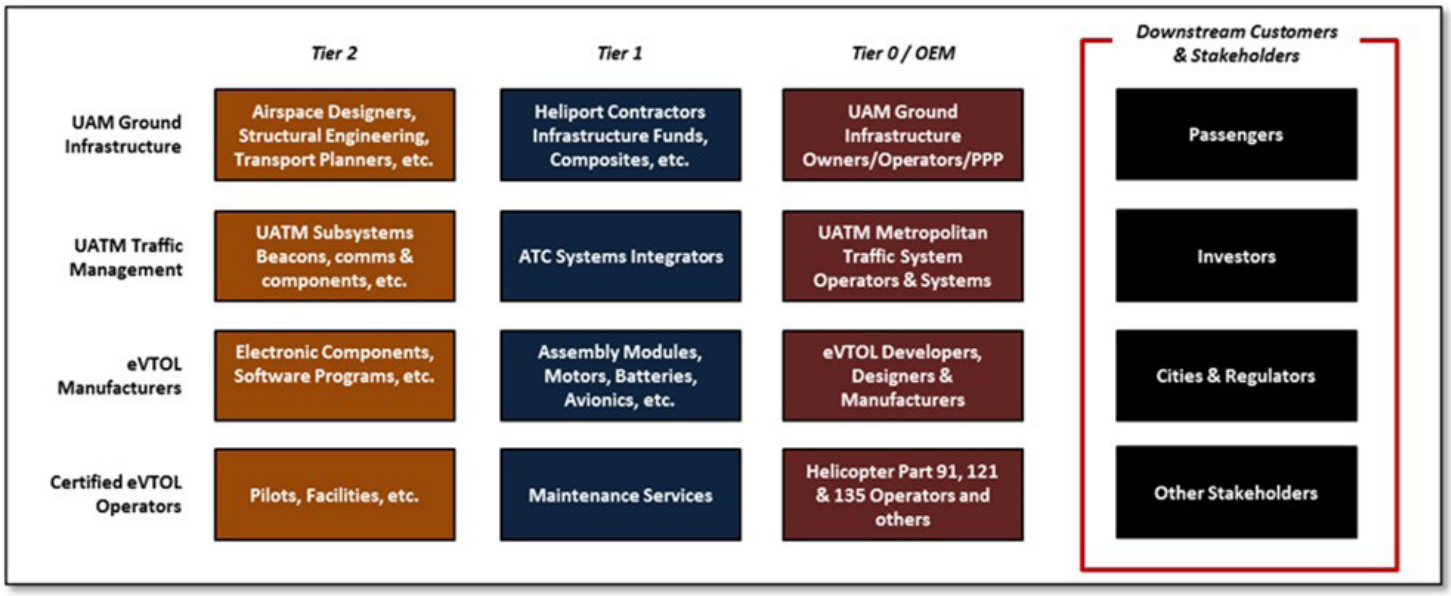
Bringing Advanced Air Mobility into operational status will require four value or supply chains (see figure below) to assemble and operate this new transportation system. Each one of these supply chains will create jobs and revenues:

- Aircraft developers and Tier 1/2/3 Suppliers (those companies selling products that end up in the final product) and the requisite ecosystem of manufacturers providing composites, precision machining, electrical systems, batteries, interiors, flight computers, simulators, and testing and training equipment, etc.
- Vertiport (landing and takeoff area) and ground infrastructure developers, and the necessary ecosystem to provide site preparation and construction, engineering, architectural services, lighting, beacon navigation nodes, and passenger amenities, etc.
- Air traffic management developers and operators and the ecosystem needed to provide high density radar, network design, automation systems, weather information, computers and equipment, and flight decision support tools, etc.
- Air Service Operators, companies overseeing the operation of the aircraft, whether eVTOL/eSTOL passenger aircraft or sUAS. Those firms currently operating helicopters may be among the first AAM service providers as they already have type certifications and pilots, and who will gradually transition the new aircraft into their operational fleets.



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Supply Chain 1: AAM Ground Infrastructure: Urban Vertiports, New Airport Facilities

The easiest and most cost-effective way to create vertiports is to remediate existing heliports. The basic elements of a heliport are clear approach/departure paths, a clear area for ground maneuvers, final approach and takeoff area (FATO), touchdown and liftoff area (TLOF), safety area, and a wind cone. This existing infrastructure can be updated for eVTOL aircraft by adding battery recharging stations and fuel stations for hybrid aircraft, as well as perimeter security, shelters, and

other amenities. Given the need to recharge batteries, the region's power grid becomes an essential factor in determining vertiport locations. Globally, many cities have heliports that are rarely or no longer used. Helicopters are often seen as a nuisance by local communities due to their noise. Given the lower noise signature of eVTOLs, it is likely that some of the unused or underutilized heliports—particularly those near hospitals—may be renovated to utilize the new aircraft.

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Fewer than half of the current inventory of heliports are in locations convenient to maximize AAM applications. Ground infrastructure will require expansion into network configurations, with each node, or vertiport, carefully located and built to ensure passenger convenience and value.

Integrating an eVTOL aviation network with the existing system of public transportation modes, especially in urban areas, requires detailed planning and analysis. With the objective of implementing the greenest, most cost-effective, and commuter-friendly transit system possible, planners must consider the needs of all users when locating vertiports to enable practical end-to-end solutions for passengers. The Commonwealth of Virginia has 85 public access heliports, including at all 66 public use airports, as well as at a limited number of hospital centers. The NEXA Advisors/UAM Geomatics Urban Air Mobility Study projected that by 2045 Virginia would need to remediate 36 existing heliports, and construct 23 new vertiports in densely populated areas, strategically placed throughout the metro regions, in addition to those presently at airports and hospitals. The Commonwealth could possibly benefit from one multiport (landing area for multiple aircraft) in Northern Virginia.

AAM Sample Vertiport Components (CAPEX and OPEX)	
Network design studies	Airport commercial eVTOL terminals
Environmental studies	Passenger shelters
Airspace flight design 3D visualization studies	Lighting systems
	CNS systems (ILS, beacons, etc.)
Concession agreements	IT and security systems
Secure project financing	Perimeter systems
Purchase or lease land	Parking
Construction permitting	Power grid updates
Architectural and engineering	FAA (etc.) permitting and certification
Site preparation and construction	Recharging capability and systems
Foundation modifications	Fire suppression systems
Platforms, Egress, walkways	Aeronautical chart preparation
Elevators	Operators, maintenance staff and related workforce
Airport AAM passenger facilities	

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While the technology is available to upgrade heliports to vertiports, regulators have not yet finalized standards. These regulations may be dependent on the types of aircraft selected, their footprint, weight, and electric or hydrogen charging requirements.

A limited list of cost elements included in the estimates for building (CAPEX or capital expenditures) and operating (OPEX or operating expenditures) the vertiports is provided in the above figure. These elements have been forecasted for Virginia's

infrastructure improvements using specific intrinsic cost data unique to each city or region, such as land cost, labor cost, and so forth.

While certain aspects of vertiports remain to be determined, it is safe to say that the development of infrastructure to support an eVTOL network has significant cost advantages over heavy-infrastructure approaches such as roads, light rail lines, bridges, and tunnels. Compared to the billions of dollars required to extend highways and subway lines, for instance, the estimate for the new vertiports projected to operate in Virginia by 2045 (a mix of remediating existing heliports and building new ones) is in the range of $300 million total.

Supply Chain 2: UTM Traffic Management Systems

The second AAM value or supply chain is that of low or mid-altitude air traffic control, which the industry universally refers to as UTM (usually referring to Uncrewed Aircraft Systems Traffic Management for drones, but also Urban Air Mobility Traffic Management for passenger-carrying aircraft and) or UATM (Uncrewed Aircraft Traffic Management or Urban air mobility Traffic Management). Air traffic management ensures safe airspace coexistence for commercial and general aviation, drones, and AAM aircraft. Currently, air traffic controllers guide airplanes and helicopters through airspace often surveilled by radar. It is likely that the first passenger AAM use cases—those eVTOL aircraft replacing and/or complementing existing aircraft operations such as Regional Air Mobility, Medevac and helicopter operators—will rely on the FAA's existing air traffic managementC system staffed by today's air traffic controllers.

UTM Sample ATC Infrastructure Components (CAPEX and OPEX)	
UTM interoperability standards and drone/eVTOL agreement selection	Network design studies
Site/network optimization study	Flight Plan and Flight Operations Database
Development of performance baselines and systems specifications	Network operations center
Power grid studies	RemoteID systems
Cyber security architecture studies	Power grid and backup systems
Physical security architecture	Weather Information Systems
Facilities (offices) rental costs	Micro Weather Detection Sensors
Automation systems and stations	Beacon Navigation Nodes
Flight Decision Support Tools	Resilient Bi-directional communication network
Computers and Equipment	General awareness sensors
	High Density Radars

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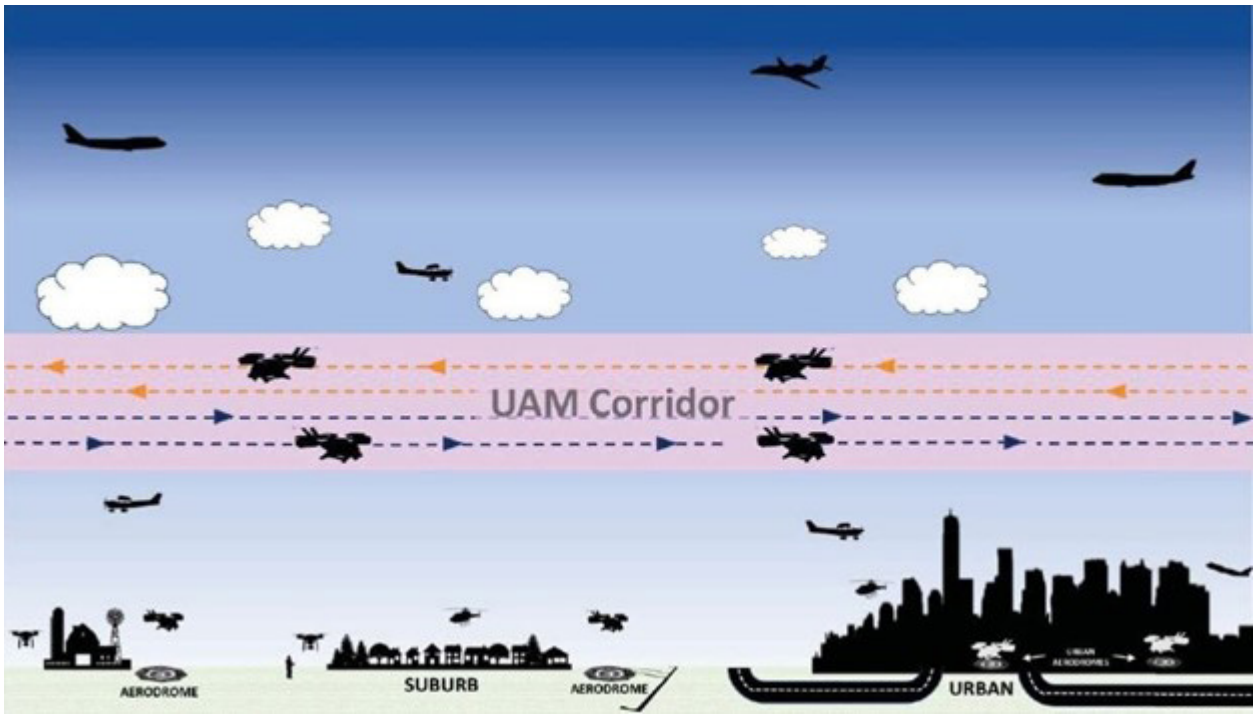
But the many new uses and routes of AAM aircraft—both passenger aircraft and drones—would add hundreds, perhaps thousands of movements to each ATC regional system each day, overloading the FAA's air traffic management capabilities. NASA and the FAA are fully aware of this challenge and have been working for several years to define new ATC systems and capabilities to augment airspace management at low and medium altitudes, which are expected to be overwhelmed with drone and eVTOL traffic. Selected costs elements necessary to implement UTM capabilities are shown in the figure above. While ensuring safe vehicle separation using fully staffed facilities, the costs for Virginia will be affordable when considering their amortization over a period of decades, should user fees be levied on operators.

Eventually, Advanced Air Mobility will need supplemental air traffic management services working in conjunction with the current FAA ATC system. Human staff and operators may become airspace managers, focused on supervising automated systems and aircraft operations, ensuring safety and,

at all times, security. A single operator could supervise many more aircraft movements than working in an airport ATC tower. A simple explanation is that aircraft will operate in layers of altitude with sUAS at the lowest level, eVTOL aircraft in the middle, and traditional aircraft at the highest, though they must also be safely guided through layers during take-off and landing (see figure below).

According to the NEXA Advisors/UAM Geomatics study, the estimated capital cost for creating an Advanced Air Mobility UTM system (CAPEX) across the Commonwealth of Virginia could be as high as $150-200 million over a 23-year period. This amount does not factor in the need for a fully staffed Network Operations Center or NOC, if Virginia chooses to pursue that model, and overseen by FAA.



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However, industry is also exploring an infrastructure model for AAM development that focuses on targeted public infrastructure development, with a focus on digital services, to complement private sector investment. The infrastructure model is referred to as Minimum Viable Infrastructure (described in more detail below) and it focuses on identifying near term, targeted investments that can enable AAM industry growth and operations without large immediate investments from the Commonwealth of Virginia. The need for affordable shared infrastructure is clear: AAM must, within a few years, become economically viable to pay off investors as well as to pay recurring costs such as equipment maintenance and upgrades, and employee salaries, and maintain public safety and convenience. Virginia hopes this unique MVI model can drive down the costs of shared infrastructure and may reduce the initial UTM estimate above by a large amount, keep the public investment focused, and support industry development and investment through shared infrastructure.

One example of a private infrastructure provider is McLean-based AURA Network Systems, a command and control communication service provider building an FAA-compliant nationwide network to accelerate advanced levels of autonomy in the National Airspace System (NAS). Utilizing unique, licensed aviation spectrum ideal for secure and reliable communications, AURA is working

to transform the concept of aviation for both crewed and remotely piloted aircraft. Over the summer of 2022, AURA successfully demonstrated its air traffic control voice solution and delivery of safety-critical telemetry data designed to enable commercial Beyond Visual Line of Sight (BVLOS) flights. The company's proprietary technologies have led to a four-year cooperative R&D agreement with the FAA and two Space Act agreements with NASA.

sUAS Provides the Runway for Minimum Viable Infrastructure

Virginia's existing leadership position in sUAS and UTM research makes the Commonwealth a logical leader in the development of safe, cost-effective, industry supportive models of UTM. Virginia is already home to leading participants in the UTM space and can leverage this experience, investment, and private industry cluster to develop initial UTM services for sUAS that can then scale into broader services for AAM. Examples of Virginia leadership in UTM include the Mid-Atlantic Aviation Partnership (MAAP) at Virginia Tech, which is not only one of the seven approved FAA Test Sites but extensively supports the development, testing, and validation of UTM and related services for the FAA. MAAP partners include the UTM and UAS Service Supplier (USS) companies based in Virginia such as Wing, ANRA, and ATA.

With an operational test site in Christiansburg, VA, Wing is developing a service for drone delivery as well as USS services to implement the airspace management component of UTM in support of their delivery operations. ANRA, another USS, is one of the leading UTM providers and helped create the Global UTM Alliance (GUTMA) and provided leadership in the development of the ASTM UTM standard. ATA is another USS focused on the provision of supplemental data services, real time data feeds, and constraints to airspace management USSs such as Wing and ANRA, and demonstrates this capability as the Virginia Department of Aviation technology partner for the Virginia Flight Information Exchange. These and other partners have the potential to help Virginia create effective, compliant, and economically sustainable infrastructure that can support the sUAS use cases in the near term.

Minimum Viable Infrastructure (MVI)

Operating sUAS under Visual Line of Sight (VLOS) and Beyond Visual Line of Sight (BVLOS) rules represents concepts of operations with vastly different needs. Operators in Virginia are seeking "Minimum Viable Infrastructure" to perform statewide BVLOS missions, though opinions vary on what it constitutes and where it should be offered.

As part of our research, we were asked to examine the lowest cost pathway to provisioning UTM to support BVLOS operations across the Commonwealth. We asked the AAM stakeholders in focus groups and in private interviews: What does the term "Minimum Viable Infrastructure" mean? What missions are urgently in need of this capability? What is the minimum technology and network capability needed to develop and field a UTM network to satisfy BVLOS uses, and how must it eventually expand to include eVTOL and eSTOL aircraft? In the conclusion of this report, we make recommendations on next steps to resolve this critical issue.

Our recommendations align the stakeholder response received with existing research and investment being conducted in the Commonwealth of Virginia. The industry believes that by focusing on those public infrastructure components that mitigate risk for more near term sUAS use cases, the sector can actually pace investment to demonstrate early returns as well as lowering the overall user and sustainment costs.

Supply Chain 3: Advanced Air Mobility Operators

Current helicopter operators are today's vanguard for AAM services. Charter helicopter companies in Virginia such as HeloAir, Hampton Roads Helicopter, Grandview Aviation, and FlexAir Aviation have excellent longstanding safety records, trained pilots, weather dispatching expertise and systems, and quality and safety programs. They are also familiar with the regulations, terrain, and locations of the existing heliports and airports in the region. As an industry, their current services do not include scheduled operations (e.g. Hampton Roads to the Pentagon), but rather missions such as Medevac services, airport shuttle services, regional charter transport, cargo delivery, tourism, and the like. Many police and civil agencies operate helicopters despite their obvious costs and downsides such as noise.

Drone operators can be independent individuals, small companies, state and federal agencies, real estate companies, and large players such as DroneUp, Amazon, FedEx, and Walmart. Their missions are diversified, and range from healthcare (isotope delivery, vaccine delivery, COVID test kits, blood transport) to package delivery, agricultural purposes, bridge inspection, real estate promotion, and other useful applications.

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Supply Chain 4: Advanced Air Mobility eVTOL Aircraft

Several eVTOL prototypes around the world are either in or nearing advanced stages of development and operational trials of one kind or another. Designs vary widely in terms of number of passengers, number of rotors, and distance traveled before recharging.

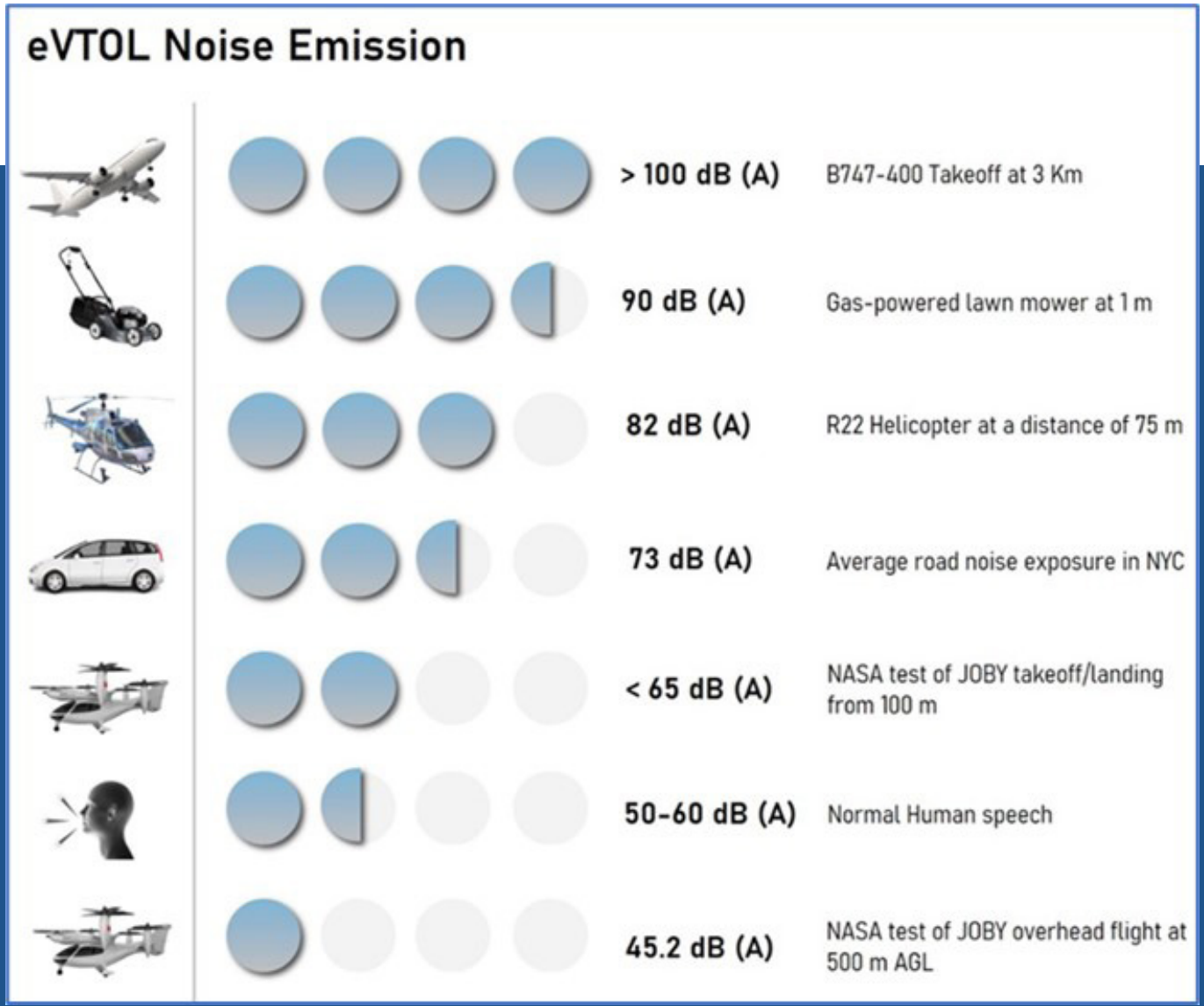
Most eVTOL aircraft currently in development are designed to be piloted, at least initially. The next two decades will see increasing use of automation and autonomy performing many functions traditionally performed by humans. Automation and autonomy offer the opportunity to reduce workload, lower costs of operations, and enhance safety for critical AAM missions and functions.

Aircraft noise is a key determinant defining success and acceptance of eVTOLs that will operate in areas of higher population density at low altitudes (see figure above). Smaller eVTOL aircraft are expected to fall well within current noise guidelines, and noise-reducing technologies hold promise for larger electric aircraft to be good neighbors as well.

Several eVTOL and eSTOL development programs are highlighted on the following pages and point

to the fact that over $15 billion is being invested in vehicle development and certification globally. This investment will carry several OEMs through certification programs beginning in 2024.

Virginia is home to a major eSTOL aircraft developer. Electra.aero, Inc. is a next-gen aerospace company with a mission to help decarbonize aviation and open new urban and regional transportation networks. Founded in 2020 by aerospace entrepreneur John Langford and located at the Manassas Regional Airport in Northern Virginia, the company is building hybrid-electric eSTOL airplanes that substantially lower emissions and operating costs to transport people and cargo more rapidly, safely, and affordably. The eSTOL aircraft's ability to operate from soccer field-sized spaces, with in-flight battery recharging, opens air service to places previously inaccessible by flight. Electra will fly a technology demonstrator aircraft in early 2023, with commercial certification planned in 2026. Compared to battery-electric VTOL aircraft, Electra's hybrid eSTOL expects to carry twice the payload at more than three times the range for a given aircraft weight.



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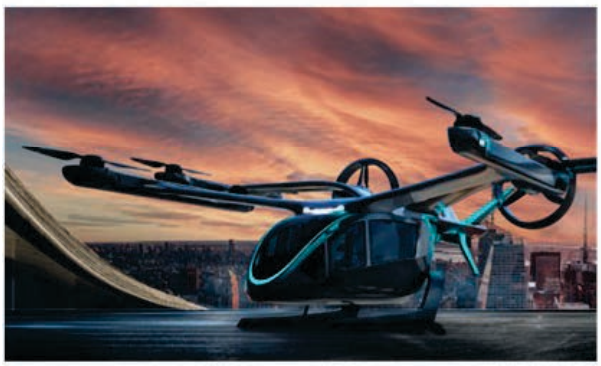
- **Archer Maker**
- San Jose, CA, USA – www.flyarcher.com
- 1+4 passenger eVTOL 12 electric propellers
- Range: 60 miles
- Speed – 150 mph
- Delivery: Undisclosed
- Orders: Provisional billion-dollar order from United Airlines for up to 200

- **Beta Technologies Alia**
- Vermont, USA – www.beta.team
- Six people or 600 pounds of cargo
- Range: 287 miles
- Speed: 170 mph
- Delivery: 2024
- Orders: Up to 250 from UPS, 20 from Blade Urban Ai Mobility

- **Electra Aero**
- Manassas, VA USA – www.electra.aero
- Nine passengers or 2,500 pounds of cargo
- Range: 450 miles
- Speed: 200 mph
- Delivery: 2028
- Orders: more than 900 conditional aircraft pre-orde



- **Eve Air Mobility (Embraer)**
- Melbourne, FL – www.eveairmobility.com
- Pilot + 4 passengers or 6 passengers
- 8 rotors and 2 ducted fans
- Range: 60 miles
- Speed: Undisclosed
- Delivery: 2026
- Orders: 1,785.

- **Jaunt Air Mobility Journey**
- Dallas, TX, USA – www.JauntAirMobility.com
- Pilot+4 passengers
- 1 lifting rotor and 4 anti-torque/cruise propellers
- Range: 120 miles
- Speed: 175 mph
- Certification: 2026

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- **Joby S4**
- Santa Cruz, CA, USA – www.JobyAviation.com
- Pilot + 4 passengers
- 6 tilting propellers
- Range: 240 miles
- Speed: 320 mph
- Delivery: 2024

- **Supernal S-A1 (Hyundai)**
- Seoul, South Korea – www.Supernal.aero
- Pilot + 4 passengers
- 6 rotors
- Range: 95 miles
- Speed: 290 mph
- Delivery: 2028

- **Vertical Aerospace VX4**
- Bristol, UK – www.vertical-aerospace.com
- Pilot+ 4 passengers
- Eight co-axial propellers
- Range: 160 miles
- Speed: 240 mph
- Delivery: 2024
- 1,350 pre-orders from American Airlines, Virgin, others totaling $5.4 billion.

- **Volocopter VoloCity**
- Bruschal, Germany – www.Volocopter.com
- Pilot + 1 passenger
- 18 fixed-pitch propellers
- Range: 35 miles
- Speed: 100 mph
- Delivery: 2023
- Orders: 150 from joint venture company with China's Aerofugia, 2 from German air medical operator ADAC Luftrettung

- **Wisk Cora**
- Mountain View, CA, USA – www.Cora.aero
- 2-passenger autonomous eVTOL with 12 lifting propellers and 1 pusher propeller
- Joint project with Boeing and Kitty Hawk
- Range: 40 miles
- Speed: 175 mph
- Delivery: 2025
- Wisk will own, maintain and operate 30 aircraft for the Blade charter flight network

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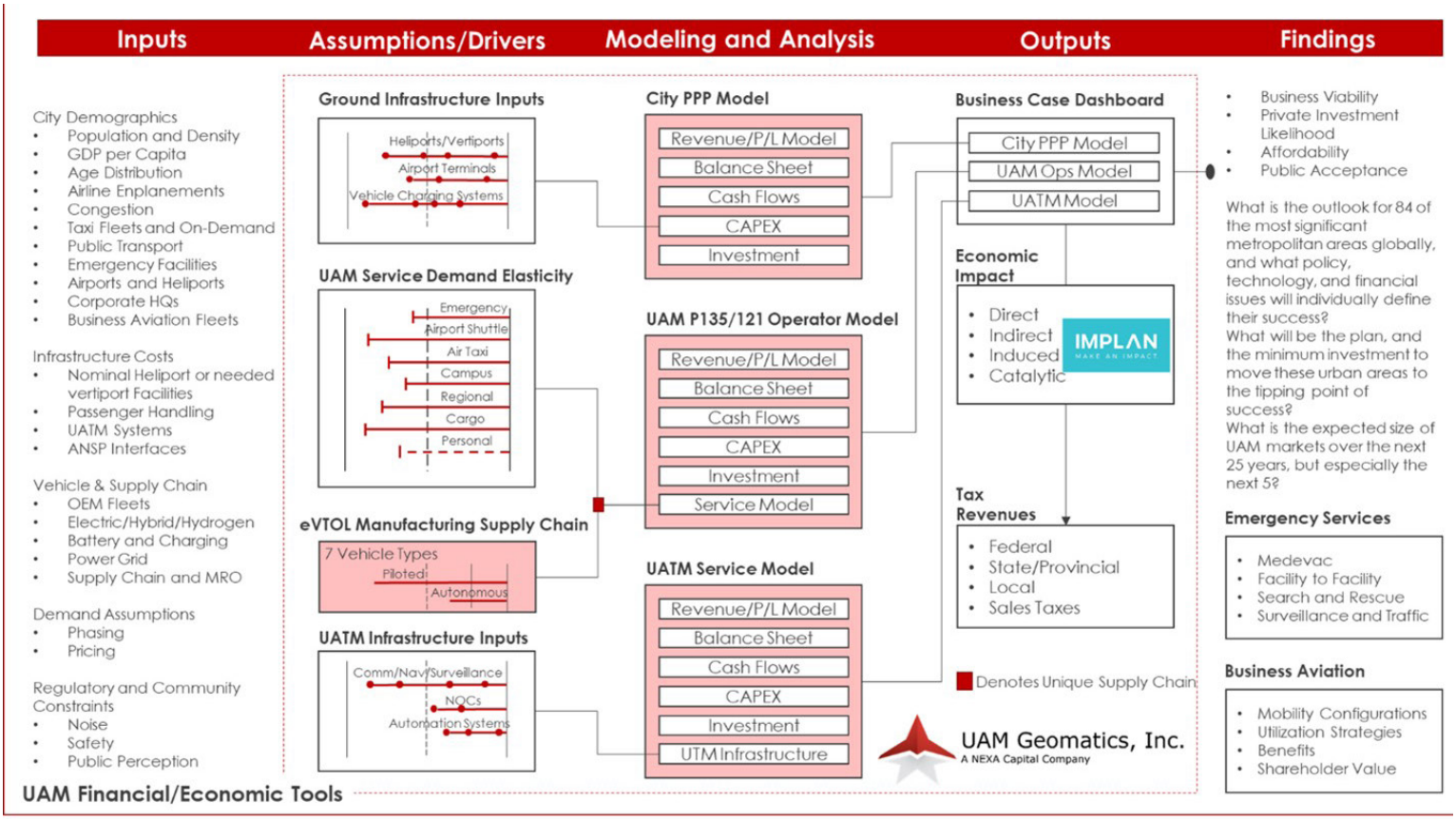
Advanced Air Mobility must, within a few years, become economically viable to pay off investors for CAPEX (Capital Expenditure) investments as well as to support recurring OPEX (Operational Expenditure) needs such as equipment maintenance and upgrades and worker salaries.
NEXA Advisors and UAM Geomatics developed the business analysis tools illustrated below to assess AAM feasibility and used them to study Virginia, examining its four major regions (North, West, Southeast, and Central) in an exacting and comparative analysis. A key goal is for each of the four supply chains shown (the "City PPP Model," the "AAM Operating Model," the "UTM Model," and the "AAM eVTOL Supply Chain") to achieve a measure of commercial success.



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According to our forecasts, the four critical supply chains all achieved this success for the Commonwealth of Virginia, in turn attracting outside capital to fund each phase of the launch.

Estimated AAM Passenger Demand for Virginia

Analysis of the major use cases' passenger demand first required separation into price-elastic (sensitive to price) and price-inelastic (less sensitive to price) forecasts. Clearly, on-demand air taxi, airport shuttle, and regional air transport services are highly price sensitive, while business aviation and Medevac are not. Many factors are considered as well, including the ability of the traveling public to afford such services. For these demand forecasts to be realistic, the analysis made use of ten factors—a methodology uniformly applied to all studies undertaken by NEXA Advisors/UAM Geomatics. These factors, adjusted to Virginia's unique demographics, estimate that by 2045, the

peak forecast year, some 66 million passengers are expected to have traveled using new eVTOL services over the 23-year forecast period. About 7.7 million passengers per year, or over 21,000 passengers per day, are forecasted by the 2041-2045 time period.

Affordability is a key factor when projecting passenger demand. Forecasted cost per ticket for the price-elastic use cases—Regional Air Mobility, airport shuttle, and on-demand air taxi—could drop to under $50 on average.

Factor	Demand Input	Description
1	Airport O/D Traffic	Historic and projected Origination & Departing Passenger Traffic
2	Mobility Substitutes	Other options – Taxi, Public Transit, Private Vehicle Costs, Fuel
3	Per Capita GDP	Weighted input according to latest GDP (PPP) of each City
4	Distances & Congestion	Average travel distances, congestion, airports to city centers, road infrastructure
5	CIMI Human Capital Indicator	IESE Cities in Motion Index (CIMI) human capital score, 10 factors including education
6	Population Density	Weighted to population density and proximity to city employment areas (downtown, industry, factories)
7	Livability	Cost of living, disposable income, taxation all weighted and averaged
8	Fortune 1000 Presence	3 ranked scores to determine passenger demand and high value transportation
9	Business Aviation Activity	Business aviation activity weighted across various cities
10	Existing Heliports	IMPORTANT data point: This is the starting point for AAM infrastructure

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Business Opportunity: Revenue and Pillars of GDP Growth

Using the five AAM use cases discussed above (medical, airport shuttle, business aviation, on-demand, and Regional Air Mobility,) the figure below shows the results of the extensive analysis provided by the financial and economic tools used in the NEXA Advisors/UAM Geomatics Urban Air Mobility study and produced in multi-year increments of revenue and capital investment estimates for the entire state. These financial estimates fall into five categories:

- CAPEX: Those capital expenditures funds used to acquire, upgrade, and maintain physical assets such as property, plants, buildings, and specialized facilities, technology, or equipment.
- OPEX: Costs that a business incurs through normal business operations. Operating expenses include rent, equipment, inventory costs, marketing, payroll, insurance, step costs, and funds allocated for research and development.
- Revenues: These represent per-passenger ticket revenues expected for eVTOL fleet operators and are based upon a rigorous demand elasticity model applied to the state.
- Aircraft Fleet Purchases: Fleet acquisition and maintenance costs to acquire and operate sufficient eVTOL and eSTOL aircraft to sustain the use cases identified.
- Aircraft Manufacturing: Should a fully funded OEM program land in Virginia, jobs created will number in the low thousands, and production revenues can be added to pillar totals.

The pillar totals for the entire 23-year forecast period estimate over $16.4 billion in direct new (and fully incremental) business activity across the Commonwealth of Virginia. The R/I (Return on Infrastructure), center right in the chart below, of 6.53, is extremely attractive to investors who generally look for a ratio above 3 or 4.

Virginia AAM Business Case
EcoSystem
2022-2045 ($US)

UAM GEOMATICS, INC.
A NEXA CAPITAL PARTNERS COMPANY

	Year	2023-2025	2026-2030	2031-2035	2036-2040	2041-2045	SUM	Pillar Totals
Demand (Passengers)		Nascent	2,287,000	5,978,000	19,253,000	38,607,000	66,125,000	
Ground Infrastructure	Ground Infrastructure OPEX	$25,890,000	$69,200,000	$119,470,000	$180,600,000	$195,490,000	$590,650,000	$899,230,000
	Ground Infrastructure CAPEX	$68,500,000	$68,910,000	$87,020,000	$24,810,000	$59,340,000	$308,580,000	
RTM/UATM	RTM/UATM Cost OPEX	$1,100,000	$12,051,000	$31,703,000	$76,725,000	$121,929,000	$243,508,000	$416,916,000
	RTM/UATM Cost CAPEX	$20,353,000	$59,603,000	$30,529,000	$34,890,000	$28,033,000	$173,408,000	
UAM Operators	Passenger Revenues	Nascent	$508,099,000	$744,083,000	$1,603,109,000	$2,783,255,000	$5,638,546,000	$8,601,009,000
	MedEvac Revenues	Nascent	$226,263,000	$348,794,000	$631,595,000	$555,910,000	$1,762,562,000	
	Cargo Revenues	Nascent	$99,162,000	$170,516,000	$321,889,000	$608,334,000	$1,199,901,000	
Vehicles	Vehicle Manufacturing	Nascent	$613,022,000	$1,052,997,000	$1,487,250,000	$1,725,403,000	$4,878,672,000	$6,511,523,000
	Vehicle Purchases	$58,800,000	$277,440,000	$280,755,000	$454,411,000	$561,445,000	$1,632,851,000	
Virginia Grand Total		$174,643,000	$1,933,750,000	$2,865,867,000	$4,815,279,000	$6,639,139,000	$16,428,678,000	$16,428,678,000

Note: Nascent - Not Meaningful

R/I	6.53

Average eVTOL/eSTOL Passengers per Day		N/M	1,253	3,276	8,791	21,155
Percent of Airline Passengers for Four Largest VA Airports		N/M	0.8%	1.9%	4.8%	10.8%
Revenues per Passenger	Upper Range	N/M	$377.69	$211.60	$141.55	$122.56
	Lower Range	N/M	$138.43	$77.55	$51.88	$44.92

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Key forecast assumptions used to produce the Virginia AAM revenues are:

- Forecasts make use of collected geospatial data to account for Virginia's existing aviation and related infrastructure.
- FAA-Certified and available eVTOLs/eSTOLs from at least some OEMs by 2026.
- Industry and FAA agreement on CONOPs (Concept of Operations) and standards for UTM by at least end of 2024.
- Multi-year CAPEX investment in urban ground and ATC infrastructure begins in 2025.
- Operators begin services in Regional Air Mobility by 2026.
- Operators begin services in all other AAM use cases, including Medevac, business aviation, airport shuttle, on-demand air taxi, and heavy cargo, by 2027.
- Significant impact from flight automation takes hold within the 2035 time frame, driving sector costs, and passenger tickets, much lower.

The ecosystem needs to provide excellent services to passengers at affordable prices at a point where the sector finds equilibrium, thereby becoming and remaining profitable. By definition, this equilibrium is achieved when for a given region such as Virginia each of the four supply chains can reach and exceed cash flow profitability.

In this report's 23-year forecasts, the NEXA team used the following macro assumptions while estimating the cost and schedule for AAM ground infrastructure:

- A large percentage of existing public, private, and unregistered heliports are first remediated to provide a baseline to support early eVTOL or eSTOL services before expansive new construction is undertaken.
- Certain numbers of heliports and vertiports are built or retrofitted to provide hybrid aircraft refueling, electric charging or fuel cell charging. The estimated costs of such charging facilities or services are rolled into the ground infrastructure costs.
- All airports within a given city's economic catch basin, whether commercial air transport or general aviation/business aviation, will receive investment in vertiport facilities and AAM traffic management services to permit safe passenger handling and eVTOL traffic volume.

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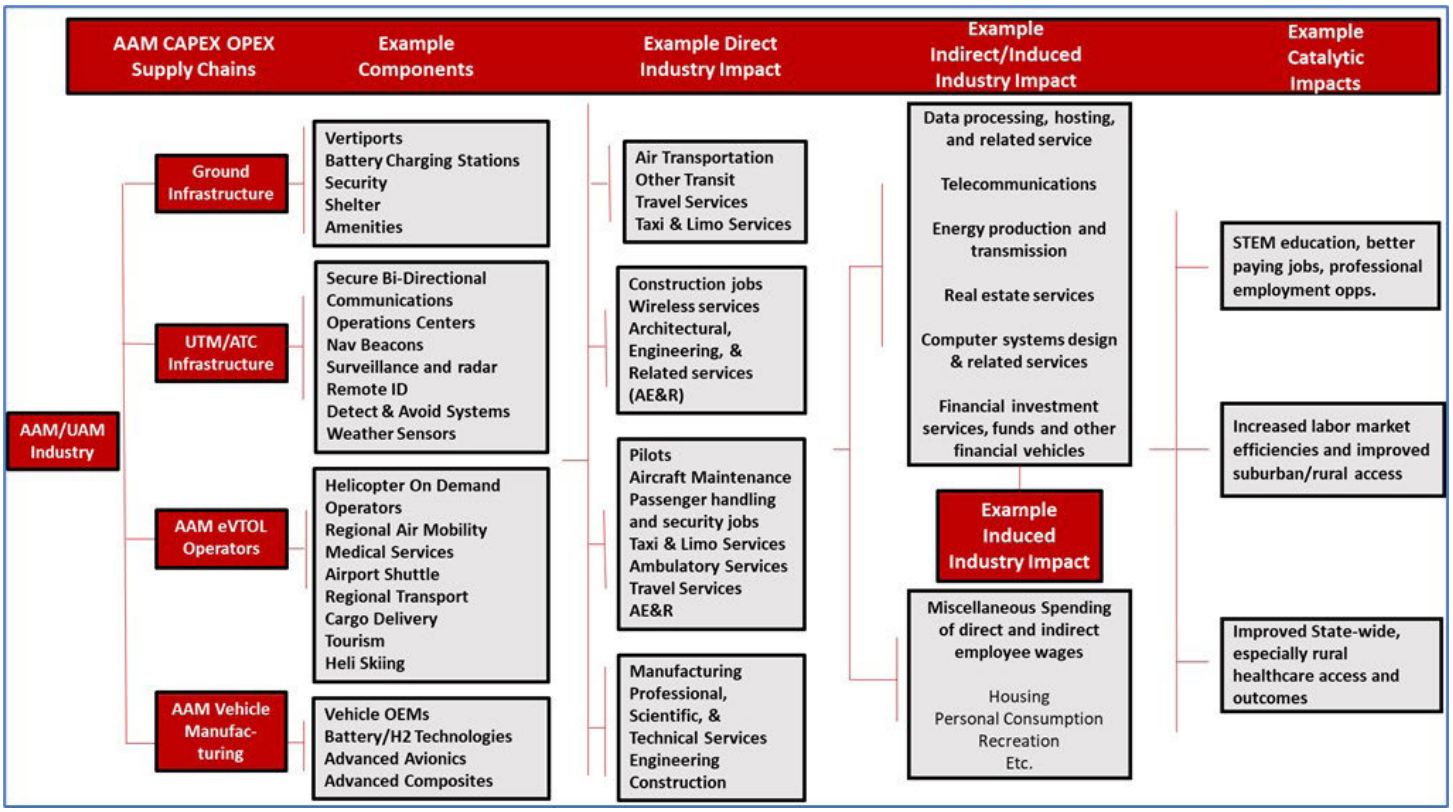
To undertake a 23-year Economic Impact Assessment (EIA) of Advanced Air Mobility for the Commonwealth of Virginia, NEXA used the IMPLAN input/output modeling tool in combination with NEXA's business case analysis model featuring four regions of Virginia: North, West, Southeast, and Central. The combination depicts the most accurate possible impact assessment of the benefits AAM will deliver to Virginia.

The results may be analyzed and carefully considered by policy planners and stakeholders, as well as state and local governments interested in job creation and general economic growth. These results will help to mobilize public sector resources to act on the AAM opportunity and possibly seize a first-mover advantage in a $1 trillion global market meant to improve mobility and drive economic growth. The figure below explains the inter-relationships between direct, indirect, induced, and catalytic economic impacts for the AAM sector, driven by the revenue, cost, and CAPEX and OPEX pillars of business activity.



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In economics, an input/output model is a quantitative methodology that represents the interdependencies between different branches of a national economy or of regional economies. The IMPLAN input/output model depicts inter-industry relationships, showing how output from one industrial sector may become an input to another industrial sector. In the inter-industry matrix, column entries typically represent inputs to an industrial sector, while row entries represent outputs from a given sector. This format shows how dependent each sector is on every other sector, both as a customer of outputs from other sectors and as a supplier of inputs. This inter-industry relationship is expressed in the form of industry coefficients, or multipliers, that depict the rate of change of output

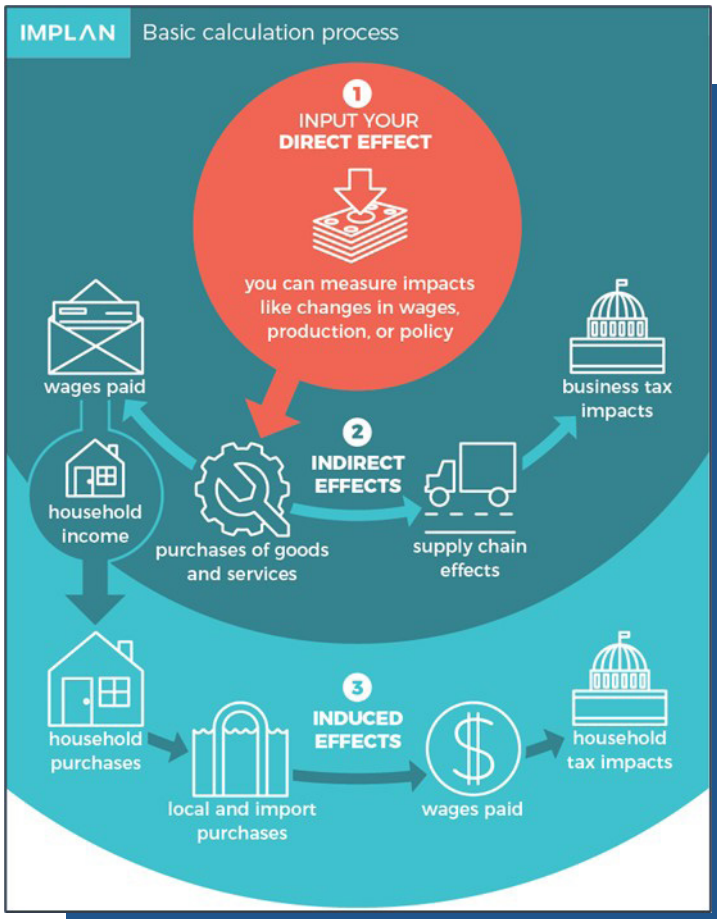
among a set of interdependent industries, from a one unit increase in output by one industry.

The IMPLAN I/O model was our model of choice in studying AAM for Virginia. IMPLAN is a recognized modeling tool used to study impacts on all sectors and at all levels of an economy.

IMPLAN's definition of output is as follows: The Output Multiplier describes the total Output generated as a result of 1 dollar of Output in the target Industry. Thus, if an Output Multiplier is 2.25, that means that for every dollar of production in this industry, $2.25 of activity is generated in the local economy: the original dollar and an additional $1.25. Econometric and input-output models contain assumptions; after all, if every variable were known, we would have a list of facts and not a forecast.

The most important assumption derived from NEXA's business forecast for Virginia includes the insertion of an "inflection point," the introduction of highly automated flight systems requiring less human intervention. For example, an emerging view of AAM over the next 25 years is that cockpit automation will be necessary to improve the integrity and thus the safety of this new market sector. Automation should eliminate pilot error, enforce sense-and-avoid rules, and safely separate all aircraft, including eVTOLs and drones. Automation will reduce the cost of operations, as well as the demand for human operators. The cost structure of the entire industry will be dramatically impacted in synchronization with the expansion of vehicle and airspace capacity.

The EIA (Economic Impact Assessment) in this report accounts for the inflection point, as will be reflected in the economic charts examined later. This is done through the input phase, whereby the NEXA model factors in automation and its impact on the overall AAM business case.



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EIAs assess the impact of an "exogenous shock"—new economic activity that stimulates growth—exploring its impact on a number of indicators such as GDP, job creation, and tax revenues. Some of these indicators will be further evaluated at three levels of analysis: direct, indirect, and induced effect. Direct effects calculate the economic value that a business or industry generates by its own means through direct hiring of its own employees, revenue generation from sales, and the portion of its business activity that contributes to regional output. Direct effects include the initial change in expenditures by consumers/producers—the exogenous shock—producing the first round of economic

activity in the form of new output, jobs, and revenues.

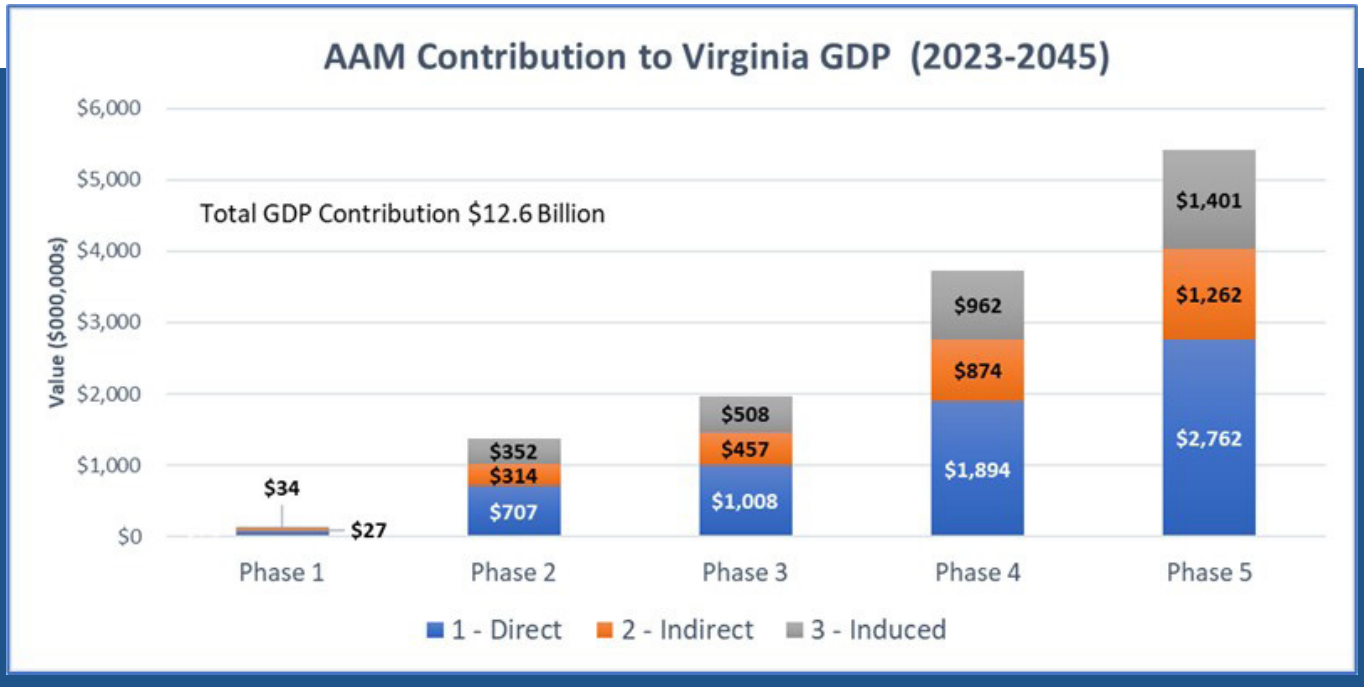
Indirect effects gauge the economic impact that results from demand created by the direct impact. Products and services are bought to support this new activity (i.e. supply chain companies).

Finally, there's the induced effect, which measures the economic impact on the broader economy resulting from demand created by employees of the new activity (direct component) and its supporting businesses (indirect component). IMPLAN defines the induced impact as follows: "the values stemming from household spending of Labor Income, after removal of taxes, savings, and commuter income. The induced effects are generated by the spending of the employees within the business supply chain."[9]

In combining the business case totals, NEXA produced consolidated operational expenses (OPEX), capital expenses (CAPEX), and revenues along the four NEXA-defined supply chains, with OPEX and CAPEX for vertiports, UTM, and aircraft, in addition to revenue for the operators. These totals, or economic outputs, have been forecasted for each phase of AAM's development in Virginia through 2045.

Economic Impact – Gross Domestic Product

GDP, or Gross Domestic Product, is defined as the total value of all domestic final goods and services produced within a specified period of time (typically a year). It is also known as value added which, according to IMPLAN, is defined as the difference between total output and the total value of intermediate inputs throughout an economy during a specified period of time. It is the total output minus intermediate outputs. In the case of AAM, total output over 23 years, calculated using NEXA's business case analysis model, is $12.6 billion. $6.4 billion is attributed to the direct impact; $2.9 billion is attributed to the indirect impact, and $3.2 billion is attributed to the induced impact.



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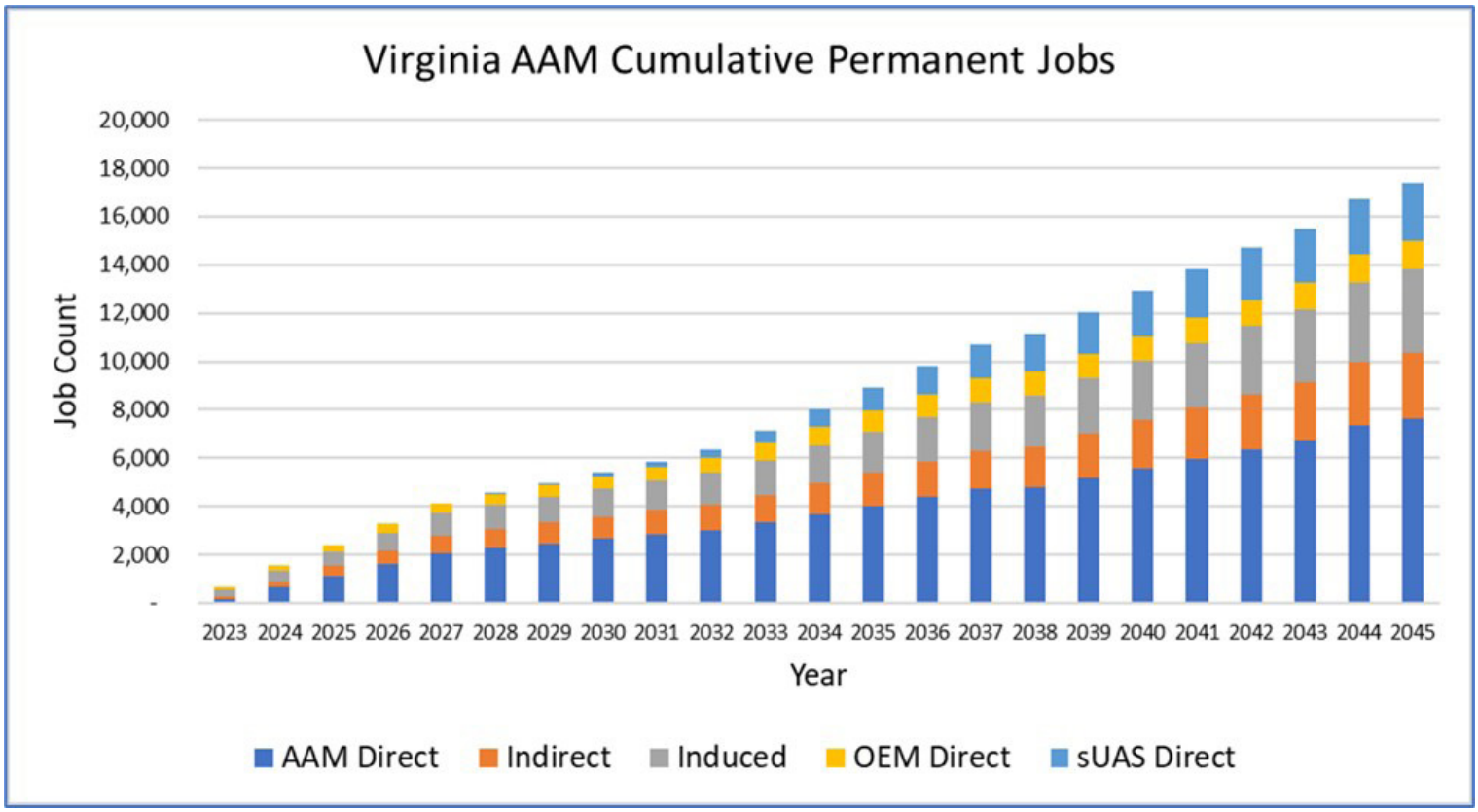
[9] https://blog.implan.com/understanding-implan-effects

Economic Impact – Jobs and Occupations

Jobs were calculated first in terms of employment, which IMPLAN defines as including both part-time and full-time annual employment. In this study, employment was derived from the total output produced by AAM at the direct, indirect, and induced levels. Since the employment count does not differentiate between type of employee, a conversion to full-time equivalent (FTE) is necessary to capture a tangible estimate of the labor count. IMPLAN provided a conversion sheet to identify the corresponding FTE count.

The jobs captured in the impact come in three tranches: the direct (jobs gained directly from AAM,) the indirect (jobs gained indirectly by the supply-chain industries supporting AAM,) and the induced (the subsequent jobs gained from induced spending in all sectors of the economy.) Together, they represent the total impact on jobs for the Commonwealth of Virginia.

The permanent FTE job numbers in the figure below reflect cumulative permanent full-time positions gained year over year. As the value of AAM increases every year, so does the labor required to support the increasing business activity. This means that by 2030 the value of AAM at the direct, indirect, and induced levels will require roughly 5,100 jobs to support it. By 2045, that number reaches nearly 17,400 FTE jobs.



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Since the direct and indirect effects of AAM account for roughly 80 percent of the impact, we see that job types, or occupations, closely align with the industries tied to AAM. Some of these occupations are reflected in the US Bureau of Labor Statistics' Standard Occupational Classification system, such as business and financial operations. Other categories, like "Engineering, Intelligence, Transportation

Systems," reflect an evolving technology sector that more accurately describes the type of jobs AAM will create.

The first two phases, or ten years of development, will see a focus in manufacturing and infrastructure development. This means jobs created to build vertiports, aircraft parts, software, and more. They will support both white-collar and blue-collar occupations such as software developers, mechanical engineers, electricians, construction laborers, technicians, and welders.

As the infrastructure to support and maintain AAM gets built out, the industry will then experience its expansion through operation of AAM services. In the latter three phases of expansion, therefore, we will see sustained growth in the flagship positions of aircraft operations. These include pilots (both commercial and cargo), freight handlers, travel agents, operation managers, and so forth.

Top 10 Occupational Groupings	Total FTEs
Business and Financial Operations	2,677
AAM Operational Support	2,092
AAM Operators	2,071
Medical and Supporting Services	1,710
All Other Professional	1,373
Hospitality	1,137
Quality Control and Safety	1,016
Travel Support Services	868
Vehicle Design and Manufacturing	311
Intelligent Transportation Systems and Infrastructure Design	208
Grand Total	**13,464**

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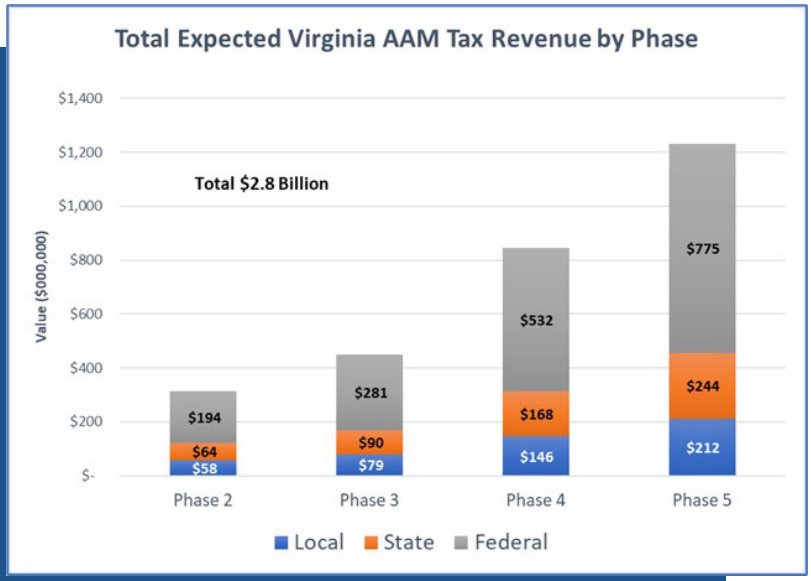
Together, these jobs make up the entire AAM sector, reflecting impacts at both the direct and indirect level. Jobs are also created at the induced level but are less related to AAM and result from overall growth of the regional economy. A summary of the top ten occupation categories is listed in the figure above, with example occupations that were produced in IMPLAN. They capture the wide array of jobs produced at the direct, indirect, and induced levels.

Economic Impact – Taxes



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IMPLAN captures tax revenues at the local, state, and federal level. The local level in particular represents totals for townships, cities, and counties for the entire state. Increased government revenues generally translate into additional government expenditures, which allows the state to invest more generously in state infrastructure, schools, social programs, and so forth.

The figure depicts these revenues at the local, state, and federal levels over each phase of growth. These values when additive reflect total revenue of $2.87 billion gained over 23 years. The local and state

governments account for $502 million and $572 million in revenue, respectively. Federal revenues account for about $18 billion.

The most important take-away of this analysis is that Advanced Air Mobility, including sUAS operations that encompass all use cases discussed throughout this report, will provide many returns, including a large contribution to the Commonwealth's tax base.

Catalytic Business and Economic Impacts for Virginia

Catalytic impacts include those effects such as spill-over that can benefit other areas of an economy, and that are not easily captured by input-output models such as IMPLAN. In air transport, catalytic impacts can sometimes create more jobs than direct employment. For example, employment and income generated in the local economy of an airport can boost the productivity of local businesses and attract economic activities such as investment and tourism.

Catalytic impacts are notoriously difficult to quantify, such as increased labor market efficiencies and suburban/rural access. While 88% of Virginia square mileage is considered rural, only 26% of Virginians live in rural areas, and 74% of Virginians live on the 12% of square mileage considered urban or suburban. Virginia has three major urban areas—northern Virginia, the Hampton Roads-Norfolk area, and Richmond.

Ease of transportation from outlying areas to urban centers will expand job opportunities and increase the customer base for urban businesses, which in turn will generate revenues and help grow the economy. Securing America's Future Energy (SAFE), an energy policy research organization, cited the following in its 2018 study:

- A 1% improvement in accessibility to a region's central business district improves regional productivity by 1.1%.
- A 10% increase in average speed of transportation, all other factors being constant, leads to a 15-18% increase in the labor market size, resulting in a 2.9% increase in productivity.
- A 10% improvement in access to labor increases productivity and regional output by 2.4%.

Another catalytic impact is improved healthcare access and outcomes. In January 2021, Virginia registered only six Level I trauma centers. Level 1 trauma centers, advanced hospitals, and health

"Much of rural Virginia has a challenge accessing metropolitan
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there are popular city pairs that
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it is not economically feasible
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opportunity to bridge those
communities to provide intrastate
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currently not available, including
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AAM has huge potential to
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Greg Campbell,
Director, Virginia Department of Aviation

care centers are impossible to cost-justify in rural and low-density areas. For instance, in Southwest Virginia, the state's only adult Level 1 Trauma Center is located in Roanoke, where residents must sometimes drive over 100 miles for trauma care.

AAM augments existing EMS operational infrastructure for First Responder events. New AAM aircraft will bring patients to the larger, more urban facilities where staffing is robust, and at times they may be used to transport those providers and professionals to the rural areas when needed.

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Ensuring Virginia Has the 7HFK 7DOHQW 5HTXLUHG IRU $

Literacy and workforce competency in technical fields are essential to the Commonwealth's financial prosperity. STEM (Science, Technology, Engineering, and Math) capability is an essential economic driver. The aggregate average salary for all STEM workers nationwide is $100,900, compared with $55,260 for non-STEM jobs.

In our three focus groups and dozens of personal interviews, stakeholders across the board expressed concern that the new AAM/sUAS industry may not blossom as expected due to lack of qualified applicants.[10] There is already a national shortage of pilots, mechanics, air traffic controllers, and engineers. The US Bureau of Labor Statistics forecasts that more than a million new STEM jobs will be added to the US economy through the 2020s, and our models forecast more than 13,000 technical jobs in Virginia by 2045, out of 17,000 new jobs overall.

Fortunately, Virginia is in a strong position to meet AAM's future workforce demands.

> ³7KH VWDWH QHHGV invest in the tech talent pipeline, ZKLFK LV NH\ WR DW EXVLQHVVHV ´
>
> Delegate Shelly Simonds,
> Member, VA House of Delegates,
> Ninety-Fourth District, Newport News

The Virginia Space Grant Consortium

The Virginia Space Grant Consortium (VSGC), a Key Player in the State's Workforce Development

Virginia is home to the Virginia Space Grant Consortium (VSGC). VSGC, a NASA/state partnership, is a coalition of five Virginia colleges and universities, NASA, state educational agencies, the Virginia Innovation Partnership Corporation, and other institutions representing diverse aerospace and aviation education and research. With its statewide mission and established success in STEM education and workforce development including unmanned systems, VSGC serves as an excellent facilitator working with education institutions at all levels and business/industry to prepare the future workforce. All organizations and STEM education and workforce providers referenced in this section have partnered with VSGC on related initiatives.

VSGC Director Mary Sandy stated, "With the sUAS/AAM curriculum development, educator professional development programs, and employer-aligned pathways offered to date, Virginia is well positioned to prepare the future workforce. We look forward to continuing to foster education and training for emerging AAM workforce needs."

With National Science Foundation (NSF) funding since 2012 to support the GeoTEd-UAS project, VSGC and partners have served as catalysts for sUAS course development and faculty training that have increased the capacity of community colleges to prepare the future workforce. VSGC has trained more than 100 educators and developed many partnerships with non-profit organizations to create real-world service-learning projects for students and faculty. VSGC has also facilitated partnerships

[10] IDTech.com."The state of STEM education told through 25 stats." May 20, 2022

between employers and colleges to ensure that curriculum is aligned with workforce needs. More than 900 students have completed sUAS courses through community colleges. DroneUp and other sUAS employers have hired students who completed these community college programs.

Universities and Colleges

In the Commonwealth of Virginia, there are many existing STEM programs that have demonstrated success in preparing the future workforce in STEM and aviation/sUAS/pilot sectors. Several four-year universities offer courses and programs that are preparing the workforce for careers as engineers, engineering technologists, robotic/autonomy technicians, commercial and remote pilots, aircraft maintenance technicians, and other jobs that can support the AAM/sUAS economy.

- Virginia Tech with its main campus in Blacksburg is one of the top engineering universities in the country, its aerospace engineering program ranked #12 in September 2022 by US News & World Report. The Virginia Tech Mid-Atlantic Aviation Partnership (MAAP) manages the Virginia Tech UAS Test Site, one of seven such FAA sites across the US.
- Liberty University in Lynchburg has an sUAS program as part of its School of Aeronautics, where graduates have the opportunity to obtain their FAA remote pilot certificate and gain experience with various sUAS and applications.
- Old Dominion University is home to the Virginia Institute for Spaceflight and Autonomy led by Dr. David Bowles, the former Director of NASA Langley Research Center. Located on the Eastern Shore, VISA is chartered to grow the entrepreneurial ecosystems for space flight and autonomy.
- Virginia Commonwealth University’s (VCU) Department of Mechanical and Nuclear Engineering and Department of Electrical and Computer Engineering are preparing the workforce of the future to develop and support autonomous and unmanned systems. Other relevant areas of expertise include surface engineering, multi-scale manufacturing and design, energy generation and storage, micro/nanotechnology, thermal sciences, solid mechanics, smart materials, and biomechanics.

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> Tombo Jones,
> Director, Mid Atlantic Aviation
> Partnership (MAAP)

Virginia's 23 community colleges are poised and ready to expand and adapt to meet the sUAS/AAM workforce as they continue to develop and offer sUAS operator/pilot pathways that include preparation for the FAA Part 107 Remote Pilot Certificate, mission planning and operations, data analysis, and sUAS maintenance.

- Virginia Peninsula Community College (VPCC) (with campuses in Hampton and Williamsburg) offers a 19-credit hour Career Studies Certificate, sUAS Flight Technician, that provides students with the knowledge and experience to conduct safe and legal operations of sUAS including manual and autonomous flight and data analysis.
- Laurel Ridge Community College with campuses in Frederick, Luray-Page, and Fauquier Counties, under the leadership of Dr. Craig Santicola has been awarded a Virginia Initiative for Growth & Opportunity Grant (Go Virginia) to host technology academies for high schools in Fauquier and Rappahannock counties that advance education, credentialing, apprenticeship, and internship opportunities in the fields of drones and robotics. Dr. Melissa Stange has been awarded an Innovative Project Grant UAS grant from the Virginia Space Grant Consortium (VSGC) to bring unmanned aircraft systems to students and the community. The program, which starts in January 2023, offers a variety of certificates and programs including preparation for the Part 107 test, drone repair, GIS and advanced mapping, flying skills, and internships or work-study.
- Germanna Community College (GCC) is a current partner with VSGC on the GeoTEd-UAS project and is developing courses in sUAS and GIS to support the future workforce. Competencies related to sUAS/AAM are being integrated in many different disciplines at GCC to increase skill development and experience and promote careers in this sector. GCC has been active in building partnerships in the region and in obtaining equipment to support instruction.
- New River Community College, Virginia Highlands Community College, Eastern Shore Community College, Tidewater Community College, Blue Ridge Community College, and Mountain Gateway Community College have also offered courses and continue to grow their credit and continuing education courses in drones.

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Dave Bowles,
Executive Director, Virginia institute for Spaceflight & Autonomy

Industry Internships and Partnerships

VSGC created the state-funded Commonwealth STEM Industry Internship Program (CSIIP) to connect undergraduate students in Virginia with paid internships with business and industry. CSIIP links companies and students in STEM, including but not limited to high-need areas such as Aviation, Aerospace, Aeronautics, sUAS, Autonomy and Robotics, Computer Science, Cybersecurity, Data Science (Data Analytics, Data Visualization, etc.), Information Technology, Engineering, Physical Science and more. CSIIP has placed nearly 900 students in internships with nearly 130 companies. Many of these students have been hired by the placement companies.

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Dr. Kimberly Brush,
Director, NASA Langley Office
of STEM Engagement

In 2021, Boeing became the first foundational partner for Virginia Tech's Innovation Campus, making a $50-million, multiyear commitment. Virginia Tech President Tim Sands said Boeing's commitment will help jump-start the university's effort to create the most diverse graduate technology campus in the country. The investment will provide student scholarships, help recruit world-class faculty, and fund STEM programs for underserved students in K-12.

In August 2022, DroneUp announced plans to spend $20.2 million to create a drone testing, training, research, and development center at Richard Bland College of William & Mary (RBC) in Dinwiddie for its employees, who will receive up to twelve college credits for an intensive, customized two-week program. Some graduates will be sent to one of the thirty-four Walmart locations in six states using drone delivery, including Virginia, while most will work at DroneUp's new Virginia Beach headquarters, which has begun the process of hiring 655 employees.

RBC President Dr. Debbie Sydow said, "I fully anticipate that many of the academy students will continue their education by taking our online course and getting either additional micro-certifications or an Associates degree. We hope that our general population students will intern at DroneUp Flight Academy and become part of the pipeline."

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High School sUAS/AAM Education

The Virginia Department of Education (VDOE) is focused on expanding STEM educational opportunities for students. In 2022, 53 percent of students graduated with an Advanced Studies diploma, with four years each of math and science.

The VDOE recently approved a new Career and Technical Education (CTE) course in sUAS that can be offered by any high school. The course competencies include Part 107, sUAS flying and operations, maintenance, and data analysis. VSGC and partners, industry leaders, and other stakeholders helped inform and shape the course. The CTE sUAS is being offered by about a dozen schools in 2022-23, and course offerings are expected to grow exponentially next year and beyond. Courses in aircraft maintenance and piloting are also available but taught on a limited basis. VDOE should be encouraged and supported to grow these course offerings by developing the necessary partnerships.

In partnership with the Commonwealth of Virginia, Averett University, Rick Aviation, Aviation Adventures, and the Virginia Department of Aviation, VSGC is offering flight academies for selected high school students statewide in response to the looming national shortage of airline pilots. The Commonwealth of Virginia, FAA, and the Virginia Department of Aviation are providing funding that permits the Pathways Flight Academies program to be offered free of charge to participants. The Academies immerse students in learning to fly through their solo flight with ground school preparation. available. Students admitted to this intensive program undertake ground school and flight training that can culminate in their first solo flight at the end of the academy.

One school with a particular focus on aerospace is Denbigh High School's Aviation Academy, a nationally recognized STEM site that specializes in piloting, aircraft maintenance, engineering, and aviation security/safety. Aviation classes begin in the 9th grade where students can choose one of four pathways:

- Aviation Technology
- Flight Operations
- Aerospace Engineering and
- Aviation Security & Safety

The school offers an FAA pilot ground school course that will prepare students for flying lessons and private pilot licensure. Denbigh partners with agencies and industry such as NASA and Northrop Grumman to ensure the curriculum reflects current trends. This year, the academy is offering a Part 107 course for the first time. Some Denbigh graduates become mechanics and other Aviation/ Manufacturing related careers, while others get their pilot's license or study aerospace or mechanical engineering at a four-year university.

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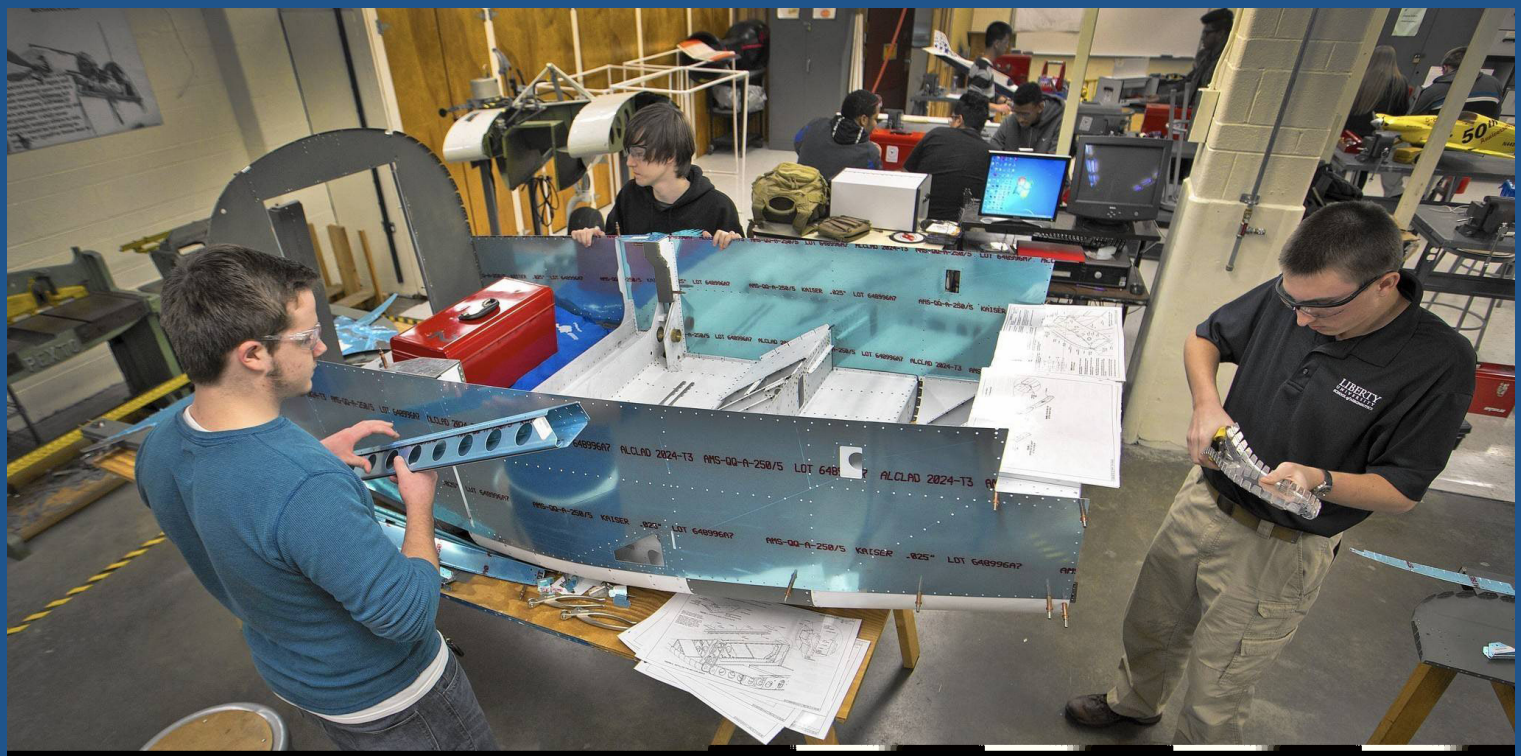
Dr. Aaron Smith,
Program Administrator,
Denbigh Aviation Academy