Advanced Air Mobility (AAM) Public Good Mission & Use Case Development

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FINAL REPORT

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Crown Innovations, Inc. is shaping the future of air transportation with concept development, design and deployment of systems and aircraft. Crown brings more than three decades working with the Federal Aviation Administration (FAA), National Aeronautics and Space Administration (NASA), states and industry. We integrate industry-leading air mobility technology and planning support, engineering, information solutions and advanced analytics that enhance system performance and provide robust solutions for government and industry clients.

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List of Acronyms

Acronym	Definition	Acronym	Definition	Acronym	Definition
AAM	Advanced Air Mobility	**AAMS**	Association of Air Medical Services	**AC**	Advisory Circular
ACO	Aircraft Certification Office	**ADA**	Americans with Disabilities Act	**ADSP**	Automated Data Service Provider
AHP	Analytic Hierarchy Process	**ATC**	Air Traffic Control	**ATM**	Air Traffic Management
ATP	Airline Transport Pilot	**ATSBM**	Air Traffic Service Business Model	**BT**	Beneficiary Travel
BVLOS	Beyond Visual Line of Sight	**CAMTS**	Commission on Accreditation of Medical Transport Systems	**CCATT**	Critical Care Air Transport Team
CCN	U.S. Department of Veterans Affairs Community Care Network	**CDC**	Centers for Disease Control and Prevention	**CFR**	Code of Federal Regulations
CHAMPVA	Civilian Health and Medical Program of the Department of Veterans Affairs	**CIT**	Cold Ischemic Time	**CITI**	CHAMPVA In-House Treatment Initiative
ConOps	Concept of Operations	**CRM**	Crew Resource Management	**CRS**	Congressional Research Service
CTOL	Conventional Take-Off and Landing	**DAV**	Disabled American Veterans	**DOD**	Department of Defense
DOT	Department of Transportation	**DOW**	Department of War	**DSCA**	Defense Support of Civil Authorities
EB	Engineering Brief	**ECT**	Emergency Care Transportation	**eCTOL**	Electric Conventional Take-Off and Landing
EMS	Emergency Medical Services	**EMTALA**	Emergency Medical Treatment and Labor Act	**eSTOL**	Electric Short Take-Off and Landing
eVTOL	Electric Vertical Take-Off and Landing	**FAA**	Federal Aviation Administration	**FEMA**	Federal Emergency Management Agency

G&A	General and Administrative Utilities	**GA**	General Aviation	**GAO**	Government Accountability Office
GSA	General Services Administration	**HAA**	Helicopter Air Ambulance	**HEMS**	Helicopter Emergency Medical Services
HEPA	High-Efficiency Particulate Air	**HHS**	U.S. Department of Health and Human Services	**HRSA**	Health Resources and Services Administration
HRTG	Highly Rural Transportation Grant	**ICS**	Industry Consensus Standards	**ICU**	Intensive Care Unit
IFR	Instrument Flight Rules	**IMC**	Instrument Meteorological Conditions	**IT**	Information Technology
IV	Intravenous Equipment	**LOA**	Letter of Agreement	**MADM**	Multi-Attribute Decision-Making Method
MedEvac	Medical Evacuation	**MEDVAMC**	Michael E. DeBakey Veterans Affairs Medical Center	**NAS**	National Airspace System
NASA	National Aeronautics and Space Administration	**NDMS**	National Disaster Medical System	**NEMT**	Non-Emergency Medical Transportation
NM	Nautical Miles	**NOTA**	National Organ Transplant Act	**NPRM**	Notice of Proposed Rule Making
NPS	National Park Service	**NRC**	Nuclear Regulatory Commission	**NVG**	Night Vision Goggles
OCC	Operations Control Center	**OCS**	Operations Control Specialists	**OEM**	Original Equipment Manufacturer
OPO	Organ Procurement Organization	**OpSpec**	Operations Specification	**OPTN**	Organ Procurement and Transplantation Network
PHMSA	Pipeline and Hazardous Materials Safety Administration	**PIC**	Pilot-in-Command	**PSS**	Passenger Support Specialist
QFD	Quality Function Deployment	**R&D**	Research and Development	**RAM**	Regional Air Mobility

ROC	Remote Operations Center	**SA**	Situational Awareness	**SHPO**	State Historic Preservation Office
SME	Subject Matter Expert	**SMT**	Special-mode Transport	**SNS**	Strategic National Stockpile
SOP	Standard Operating Procedure	**SRM**	Solar Radiation Management	**STOL**	Short Take-Off and Landing
SysML	System Modeling Language	**TFMS**	Traffic Flow Management System	**TFR**	Temporary Flight Restrictions
TLX	Task Load Index	**TOPSIS**	Technique for Order of Preference by Similarity to Ideal Solution	**TSA**	Transportation Security Administration
UAM	Urban Air Mobility	**UAS**	Unmanned Aircraft Systems	**UAV**	Unmanned Aerial Vehicle
UCT	Urgent Care Transportation	**UNOS**	United Network for Organ Sharing	**UPS**	United Parcel Service
USC	United States Code	**UTM**	UAS Traffic Management	**VA**	U.S. Department of Veterans Affairs
VATC	Veterans Affairs Transplant Centers	**VHA**	Veteran Health Administration	**VTN**	Volunteer Transportation Network
VTOL	Vertical Take-Off and Landing	**VTS**	Veteran's Transportation Service	**WG**	Working Group
WHO	World Health Organization				

Executive Summary

The Crown Innovations, Inc. (Crown) team—Crown, supported by Georgia Tech's Aerospace Systems Design Laboratory and GRA, Incorporated—investigated Advanced Air Mobility (AAM) capabilities for potential "public good" applications. The definition of "public good" used in this study aligns with the 2023 NASA-sponsored research by Deloitte [1], which describes such applications as those leveraging AAM capabilities to benefit the public, with services available to all members of society at no additional cost to the end beneficiary. Our study spanned Urban Air Mobility (UAM), Regional Air Mobility (RAM), and low-altitude Unmanned Aircraft Systems (UAS) as candidate application categories.

Using a structured down-selection process, we evaluated 59 applications: 40 previously defined by Deloitte and 19 that we newly identified. We used the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) methodology to guide our selection of two applications to examine in depth: Patient Transport in UAM vehicles and Organ Transport via UAS platforms.

The selected applications demonstrate strong potential for federal support and integration in the United States (U.S.), particularly within the transportation and medical service infrastructure of the U.S. Department of Veterans Affairs (VA). The anticipated implementation timeframe is "near term" (3–5 years), based on current regulatory, commercialization, and integration progress by AAM Original Equipment Manufacturers (OEMs). Key end users of these applications include public and private healthcare systems, Organ Procurement Organizations (OPOs), medical networks, and rural or semi-urban patient populations—all of whom stand to benefit from the integration of AAM technologies into public good applications.

For the Patient Transport application, we developed the following two missions:

1. AAM-enabled rural urgent transfers (100 mile range) and
2. Inter-hospital transfers within the VA medical network (50 mile range).

Although missions within the Patient Transport application may be performed by private health care networks, the discussion in this paper focuses on reducing travel time and logistical complexity for patients accessing medical care specifically in the VA medical network. AAM could help address existing challenges the VA faces, including fragmented and inefficient ground and air logistics, especially in rural areas, leading to elevated costs and extended travel times for critical care.

Anticipated benefits of AAM operations for the Patient Transport application include faster and more efficient methods for rural and inter-hospital transfers, while reducing reliance on costly helicopter emergency medical services (HEMS). Implementing AAM for rural patient transportation could significantly expand access to care for underserved veterans. AAM aircraft are expected to offer competitive acquisition costs and lower operating expenses compared to traditional air transport and, although they will likely remain more expensive than ground transportation, will likely be faster than ground transport.

For the Organ Transport application, we identified the following two missions:

1. UAS-based first-/last-mile (5–50 miles) organ delivery connection to airports and
2. UAS-based round-trip organ deliveries (5–150 miles) within a medical network.

The primary objective of the Organ Transport application is to reduce cold ischemic time (CIT) of the organs, thereby improving transplant outcomes for patients. CIT is defined as the time period from when a donor organ stops receiving blood from the donor patient to when it is reconnected

to a receiving patient's blood supply to complete the organ transplantation [2]. We reviewed multiple studies that cited existing challenges, including delays and logistical issues, with commercial flight-based organ delivery. Although charter flights and ground transportation can provide more reliability than commercial flights, AAM-based solutions may provide another means of reducing CIT and improving patient outcomes. Other anticipated benefits of AAM operations for the Organ Transport application include fewer handoffs between medical staff and couriers and delivery costs competitive with or lower than existing air ambulance or other commercial flight options.

Our study also identified key constraints that may hinder speedy AAM implementation for these public good applications. Certification gaps exist for medical applications involving UAM and UAS platforms, as the Federal Aviation Administration (FAA) has not yet approved any operating certificates for such operations. Additional challenges include gaps in Commission on Accreditation of Medical Transport Systems (CAMTS) compliance processes for AAM applications. Furthermore, modernizing infrastructure—such as electric charging stations and landing zones—will require significant investment per site, depending on operational requirements and landing location of the UAM/UAS aircraft. Weather, aircraft range limitations, and VA budget constraints also pose barriers to deployment. To support VA integration, coordination with the VA Community Care Network will be essential to expand transportation options to include AAM.

Despite these challenges, recent industry developments and policy changes have created new opportunities for AAM integration efforts. The AAM Coordination and Leadership Act (2022) established an interagency working group to support AAM safety, infrastructure, and federal investment planning; this group released a National Strategy in late 2025 that includes a recommendation (Recommendation 4.4) for exploring public good AAM applications. The FAA Reauthorization Act of 2024 introduced greater flexibility in oversight and engineering for AAM aircraft by the FAA, including pathways to support future medical applications. In August 2025, the FAA issued a Notice of Proposed Rulemaking (NPRM) for Part 108 to enable Beyond Visual Line of Sight (BVLOS) operations—critical for UAS organ transport missions. Concurrent with the FAA continuing to explore certification means for AAM aircraft for various operational envelopes, technology maturation, including aircraft design improvements in payload capacity and endurance, will enable additional medical applications.

Based on these findings, we recommend that AAM industry leaders and stakeholders establish pilot programs at select VA facilities in rural and underserved communities. These programs should initially utilize existing helipads and airports, with plans to scale as technologies and regulations mature. Collaboration with AAM OEMs will be essential to identify integration requirements, including charging infrastructure, vehicle handling characteristics for both patient and organ transport, and pathways for future regulatory compliance.

1 Introduction

The Crown Innovations, Inc. (Crown) team—Crown, supported by Georgia Tech's Aerospace Systems Design Laboratory and GRA, Incorporated—investigated Advanced Air Mobility (AAM) capabilities for potential "public good" applications. This study focused on Urban Air Mobility (UAM), Regional Air Mobility (RAM), and low-altitude Unmanned Aircraft Systems (UAS) as candidate application categories. The U.S. federal government, state governments, and local and tribal agencies could better serve their constituents by incorporating AAM vehicles and operations to support public good applications to expand transportation. Our study aimed to further explore public good applications by building upon the foundational work presented in the 2023 NASA-sponsored report developed by Deloitte [1], and our work makes progress toward Recommendation 4.4 of the U.S.'s AAM National Strategy released in Dec 2025 [3]. We examined applications that would support federal government interests and goals with the following objectives in mind:

- Identify a set of public good applications and down-select two that have high potential to benefit from deploying AAM capabilities for more detailed analysis
- For each of the down-selected applications, define constituent missions by developing Concepts of Operations (ConOps) describing the current state and future state (with AAM) including technical and operational requirements
- Discuss key assumptions, constraints, enablers, and non-aviation systems needed
- Perform an initial cost assessment

To maintain consistency with NASA's AAM framework, we adopted a terminology hierarchy that distinguishes between applications, missions, and use cases, as shown in Figure 1.

1. **Application Category**: The high-level mission/domain above the specific application, implying high-level operational characteristics *(e.g., UAM, RAM)*
2. **Application**: The business application/service, providing more context and adding specificity to the application category *(e.g., Air taxi, Air ambulance, Middle-mile cargo delivery)*
3. **Mission**: overview and description of a particular application, including purpose for it and specific parameters to describe a flight
4. **Operation**: The breaking apart of the mission into operational elements, not specifying users/roles (e.g., *Vertiport departure, Vertiport arrival, On-ground energy replenishment)*
5. **Use Case**: The system's behavior as it responds to the actions of the primary actor for the nominal ("sunny day") operation *(e.g., Onboard PIC departs vertiport, Vertiport manager manages takeoff)*
6. **Scenario**: Specific solution path and actor(s) for contingency and off-nominal processes
   (e.g., Onboard PIC departs vertiport –Contingency/Off-nominal, Vertiport manager manages takeoff –Contingency/Off-nominal)

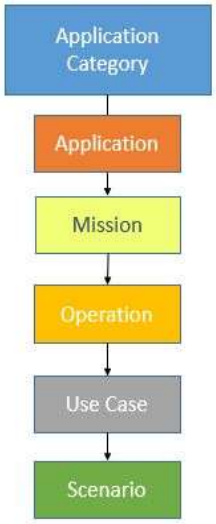


Figure 1. Terminology Hierarchy Definitions

This study focused on federally led applications, either operated directly by federal agencies or funded through federal budgets, to establish viable pathways for AAM integration into public good operations. We expect the primary benefit of applying AAM to public good applications is the efficiency gained by shifting certain operations from ground-based transportation, which can

experience delays that negatively impact mission objectives, to more air-based transportation. We test this theory by assessing the proposed air-based solutions, which are expected to reduce travel constraints and enable faster, more timely execution of various applications. When considering this transition of applications from a federal stakeholder perspective, this shift will allow for more efficient use of resources currently consumed in ground-based operations.

Technical and operational requirements were derived for each application by defining two missions per application, based on a structured down-selection process. The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) methodology guided the selection, using current ground and air transportation modes as a baseline for comparison. This process enabled us to develop structured Concepts of Operation (ConOps), to illustrate both how the missions are fulfilled today and how AAM capabilities would provide benefits relative to current methods. To balance the analysis of benefits, we also estimated the costs of using AAM relative to the baseline.

Following this Introduction, Section 2 outlines the technical approach for this study, including our structured down-selection process and associated definitions and assumptions. Section 3 presents the first selected application, Patient Transport, with a description of the supporting missions; assumptions, constraints, enablers, and needed non-aviation systems; and the associated cost assessment of utilizing AAM technologies for future VA patient transport operations. Section 4 is structured similarly to Section 3, while focusing on our second selected application, Organ Transport. Section 5 concludes the report by summarizing our effort and providing recommendations for next steps in implementing these public good AAM applications.

2 Application Down-Selection

We developed a decision-making framework to assess, grade, and rank an extensive list of public good applications that may be performed with AAM capabilities. In the workflow of assessing the qualities of each application, the methodology consisted of two primary evaluation phases:

- **Adopter Potential Comparison:** This phase involves comparing AAM concepts against the current systems used to perform a public good application (Baseline) to qualitatively assess their ability to meet application-specific requirements.
- **Criteria Grading and Ranking:** This phase ranks the application based on system-level impact and feasibility metrics.

The following sections provide further details of these two phases of our application down-selection process.

2.1 Adopter Potential Comparison

In the Adopter Potential Comparison phase, we defined five categories that supported further rating criteria. The five categories and their definitions were based on our research of the current state of transportation needs and how these needs will evolve to future-state AAM applications:

- **Adaptability to Commercial Application:** Grading the uniqueness of the public good application and how useful it would be for industry to invest in as an application that could eventually be adapted to commercial use.
- **AAM Technologies Leveraged:** Assessing how many AAM-specific technologies or other capabilities are leveraged to perform the application.
- **Timeframe Required:** Grading how early this application can be deployed (with respect to how mature the required AAM capabilities are).
- **Amount of Public Good Achieved:** Grading how much societal impact the public good application has considering the impact of any single mission with how frequently it occurs.
- **Cost Savings:** Assessing the financial efficiency of deploying AAM capabilities to perform this public good application.

To compare AAM concepts against existing systems (the Baseline) in performing public good applications, the Pugh Evaluation Matrix was selected for its simplicity and effectiveness in evaluating multiple design options against a consistent set of criteria. Although a Quality Function Deployment (QFD) approach was initially considered, it added unnecessary complexity and was impractical for the initial evaluations of the different applications at the level of detail of interest for this study.

For each of the 59 total potential AAM public good applications, the following twenty criteria were considered in evaluating the ability of an AAM concept to fulfill the specific needs of a given application relative to the current system.

1. **Distance Covered per Operation:** Range/area covered by the system
2. **Speed of Deployment:** Time to prepare and deploy assets on a mission and reach the application area
3. **Access to Remote Location and Coverage Capabilities:** Assessment of areas accessible by the system, including maximum operational elevation when relevant
4. **Payload Capacity:** Ability to carry necessary equipment or cargo
5. **Passenger Payload:** Capacity to transport people
6. **Infrastructure Requirements:** Physical support structures needed for operation (e.g., take-off/landing areas, charging/refueling stations)

7. **Availability of the System:** Amount of time the system will be available for operations, considering complexity of maintenance and time required to refuel or recharge
8. **Energy Efficiency:** Energy consumption rates
9. **Application Duration:** Operational endurance or runtime
10. **Stationary Capability:** Ability to remain static during operation (e.g., hovering)
11. **Noise Footprint:** Sound levels produced during operation
12. **Carbon Emissions:** Lifecycle carbon emissions
13. **Weather Resilience:** Capability to operate under various weather conditions
14. **Public and Operator Safety:** Risk of incidents affecting both the public and operators
15. **Level of Data Acquisition Accuracy needed:** Necessary quality and resolution of data collected to fulfill application need
16. **Data Gathering Capabilities:** Effectiveness in collecting required information
17. **Operational Personnel:** Number and type of personnel required for operation
18. **Training Complexity:** Amount of training necessary for operators
19. **Ergonomics and Comfort:** Comfort levels for crew and passengers (when applicable)
20. **Level of Autonomy:** Degree of automation (e.g., fully autonomous, remotely piloted, piloted)

Each of these criteria was assigned a weighting between 0 and 5, to reflect its relative importance to the particular application under consideration based on literature review and engineering judgement. To ensure consistency across evaluations of all 59 public good applications, a total of 50 weighting tokens were distributed per application.

A selected AAM concept aircraft[1] and supporting systems were then compared against the baseline (e.g., ground vehicle, helicopter, etc.) for each criterion. The comparison was scored as follows:

- **+1:** AAM performs better than the Baseline in meeting the application requirement
- **0:** AAM performs at the approximately the same level
- **-1:** AAM performs worse than the Baseline

Each score was multiplied by its corresponding weighting, and the total sum produced an Adopter Potential score for the application, quantifying the technical feasibility and suitability of using AAM for the application.

This structured approach ensured a consistent evaluation of AAM concepts across diverse public good applications.

2.2 Criteria Grading and Ranking

In the Criteria Grading and Ranking phase, for each of the 40 applications reviewed from Reference [1] and the 19 original applications developed by our team (see Appendix A), we developed ranking criteria and quantitative assessments based on a literature review of the various mission components (see Appendix B). We then used NASA Subject Matter Expert (SME) input to finalize the criteria rankings. This process involved some subjective considerations based on the current political and industry environments for AAM and aviation; therefore, the results could vary in future reviews of this content based on developments at that time.

[1] The aircraft type considered varied for each application under consideration, and these concepts included unmanned aircraft system (UAS), electric vertical take-off and landing (eVTOL) aircraft, electric conventional take-off and landing (eCTOL) aircraft, hybrid-electric vertical take-off and landing (VTOL) aircraft, and hybrid-electric conventional take-off and landing (CTOL) aircraft.

To systematically compare and rank the selected public good applications, the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) was employed for this study. This multi-attribute decision-making (MADM) method was chosen over alternatives such as the Analytic Hierarchy Process (AHP) and NASA Task Load Index (TLX)-like methods due to its scalability when analyzing 59 different AAM applications, its ease of use, and the ability to integrate both subjective and objective evaluations. These features are critical given the extensive list of applications and diverse evaluation criteria.

TOPSIS operates by identifying theoretical ideal and anti-ideal solutions that serve as normalized benchmarks for comparison. The theoretical ideal solution was established by determining the most-preferred values for each evaluation criterion across all alternatives, and the theoretical anti-ideal solution was defined by the least-preferred values for each criterion across all alternatives. Each application was then assessed based on its Euclidean distance from these ideal and anti-ideal points, facilitating a ranking that reflects proximity to the theoretically optimal solution.

The evaluation encompasses six criteria, each weighted according to stakeholder priorities:

- **Adopter Potential:** As described above and calculated using the Pugh Evaluation Matrix
    - A higher number from the Pugh matrix indicated a higher likelihood for AAM vehicles to outperform the baseline for a specific mission.
- **Difference to Other Commercial Applications:** Measures how unique the application is compared to commercial applications
    - *1 = Very Similar: Nearly identical to commercial application*
    - *2 = Moderately Different: Some overlap but added requirements*
    - *3 = Completely Unique: Has no clear commercial counterpart*
    - High uniqueness is indicative of a need for public investment to achieve the capability because commercial entities are unlikely to invest in applications for which there is not a commercial counterpart.
- **AAM Technologies Leveraged:** Quantifies the extent to which AAM-specific technologies are required for successful execution (e.g., quiet VTOL, autonomous flight, and integration into air traffic management systems)
    - *1 = Low: Could be performed with existing technology*
    - *2 = Medium: AAM technology provides some additional capability but is not necessary for all aspects of the application*
    - *3 = High: Advanced AAM technology integration is necessary to perform the application*
    - The more benefit AAM technologies provide in accomplishing the application, the higher the score. The need for more AAM technologies is anticipated to drive research and support maturation of the AAM industry.
- **Timeline Required:** Estimates how soon the application could be deployed based on the maturity of required technologies and regulatory considerations
    - *1 = Long-Term (10+ years)*
    - *2 = Mid-Term (5-10 years)*
    - *3 = Short-Term (1-5 years)*
    - *4 = Immediate (>1 year)*
    - A quicker integration/certification of the AAM technology to more rapidly support the application is preferred. The sooner the AAM capabilities could be fielded for the application, the easier it would be to justify funding of the application (partnered with the next criterion).

- **Cost Savings:** Assesses the economic advantage of deploying AAM compared to the baseline system
  - *1 = None or Low*
  - *2 = Medium*
  - *3 = High*
  - An expected reduction in costs scored higher because the goal is to spend less money than the baseline, while providing the same or better outcomes.
- **Amount of Public Good Achieved:** Evaluates the societal benefit based on the frequency and severity of the application's impact
  - *1 = Low*
  - *2 = Medium*
  - *3 = High*
  - The more potential for public good achieved is the desired direction of the ranking. The goal is to select applications that achieve higher levels of public good through additional access to communities, render more efficient services, or lessen the burden to conduct the operation for a given end-user.

Each criterion was assigned a specific weight reflecting its importance to stakeholders on a scale of one to ten. The TOPSIS analysis then calculated the relative closeness of each application to the theoretical ideal solution, producing a ranked list that informed the selection of applications best suited for AAM implementation. An example ranking using this method is shown in Figure 2 with the following evaluation criteria weights (out of a maximum of 10):

- Adopter Potential: 8
- Difference to Other Commercial Applications: 2
- AAM Technologies Leveraged: 2
- Timeline Required: 2
- Cost Savings: 2
- Amount of Public Good Achieved: 2

The long bars indicate the primary AAM aircraft type that is anticipated to perform the application, with light blue indicating a passenger-carrying-scale aircraft (denoted “eVTOL and other” in the legend) and dark blue representing a non-passenger-carrying UAS (or “Drone”). While Figure 2 reflects the ranking using the weights listed above, we did a sensitivity analysis by varying the criteria weights to test how (and how much) applications would move up/down in the ranking.

We also considered whether the federal government is involved at all with each application and, if it is, how likely it is to fund and/or to directly execute it. Specifically, these five categories are shown as a bar on the left side of the chart in Figure 2:

- **No Involvement:** Federal government is not involved in the funding or execution of this application (shown as void in Figure 2)
- **Unlikely Funded:** Federal government may, but is unlikely to, fund a commercial entity to perform this application (and will not execute it directly with government assets and personnel)
- **Unlikely Execution:** Federal government may, but is unlikely to, execute this application directly with government assets and personnel and may, but is unlikely to, fund a commercial entity to perform this application
- **Likely Funded:** Federal government will not execute this application directly with government assets and personnel but is likely to fund a commercial entity to perform it
- **Likely Execution:** Federal government is likely to execute this application directly with government assets and personnel

From the criteria weighting sensitivity analysis and consideration of federal government involvement, we ultimately chose two applications for further analysis: **Patient Transport (eVTOL/eCTOL)** and **Organ Transport (UAS)**. These applications were generally rated highly in the TOPISIS evaluations as criteria weights were modified, and they represent the highest rated missions for the two aircraft types (i.e., "Drone" and "eVTOL and other") shown in Figure 2, which uses the weights listed above. Additionally, these applications showed high potential for effective integration into current federal agency operations with the Department of Veterans Affairs (VA), while being supported by private manufacturers, infrastructure development, and end users. Our analytical process and subject matter expertise led us to conclude that, in the Spring 2025 timeframe, these choices best represented the current regulatory policy frameworks, political environment, and the expressed need for efficient transportation services in the medical field, which is generally well-accepted as a "public good" category.

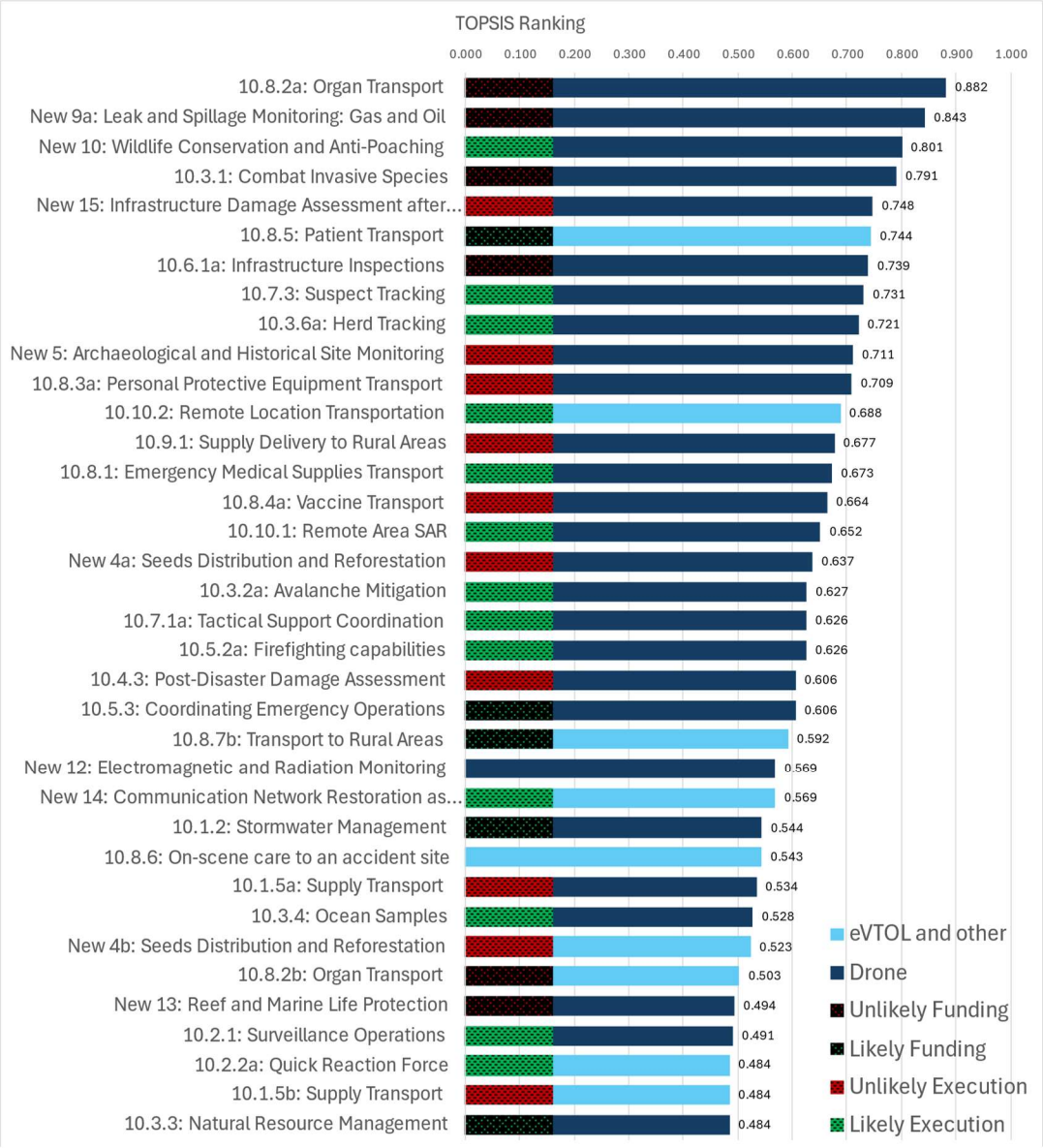


Figure 2. Overall Rankings for an Example Set of Evaluation Criteria Weights

3 Application 1: Patient Transport

3.1 Purpose and Scope

Our first selected application is Deloitte's 10.8.5: Patient Transport [1]. Deloitte describes this application as transferring patients between medical facilities for better treatment or alleviating facility capacity issues. Some of the primary benefits of this application come in the form of providing a more accessible and efficient method of transportation compared to current ground and MedEvac helicopter operations [1]. In the scope of this application, accessibility is defined as increased access to medical vehicle transportation, which can be particularly limited in communities where citizens depend on neighboring cities for Emergency Medical Services (EMS) due to budget limitations in their own towns.

There are three main types of medical transportation: Non-Emergency Medical Transportation (NEMT), Urgent Care Transportation (UCT), and Emergency Care Transportation (ECT). These three types are differentiated on the severity of the patient's medical condition and the associated time criticality of the transportation need. For NEMT, the patient's conditions are non-life-threatening, and transportation can be performed via "normal" means (e.g., a van ride in normal road traffic). In urgent applications, the medical scenario of the patient is not imminently life-threatening but is elevated past what normal transportation means could provide to ensure best-chance recovery for the patient. ECT is needed when the patient is experiencing life-threating conditions that require immediate medical attention, and the distinction between urgent and emergency applications is the time-to-safe arrival of the patient based on their current medical needs. Figure 3 lists key symptoms and needs that would result in each of these three different levels of medical transportation. The timeliness of the different care levels is defined by the "Time Criticality" variable, which has the following levels:

- **Low:** Non-life threatening; time is based on scheduling of appointments
- **Medium:** Non-life threatening, but needs attention soon for best-chance recovery or care required to prevent symptoms from elevating to life-threatening
- **High:** Can be life threatening; requires immediate attention for critical care

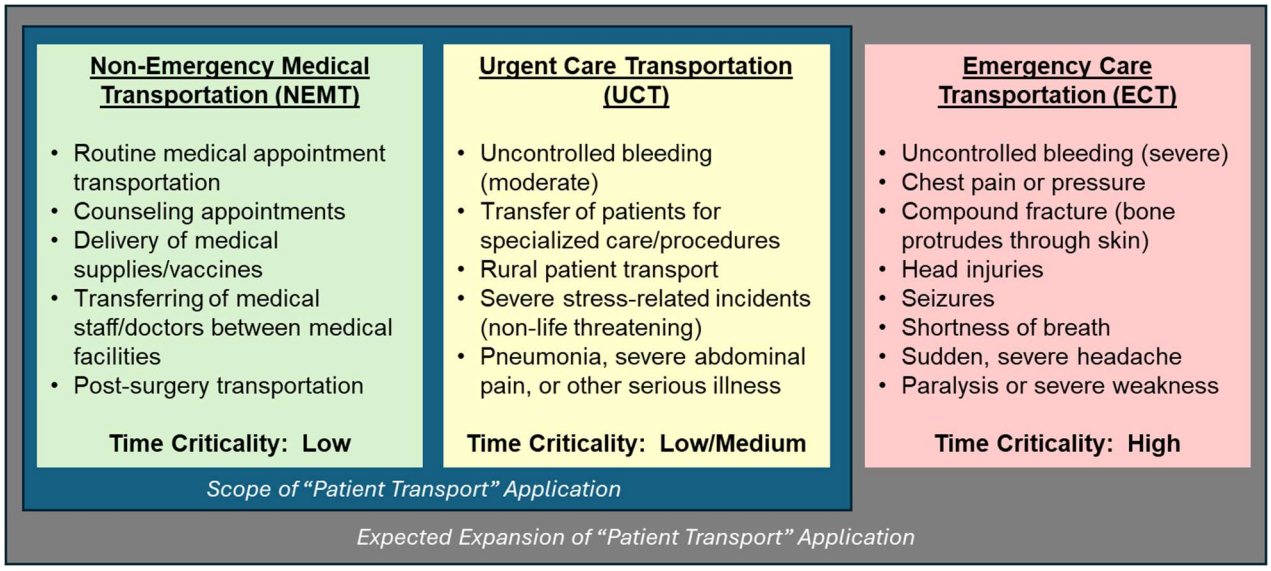


Figure 3. Scope Definition of "Patient Transport" Application Needs Based on Time Criticality [4] – [6]

Our focus in this application is primarily on “non-emergency” and “urgent” operations rather than “emergency” operations of medical patient transportation, as described in Figure 3. Through a review of multiple federal stakeholders involved in medical response, we determined that emergency and disaster transport roles are already well-supported through existing air and ground systems [7], [8], [9] and there have been studies exploring the use of AAM emergency care transportation [10]. Through the Stafford Act of 1988 and the Federal Emergency Management Agency’s (FEMA’s) tiered response system, ground- and air-transportation methods have been established with supporting policy and directives when emergency operations and support are required [11], [12]. However, while we have focused on NEMT and UCT needs, this application could also be extended to include ECT.

While several federal stakeholders provide medical transportation under emergency conditions as requested by state/local authorities, the VA is distinct in its ongoing responsibility to deliver routine and urgent medical care to veterans across the U.S., including in remote, rural communities that have limited or no medical services nearby. Unlike other agencies (e.g., Department of War (DOW)) that may maintain their own aviation assets or have streamlined contract air access (e.g., FEMA), the VA primarily relies on ground-based transport through a mix of in-house, volunteer, and partner-provided services. This structural reliance — coupled with increasing care demands — makes the VA a strategically important department for evaluating how AAM may close critical access gaps in non-emergency settings.

Gaps exist in providing timely, routine care access for veterans, particularly in rural areas [13]. By focusing on non-emergency and urgent-use scenarios for patient transport, where trips are typically initiated by veterans or their healthcare providers, this first application captures an under-addressed, yet likely high-impact, segment of the market. For example, accessibility may be improved in instances where the VA depends on volunteers as part of the Volunteer Transportation Network (VTN) due to a lack of VA staff to transport VA patients from their home to medical centers through the Veteran’s Transportation Service (VTS) [14]. Additionally, the VA’s patient transport applications have strong parallels with private healthcare needs; the VA may be able to provide an initial marketplace for AAM patient transport services that can later be expanded by the private healthcare system, thus benefitting non-veteran Americans.

3.2 Description of Application and its Missions

The following mission examples support the overarching application definition. We begin our analysis by defining AAM operations as they relate to urgent and non-emergency medical needs of veterans in rural communities and within VA hospital networks (henceforth referred to as Missions 1 and 2, respectively). Also included in these missions is the transportation of VA medical staff/doctors to and from facilities to patient locations or supporting clinics in the VA Community Care Network (CCN).

3.2.1 Mission 1: Rural Patient Transfer (Urgent)

For matters in which a patient requires medical support, but the situation is non-life-threatening, urgent transfer of the patient is expected to use an AAM aircraft with onboard medical equipment that would support the transportation of one patient with supporting medical crew (2 – 3 medical professionals, as deemed necessary based on the level of care required) [15]. Additionally, this mission could include the transport of medical professionals to VA rural clinics and facilities that are experiencing staffing shortages. The AAM vehicle will be required to incorporate medical systems, such as oxygen tanks, medical equipment storage, High-Efficiency Particulate Air (HEPA) air filtration, and enough space and locking mechanisms for a patient’s gurney and/or

wheelchairs. The trigger for this mission could come from a private hospital, medical facility, or doctor's office requesting a transfer of a veteran patient to a specific VA hospital, or vice versa. The need for these transports would stem from the need for specialized equipment or care that may only be provided at other facilities.

Given the state of the art of battery technology and associated range limitations of eVTOL AAM aircraft, the distance required to be covered is a key parameter for this mission. Our research identified two relevant data points:

- A study [13] that was partly funded through the VA's Health Systems Research & Development and VA's Office of Rural Health found that, "The average one-way distance that Veterans traveled to a VA primary care clinic was 44.5 miles."
- A U.S. General Accountability Office (GAO) study [16] found that the percentage of the Veteran population living within selected distances of VA acute care facilities included 94% within 100 miles of a hospital and 99% within 100 miles of an outpatient clinic.

Based on this data, we assumed a range of 100 miles plus the reserves specified by the FAA would be required for the rural patient transfer mission. This range assumes appropriate charging facilities are available at the hospital/clinic.

The high-level concept of operations for the current state (without AAM) starts with a helicopter that is assumed to be at a medical facility within controlled airspace receiving a trigger event, such as a dispatch call. Starting in Class B, C, or D airspace, it communicates with the air traffic control (ATC) tower for take-off and to coordinate while inside of controlled airspace. At some point along the flight path, the helicopter enters uncontrolled, Class G, airspace. The helicopter is responsible for visually seeing and avoiding other air traffic (e.g., a crop-dusting aircraft). As the helicopter approaches the pick-up site, it lands in the area, not necessarily on an official helipad or airfield, and onboards the patient and medical professionals. It then conducts a return flight, deconflicting with nearby air traffic and communicating with the appropriate air traffic control facility to enter controlled airspace at the appropriate time. It then lands at the medical facility, offloads the passengers and prepares for the next trigger event.

An alternative current state for Mission 1 is performance of the mission by a ground vehicle, i.e., an ambulance. In this case, the mission starts with the same trigger event, but the dispatcher decides to employ a ground vehicle rather than an aircraft. The starting and ending nodes are the same but the ground vehicle must navigate roadways and any traffic along the route.

The future state when AAM is implemented has the potential to either reduce the cost of the operation (as compared to a helicopter) or reduce the response time (as compared to an ambulance). The primary benefit mechanism for reducing cost is the anticipated lower operating costs of AAM electric aircraft (discussed below in section 3.6). These aircraft may operate from typical airports with CTOL aircraft, which would likely help reduce costs, but would increase the time and complexity of operations since there would be first-/last-mile travel legs required for the patient to reach the aircraft. A secondary benefit mechanism for reducing cost is improved air traffic management integration—response time of the AAM aircraft may be reduced by automating pre-flight approvals and strategically deconflicting with other aircraft in the area. This improved air traffic management (ATM) integration may result in less operational time and a corresponding reduction in operating costs. The benefit mechanisms for reducing the response time compared to an ambulance are the more direct path ("as the crow flies"), avoiding ground traffic congestion, and faster cruising speed of the AAM aircraft. Finally, our analysis assumes that pilots are still onboard the AAM aircraft; the incorporation of advanced automation/autonomy that removes onboard pilots could further reduce costs.

3.2.2 *Mission 2: VA Hospital Patient Transfer (Urgent and Non-Emergency)*

Based on the current needs seen in private hospital patient transfers between in-network locations, the second mission involves inter-hospital transfers within the VA medical network. These inter-hospital transfers would include both transferring patients and medical professionals. These operations are expected to lessen the overall expense of transfer compared to MedEvac helicopters and be more time efficient compared to current ground transportation methods. This mission uses AAM aircraft that are capable of carrying one patient with supporting medical crew (2 – 3 medical professionals, as deemed necessary based on the level of care required for the transfer), but the range is expected to be shorter than in Mission 1 based on discussions with medical professionals who mentioned the need for in-network transfers between hospitals in urban settings [9]. We assume a nominal range of 50 miles to approximate the breadth of a typical urban hospital network.

The high-level concept of operations for the current state (without AAM) is mostly similar to that for Mission 1, with the current vehicles being helicopters or ambulances. The distinction is that in Mission 2 the starting and ending nodes are both hospitals or other acute care facilities. As with Mission 1, the benefit mechanisms for the future state (with AAM) are reduced costs and response times, compared to current air and current ground operations, respectively.

Additional details regarding VA transport policies and procedures regarding patient transport are provided in Appendix C.

3.3 Technical and Operational Requirements

To deepen our understanding of the application and analyze its constituent missions, we derived requirements through a literature review of current operations. Some of the more relevant requirements for the application are the distance between facilities, interior noise during transportation of the patient, ergonomics (both for the patient as well as for the medial professionals administering care), response time, and sufficient payload capacity. Noise levels within the cabin are crucial, as excessive noise from rotors, engines, or external winds can hinder the ability for medical professionals to monitor vital signs and promptly address emergent medical issues. Patient comfort and ergonomics are other important requirements, especially for patients undergoing interfacility air transport due to severe trauma, organ transplantation, high-risk surgical procedures, or acute syndromes. Additionally, payload capacity must accommodate necessary medical equipment and personnel to ensure comprehensive in-transit care [7]. Therefore, maintaining a stable environment is essential to prevent condition deterioration.

Patient transport operations rely on specialized ground and aviation infrastructure to maintain continuity of care. For ground operations, ambulances must meet federal KKK-A-1822F safety standards while providing Americans with Disabilities Act (ADA)-compliant access and advanced medical capabilities [17]. Similarly, air transport requires FAA-certified aircraft configured for critical care, with integrated tracking systems and biocontainment features for infectious disease cases [18], [19]. Both modalities incorporate interoperability standards to coordinate with National Disaster Medical System (NDMS) hospital networks and federal medical response systems.

Table 1 outlines technical and operational requirements for ground and air transportation assets used during disasters or public health emergencies. While we are not focused on such emergency applications, we use these requirements as an upper bound for the less stringent requirements for non-emergency and urgent transport operations; for our purposes, they represent “desirements.”

Beyond technical and operational requirements, there are also regulatory requirements. No AAM aircraft have been certified to date by the FAA. Operations will require FAA approvals. 14 CFR Part 135, Subpart L, lists the current operational requirements for medical transportation of patients, and operations are authorized through Operations Specifications (OpSpec) for Helicopter Air Ambulance (HAA) Operations or Air Ambulance Operations – Airplane (A021 and A024, respectively), based on the type of aircraft chosen for the operations or via compliance to the associated policy under 14 CFR Part 91 [20]. Furthermore, missions under this application will occur under 14 CFR Part 135 [21]. Since the future AAM aircraft will be carrying passengers and potentially medical cargo, review of Advisory Circulars (ACs) 135-14 and 120-49 would be appropriate for the certification of Air Carriers, and the associated methods and procedures required in obtaining this certification, respectively [22], [23].

Table 1. Transportation Requirements for Federal Government-Provided Patient Transport During Disasters or Public Health Emergencies

Universal Accessibility • ADA-compliant designs (56" door height, 30" wheelchair lifts) • Four-point wheelchair securement with lap/shoulder belts • Capacity for medical equipment (oxygen tanks, monitors) and service animals **Vehicle Safety Standards** • KKK-A-1822F federal specifications (crashworthy construction, electrical systems) • GVS 2.0 (Ground Vehicle Standard) for rollover protection for patient compartments **Medical Operations** • CAMTS-accredited medical transport capabilities • Strategic National Stockpile (SNS) compatible equipment integration **Communication Systems** • P25 Phase II radios for federal/state Emergency Medical Services (EMS) coordination • Dual dispatch options (phone and app-based scheduling) **Personnel & Compliance** • State-specific vehicle/driver/insurance certifications • Minimum First Aid/CPR certification for all crew members	**Core Patient Transport Capabilities** • Commission on Accreditation of Medical Transport Systems (CAMTS)-accredited for medical transport services • ADA-compliant loading/unloading systems for patients with mobility needs • Secure storage and delivery of medical oxygen and equipment • Specialized containment protocols for infectious disease cases **Aircraft & Crew Standards** • FAA Part 135 certified aircraft • Pilots holding First- or Second-Class FAA Medical Certificates with Instrument Meteorological Conditions (IMC) ratings and airline transport pilot (ATP) certificates • Terrain/weather avoidance systems and Night Vision Goggle (NVG)-compatible operations • Dedicated voice communication between flight and medical teams **Critical Care Operations** • Appropriate personnel; a model is the military Critical Care Air Transport Team (CCATT) concept that consists of 1 physician/1 nurse/1 respiratory therapist per patient • HEPA filtration systems **Infrastructure & Safety** • Pre-approved landing zones meeting FAA AC 150/5390-2 or AC 150/5300-13 standards • Hospital helipads with 24/7 accessibility
References: [17] - [25]	

3.4 Assumptions, Constraints, Enablers, and Non-Aviation Systems Needed

This section starts with an outline of assumptions for the patient transport application for VA patients to/from rural communities and associated VA facilities. We also generated a list of initial constraints, but this list may need to be updated as regulations, technology maturity, and political priorities change in the coming years before implementation of these missions. Next, we list key enablers to accelerate the adoption and deployment of the application. Finally, we discuss some non-aviation systems that will be needed to support the application.

3.4.1 Assumptions

While many of the assumptions are similar for both reference missions, there are some differences. Specifically, Mission 2 will use short-range AAM aircraft capable of transporting one patient and a small medical crew. In Mission 2, the operational context is short-range transfers within a defined system, unlike Mission 1's broader geographic scope with many potential nodes in the network (not just VA facilities, but airports, private vertiports, etc.).

The assumptions outlined in Table 2 support a concept of operations in which the VA integrates AAM solutions encompassing next-generation aircraft. These mission assumptions pertain to the use of only electric vehicles for the future state of these operations.

Table 2. Assumptions for Reference Missions with All-Electric Aircraft

Category	*Mission 1: Rural Patient Transfer*	*Mission 2: VA Hospital Patient Transfer*
Aircraft Certification and Availability	AAM aircraft are certified and available - dedicated, shared or contracted for VA patient transport missions. Certification is assumed for MedEvac operations under Part 135 or operating under a public aircraft exemption.	*Same as Mission 1.*
Payload	Aircraft support 2,000-3,000 lb. payload (2 pilots[2], 1 patient + 2–3 medical crew + equipment)	*Same as Mission 1.*
Range	Up to 100 miles usable range (plus Visual Flight Rules reserves) [24][25].	Shorter range, less than 100 miles.
First- and Last-Mile Transportation	Not always required. If patient needs additional transportation assistance to and from a medical facility or aircraft take-off and landing location (e.g., a local airport), it can be provided via van or ground ambulance for urgent transfers or through contracted transportation network companies (e.g., Uber and Lyft) and volunteer programs for non-urgent transfers.	Not expected to be incorporated into this mission, since the aircraft is expected to directly transport patients from facility to facility that have helipads/landing areas for UAM aircraft.

[2] A two-pilot operation is assumed here for initial operations, but AAM may enable single-pilot operations in the near term and eventually no onboard pilot over a longer time horizon.

Aircraft Dispatch Readiness	Aircraft can be rapidly deployed due to electric propulsion (minimal startup time) assuming pilots and crew are available. Other dispatch considerations will include pilot availability, aircraft energy state, and weather.	*Same as Mission 1.*
Turnaround Operations	Fast charging facilities (i.e., sufficiently fast to allow turnaround times that enable multiple daily flights) are available at both ends (e.g., power carts or fixed chargers).	*Same as Mission 1.*
Medical Configuration	Aircraft are fitted for gurney patients and emergency care (oxygen, intravenous equipment (IV), monitors, defibrillator, etc.).	*Same as Mission 1.*
Piloting Requirements	Pilots will be required to hold an instrument rating, a second-class FAA-issued medical certificate, and hold at least 2,000 flight hours, where at least 1,000 hours are as pilot-in-command. Night operations will require additional training [34].	*Same as Mission 1.*
Medical Crew Accommodation	Cabin supports 2–3 medical professionals providing care in transit as determined by the urgency and/or medical professional.	*Same as Mission 1.* Medical professional requirements differ based on the urgency
VA System Integration	Missions integrate with existing VA dispatch and care coordination (e.g., VTS), with clinicians triggering transport requests as needed.	*Same as Mission 1.*
Landing Infrastructure	Urban VA sites use existing helipads; rural sites use flat zones, airports, or retrofits to existing infrastructure (like parking lots, rooftops etc.); VA adds vertiports over time at its facilities.	Primarily uses existing urban helipads and future vertiports as they become available; less emphasis on Short Take-Off and Landing (STOL)/CTOL options as compared to Mission 1.
Airspace Access and Management	Missions have access to low-altitude airspace while avoiding restricted zones such as Temporary Flight Restrictions (TFRs) and, if flying to/from major airports, have access to standard commercial approach/departure paths.	*Same as Mission 1.*
Weather	Missions are performed in both visual and instrument meteorological conditions. Aircraft do not operate in severe weather conditions (e.g., storms, icing), and backup transport options are assumed in these cases.	*Same as Mission 1.*
Funding	The VA covers costs through internal budgets or reimbursable arrangements with AAM providers.	*Same as Mission 1.*

3.4.2 Constraints

Multiple operational constraints exist for the missions expected under the patient transport application, which may limit feasibility, scalability, and timing. These stem from regulatory,

technical, infrastructure, financial, and workforce-related factors that must be resolved before full-scale deployment is viable.

- ***Medical Standards Constraints:*** Aircraft performing these missions must comply with Commission on Accreditation of Medical Transport Systems (CAMTS) standards for medical equipment storage and Emergency Medical Treatment and Labor Act (EMTALA) for treatment and management of medical staff [26]. This includes onboard medical equipment, certified medical staff, and ensuring patient stability.
- ***Infrastructure Constraints:*** Most VA and partner sites currently lack suitable landing infrastructure. New vertiports and modified helipads (including adding charging stations) require environmental reviews, zoning approvals, and capital investment. In the interim, reliance on nearby airports will add time and complexity via additional ground transfers.
- ***Technology Constraints:*** AAM aircraft currently under development have limitations in range, payload, weather performance, and turnaround times. None of the platforms are proven in high-tempo medical missions, limiting immediate readiness.
- ***Cost Constraints:*** Aircraft acquisition, vertiport construction, initial hiring of staff, and charging upgrades are significant capital expenses. Operating costs include electricity, battery wear, and crew. If the VA were to bear the full costs for initial deployment and operations without newly allocated resources, budget pressures may limit scope to pilot programs or high-need areas only or possibly prevent any adoption of this application.
- ***Workforce Constraints:*** Training pipelines, medical readiness, and retention challenges of the workforce could limit readiness. As a result, operations may be restricted to limited hours.
- ***Airspace Constraints:*** Flights may be restricted to designated corridors or subject to delay due to congestion, proximity to controlled airports, or safety restrictions. Public acceptance and noise concerns may also limit routing options.

3.4.3 Enablers

Mission enablers and enhancements for AAM in VA medical transport include policy and legislative support, public-private partnerships, integration with the VA healthcare system, infrastructure investments, technological advancements, and environmental incentives. These enablers are the same for both of the missions in this application.

- The Advanced Air Mobility Coordination and Leadership Act [27] and AAM National Strategy [3] acknowledged the potential of AAM, though challenges remain in translating this potential into broad, effective deployment.
- The FAA Reauthorization Act of 2024 [28] outlined initial steps to support vertiports and powered-lift aircraft integration. However, tangible funding and infrastructure investments are still needed for large-scale deployment. Public-private partnerships would be helpful in overcoming technical and operational challenges. By working with aircraft manufacturers and healthcare providers, the VA can leverage external expertise and share costs, accelerating implementation.
- The VA's existing healthcare and transport infrastructure provides a strong foundation for integrating AAM into medical missions. With established systems for scheduling and funding transport, adding AAM as a transportation mode may be accomplished with minimal disruption. The VA's ability to control both the transport and patient care process offers advantages in coordination, though this requires seamless integration with current information technology (IT) systems and medical protocols.

- Investments in infrastructure, including vertiports and charging stations, will be required to support electric AAM aircraft, and targeted funding from federal or state sources could potentially help mitigate initial costs.
- The development of training programs for AAM-specific roles and the certification of AAM aircraft for medical transportation are prerequisites for operations.
- Technological advancements, such as improvements in battery life and autonomous flight, will further support these VA missions.

3.4.4 Non-Aviation Systems Needed

The patient transport application will need specific medical systems to be established for the anticipated missions.

Medical Equipment, Systems, & Compliance

In both reference missions described, the aircraft will be required to comply with the necessary aviation standards and the necessary CAMTS accreditation standards since the aircraft becomes a piece of medical equipment utilized for patient care [26]. Additionally, the necessary medical equipment will include the following to allow for care in urgent and non-emergency missions:

- *Oxygen Cylinder Compliance:* Oxygen tanks used for EMS services, whether for ground or for air medical transport, will need to be tested and secured per federal DOT hydrostatic test expiration dates and compliance requirements [29].
- *Infectious Disease Training:* Medical staff and crew will need to meet requirements for the containment of airborne pathogens within the cabin during operations, and procedures and systems to return the cabin to a sanitary state in between patient deliveries to allow for additional operations to occur in a given flight schedule.
- *Dispatch Training and Coordination:* If patients are moving between VA and private hospitals, the Operations Control Center (OCC) of the VA facility will need the associated training and standard operating procedures (SOPs) to properly coordinate with private hospital dispatch centers for patient transfers. Coordination with private EMS and fire departments in rural communities will also be required [30].

Medical Safety and Security

In the missions within this application, medical professionals will be supporting the AAM crew in the transport of the patient and all involved must ensure a safe medical scene. For example, in the case of an agitated patient, the crew will need to be appropriately trained. Safety precautions should be documented in established SOPs for the crew's 1) personal safety, 2) safety of the supporting team members, and 3) safety of the patient [31] [32].

Additionally, as AAM operations continue to integrate more automated systems and associated technology, the data shared with medical professionals, dispatchers, the OCC, and others for the mission flight plan and patient care must be secure. Appropriate security (including cybersecurity) protocols must be established for data transfer between all necessary stakeholders in a given patient transport mission to prevent cyberattacks similar to the one in 2023 that caused multiple hospitals across multiple states to shut down emergency rooms, causing surges in ambulance diversions to other hospitals [33], [34]. Access control, authentication, secure devices in the cabin, and regular data security training will be necessary for future AAM patient transport operations.

3.5 Cost Assessment of Patient Transport

As discussed above, there is a fundamental distinction in Patient Transport between ground- and aircraft-based non-emergency and urgent care services vice primarily aircraft-based emergency

care. The initial application of AAM aircraft is likely to be more focused on the former since true emergency care via aircraft typically requires significant weight and power capabilities to carry the necessary medical equipment/systems and personnel. Current Costs of Ground Transport

The costs associated with providing ground-based NEMT services can be significant. Table 3 shows some generic estimates of NEMT pricing for a variety of services.

Table 3. Ground-Based Non-Emergency Medical Transportation Rates [35]

Types of Charge	Weekday Business Hours	Weekends & Off Hours	Holidays
Ambulatory – Base Rate	$25 - $30	$30 - $40	$35 - $45
Wheelchair – Base Rate	$45 - $50	$75 - $90	$85 - $100
Stretcher – Base Rate	$100 - $200	$125 - $225	$150 - $250
Plus Time and Mileage			
Mileage Fees	$3 - $5 Per Mile	$5 - $7 Per Mile	$5 - $10 Per Mile
Wait-Time Fees (per 30 minutes)	$15 - $30	$15 - $30	$15 - $30
Additional Attendant Fees (per 30 minutes)	$5 - $10	$5 - $10	$5 - $10

We note that these are nominal retail prices from private providers, not operating costs, and the estimates are most relevant for transportation across short distances within an urban or metropolitan area. Even so, these estimates would appear to suggest that AAM services could have a difficult time competing with short-haul ground-based services on a direct cost basis, at least initially, as will be discussed below.

On the other hand, a more relevant baseline may be either individual or shared transportation of patients over longer distances, which might be a better target for AAM services. The VA itself operates the Highly Rural Transportation Grant (HRTG) program that helps veterans in specific rural areas travel to VA or VA-authorized health care facilities. This is a small program with an annual budget of around $3 million. The VA estimates that over one-third of enrolled Veterans live in rural or highly rural areas, so there is a recognized need for transport over longer distances than just within a metropolitan area.

While it is difficult to construct accurate estimates, using the above numbers we see that ground transport services over long distances could be quite expensive: assuming $5 per mile plus $250 in other costs, a one-way 100-mile trip would cost on the order of $750. As will be suggested below, if new AAM technologies can be operated more cost-effectively than current air transportation options, they may be competitive with ground-based costs and provide significant time savings as well.

3.5.1 Current Costs of Air Transport

While the above discussion suggests that AAM vehicles may be better suited to non-emergency or urgent care missions, it is still useful to assess the current baseline for how air ambulance patient transport (which includes emergency care) is accomplished today using conventional aircraft. A starting point for characterizing the current market is to identify the overall size of the

aircraft-based air ambulance market and what types of aircraft are currently used. A downstream refinement would seek to quantify the share of Federal-Government-funded missions.

For this purpose, we utilize the FAA's Air Traffic Service Business Model (ATSBM), which in turn relies on data from the Traffic Flow Management System (TFMS) [36]. TFMS processes a variety of data sources and assembles them into a single record for each flight in the U.S. that flies under Instrument Flight Rules (IFR) and is captured by the FAA's enroute computers.

The ATSBM model takes the TFMS flights and assigns them to 43 different user categories, one of which is air ambulance.[3] For FY2023, ATSBM identified over 230,000 air ambulance flights, utilizing over 200 different aircraft types, including jets, turboprops, pistons, and helicopters.[4] In addition, total unit operating costs (including fuel and oil, other variable costs, and fixed costs) are assigned to each flight based on numbers published in Conklin & de Decker's Aircraft Operating Cost and Performance Guide [37]. Table 4 shows summary totals for all air ambulance flights.

Table 4. ATSBM Air Ambulance Flights for FY2023 by Aircraft Type [37]

Type	Total Flights	Avg. Distance (miles)	Avg. Hours	Avg. Speed (mph)	Total Cost Per Hour
Jet	61,894	516	1.49	324	$6,015
Turboprop	152,445	205	0.95	211	$2,988
Piston	4,159	271	1.60	162	$933
Helicopter	14,412	106	0.86	135	$3,731
Combined	232,910	282	1.10	236	$3,802

Unit helicopter costs are relatively high due to their high fixed and variable operating costs. In addition, their average distance travelled is much lower for air ambulance helicopters as compared to fixed wing aircraft. Thus, these data suggest that, at least initially, the opportunities for AAM vehicles (and particularly electric aircraft that have shorter range capabilities than hybrids) are likely to be targeted at patient transport services currently provided by conventional helicopters.

In the ATSBM model, the air ambulance category is simply considered part of the General Aviation (GA) user group for cost purposes; thus, the cited cost per hour in Table 4 is partially based on a variable cost per hour that does not account for any additional on-board personnel beyond the pilot. Therefore, the costs shown in Table 4 do not reflect much higher costs that may be specifically attributable to specialized air ambulance flights that typically require paramedic and/or EMT personnel on board. In addition, the fixed costs attributable to such flights may be quite high due to low utilization rates. Accounting for these factors, a prior detailed air mobility study for NASA completed in 2018 suggests that the relevant costs for helicopter Air Ambulance flights is close to $10,000 per transport [10].

3.5.2 Estimated Cost Assessment Utilizing AAM

Any cost assessment of an AAM mission development effort should consider both initial aircraft acquisition costs and associated operating expenses. The cost assessment for this effort is based on current market analysis of AAM aircraft that are advertised for patient transport and associated

[3] A flight is assigned to the air ambulance category if it is flagged as a MedEvac flight in TFMS or if the flight operator is identified as an air ambulance entity.
[4] The jet, turboprop, and piston categories are all fixed-wing aircraft.

medical operations, but future aircraft designs may drive a different cost structure based on different system requirements that were not originally envisioned in this effort. The following subsections outline considerations regarding AAM aircraft acquisition costs and operating costs to support the VA patient transport application.

AAM Aircraft Acquisition Costs

Selling and leasing prices of AAM vehicles will obviously be influenced by overall vehicle characteristics, including (but not limited to) the design and complexity of the aircraft, the use of electric power or conventional fuel, battery size and capacity, autonomous features (if any), range, passenger and/or payload capacity, etc.

A useful starting point is to first consider published estimates of projected purchase prices for some vehicles currently under development. For example, Jump Aero is designing an eVTOL called the JA1 Pulse, which is tailored to short-range rapid response EMS in rural areas.

While this is specifically not the same focus as the short-range non-emergency VA transport mission being considered here, many of the characteristics of the Jump Aero vehicle overlap with the type of vehicle relevant for the ConOps in this patient transport application. The anticipated purchase price of the JA1 Pulse is $1.8 million (within a “likely” range of $1.6-$2.5 million) according to a white paper published by the company in 2024 [38].

Archer Aviation is developing an eVTOL aircraft with six propellers to carry four passengers and a pilot. It is being designed to accommodate 20-50 mile trips within urban areas with a cargo payload of around 1,000 pounds. Called the Archer Midnight, it has an anticipated selling price of $5 million [39]. Electra is another startup developing a 9-passenger eSTOL vehicle with a 3,000-pound payload and a range of up to 1,100 miles. Called the EL9 Ultra Short, press releases by Electra are consistent with an anticipated selling price of around $4.5 million [40].

The suggested range of about $2 to 5 million appears to be a sweet spot for many eVTOL vehicles.[5] If accurate, such prices compare competitively with conventional helicopters. For example, the price of a light helicopter such as the Bell 407 is in the range of $2.5-$3 million, while a larger vehicle such as the Airbus H145 is around $10 million (both of these vehicles are commonly used for EMS transport) [41].

Basing Costs

When considering the reference missions listed in this report, the addition of base stations for charging and/or maintaining electric vehicles is likely a necessary addition to future cost assessments. Further, while design considerations and requirements are outlined in EB 105A [42], they have yet to be officially assessed for development costs expected to be associated with future AAM operations. In the meantime, the cost of upgrading a current helipad to include electrification and required charging stations has been estimated in the range of a $1.4 million investment (2021 prices) [43]. This is a starting point subject to potential escalation based on the location, whether an electric grid to support the charging stations is in place, and whether there is an established helipad. Additional costs will be expected from construction management, permitting, labor, and materials at the time of construction.

[5] The examples given here obviously do not cover the entirety of the relevant AAM space. As would be expected, cost estimates for some designs are quite speculative (if they exist at all). For example, ERC is a European-based company that is developing an eVTOL designed specifically for medical patient transportation; it allows for efficient stretcher loading for a single patient and in-flight care by an additional passenger. The current vehicle design has a projected range of about 110 miles and can fly for up to 60 minutes. To our knowledge, ERC has not released any cost estimates for their aircraft.

We note that the aforementioned NASA-funded urban air mobility study indicates that there is already a mature set of over 900 bases to support air ambulance and helicopter operations spread across the U.S. [10]. The “Rotary Wing and Air Ambulance Bases” map from that study is reproduced below as Figure 4.

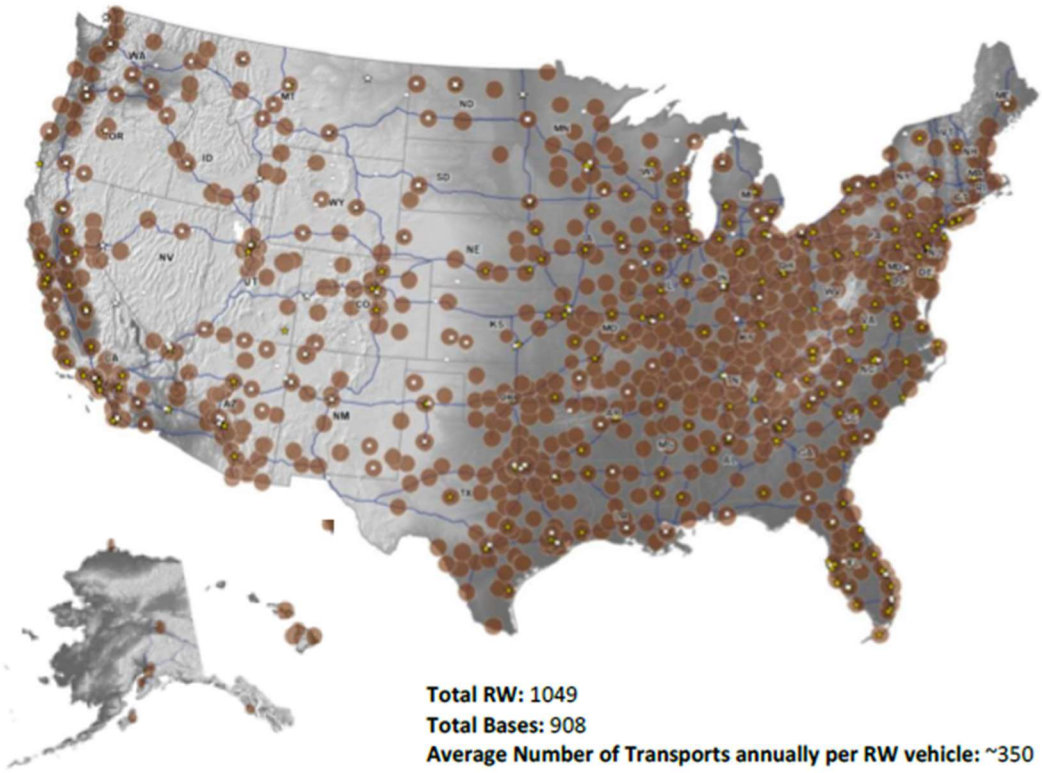


Figure 4. Existing Helicopter and Ambulance Bases (reproduced from Ref [9])

As seen in Figure 4, there is less coverage in rural areas where there may be an opportunity for AAM vehicles to fill in the gaps. When exploring the development of a new vertiport, it is expected that the full development costs may range between $3.5 and $12 million dollars, based on specific sites and if the vertiport is a ground-based vertiport versus developing a vertiport on-top of an established VA medical facility [44]. For the reference missions outlined in this report, it is expected that costs will be on the lower end of the spectrum considering the use of established VA medical facilities and leveraging local airports/helipads. As future AAM operations become more integrated into the national airspace system (NAS), it is expected that vertiports utilized for various mission profiles would support urgent and non-emergency patient transport missions; therefore, costs associated with the use of the vertiport would be comparable to current airport parking, fueling, and leasing fees.

Operating Costs

The main competitive advantage foreseen for electric compared to conventional aircraft is typically in reduced operating and maintenance costs. Two of the key drivers of projected cost savings include lower maintenance costs for electric vehicles (due to fewer moving parts in the propulsion system) and the effective cost per mile or hour of electricity vs conventional fuel.

For example, Beta Technologies is developing both an eVTOL called the Alia A250, and an eCTOL called the Alia CX300 [45]. Both vehicles will be able to accommodate up to five

passengers, will require a single pilot, and have a single fixed pitch propeller; the A250 VTOL will also have four lift propellers. Beta claims that hourly operating costs for the VTOL aircraft will be up to 40 percent lower relative to comparable non-electric VTOLs. Similarly, the operating costs for the CTOL variant are claimed to be up to 67 percent lower relative to comparable non-electric conventional aircraft. However, to our knowledge, Beta has not published further details to support these estimates.

The aforementioned Jump Aero white paper suggests direct operating costs of $424 per flight for the JA1 Pulse vehicle. These operating costs are driven primarily by so-called “battery reserve” costs that are supposed to reflect not only direct battery costs (including electricity) but also replacement at end-of-life. Other non-battery operational costs are included as “indirect costs,” which total $685,000 per vehicle per year. These include items such as pilot and crew salaries, general and administrative (G&A) utilities, and maintenance, as well as more traditional overhead items such as aircraft amortization, insurance and administrative overhead. The Jump Aero whitepaper appears to suggest that utilization rates will range anywhere from one operation every other day to as many as three per day in more populated areas.

If we use two operations per day as the average, this suggests total direct plus indirect operating costs of around $1360 per operation for the JA1 Pulse vehicle (representing an AAM example). In comparison, using the data in Table 3, an example ground operation (weekday, with a stretcher, 50 miles, and a 30-minute wait) would be approximately $380 and, using the data in Table 4, an example 1-hour air ambulance operation (using the “combined” data point) would be approximately $3802. It is important to note that these estimates overall rely on a number of realistic but uncertain assumptions, including service pre-deployment of aircraft at existing general aviation (GA) airports, rural coverage areas, utilization rates, amortization costs, etc.

Other considerations in developing costs per mission will depend on the type of flight scheduling parameters, such as the number of ferry legs (positioning and de-positioning flights) required, and whether operations will be largely at existing helipads and field landings, or whether they will involve built for purpose landing facilities (such as vertiports), with attendant landing and handling charges, reflecting the capital investment in those facilities.

As illustrated above, relevant cost estimates for services to be provided by AAM vehicles will depend on a detailed review of both their acquisition and operating costs and aircraft utilization, and the relationship between all of them. These conclusions are largely consistent with the aforementioned prior UAM market study performed for NASA in 2018, which concluded that eVTOLs are unlikely to compete with ground ambulances, but that eVTOLs and hybrid-electric aircraft could compete in the rotary wing market [10].

4 Application 2: Organ Transport

4.1 Purpose and Scope

Our second selected application is Deloitte's 10.8.2: Delivering organs for medical transplant (a.k.a. "Organ Transport"). Deloitte describes this application as the means to support delivery of critical organs needed for transplant. In organ transport, time is a critical factor to improve the outcome for patients. By using UAS as one of the means of moving organs from donors to recipients, hospitals and medical stakeholders could effect a more efficient, safer, and cost-effective means of organ transport.

Some of the more relevant considerations for the organ transport application include the capability to cover the distance between donor and recipient facilities, safe storage of the organ, appropriate "hazardous material" protocols, and delivery time. In a recent review of organ transport challenges, the United Network of Organ Sharing (UNOS) stated that kidneys are the most transplanted organ, as well as the organ that travels most by commercial air. Currently, commercial air travel is the primary method of any long-distance organ transport, but is quoted to be the least reliable [46]. Since organ procurement organizations (OPOs) rely heavily on commercial air transportation, they experience various complexities and errors in scheduling, maintaining correct chain of command to direct hand-offs,[6] as well as issues in accessing cargo offices of commercial air carriers for 24/7 organ deliveries[7] [47].

The roles of the federal government in this application include maintaining the Organ Procurement and Transplantation Network (OPTN) and providing oversight and grant funding to Organ Procurement Organizations (OPOs). While private medical networks have their own means of coordinating with OPOs, we focus on the VA as the priority federal agency for this application, as we did for the Patient Transport application earlier.

The VA's organ transplant mission is executed through its Veterans Health Administration (VHA) network of transplant centers. All VA transplant programs are members of the national OPTN under the National Organ Transplant Act of 1984 [48]. VA facilities comply with OPTN bylaws and federal transplant regulations just like civilian centers [49]. At a high level, the steps followed to transport an organ are:

- ***Step 1 – Transplant Approval*:** Upon organ availability, transplant teams (VA surgeons or OPO coordinators) confirm suitability and "arrangements are made to procure, transport, and store the donated organ, and for the transplant candidate to travel to the transplant center for surgery [50]."
- ***Step 2 – Organ Transport Management*:** Organ transport is managed by the OPO or affiliated couriers. Once a donor organ is recovered (at a VA or non-VA hospital), certified OPO staff or contracted medical couriers promptly arrange travel to the transplant center.
- ***Step 3 – Transport Mode Selection:*** The next step is to select an appropriate mode of transport for the patient and/or organ, depending on the most efficient means to connect the organ with the receiving patient. Considerations include:

[6] In transporting organs, individuals generally serve as couriers to ensure the organ is moved where and to whom it should be. A hand-off between couriers may occur at various points, such as when modes of travel change.
[7] Organs are sometimes transported in the cargo hold of aircraft; because airline cargo offices are generally only open during regular business hours and flights often occur outside of these time windows, there can be instances where the organ cannot be picked up because the cargo office is closed.

- **Level of urgency.** For urgent cases, the VA can prioritize direct airlift for short distances to avoid delays. The guiding rationale is organ viability and patient outcome.
- **Cold ischemic time limits**. The cold ischemic time (CIT) of organs is defined as the time period from when a donor organ stops receiving blood from the donor patient to when it is reconnected to a receiving patient's blood supply to complete the organ transplantation [2]. Minimization of the organ's CIT is vitally important. Organs that require continuous fluids or oxygenation of the tissues will require the use of a warm perfusion machine, which can increase the time outside of the body by six to 12 additional hours, where most organs/solid tissues are only viable in cold storage for six to 30 hours [51]. Table 5 lists the most common organs transported for transplantation services and the average limits of CIT for each.

Table 5. Average CIT Limits of Most Commonly Transported Organs [52], [53]

Organ	CIT Limit *(hours)*
Heart	6
Lungs	6
Liver	12
Pancreas	18
Kidney	36

- **Within region or inter-region transport**. For transportation of organs within the same region, a ground courier or ambulance is the preferred option whereas an organ from another state typically utilizes air travel booked by the OPO. Certain organs with low CIT limits typically use air charter or MedEvac. Table 6 summarizes typical organ transport logistics.

Table 6. Typical Organ Transport Logistics by Mode [54], [55], [56]

Mode	Vehicle	Trigger(s) for Mode	Crew/Team & Required Systems	Travel Distance
Ground	Ambulance	• Within a medical network or between proximate hospitals. • Extremely time-sensitive transplantations (i.e., hearts, blood transfusions, etc.), where warm perfusion technology can be used to help increase the viability of the organ.	• Surgical team for removal and placement; this team rides along with the organ. • EMS Crew to drive the ambulance.	Short (5 – 50 miles)
	Regular Automobile (car, van)	• Transfers over short distances when the organ can remain viable with cold storage. • Best for blood and tissue transfers or for research purposes where a patient is not waiting for the transfer.	• Research team, medical team, or courier. • Driver, which can also be a member of the research or medical teams.	Short (5 – 50 miles) or Medium (50 – 150 miles)
Air	Helicopter	• Emergency situations where transplantation is required over short to medium distances	• Surgical team for removal and placement; this team may ride along with the organ • Take-off/landing pads at hospitals used if available	Medium (50 – 150 miles)

	Commercial Aircraft or Charter Aircraft (if commercial flight is not available or timely)	• Emergency situations where transplantation is required over long distances or when specialty transplant centers are required for the procedure. • Cold storage or warm perfusion systems can be used, but require strict hand-off procedures due to the multiple personnel involved (e.g., medical staff, courier, TSA, airline cargo staff)	• Surgical team for removal and placement; this team may ride along with the organ. • Courier for organ transport • Aircraft crew/cargo staff/airline personnel • EMS Crew to drive the ambulance to/from airports.	Long (150+ miles)

4.2 Description of Application and its Missions

The envisioned use of UAS for organ transport encompasses two mission examples:

1. Using a UAS to cover short distances (5 – 50 miles) for moving an organ on “first-mile” and/or “last-mile” legs to connect to other modes of transportation, and
2. Using a UAS with greater range to cover short or medium distances (5 – 150 miles) for moving an organ between locations within a medical network.

No mention of the size of the UAS is provided here because the upcoming FAA 14 CFR Part 108 may obviate the need to strictly distinguish between use of “small” (< 55 pounds) and larger UAS. Additionally, sUAS are likely incapable of providing sufficient payload capability to perform some organ transport missions due to the weight of commercially available organ transport containers, which are generally on the order of 10 – 100 pounds. Containers on the low end of the size range that may be feasible with sUAS resemble little more than coolers for cold storage, and heavier containers generally provide improved cold storage or automated perfusion capabilities [57], [58], [59]. More advanced perfusion capabilities can require even larger and heavier storage containers, and some organ transports require a surgical team to ride along with the organ. Missions requiring beyond approximately 100 pounds of payload in practice will be very similar to the Patient Transport application discussed previously in Section 3; therefore, we focus our discussion here on storage systems in the lower- to middle-portion of the storage size range, from approximately 10 – 50 pounds.

In the current state, the high-level concept of operations for both organ transport missions starts with the hospital receiving a demand for an organ. Once an organ is identified, the procurement team is notified and dispatched from the starting location by ground transportation. While potentially encountering ground traffic, the procurement team travels to the harvesting site where the donor organ is located and the organ is evaluated to determine suitability. Once approved, the procurement team notifies the medical team at the recipient site. The organ is harvested, then properly stored and loaded onto the ground transport with the procurement team. The team then travels to either the airport (Mission 1) or the recipient medical site (Mission 2) for delivery. Upon arrival, the organ is transferred to courier at the airport (Mission 1) or the recipient medical team for the medical operation (Mission 2).

4.2.1 Mission 1: First-Mile / Last-Mile Organ Transport

In the future state of this mission, a UAS replaces a ground vehicle in fulfilling the first-mile and/or last-mile stage (nominally 5 – 50 miles) of an organ delivery to help shorten the overall transport time and CIT. The trigger for this mission would be where the need for organ transport is directed by the National Organ Registry. Operating under Part 108 rules, a UAS would be loaded with the organ and sent from the donor hospital to a local airport where a courier would be waiting to receive the organ for either a charter or commercial flight for a regional or cross-country delivery.

On the other end of the journey, once the charter or commercial flight lands at the destination airport, a courier would then place the organ and associated medical systems in an appropriate cargo container on another UAS that would directly take the organ to the receiving hospital.

The use of a UAS would shift at least one leg of ground transportation to the air (it is not required that both the first-mile and last-mile legs be shifted) in the regional or cross-country delivery (≥150 miles between donor and recipient) of the organ. In bypassing busy urban surface traffic, the CIT is potentially shortened, and the viability of the organ is increased.

4.2.2 Mission 2: Intra-Network Organ Transport

In the future state of this second mission example, the UAS completes the full round-trip delivery of the organ within a medical network (nominally 5 – 150 miles), substituting for a ground vehicle. The UAS would operate under the upcoming 14 CFR Part 108 rule for medium distance transportation as a Beyond Visual Line of Sight (BVLOS) operation. As with Mission 1, the trigger would come from the National Organ Registry and/or local hospital personnel managing the organ transplant. This mission begins when a hospital identifies a procured organ that may require a shorter transportation time than could be achieved by standard ground transportation. The hospital would dispatch a procurement team to meet at the site of the donor organ to verify that it meets the necessary patient requirements. While the team verifies patient requirements, a UAS would be waiting at the donor hospital to transport the organ. Upon approval from the procurement team, they would recover, package, and place the organ in an appropriate cargo loader on the UAS. The UAS would then fly to the receiving hospital where a separate retrieval/surgical team would unload the organ and do a secondary verification for patient transplantation.

As in Mission 1, using the UAS for transporting the organ would help in reducing the CIT by replacing ground transportation from donor to recipient in regional deliveries.

4.3 Technical and Operational Requirements

The FAA has specific requirements for package and baggage handling which extend to the handling of organs on commercial and charter flights [54], [55], [60]. Table 7 lists the current technical and operational requirements for Part 121 organ transport.[8] The oversight of each requirement listed is the responsibility of the FAA, except for the last one, for which TSA has responsibility.

Table 7. Technical and Operational Requirements for Transporting Organs via Part 121 Flights

Requirement Reference	Definition	Technical or Operational Requirement
14 CFR Part 5	Safety Management System, which would include systematic procedures, practices, and policies for the management of safety risk. **For Organ Transport:** SMS in place for storage, communication, and safety transport of organ and related materials.	Operational

[8] Many of these requirements may be relevant even under non-Part 121 flights.

14 CFR Part 121 **Section 119.49(a)(9)**	Part 121 Operations to have operations specifications (OpSpecs), including authorization of methods for controlling weight and balance. **For Organ Transport:** Weight and balance calculations if multiple organs are being transported with associated medical packaging/systems.	Technical
14 CFR Part 121 **Section 121.135(b)(21)** **and** **Section 121.153(b)**	Part 121 operator to use approved weight and balance control systems and procedures for maintaining aircraft weight and center of gravity (COG) to comply with applicable airworthiness requirements. **For Organ Transport:** Weight and balance control system will need to be able to account for organ storage devices/supporting systems to maintain aircraft COG.	Technical
14 CFR Part 121 **Section 121.285**	Part 121 cargo being stowed in the passenger compartment must comply with specific storage and handling requirements. **For Organ Transport:** Storage of organs that are intended to ride in the passenger compartment must be stored correctly and safely for non-medical personnel to handle during loading and off-loading.	Technical
14 CFR Part 121 **Sections 121.415, .427, and .433**	Part 121 initial and recurrent training on duties of all crewmembers and aircraft dispatchers. **For Organ Transport:** Crewmembers and aircraft dispatchers must be up-to-date on organ transport procedures, communications, and appropriate hand-offs in a designated “MEDEVAC” flight plan.	Operational
14 CFR Part 121 **Sections 121.415(a)(1)(ii), .427, and .433**	Part 121 initial and recurrent training for pilots and flight engineers for determining weight and balance, runway limitations for take-off and landing for each airplane operated by the air carrier. **For Organ Transport:** Pilots and flight engineers need to understand the impact of flying organs with their associated packaging and support systems. Pilots and flight engineers must understand the impact it may have on flight profiles of different aircraft types.	Operational
14 CFR Part 121 **Sections 121.422(a)(2)(ii), .427, .433**	Part 121 initial and recurrent training for dispatchers for determining weight and balance calculations for each aircraft type operated by the air carrier. **For Organ Transport:** Dispatchers need to understand the impact of flying organs with their associated packaging and support systems.	Operational
14 CFR Part 121 **Section 121.589**	Part 121 Requires air carriers to have an approved Carry-on Baggage Program in its OpSpecs. **For Organ Transport:** The Carry-On Baggage program must include guidance on how organs must be appropriately stored if being transported as carry-on baggage by a courier.	Operational

FAA's Aeronautical Information Manual (AIM), Chapter 4, Sect. 2	Radio Communications Phraseology and Techniques for ATC: Use of "MEDEVAC" call sign verbally to obtain ATC priority handling, should also be included in filed flight plan. **For Organ Transport:** The "MEDEVAC" call sign is appropriate for the transportation of organs in urgent situations, and other lifesaving medical events. "MEDEVAC" is to be used with extreme discretion, and priority is first given to air ambulance flights and should be used for that portion of the flight requiring priority handling. [73]	Operational
TSA Cares: Fragile Medical Materials (Human Organ Transport)	Courier pre-arrangement (when feasible) with Transportation Security Administration (TSA) supervisors or a Passenger Support Specialist (PSS) prior to or upon arrival at a TSA checkpoint allows for validation of documentation of the organ and courier, appropriate screening procedures to be used on the organ/materials, and expeditious means of getting the organ on the correct flight/mode of transportation.	Operational

4.3.1 Landing Zone Requirements

It is expected that as hospitals and VA organ transplantation centers start to investigate organ transport via UAS, they will use already designated "Emergency" transportation zones for organ delivering/receiving (i.e., near helipads for MedEvac helicopters or near ambulance parking areas). Currently there are no federal regulations directing the design or size of a UAS landing zone, but the following are considerations that should be made at a hospital or VA facility for the purpose of organ transport:

- ***Avoid hazards:*** When considering co-locating a UAS landing zone with a currently operating MedEvac helipad, the UAS landing zone must be clear from the helicopter's take-off/descent trajectory and not located within the path to entry into the medical facility when the helicopter is loading/unloading. Tie downs should be included to prevent the UAS from being blown away from rotor down-wash.
- ***Space to load organ/supporting systems:*** The UAS landing zone must have enough space surrounding it to be able to load and unload the organ, associated packaging, and supporting systems without causing damage to the organ or UAS.
- ***Appropriate storage of UAS when not in use:*** Most UAS are built from carbon fiber and other materials not suitable for long durations in wind, direct sun, or rain. When not in use, the UAS should be stored in such a way that prevents deterioration of flight-critical components and routinely maintained for safe and reliable operations.

4.3.2 Aircraft Design Requirements

Fixed-wing aircraft generally have longer endurance/ranges than pure rotorcraft/multirotor aircraft, and some UAS currently being tested in healthcare operations can take-off and land vertically but transition to horizontal flight for efficiency and endurance purposes. The UAS marketplace continues to evolve in this domain and hybrid VTOL/fixed-wing aircraft with moderate range/endurance will likely be a useful candidate for this mission. Additionally, the landing zone and supporting infrastructure will drive the choice of UAS design.

As mentioned above, the UAS will require cargo bays that can hold the appropriate packaging and supporting systems of the transported organ. In some instances, different UAS could be used based on if the organ is traveling with a supporting system. Therefore, some hospitals or VA

centers may have a fleet of UAS based on the type of organ, supporting systems required, and transport range.[9]

Handling qualities of the UAS and thermal conditions of the cargo bay must be tested to verify that the organ is maintained structurally and thermally. While we expect that the organ will be packaged with ice packs and other packaging materials to maintain its temperature, the internal temperature of the cargo bay should not significantly change the CIT of the organ.

We expect that with these operations occurring in compliance with Part 108, certification of the UAS will be directed by the regulations within that rule once it is published and compliance dates are established.

4.3.3 Crew Requirements

The UAS aircraft crew will need to hold First- or Second-Class FAA medical certification for operations of medical transport, unless future UAS regulations state otherwise for Part 108 or medical operations. Specific training that may be required in any future iteration of the organ transport application includes the following, which are necessary today for air ambulance pilots [61]:

- Terrain and weather avoidance maneuvers
- Infection control and safety protocols for organ packaging and storage on the UAS
- Aircraft systems, both aviation and non-aviation (e.g., organ support systems, radios)
- Organ loading and unloading procedures
- Flight planning and coordination with VA hospitals, EMS agencies, ATC
- Regular training for operating procedures, VA patient plans, flight hazards, etc.

If nighttime operations are planned, specific training for crew and other personnel may also be required.

4.3.4 UAS 3rd Party Service Providers & Remote Operations Centers Requirements

With the expected adoption of Part 108 and the associated Part 146, UAS Automated Data Service Providers (ADSPs) will need to be specialized to support the VA and OPOs for organ transport operations, including considerations for organ-transport-specific data to effectively enable flight planning coordination and safe operations. When considering BVLOS operations, some UAS organ transport missions may need to fly above 400 feet (outside of Class G airspace), requiring coordination with ATC for specialized medical flight designations and clearances [62] which may be facilitated by ADSPs. ADSPs and Remote Operations Centers (ROCs) established for organ transport should be specialized in medical transport and have dispatchers and systems that are able to communicate effectively with local medical staff and OPOs to verify correct digital security and flight planning of the organ through both Mission 1 and 2 scenarios [63]. The following are additional considerations for UAS organ transport operational environments:

- ***Shared Flight Safety Responsibility between Stakeholders:*** Each organ transport operation that will use an ROC will require at least one qualified staff member who is educated in medical transport logistics and terminology to communicate effectively with the medical retrieval and recipient teams. Additionally, the ROC may be required to communicate with OPO staff to coordinate travel distances and locations to minimize the organ's CIT. The ROC will be responsible for communicating with the pilot in command

[9] Some organ transports require a surgical team to ride along with the organ. In these cases, the requirements mirror those of the patient transport application discussed previously (in Section 3), and Part 108 UAS operations are not applicable.

(PIC), who is likely to be located at the ROC, and hospital staff for landing and loading/unloading of the organ. The ROC may require associated crew resource management (CRM) support in high-workload situations or when multiple organs are being delivered to/from multiple locations.

- ***Supporting Standard Operating Procedures:*** SOPs will be required for associated training, operational performance metrics and for review by the FAA and VA for auditing purposes. Additionally, to support organ transport decision-making, SOPs will direct future selection of UAS aircraft for given missions if a VA facility is able to support a fleet of vehicles with various payload capacities, various range envelopes to serve different facilities, and/or multiple authorizations/certifications of aircraft and personnel based on the mission profile (i.e., Mission 1 or Mission 2 flight profiles).
- ***Technology & Communications for Improved Situational Awareness (SA):*** Like an air traffic control tower, the ROC will be required to use technology, and communication means to provide in-time SA to pilots and VA medical staff. These technologies and communication methods should be applicable for the missions of a given VA medical facility to facilitate entry and exit of the aircraft at the hospitals or landing zones. Additionally, in times of surge missions across the VA network of facilities, ROCs will need to be interconnected to each other to be able to spread missions across multiple medical facilities.

4.4 Assumptions, Constraints, Enablers, and Non-Aviation Systems Needed

This section outlines the assumptions for integrating AAM capabilities into organ transport missions managed by the VA. These assumptions are based on how the VA currently coordinates organ procurement and transport in partnership with OPOs and transplant centers. Constraints are then identified, many of which relate to time sensitivity, medical handling, infrastructure, and policy gaps. Next, key enablers are presented to guide future alignment of AAM technology with federal organ transport operations. Finally, we discuss some non-aviation systems that will be needed to support the application.

4.4.1 Assumptions

The assumptions outlined in Table 8 support a ConOps in which the VA integrates AAM solutions (i.e., UAS) and novel operational models for organ transport.

Table 8. Assumptions for Organ Transport Missions

Assumption Category	Assumption
Aircraft Certification and Availability	UAS will be certified and operational for long-distance package delivery, with appropriate medical warning labels. Though we expect operations under Part 108, if operations are conducted under Part 135, then associated Pipeline and Hazardous Materials Safety Administration (PHMSA) standards apply for medical equipment transport, and it is possible that these standards will be applied to future Part 108 operations also.
Payload & Containment	Organ containers are expected to be in the range of 10 - 50 pounds based on current dimensions and designs [98]. Large (i.e., other than “small”) UAS are assumed to be able to accommodate containers on the heavier end of this spectrum, which may be equipped with automated organ preservation systems, for both missions considered.
Delivery Range	Mission 1 (first-mile/last-mile): 5 – 50 miles; Mission 2 (intra-network): 5 – 150 miles
Dispatch Readiness	Aircraft can be rapidly deployed due to electric propulsion (minimal startup time), and specialized use (i.e., not designated as a multi-use UAS for other types of package delivery).

Turnaround Operations	Turnaround time between missions is manageable via battery swap or fast charging, enabling multiple daily flights.
Medical Storage Environment	Aircraft can provide thermal and shock control, consistent with cold ischemia or normothermic transport.
Handling & Handoff, Crew	Assumes the system has SOPs in place for sterile transfer and chain of custody logging between VA centers, couriers, and flight crews.
Landing Infrastructure	For Mission 1: Local airports may include a UAS landing zone specific for organ delivery and pick-up that separates the operation from current cargo operations. For Mission 2: Urban VA sites use current emergency zones to incorporate a UAS landing zone. Rural sites may also use current emergency zones, or establish new UAS landing zones, if spacing permits.
Charging Infrastructure	Charging or battery swap capabilities assumed at landing zones (e.g., power carts or fixed chargers). Battery swaps are possible, but it is more likely that charging pads for organ transport UAS will need to be installed at medical facilities and/or airports.
Airspace Access and Management	Missions will have access to low-altitude airspace and avoid restricted zones or manage them via corridors. UAS will need to operate in accordance with TFRs and will need flight plans that do not interfere with the typical approach/departure paths of large commercial airliners.
Weather Operations	Missions are performed in both visual and instrument meteorological conditions. UAS will not operate in severe weather conditions (e.g., storms, icing), and backup transport options are assumed in these cases.
Terrain Considerations	Organ transport is expected to end at a medical facility; therefore, flying over various terrain conditions should not impede the operation. Sensor packages are expected to be installed on the UAS to prevent any terrain collisions.
Funding	The VA covers costs through internal budgets or reimbursable arrangements with insurance providers of the patients for delivery operations and associated staff involvement.

4.4.2 Constraints

Multiple operational constraints exist for the missions expected under the organ transport application, which may limit feasibility, scalability, and timing. These stem from regulatory, technical, infrastructure, medical, financial, and workforce-related factors that must be resolved before full-scale deployment is viable.

- ***Medical requirements:*** Different organs have strict CIT limits (see Table 5). This will restrict UAS routing flexibility and necessitate highly reliable operations.
- ***Regulatory Constraints:*** There is no existing FAA certification standard for autonomous unmanned organ flights. We expect UAS organ transport operations to be conducted under Part 108, which is not yet finalized.
- ***Infrastructure Constraints:*** Most VA and partner sites currently lack suitable landing infrastructure for UAS. New UAS landing zones will require environmental reviews, zoning approvals, and capital investment. In the interim, reliance on nearby facilities that may currently have or plan on establishing UAS landing zones will add time and complexity by including additional ground transfer logistics.
- ***Technology Constraints:*** Current UAS designs have limitations in range, payload, weather performance, and turnaround times. Current vehicles may require long recharging or maintenance cycles that could impede efficient organ transport missions. None of the platforms are proven in high-tempo medical missions, limiting immediate readiness.

- ***Cost Constraints:*** Aircraft acquisition, landing zone construction, staffing, and charging upgrades are significant capital expenses. Operating costs include electricity, battery wear, and crew. Budget pressures may limit scope to pilot programs or high-need areas.
- ***Workforce Constraints:*** Training pipelines, medical readiness, and retention challenges of the workforce could limit readiness.
- ***Airspace Constraints:*** Flights may be restricted to designated corridors or subject to delay due to congestion, proximity to controlled airports, or safety restrictions. Public acceptance and noise concerns may also limit routing options.

4.4.3 Enablers

After implementation, it is believed that Part 108 will make additional UAS operations, including organ transport, a more viable ConOps compared with the current state. Currently, UAS are used to transport medical supplies from medical facilities to areas in need. However, due to payload limitations and regulatory constraints, organ transport has been discussed but not yet implemented [64]. The development of associated guidance material and industry standards — including considerations for correct packaging, deployment, and hazardous material considerations — will be essential in enabling these operations. Additional enablers for integrating UAS organ transport for VA operations would include:

- ***Policy and legislative support:*** The publication of Part 108 and related guidance materials is necessary to authorize these operations. Further regulatory policies, particularly concerning UAS traffic management (UTM) and possible prioritization of emergency medical-related flights, will be required to manage airspace and prevent conflicts between organ transport UAS and other UAS operating near medical facilities.
- ***Public-private partnerships:*** Whether the VA chooses to operate its own UAS or to collaborate with private operators, partnerships must be established among UAS providers, the VA, private medical facilities, and OPOs.
- ***Integration with the VA healthcare system:*** Like the VA's existing patient transport volunteer system, UAS organ transport will require strategic planning and integration into the broader VA healthcare infrastructure.
- ***Infrastructure investments:*** Both physical and digital infrastructure enhancements are needed to support UAS organ transport. As previously noted, designated landing zones must be established at hospitals for UAS-based organ delivery and pickup.
- ***Research and Development (R&D) in transporting organs via UAS:*** Further R&D is needed to ensure safe transport of organs via UAS. Industry standards should be developed to guide packaging and onboard systems specifically designed for organ transport.

4.4.4 Non-Aviation Systems Needed

In addition to the aviation systems defined, the UAS organ transport application will require specific medical systems to be established for the anticipated missions.

In both reference missions described, the UAS envisioned for each mission will be required to comply with the necessary aviation standards, but also the necessary CAMTS accreditation standards since the aircraft becomes, by definition, a piece of medical equipment utilized for patient care [26]. These standards may need tailoring to account for the UAS not carrying people

onboard. Additional non-aviation systems needed to allow for the most efficient and accessible form of care include:

- ***Infectious Disease Training and Procedures:*** Medical staff and crew will need to meet requirements for the containment of airborne pathogens within the cargo bay during operations, and they will need to follow correct procedures to return the cargo bay to a sanitary state in between organ deliveries to allow for additional operations to occur in a given flight schedule.
- ***Organ Support Systems:*** Depending on the robustness of the organ outside the body, some organs may need supporting equipment to keep tissues viable or muscles moving during transport. There is likely a practical limit to how large the UAS needs to be before it makes more sense to simply use an aircraft large enough to carry passengers—in that case, this application blends into our first application, Patient Transport, in terms of the aircraft type.
- ***Dispatch Training and Coordination:*** If the organ is being delivered between VA and private hospitals, the ROC of the VA facility will need the associated training and SOPs to properly coordinate with private hospital dispatch centers for organ transport. Additionally, coordination between other modes of transportation may be required in first-/last-mile deliveries.

4.5 Cost Assessment of Organ Transport

Regardless of the transport mode(s) used, it is important to recognize that the direct cost of transporting organs is likely to be a small fraction of the overall organ procurement costs incurred by OPOs. The U.S. Department of Health and Human Services (HHS) and the Health Resources and Services Administration (HRSA) oversee the reimbursement of travel expenses of the organ transportation and the patient travel expenses that are facilitated by the OPO with the transplant center best suited for the procedure. For example, a study published in 2021, using data from 51 of the 58 OPOs nationally, estimated that transport costs for kidneys from deceased donors represented about 7.5% of the direct procurement costs ($1,200 out of $15,998 total direct), and a little over 3% of total procurement costs ($1,200 out of $35,400 direct and overhead) [65]. Combined with the fact that time is such a critical factor in organ transport, it is reasonable to presume that relative transport costs may not be a primary driver of AAM adoption. Nevertheless, it is useful to start by assessing the costs of current organ transport modes.

4.5.1 Current Costs of Ground Transport

In scenarios involving ground transport (directly from the donor site to the transplant site or last-mile transport to/from an airport or heliport), there are private courier and ambulance companies that can provide dedicated ground delivery services for organ transport. While it is difficult to obtain specific cost estimates, one simplistic but reasonable method to get a probable lower bound on ground transport costs is to consider the quickest “overnight” shipping solutions from a conventional shipper such as FedEx or United Parcel Service (UPS). As an example, if using a commercial kidney transporter container weighing 45 pounds, we found the cost of FedEx’s highest priority shipping service for a 25” x 25” x 25” container of that weight to be close to $500 for short-haul trips that range anywhere from 20 to 80 miles [66]. This is likely to be a very low minimum bound on relevant transport costs as it does not include explicit continual oversight and/or monitoring that is often desirable for organ transport.

4.5.2 Current Costs of Air Transport

There will be a very large effect on costs associated with air transport depending on whether an organ is shipped as cargo on an existing scheduled service or via chartered aircraft. Rates for

cargo (below the wing) on a scheduled flight can be quite inexpensive; for example, using the online calculator for American Airlines, a single box weighing up to 50 pounds can be shipped across the country for less than $150. Paying the full cost for a chartered or air ambulance flight is much more expensive. As previously described above in Table 4, systemwide average costs for Air Ambulance flights range from a little over $900 per hour for piston aircraft to over $6,000 per hour for jets. Based on these estimates alone, we can expect that, purely from a cost perspective, UAS (which will likely have much lower direct operating costs than conventional charter aircraft) could be well positioned to be successful in providing organ transport services in cases where air ambulance services (or charter services operating MEDEVAC flights) are required.

4.5.3 Estimated Cost Assessment Utilizing AAM

Functionally, the primary advantage for drone transport relates to *time* rather than *cost* savings. This is an overriding consideration given the maximum CITs, as defined previously in Table 5. That said, more organs may be able to reach more people because using UAS allows them to be moved more quickly. From a cost perspective, this may enable fewer organs to be "wasted" thus enabling lower costs per organ transplant overall (even if the direct transport cost is not less using a UAS).

To get a sense of the potential costs involved in procuring and operating UAS for organ transport, we can initially look at currently available drones with sufficient payload capacity and range. To do so, attention is focused on drones with a range of at least 20 miles and a payload capacity of at least 50 pounds. These payload and range requirements together actually exclude most current commercially available UAS (many may satisfy one, but not both criteria), but four examples (at different stages of development) were considered, depicted in Table 9 [67], [68].

Table 9. Examples of Drones for Potential Organ Transplant [67], [68]

UAS Characteristic	Ehang EH216-S	Jouav CW-80E	Defour Aero2	Elroy Chapparal
Design	Multirotor eVTOL	Fixed Wing VTOL Hybrid-electric	Tilt Wing VTOL Hybrid-electric	Fixed Wing eVTOL
MTOW (lb)	1325	240	460	1215
Payload (lb)	485	55	115	500
Range (miles)	22	62	250	300
Cruising Speed (mph)	62	56	150	143
Fully Loaded Flight Time (min)	21	*Unknown*	180	*Unknown*
Price ($)	$410,000	$150,000	*Unknown*	*Unknown*
Current/Projected Primary Uses	Passenger transport; Logistics	Mapping; Surveillance; Emergency Response	Cargo Transport	Cargo Transport

Geographic Considerations

Due to the time constraints on organ preservation and the range limits of current UAS, information on typical organ travel distance for transplants is key to assessing the potential market and costs involved.

To aid this analysis, data were obtained from OPTN's national database of organ donations, waitlists, and transplant activity for the years 2021-2024. For these years, data is reported for 250 different transplant centers; Table 10 shows the distribution of transplants by distance to the transplant center for different organs [69].

Table 10. Organ Transplants by Distance to Transplant Center, 2021-2024 [69]

Distance (mi)	All Organs	Kidney	Liver	Heart	Lung
0-150	56%	64%	54%	29%	32%
151-200	10%	11%	8%	10%	9%
201-250	9%	9%	7%	9%	9%
251-500	14%	5%	26%	39%	21%
500+	11%	11%	5%	14%	29%
Grand Total	**100%**	**100%**	**100%**	**100%**	**100%**

Over the indicated time period, the organ types shown in Table 10 make up almost 98 percent of all transplants; kidney transplants alone account for over 58 percent and liver transplants comprise about 23 percent. Surprisingly, despite their shorter preservation times, heart and lung transplants are more likely to involve longer distances than kidney and liver transplants. This may be due to differences in the difficulty of matching donors and recipients.

Given the available range and payload capabilities, at least for the near term, the relevant market is focused on transplants representing the first row of data in the above table. Overall transplant counts for this 0–150-mile range averaged about 25,000 per year between 2021 and 2024. In principle, over the longer term the availability of longer-range/higher-capacity drones could alter the current distributions shown above.

On a per unit basis, the average number of such transplants per center has grown modestly over this time frame, reaching an average of about 106 for 2024. But the distribution of these transplant counts is heavily skewed. For calendar year 2024, data were reported for 244 different centers; of these, the VA has contracts with 14 centers to provide transplant services for veterans, and the distribution of numbers of transplants performed where the organ transport distance is no more than 150 miles is shown in Table 11 below.

Table 11. Count of Transplant Centers by Number of Transplants Involving Organ Distance ≤150 Miles, 2024 [69]

Number of Transplants With Organ Distance ≤ 150 miles to Transplant Center, 2024	All Transplant Centers	VA Transplant Centers
0-49	111	6
50-99	39	2
100-199	40	1
200-299	35	4
300+	19	1
All	244	14

For both VA centers and the nation at large, nearly half of all transplant centers carry out less than 50 transplant operations per year involving organ transport distances of 150 miles or less. But even at this limited distance, the corresponding area around each center is over 70,000 square miles; this suggests a sparse distribution of demand for "short-range" organ transport geographically.

For this analysis, an even more relevant issue is the distribution of *donor sites* where the organs are harvested and their distance to the transplant center. The OPTN database does not include information on organ travel distances by donor site, and there are many more donor organs harvested than are actually used in transplants. But OPTN does report the number of transplanted organs by donor site. For 2024, there were 2,250 different donor sites reported; again, the distribution of the number of transplanted organs by donor site is quite dispersed, as shown in Table 12.

Table 12. Count of Donor Recovery Hospitals by Number of Transplanted Organs, 2024 [69]

Number of Transplanted Organs, 2024	Avg. Number of Transplanted Organs, 2024	Donor Recovery Hospitals
1-9	4.4	960
10-49	22.8	877
50-99	69.0	219
100+	137.3	94

Taken as a whole, and given the acute time sensitivity associated with organ transport, the data in the tables above suggests very low utilization rates for dedicated drones to be used solely for organ transport in many locations, although in principle a single drone may be able to serve multiple donor sites and provide transport to multiple transplant centers depending on relative distances between sites. For practical implementation, careful planning and analysis would need to be carried out to identify suitable staging locations for the vehicles.

Unit Cost Estimates

The following UAS cost assumptions use the parameters shown above in Table 9 as a starting point and then make various adjustments based on range capability and other factors:

- ***Average Flight Duration/Distance*:** 60 minutes / 60 miles
- ***Annual Number of Flights:*** 200 (assumes out and back for 100 organ transports)
- ***Expected Lifecycle:*** 2-4 years
- ***Acquisition Cost:*** $200,000-$400,000

- ***Energy Use:*** 20-25 kWh per flight (estimate partially derived from Ehang reported battery size of 17 kWh for EH216-S vehicle with large payload capacity but very short range)[10]
- ***Electricity Cost:*** 13.48-13.77 cents per kWh (U.S. averages for 2025-2026 from US Energy Information Administration (EIA)) [70]
- ***Annual Insurance Cost:*** $17,500-$25,300 assuming base premium of 3% of drone value, $7440 flight risk and liability; plus 30% add-on for payload insurance, heavy lift and related capabilities [71]
- ***Annual Maintenance Cost***: $6,000-$18,000 (assumes 50 percent markup from estimates given in Reference [72] based on large weight and range requirements)
- ***Other Overhead (including remote pilot) and Profit:*** 25% of all other cumulative costs

With these assumptions, the range of estimated costs are shown in Table 13. The total fully loaded cost per 1-hour flight is estimated at $500-$1,500; thus, the relevant cost for each transport including the return to base is double that, or $1,000-$3,000. These are notional costs given the large uncertainties regarding design, market pricing and unknown future certification and production approvals that would be needed from FAA.

Table 13. Life Cycle and Per Unit Cost Estimates

Cost Variable	4-Year Lifecycle (800 Flights) with Lowest Range of Costs	2-Year Lifecycle (400 Flights) with Highest Range of Costs
Acquisition Cost	$200,000	$400,000
Electricity Cost	$2,200	$1,400
Insurance Cost	$70,000	$50,600
Maintenance Cost	$24,000	$36,000
Total Lifecycle Cost	$296,200	$488,000
Direct Cost per Flight	$370	$1,220
Other Overhead	25%	25%
Total Cost per Flight	$500	$1,500
Total Cost per Roundtrip	$1,000	$3,000

These estimates may be somewhat optimistic since they do not consider other potential infrastructure costs associated with storing or staging vehicles at specific locations. On the other hand, direct vehicle acquisition and operating costs may well decline in the future as better battery and flight technologies are developed, and as remote piloting technologies and regulations allow a single pilot to control multiple vehicles simultaneously.

As a point of comparison, the estimated average hourly cost of current air ambulance transport options (as shown in Table 4) ranges from $933 for piston aircraft to $6,015 for jet aircraft.[11]

[10] Direct electricity costs, regardless of the uncertainty in actual energy use per flight, will be a very small portion of total costs.

[11] Unlike the dedicated UAS scenario, these estimates for current flying options do not presume that they must dead-head back to their original location. For helicopters specifically, the count and distribution of existing bases shown in Figure 4 above support the reasonableness of this assumption.

5 Conclusions and Recommendations

AAM applications hold the promise of advancing technology and means to better serve the public in addressing transportation challenges. Our effort started by reviewing prior analysis that had identified a set of public good applications, to which we added several new ones. We then developed and applied a structured, repeatable process to down-select applications for deeper analysis. That process identified critical gaps and opportunities where AAM solutions could enhance patient outcomes for two medical transport applications: Patient Transport and Organ Transport. We further focused our analysis on the air medical operations (with supplemental ground transportation, when deemed appropriate for either time or cost characteristics) within the VA healthcare system as a particular federal government stakeholder.

In our first chosen application, patient transport using an AAM vehicle, the current state is marked by patient transfers being predominantly conducted via ground transportation. Such transfers are constrained by limited access to VA members and the absence of a dedicated VA-owned vehicle fleet. Most VA patient transports are conducted via volunteer transportation programs, which do not always allow for consistent means of transportation, particularly for rural VA patients—travel distances for rural patients to specialized care facilities can often exceed 100 miles. When exploring interfacility transfers, cost continues to be the driving factor on patients' transportation in non-emergency and urgent scenarios.

In our second chosen application, organ transport using UAS, we found that the current state of organ transport has faced increasing scrutiny and federal oversight due to inefficiencies and delays associated with commercial airliner use. Congressional directives, modernization efforts by HHS, and recent publications from industry working groups tasked to explore means to improve organ transport have all underscored the urgency to explore other means and systems for improved transportation. Our analysis shows potential for UAS-based organ transport to improve first-mile/last-mile and intra-network missions.

The expected benefits of AAM for these applications center around improved speed relative to ground transportation and reduced operating costs relative to current air transportation, though we note that, because these aircraft are still in development, our cost estimates are approximations based on very limited data. We also identified several barriers for near-term deployment. Aircraft certification, infrastructure readiness, and medical standards compliance for these new aircraft platforms are significant hurdles for industry OEMs. Accordingly, forecasting scalability and affordability for the VA is challenging to determine currently. Pilot programs, such as the AAM and eVTOL Integration Pilot Program [73], could help efforts to validate operational feasibility and financial sustainability.

Based on our assessment of the current industry environment for public good AAM applications, such as the two analyzed in this report, we recommend strategic partnerships among the VA, OEMs, and private healthcare providers to support pilot programs. Federal support from agencies such as the DOT and the VA, either through regulatory policy or grant funding, would further accelerate adoption. Infrastructure investment would also be beneficial. By leveraging compliance to EB105A and other guiding FAA policy, existing helipads and airports could provide initial entry for the proposed medical applications, leading to future use of dedicated vertiports and charging/landing pads for both crewed and uncrewed aircraft.

Technology enablers—including advancements in battery systems, autonomous flight capabilities, noise reduction, and digital infrastructure (e.g., UTM)—are areas in which NASA, other federal partners, and industry stakeholders can support these progressive integration efforts. However, long-term operational sustainability will depend on the development of cost-effective models that align with the VA's future budget and resources. Fiscal constraints may

hinder direct VA operations or procurement of AAM aircraft for the two chosen applications, which would likely necessitate other operational models, such as contracting and partnership models with OEMs and operators.

We identified key end users to include public and private healthcare systems, OPOs, medical networks, and patient populations. To support the integration of AAM into existing healthcare systems, we recommend the following next steps for NASA:

- **Support the implementation of pilot programs** at select VA networks and transplant hubs, leveraging existing helipads/airports first.
- **Assist the VA in assessing charging infrastructure requirements** for UAS/AAM landing zones at hospitals and clinics based on NASA's UAS/AAM expertise.
- **Partner with the VA and/or other organizations involved with organ transport to study organ handling characteristics** on UAS platforms.
- **Engage in industry standards development** to inform UAS design, handling, and operational requirements, supporting compliance pathways for Part 108 and Part 146 when they are finalized.
- **Collaborate with AAM OEMs** to identify integration needs, such as autonomous operations, communications between vehicle and Automated Data Service Provider(s) (ADSP), and landing zone requirements.

In conclusion, AAM holds potential for improving veteran healthcare access and outcomes. These patient and organ transport public good applications represent viable, beneficial avenues for the federal government to demonstrate initial AAM operations to help the industry learn and mature.

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Appendix A – 19 New Applications Reviewed

The following table is a template for the description of the additional applications that were developed by our team beyond the ones originally developed by Deloitte [1]. In the following pages, the 19 additional missions are described in their own respective tables.

New Application #: Public Good Application TEMPLATE	
Executive Summary	
Prose Overview	*Summary of New Application Details*
Application Category	*Operational Category*
AAM Platform Type	*Determine the optimal AAM equipment type (e.g., drones, eVTOLs) based on operational requirements and benefits.*
Description of Application	
Clearly articulate the public good application by describing its primary function, target application, and intended outcome.	
Current Method and Issues	
Examine existing methods and their limitations, such as inefficiencies, risks, or high costs.	
Market Summary	
Estimate the U.S. market size based on demand, scalability, and potential economic impact.	
Relative Value to General Public	
Evaluate the application's value to the general public based on the frequency and significance of its impact (e.g., safety, convenience, environmental benefits).	
Why use AAM?	
• ***Operational Safety:*** *Analyze the safety implications of the proposed AAM solution, including risks to operators, users, and bystanders.* • ***Time Savings:*** *Determine the time efficiency of the AAM solution compared to current practices, emphasizing speed of operations or responsiveness.* • ***Cost Benefits:*** *Compare the cost implications of the AAM solution against traditional methods, focusing on operational and long-term savings.*	
Federal Partnerships	
Assessment of key partnerships with varying federal agencies, based on public or private authority. Input or coordination with additional federal agencies included with defined area of expertise.	

New Application 1: Traffic and Congestion Monitoring	
Executive Summary	
Prose Overview	Urban traffic congestion hampers productivity, safety, and the commuter experience. Real-time monitoring of traffic flow can offer actionable insights to alleviate congestion. Traditional ground-based systems often operate reactively and are limited in scope. AAM offers an advantage by providing more timely, dynamic data to assist with traffic management. While the cost savings may be minimal, AAM can offer moderate time savings and improved traffic monitoring, particularly in congested areas. However, its direct impact on road safety is limited, and AAM should be seen as a complementary tool rather than a comprehensive solution.
Application Category	Other Applications
AAM Platform Type	**Drone** – Persistent monitoring with real-time data transmission over urban areas.
Description of Application	
The application involves real-time traffic monitoring to optimize congestion management. It aims to provide accurate, dynamic traffic flow analysis, enabling quicker interventions and improved roadway efficiency.	
Current Method and Issues	
Current methods rely on ground-based monitoring, including cameras and sensors, which are often reactive, limited in coverage, and slower in providing actionable insights.	
Market Summary	
Large market in urban mobility solutions, focused on alleviating congestion and improving traffic flow.	
Relative Value to General Public	
High - Direct impact on commuter efficiency and reduction in travel time.	
Why use AAM?	
• **Operational Safety:** Enables monitoring without putting personnel in high-risk environments like highways or overpasses. • **Time Savings:** Moderate time savings for real-time traffic monitoring and quicker response to congestion issues. • **Cost Benefits:** Minimal cost savings. AAM can complement traffic management systems but does not drastically reduce infrastructure or operational costs.	
Federal Partnerships	
Federal agencies like the DOT can integrate aerial traffic monitoring into the Intelligent Transportation System (ITS) program, while the FAA ensures airspace safety and operational compliance. Partnerships with State DOTs, metropolitan planning organizations (MPOs), and agencies like National Highway Traffic Safety Administration (NHTSA) can support safety initiatives linked to congestion mitigation.	

New Application 2: Environmental and Air Quality Monitoring	
Executive Summary	
Prose Overview	Monitoring pollutants and environmental changes is essential for public health and safety. Traditional ground-based sensors often fail to cover localized sources of pollution. AAM can help by providing more extensive and real-time data in areas that are difficult to monitor. However, it has limited direct benefits to safety, as the primary focus is environmental data collection. While it can offer minor time savings, AAM does not drastically reduce costs compared to existing methods. Its real value lies in improving public awareness and aiding in early detection of pollution issues, particularly in remote areas.
Application Category	Other Applications
AAM Platform Type	**Drone –** Equipped with sensors for precise and localized air quality measurements.
Description of Application	
Focusing on monitoring pollutants and environmental changes using sensors. Utilizing sensor packages that provide consistent data gathering of environmental conditions that do not expose pilots to unsafe air quality conditions.	
Current Method and Issues	
Ground sensors have limited range and can miss localized pollution sources. Additionally, the use of weather balloons is susceptible to uncontrolled wind direction for retrieval.	
Market Summary	
Established market, with increasing focus on public health and environmental safety.	
Relative Value to General Public	
Medium - Impacts public health and awareness of air quality issues.	
Why use AAM?	
• **Operational Safety:** Limited direct impact on safety, though real-time monitoring could provide early warnings for hazardous conditions (e.g., pollution levels). • **Time Savings:** Minor time savings over traditional air quality monitoring methods, especially for remote or difficult-to-reach areas. • **Cost Benefits:** AAM can be an additional tool for monitoring, but the cost reduction in air quality monitoring is marginal, as existing systems are already established.	
Federal Partnerships	
Federal agencies like the Environmental Protection Agency (EPA) could either utilize their own drone program for air quality assessments or partner with research entities that will utilize drones to perform experiments/monitoring in given environments.	

New Application 3: Renewable Energy and Utility Management	
Executive Summary	
Prose Overview	Renewable energy infrastructure, such as wind and solar farms, requires regular inspection and maintenance. AAM can aid in this process by providing access to hard-to-reach areas. While traditional manual inspections are slow and can be hazardous, AAM reduces the risks associated with manual labor and speeds up the process to some extent. However, cost savings from using AAM are moderate at best. While it improves the efficiency of inspections, it does not eliminate the need for other resources or reduce infrastructure costs significantly.
Application Category	Inspection
AAM Platform Type	**Drone –** Efficient for inspecting wind turbines or solar panels in remote areas.
Description of Application	
Inspecting and maintaining renewable energy infrastructure, such as solar and wind farms. This can include the use of AAM vehicles for inspection, installation, or associated maintenance.	
Current Method and Issues	
Manual inspections are labor-intensive, slow, and often dangerous. Large wind turbines and water dam turbines require trained personnel climbing extreme heights for observations, which is hazardous and not consistent.	
Market Summary	
Moderate market with significant activity in renewable energy sectors, particularly in sustainability and infrastructure maintenance.	
Relative Value to General Public	
Low - Supports energy sustainability and operational efficiency.	
Why use AAM?	
• **Operational Safety:** AAM can improve safety by inspecting hard-to-reach infrastructure, reducing the risk of accidents during manual inspections. • **Time Savings:** Modest time savings for inspecting renewable energy infrastructure faster than traditional methods. • **Cost Benefits:** AAM can provide moderate cost savings by enabling proactive monitoring, potentially preventing costly maintenance issues.	
Federal Partnerships	
The Department of Energy (DOE) could support partnerships with public agencies, such as the FAA for airspace management, Bureau of Land Management (BLM) for wind and solar farms on federal land, and State Energy Offices for inspection compliance.	

New Application 4: Seed Distribution and Reforestation	
Executive Summary	
Prose Overview	Distributing seeds efficiently in reforestation efforts is essential for ecosystem restoration. AAM can assist by reaching remote and difficult-to-access areas faster than traditional methods. While this reduces the need for manual labor and improves coverage, it does not eliminate all logistical challenges. The cost savings are modest, and although AAM speeds up delivery, it may still require substantial resources for ground support. AAM's role in this application is valuable but should be viewed as part of a larger reforestation effort, not a standalone solution.
Application Category	Agriculture
AAM Platform Type	**Drone or eVTOL –** Can carry larger payloads for covering larger reforestation areas.
Description of Application	
Distributing seeds efficiently in hard-to-reach reforestation areas. Similar to agricultural spraying, seed distribution in forested regions must be done at a low altitude that may be dangerous for other aircraft platforms.	
Current Method and Issues	
Manual seed distribution is slow, labor-intensive, and often ineffective in coverage. Additionally, low-altitude drops can be dangerous to piloted operations flying near powerlines.	
Market Summary	
Niche market focused on environmental sustainability and reforestation efforts.	
Relative Value to General Public	
Low - Benefits environmental health but less direct impact on the public.	
Why use AAM?	
• **Operational Safety:** AAM improves safety for workers by reducing their need to operate in hazardous, difficult environments (e.g., remote or mountainous areas). • **Time Savings:** Time savings due to faster delivery of seeds to large, hard-to-reach areas compared to traditional methods. • **Cost Benefits:** Modest cost savings. AAM helps reduce manual labor costs and increases efficiency but does not eliminate the need for other resources.	
Federal Partnerships	
The US Department of Agriculture's Forest Service could support a partnership with a trained company or team of experts that would deploy drones for the seed distribution operation. Additionally included in the effort would be the FAA (airspace safety), BLM (federal land access), and the EPA (environmental impact oversight).	

New Application 5: Archaeological and Historical Site Monitoring	
Executive Summary	
Prose Overview	Monitoring and protecting archaeological sites from damage and looting is an ongoing challenge. AAM offers a way to enhance site protection by providing aerial surveillance, which traditional ground patrols lack. However, AAM's role in safety is limited, as it helps with site monitoring but does not directly prevent incidents. The cost savings from AAM are also moderate, as the capital investment required may not justify the reduction in labor costs. While the time savings are small, AAM enhances the ability to monitor vulnerable sites more efficiently compared to ground-based methods.
Application Category	Conservation
AAM Platform Type	**Drone –** Cost-effective for protecting and inspecting sensitive, hard-to-reach locations.
Description of Application	
Protecting and monitoring historical sites from looting and environmental damage. Sensor systems to be able to measure or record current level of deterioration of the site.	
Current Method and Issues	
Ground patrols lack visibility and can be easily circumvented. Some historical sites cannot be compromised with camera systems to be able to maintain the integrity of the site.	
Market Summary	
Small market focused on cultural heritage preservation and archaeological research.	
Relative Value to General Public	
Low - Important for heritage conservation but limited public engagement.	
Why use AAM?	
• **Operational Safety:** Minimal direct impact on safety, though drones can help avoid the need for people to physically access potentially hazardous sites. • **Time Savings:** Small time savings compared to traditional methods like on-ground surveys. • **Cost Benefits:** Limited cost savings, as drones would likely reduce labor costs but still require some capital investment.	
Federal Partnerships	
Federal agencies like the National Park Service (NPS) could utilize drone programs to support protection and monitoring efforts of National Historical sites. Supporting organizations would be the FAA (airspace safety), State Historic Preservation Offices (SHPOs), and the Department of Homeland security (DHS, security for sensitive sites).	

New Application 6: Crowd Management at Large Public Events	
Executive Summary	
Prose Overview	Managing large crowds during public events is crucial for safety. AAM can improve crowd control by offering real-time aerial surveillance to spot hazards or incidents. While it helps with situational awareness, AAM does not replace ground personnel but rather complements existing systems. Cost savings could be realized through reduced manpower needs. Time savings are moderate as AAM can provide quicker responses to crowd-related issues. However, its effectiveness depends on event scale and infrastructure availability, and it may not be applicable to all types of events.
Application Category	Other Applications
AAM Platform Type	**Drone –** Real-time aerial surveillance for effective crowd control.
Description of Application	
Assisting in crowd control and safety measures during events with aerial surveillance. Distinct from other applications defined for police surveillance.	
Current Method and Issues	
Ground monitoring is reactive and can be ineffective in emergencies. Additionally, use of police helicopters can be costly and timeliness of dispatch can minimize success rates.	
Market Summary	
Moderate market in event management and safety services, focusing on large-scale public gatherings.	
Relative Value to General Public	
Medium - Directly impacts public safety and event management efficacy.	
Why use AAM?	
• **Operational Safety:** AAM improves safety by enhancing situational awareness, helping to spot hazards or incidents quickly. • **Time Savings:** Moderate time savings by providing real-time aerial surveillance, enabling quicker responses to crowd-related incidents. • **Cost Benefits:** AAM could offer some cost savings by reducing the need for personnel on the ground for surveillance and monitoring.	
Federal Partnerships	
The DHS may choose to partner with agencies, such as the FAA (airspace management), DOT (traffic coordination), and Local Law Enforcement Agencies to deploy drone surveillance programs for large crowds for events such as political rallies, multi-day concerts, or marathons.	

New Application 7: Aerosol Dispersal for Solar Radiation Management	
Executive Summary	
Prose Overview	Solar Radiation Management (SRM) aims to mitigate climate change effects by dispersing aerosols to reflect sunlight. Traditional methods for geoengineering lack precision, and AAM could offer a more controlled approach for aerosol dispersal. However, the potential impact on operational safety is minimal, as the primary concern is environmental intervention rather than human safety. AAM's cost savings are marginal due to the significant investment required for SRM projects, and time savings are negligible due to the scale of operations. The public impact remains speculative, as the long-term effects of SRM on climate are still uncertain.
Application Category	Weather
AAM Platform Type	**eCTOL –** Requires long endurance and large payload capabilities for atmospheric missions.
Description of Application	
Disperse aerosols to reflect sunlight and mitigate climate change. Possible to utilize similar spraying mechanisms used in other spraying applications.	
Current Method and Issues	
Traditional methods lack precision and scalability based on the needed altitude and access to airspace.	
Market Summary	
Niche market, highly focused on climate engineering and research efforts for geoengineering applications.	
Relative Value to General Public	
Low - Addresses environmental concerns but with uncertain direct public impact.	
Why use AAM?	
• **Operational Safety:** Limited impact on operational safety, as the primary focus is on climate intervention, not safety. • **Time Savings:** Time savings are negligible due to the complexity and scale of SRM operations. • **Cost Benefits:** Cost savings are minimal, as the technology requires substantial investment and infrastructure, with uncertain long-term benefits.	
Federal Partnerships	
For research purposes, the DOE may choose to implement a drone program for aerosol dispersal for SRM, partnering with the FAA (airspace safety), EPA (environmental compliance), and National Oceanic and Atmospheric Administration (NOAA, atmospheric monitoring).	

New Application 8: Geoengineering & Cloud Seeding for Increased Albedo	
Executive Summary	
Prose Overview	Cloud seeding aims to enhance cloud albedo and reduce the effects of global warming. AAM could improve the precision of this technique, offering better control over the dispersal of agents in the atmosphere. While geoengineering efforts may eventually have an environmental impact, the public's awareness and visibility of these efforts are low. The cost savings are minimal given the scale and complexity of geoengineering, and the time savings are limited due to the need for extensive planning and execution. The public impact is speculative, and AAM serves more as an experimental tool than a practical solution for large-scale climate change mitigation.
Application Category	Weather
AAM Platform Type	**eCTOL –** Capable of long-range operations and carrying heavy seeding materials.
Description of Application	
Enhancing cloud albedo to reflect more sunlight back into space. Similar to Deloitte's 10.11.1 in terms of expected results, but different methodology in measuring current cloud albedo.	
Current Method and Issues	
Current methods have limited efficacy and are difficult to scale. Other methodologies have been sought to achieve similar results.	
Market Summary	
Specialized market focused on experimental climate mitigation technologies.	
Relative Value to General Public	
Low - Could yield significant environmental benefits, but with low visibility to the public.	
Why use AAM?	
• **Operational Safety:** Geoengineering efforts may have indirect safety impacts by reducing global temperatures, but this is speculative. • **Time Savings:** Time savings are limited because geoengineering projects typically require extensive planning and resources. • **Cost Benefits:** Minimal cost savings, as geoengineering is a high-cost intervention with long-term, uncertain financial benefits.	
Federal Partnerships	
Federal agencies like NOAA could partner with a drone team that would measure and monitor cloud seeding operations. Additional oversight may come from the FAA (airspace management), DOE (research support), and State Water Resource Agencies.	

New Application 9: Leak and Spillage Monitoring	
Executive Summary	
Prose Overview	Detecting leaks in pipelines and storage facilities is critical to preventing environmental damage. AAM offers an advantage by providing real-time monitoring, potentially identifying leaks faster than manual inspections. While the cost savings could be significant if leaks are detected early, AAM does not eliminate the need for ground-based inspections. Its main value is in improving safety by reducing the risk of environmental disasters. The time savings are moderate compared to traditional methods, but AAM's primary role is in providing better and quicker responses rather than radically cutting costs.
Application Category	Inspection
AAM Platform Type	**Drone –** Easily deployable for precise detection and monitoring of leaks. **Wing-in-Ground** effect aircraft can also be used for offshore rigs.
Description of Application	
Detecting and monitoring leaks in pipelines and storage facilities. Long-distance observations are required, which may extend past the availability and capabilities of piloted operations.	
Current Method and Issues	
Manual checks are labor-intensive, slow, and can be hazardous. If using experts on the ground, could be difficult to access, and experts in piloted operations could be expensive.	
Market Summary	
Established market in the energy sector, driven by regulatory requirements and safety standards for pipeline integrity and environmental protection.	
Relative Value to General Public	
High - Major implications for environmental safety and public health.	
Why use AAM?	
• **Operational Safety:** AAM improves safety by providing real-time monitoring, potentially reducing the risk of environmental disasters by detecting issues early. • **Time Savings:** Moderate time savings in detecting issues faster compared to manual inspections or traditional monitoring methods. • **Cost Benefits:** Cost savings could be significant by detecting leaks sooner, minimizing the scale of damage, and reducing response costs.	
Federal Partnerships	
Federal agencies like the Pipeline and Hazardous Materials Safety Administration (PHMSA) may partner with a private company for the monitoring efforts, but this will require additional oversight from the FAA (airspace safety), the EPA (environmental compliance), and the DOE (energy infrastructure oversight).	

New Application 10: Wildlife Conservation and Anti-Poaching	
Executive Summary	
Prose Overview	Surveillance for wildlife conservation is crucial in regions at risk of poaching. AAM helps by providing more extensive monitoring coverage, reducing the need for ground patrols in dangerous areas. While it improves operational safety for personnel, the cost savings are modest, and AAM does not eliminate all the challenges faced by conservation efforts. Time savings are significant in enabling faster responses to poaching activities. However, the public impact is limited, as the value of wildlife conservation is often less visible to the broader population.
Application Category	Conservation
AAM Platform Type	**Drone –** Persistent surveillance to track poachers and monitor wildlife habitats.
Description of Application	
Surveillance and tracking wildlife to prevent poaching. Drones can help with wildlife tracking for migration patterns or setting perimeters on protected sites for surveillance against poachers.	
Current Method and Issues	
Ground patrols are limited and can be risky for personnel.	
Market Summary	
Small, specialized market with a focus on conservation efforts, particularly in regions with high wildlife trafficking concerns.	
Relative Value to General Public	
Low-Medium - Critical for wildlife preservation with moderate public awareness.	
Why use AAM?	
• **Operational Safety:** AAM improves operational safety by reducing the need for human presence in hazardous environments and enhancing early detection of poaching. • **Time Savings:** Time savings by enabling faster detection and intervention in poaching cases compared to traditional methods. • **Cost Benefits:** AAM could reduce operational costs related to anti-poaching efforts by enhancing monitoring capabilities with fewer ground resources.	
Federal Partnerships	
Federal agencies like US Fish and Wildlife Service (FWS) may explore a partnership with local police agencies to help monitor protected species. Additional oversight may come from the FAA (airspace safety), DHS (anti-poaching enforcement), and State Wildlife Agencies.	

New Application 11: Waste Management for Remote Locations	
Executive Summary	
Prose Overview	Managing waste in remote or isolated areas presents unique challenges. AAM can expedite waste collection by accessing areas that are difficult to reach with traditional methods. While it reduces the need for manual labor, the cost savings are not substantial, as the investment in AAM technology is significant. Time savings are moderate, as AAM enables faster identification and collection, but other infrastructure challenges remain. Its impact on the general public is limited, but it plays a role in improving sanitation and environmental health in hard-to-reach areas.
Application Category	Other Applications
AAM Platform Type	**eVTOL or large Drone –** Larger capacity for carrying waste materials from remote areas.
Description of Application	
Facilitating waste collection and management in inaccessible areas. eVTOLs or large drones with sufficient payload capacity may be able to pick up waste from residences that are set at large distances from main roads or locations that require additional support.	
Current Method and Issues	
Ground collection methods are slow and costly, often leading to inefficiencies.	
Market Summary	
Niche market driven by environmental sustainability efforts, focused on remote areas with limited infrastructure.	
Relative Value to General Public	
Low-Medium - Improves local sanitation but with limited public visibility.	
Why use AAM?	
• **Operational Safety:** AAM can improve safety by reducing the need for personnel to travel to dangerous or inaccessible waste management sites. • **Time Savings:** Moderate time savings by enabling quicker monitoring and waste collection in otherwise inaccessible areas. • **Cost Benefits:** Some cost savings by reducing the need for manual waste collection and transport in remote areas, though the investment in equipment is substantial.	
Federal Partnerships	
Federal agencies like the EPA may be involved in these operations, but local Waste Management companies will most likely partner with the FAA (airspace safety) and State/local solid waste management authorities to be able to leverage AAM platforms for this operation.	

New Application 12: Electromagnetic and Radiation Monitoring	
Executive Summary	
Prose Overview	Monitoring radiation levels in areas affected by environmental hazards is crucial for public safety. AAM can provide real-time data collection, allowing for quicker responses to potential radiation risks. However, it has a limited direct impact on safety, as it mainly facilitates monitoring rather than preventing incidents. The cost savings are modest, as AAM enhances existing methods but does not replace them entirely. Time savings are significant in terms of quicker data collection and response times. The public impact is low but vital in areas with specific radiation risks.
Application Category	Other Applications
AAM Platform Type	**Drone –** Compact and ideal for localized detection of radiation hotspots.
Description of Application	
Monitoring radiation levels in affected regions for public safety. Sensor systems installed on drones could protect personnel from radiation in dangerous zones.	
Current Method and Issues	
Traditional monitoring is often slow and reactive, leading to delayed responses.	
Market Summary	
Moderate market, particularly relevant to environmental monitoring and disaster management in areas prone to radiation risks.	
Relative Value to General Public	
Low - Vital for public health, though visibility may vary based on incident frequency.	
Why use AAM?	
• **Operational Safety:** AAM can enhance safety by providing faster, safer monitoring of radiation levels, especially in hazardous environments. • **Time Savings:** Time savings by enabling real-time radiation monitoring, improving response times to potential hazards. • **Cost Benefits:** AAM provides modest cost savings over traditional methods by allowing remote and quicker monitoring of radiation levels.	
Federal Partnerships	
The DOE, in monitoring nuclear and radiation safety at different sites may want to implement a drone inspection program, with additional partnerships with the FAA (airspace safety), the Nuclear Regulatory Commission (NRC, nuclear monitoring compliance), and DHS (emergency management).	

New Application 13: Reef and Marine Life Protection	
Executive Summary	
Prose Overview	Protecting coral reefs and marine ecosystems is essential for ecological balance. AAM provides a way to monitor these ecosystems more efficiently than traditional methods. While the cost savings are minimal, AAM can help in more extensive monitoring, particularly in areas difficult to access by boats or divers. Time savings are moderate, as AAM enables quicker and more thorough data collection. However, the direct public impact is low, as the focus is on environmental conservation, with benefits that are not always immediately visible to the broader population.
Application Category	Conservation
AAM Platform Type	**Drone –** Lightweight and efficient for consistent monitoring of marine ecosystems.
Description of Application	
Monitoring and protecting coral reefs and marine ecosystems from threats. Drones can be deployed for scouting to be supported with further unmanned systems in the water for further exploration.	
Current Method and Issues	
Traditional monitoring methods are labor-intensive and limited in scope.	
Market Summary	
Small market with a focus on marine conservation and environmental protection, supported by non-governmental organizations and government research programs.	
Relative Value to General Public	
Low - Essential for ecological health but with indirect public benefits.	
Why use AAM?	
• **Operational Safety:** AAM can improve safety indirectly by enhancing monitoring of marine ecosystems, reducing the risks posed by environmental threats. • **Time Savings:** Time savings by enabling quicker and more extensive monitoring of marine environments compared to traditional methods. • **Cost Benefits:** Cost savings are minimal; AAM can help monitor marine life efficiently but does not significantly reduce the costs of marine conservation efforts.	
Federal Partnerships	
NOAA, in partnership with different research entities, may want to leverage a drone program that partners with their underwater submersible research. Additional oversight will be needed from the FAA (airspace management), EPA (marine environment compliance), and State Coastal Agencies.	

New Application 14: Communication Network Restoration as Temporary Communication Relays	
Executive Summary	
Prose Overview	Restoring communication networks in disaster-stricken areas is crucial for effective emergency response. AAM can restore communications faster than ground-based solutions, providing temporary relays where infrastructure has been damaged. While the cost savings could be moderate, the technology's primary benefit lies in speed of deployment and ensuring connectivity during critical times. However, AAM does not replace all ground efforts, and its value is more about improving emergency response rather than offering a long-term infrastructure solution. Its public impact is more about crisis management and less about everyday communication needs.
Application Category	Disaster Response
AAM Platform Type	**Drone –** Supports temporary communication relays with required payload flexibility.
Description of Application	
Restoring communication networks in crisis situations with relays. Drones could be used as a means to expand wireless internet signals.	
Current Method and Issues	
Ground solutions can be slow and inefficient during emergencies.	
Market Summary	
Targeted market in emergency communication solutions, especially in disaster-stricken areas requiring rapid infrastructure restoration.	
Relative Value to General Public	
Low - Important for crisis management but less visible to the public.	
Why use AAM?	
• **Operational Safety:** AAM can improve safety by rapidly restoring communication networks in crisis situations, ensuring that first responders can coordinate efforts. • **Time Savings:** Significant time savings by providing temporary communication relays during emergency situations, speeding up response efforts. • **Cost Benefits:** Some cost savings by enabling faster restoration of communications without the need for extensive ground infrastructure.	
Federal Partnerships	
Federal agencies like the DHS (emergency communication) may want to partner with the FAA (airspace management), Federal Communications Commission (FCC, communications regulation), and FEMA (disaster recovery coordination) in instances of major destruction due to natural- and man-made disasters.	

New Application 15: Infrastructure Damage Assessment after Natural Event or Man-Made Disaster	
Executive Summary	
Prose Overview	Post-disaster infrastructure damage assessment is vital for recovery planning. AAM can expedite the assessment process by providing real-time aerial data, reducing the need for large ground teams. The cost savings could be moderate, as AAM accelerates assessments and recovery efforts. Time savings are significant, allowing for quicker decision-making and resource deployment. While the public impact is high in disaster-prone areas, its value is context-dependent and may not always be apparent in regions less affected by such events.
Application Category	Disaster Response
AAM Platform Type	**Drone –** Ideal for capturing real-time images and videos of damaged infrastructure.
Description of Application	
Assessing damage to infrastructure for effective disaster response. Drones can be used to more quickly perform an assessment and to access areas that are no longer accessible to regular crews for assessment.	
Current Method and Issues	
Manual assessments are slow, limited, and often dangerous.	
Market Summary	
Established market, widely used by governments and insurance companies for post-disaster assessments and recovery planning.	
Relative Value to General Public	
Medium-High - Direct impact on recovery operations, enhancing community resilience.	
Why use AAM?	
• **Operational Safety:** AAM improves safety by offering real-time, aerial damage assessments, which allow for better coordination of emergency services. • **Time Savings:** Significant time savings by providing faster damage assessments, allowing for quicker response and recovery planning. • **Cost Benefits:** Cost savings can be moderate by reducing the need for extensive ground teams to assess damage and by accelerating the recovery process.	
Federal Partnerships	
FEMA may consider partnering with the FAA (airspace safety), DOT (transport infrastructure assessment), and the USACE (Army Corps of Engineers for engineering analysis) to install a drone program for disaster assessment.	

New Application 16: Monitoring Sewage and Drainage Systems	
Executive Summary	
Prose Overview	Monitoring sewage and drainage systems is essential for urban management, particularly in areas prone to flooding. AAM can provide real-time monitoring of these systems, identifying blockages or issues before they escalate. The cost savings are moderate, as AAM improves system monitoring but does not eliminate other infrastructure costs. Time savings are modest, allowing for quicker responses to prevent flooding. The impact on the general public is moderate, as flooding and contamination pose significant risks but affect fewer people on a daily basis compared to larger-scale natural disasters.
Application Category	Inspection
AAM Platform Type	**Drone –** Compact and effective for navigating narrow or inaccessible areas.
Description of Application	
Drones could fly within underground sewage and drainage systems to monitor cracks and structural integrity to prevent future flooding and contamination.	
Current Method and Issues	
Currently done with manual inspections or static sensors, which may be inadequate to detect issues in real-time or remote locations.	
Market Summary	
Moderate market focused on urban infrastructure and environmental management, especially in cities with aging systems prone to flooding.	
Relative Value to General Public	
Medium - While the impact of local flooding and contamination is significant, it affects fewer people compared to large-scale national disasters.	
Why use AAM?	
• **Operational Safety:** Limited direct impact on safety, although better monitoring of systems can reduce risks associated with flooding and contamination. • **Time Savings:** Modest time savings by providing quicker identification of issues, which can reduce the response time for repairs. • **Cost Benefits:** Some cost savings by enabling more efficient maintenance and early detection of issues in sewage and drainage systems.	
Federal Partnerships	
The EPA may support inspection companies, with additional oversight obtained from the FAA (drone pilot certification) and State Water and Sanitation Boards.	

New Application 17: Identifying Fire Risks by Monitoring Vegetation Density and Dryness	
Executive Summary	
Prose Overview	AAM can help identify potential fire risks by monitoring vegetation and environmental conditions. While traditional methods like ground surveys and satellite imagery are less frequent and less precise, AAM offers more immediate data to predict fire hazards. Time savings are significant in enabling early detection of fire risks, allowing for faster preventive actions. However, AAM's cost savings are limited, as it complements existing methods rather than replacing them. The public impact is high in fire-prone areas, but its reach is less universal in regions where wildfires are not frequent threats.
Application Category	Firefighting
AAM Platform Type	**Drone –** Equipped with sensors for detailed vegetation mapping and fire risk assessments.
Description of Application	
Identifying fire risks by monitoring vegetation density and dryness. AAM vehicles can fly over large ranges of forests, agricultural land, etc. to assess possible fire risk.	
Current Method and Issues	
Currently done with ground surveys and satellite imagery, which can be less frequent and less precise.	
Market Summary	
Small to moderate market within wildfire management, especially in regions prone to forest fires and droughts.	
Relative Value to General Public	
High - Wildfires are a frequent and costly event in certain regions, but their impact is typically localized and not a constant threat for all U.S. citizens.	
Why use AAM?	
• **Operational Safety:** AAM enhances safety by enabling early identification of fire risks, allowing for preventative measures to be taken. • **Time Savings:** Significant time savings by allowing quicker detection of fire risks, enabling faster preventive measures and response. • **Cost Benefits:** AAM provides modest cost savings by enabling quicker identification of potential fire hazards, reducing the need for extensive ground surveys.	
Federal Partnerships	
The US Forest Service may want to partner with a drone inspection company that could inspect high fire-risk zones. Additional partnerships may include the FAA (airspace safety), NOAA (weather data), and State Fire Management Agencies.	

New Application 18: Disaster Early Warning Systems	
Executive Summary	
Prose Overview	AAM can enhance disaster early warning systems by providing real-time data collection and monitoring. Traditional systems, such as meteorological and seismic monitoring, are limited in scope and timeliness. AAM offers faster, more accurate data, improving early warning capabilities and allowing quicker responses to natural disasters. While cost savings are modest, AAM offers significant time savings by providing earlier warnings and enabling more effective evacuations. The value is higher in disaster-prone regions, but the public impact is context-specific and varies depending on local risk profiles.
Application Category	Disaster Response
AAM Platform Type	**Drones –** Can deploy sensors or communication equipment to critical areas ahead of disasters.
Description of Application	
Establishing disaster early warning systems to improve preparedness and response by using drones for data collection in areas that experience consistent natural disasters.	
Current Method and Issues	
Currently reliant on seismic and meteorological data, which can be limited in coverage and timeliness.	
Market Summary	
Growing market, driven by increased focus on disaster risk reduction and improving public safety systems.	
Relative Value to General Public	
Medium - The value is high in specific disaster-prone areas, but not every region faces these risks regularly.	
Why use AAM?	
• **Operational Safety:** AAM enhances safety by providing real-time monitoring, which can improve the accuracy of early warning systems and prevent casualties. • **Time Savings:** Significant time savings by providing faster, more accurate data for early warning, allowing for faster evacuations and response. • **Cost Benefits:** Cost savings are modest as AAM can enhance existing systems, though it will not drastically reduce costs.	
Federal Partnerships	
Federal agencies like FEMA may want to partner with research organizations that have the capability to utilize drones to monitor areas of interest. Additional oversight from the NOAA (weather forecasting), USGS (US Geological Survey, geological data), and FAA (airspace management) may be needed.	

New Application 19: Biodiversity Mapping	
Executive Summary	
Prose Overview	Monitoring biodiversity is critical for understanding ecosystem health, tracking species populations, and implementing effective conservation strategies. Traditional methods of biodiversity mapping often rely on ground surveys, satellite imagery, and stationary sensors, which can be time-consuming and limited in scope. AAM can improve biodiversity mapping by providing real-time, high-resolution data from aerial platforms, which can cover larger and more remote areas than traditional methods. However, while AAM can significantly enhance data collection, its cost-effectiveness is moderate.
Application Category	Conservation
AAM Platform Type	**Drone –** Cost-effective and precise for collecting data over diverse ecosystems.
Description of Application	
Mapping biodiversity to inform conservation strategies and protect ecosystems. Drones can be used without being intrusive to protected species and ecosystems.	
Current Method and Issues	
Typically done with ground surveys and satellite imagery, which can be labor-intensive, costly, and provide limited data.	
Market Summary	
Small market, but crucial for conservation efforts, particularly in biodiversity hotspots or endangered ecosystems.	
Relative Value to General Public	
Low - Biodiversity conservation is vital, but the direct impact on daily life for most individuals is less tangible compared to other public needs like healthcare or disaster response.	
Why use AAM?	
• **Operational Safety:** Minimal direct impact on operational safety, as it is more focused on conservation and ecosystem health. • **Time Savings:** Time savings are moderate, as AAM can gather data on large areas more quickly than traditional methods like field surveys. • **Cost Benefits:** Limited cost savings; AAM may help gather data more efficiently but does not reduce overall conservation costs significantly.	
Federal Partnerships	
The US Fish and Wildlife Service (FWS) may want to implement a drone inspection program for biodiversity and ecosystem management. Additional oversight from the NOAA (marine biodiversity), USGS (mapping), State Wildlife and Conservation Agencies may be needed.	

Appendix B – TOPSIS Scoring and Criteria for Applications

Team Crown's process for analyzing the complete list of applications (both the Deloitte and new ones) is outlined in this appendix to support reproducibility of the down-selection process. The following subsections define the components used to create our down-selection strategy. All content is maintained in an Excel spreadsheet, with formulas and macros enabled to calculate and arrange the applications relative to one another for a final ranking. This material is in support of Section 2 – Application Down Selection, which defines the process and provides justifications in criteria selection.

***** Note: For readability, the pages transition from "Portrait" to "Landscape" *****

B.1 Criteria Weighting for Applications Reviewed

The following table lists all rankings provided to the full list of applications based on the mission/application criteria. Down the first column is the full list of applications, while the rows are the weighting "tokens" assigned for each criteria. The applications that contain no tokens were deemed not appropriate for this study due to one or more of the following reasons:

- It is currently being done in private markets.
- The expected maturity of the application and/or AAM vehicle will outpace the benefit to the general public
- Not enough data is available at this time to assess if the application could be leverage effectively as a public good mission.

Table B-1. Criteria Weight per Application

Mission Criteria → / Public Good Applications ↓	TOTAL TOKENS	Distance Covered per Operation	Speed of Deployment	Access to Remote Location and Coverage Capabilities	Payload Capacity	Passenger Payload	Infrastructure Requirements	Availability of the System	Energy and Resources Efficiency	Mission Duration	Stationary Capability	Noise Emission	Carbon Footprint	Weather Resilience	Public and Operator Safety	Operational Cost	Initial Acquisition Cost	Level of Data Acquisition Accuracy needed	Data Gathering Capabilities	Operational Personnel	Training Complexity	Ergonomics and Comfort	Level of Autonomy
10.1.1: Crop Data	**0**																						
10.1.2: Stormwater Management	**50**	3	0	4	3	0	1	1	3	2	2	3	3	2	4	2	2	5	5	1	1	0	3
10.1.3: Water Monitoring	**50**	5	0	4	3	0	1	2	3	3	2	1	1	2	1	3	3	5	5	1	1	0	4

10.1.4: Flood and Drought Management	**50**	5	0	5	3	0	1	1	3	3	1	1	1	3	1	3	3	5	5	1	1	0	4
10.1.5a: Supply Transport	**50**	4	1	5	5	0	3	2	3	2	0	1	4	3	4	3	3	0	0	1	1	1	4
10.1.5b: Supply Transport	**50**	5	1	5	5	0	4	2	3	3	0	1	3	3	4	3	3	0	0	2	2	1	0
10.2.1: Surveillance Operations	**50**	5	3	5	3	0	1	2	3	3	2	0	1	3	3	2	2	5	5	1	1	0	0
10.2.2a: Quick Reaction Force	**50**	4	5	3	0	5	1	1	3	4	2	2	2	3	5	3	3	0	0	1	2	1	0
10.2.2b: Quick Reaction Force	**0**																						
10.3.1: Combat Invasive Species	**50**	4	1	4	5	0	2	1	4	3	3	2	2	1	5	3	3	0	0	1	2	0	4
10.3.2a: Avalanche Mitigation	**50**	4	1	4	4	0	1	1	3	4	3	3	2	4	5	3	2	0	0	1	1	0	4
10.3.2b: Avalanche Mitigation	**0**																						
10.3.3: Natural Resource Management	**0**																						

10.3.4: Ocean Samples	**54**	3	1	3	3	0	3	1	1	4	3	3	2	4	2	3	3	5	5	1	2	0	2
10.3.5: Wildlife Relocation	**52**	5	2	3	5	1	3	1	3	4	0	4	3	3	1	3	3	0	0	2	1	5	0
10.3.6a: Herd Tracking	**0**																						
10.3.6b: Herd Tracking	**0**																						
10.4.1a: Provide Relief Aid	**0**																						
10.4.1b: Provide Relief Aid	**0**																						
10.4.2: Difficult to Reach Rescue	**0**																						
10.4.3: Post-Disaster Damage Assessment	**0**																						
10.5.1a: Supply and Personnel Transport	**0**																						
10.5.1b: Supply and Personnel Transport	**0**																						

10.5.2a: Firefighting capabilities	**0**																						
10.5.2b: Firefighting capabilities	**0**																						
10.5.3: Coordinating Emergency Operations	**0**																						
10.6.1a: Infrastructure Inspections	**0**																						
10.6.1b: Infrastructure Inspections	**0**																						
10.6.2a: Routine Tower and Line Inspections	**0**																						
10.6.2b: Routine Tower and Line Inspections	**0**																						
10.6.3: Airport Surveillance	**0**																						
10.7.1a: Tactical Support	**51**	5	3	5	2	0	0	0	0	3	3	3	2	2	5	2	4	3	5	2	2	0	0

Coordination																							
10.7.1b: Tactical Support Coordination	**0**																						
10.7.2: Prison Surveillance	**0**																						
10.7.3: Suspect Tracking	**0**																						
10.7.4: Bomb Threat Response	**0**																						
10.8.1: Emergency Medical Supplies Transport	**0**																						
10.8.2a: Organ Transport	**50**	5	5	5	3	0	2	5	3	0	0	1	1	5	5	0	0	0	0	3	3	0	4
10.8.2b: Organ Transport	**50**	5	5	5	3	0	2	5	3	0	0	1	1	5	5	0	0	0	0	3	3	0	4
10.8.3a: Personal Protective Equipment Transport	**50**	3	1	4	5	0	3	4	4	0	1	5	2	5	5	0	0	0	0	2	2	0	4
10.8.3b: Personal Protective	**50**	3	1	4	5	0	3	4	4	0	1	5	2	5	5	0	0	0	0	2	2	0	4

Equipment Transport																							
10.8.4a: Vaccine Transport	**50**	4	3	4	4	0	2	4	4	0	0	4	3	5	5	0	0	0	0	2	2	0	4
10.8.4b: Vaccine Transport	**50**	4	3	4	4	0	2	4	4	0	0	4	3	5	5	0	0	0	0	2	2	0	4
10.8.5: Patient Transport	**50**	4	5	2	3	3	2	4	3	0	0	4	1	4	5	0	0	0	0	3	3	4	0
10.8.6: On-scene care to an accident site	**50**	3	5	4	2	2	3	5	2	2	1	1	1	3	4	0	0	0	0	3	3	3	3
10.8.7a: Transport to Rural Areas	**50**	4	3	5	2	3	4	4	3	2	0	1	4	3	4	0	0	0	0	3	2	1	2
10.8.7b: Transport to Rural Areas	**50**	4	3	5	2	3	4	4	3	2	0	1	4	3	4	0	0	0	0	3	2	1	2
10.9.1: Supply Delivery to Rural Areas	**50**	3	3	5	5	0	5	4	3	3	0	1	4	3	4	0	0	0	0	1	1	1	4
10.9.2: TRL Testing	**0**																						
10.9.3: Event Mass Transportation	**50**	4	2	3	0	4	3	4	4	3	0	3	4	2	4	0	0	0	0	2	2	3	3
10.10.1: Remote Area SAR	**50**	5	4	4	2	1	1	4	1	4	1	1	1	3	4	0	0	4	4	2	1	0	3

10.10.2: Remote Location Transportation	**50**	3	5	5	3	3	2	4	2	3	3	1	1	3	4	0	0	0	0	2	2	3	1
10.11.1: Improve Daily Forecasting	**50**	5	3	5	1	0	0	5	3	4	0	2	3	3	2	0	0	5	5	1	0	0	3
10.11.2: Natural Disaster Monitoring	**50**	5	2	5	2	0	1	5	1	3	0	0	1	5	4	0	0	5	5	2	2	0	2
New 1: Traffic and Congestion Monitoring	**0**																						
New 2: Environmental and Air Quality Monitoring	**0**																						
New 3: Renewable Energy and Utility Management	**0**																						
New 4a: Seeds Distribution and Reforestation	**0**																						
New 4b: Seeds Distribution	**0**																						

and Reforestation																						
New 5: Archaeological and Historical Site Monitoring	**0**																					
New 6: Crowd Management at Large Public Events	**0**																					
New 7: Aerosol Dispersal for Solar Radiation Management (SRM)	**0**																					
New 8: Geoengineering & Cloud Seeding for Increased Albedo	**0**																					
New 9a: Leak and Spillage Monitoring: Gas and Oil	**0**																					
New 9b: Leak and Spillage	**0**																					

Monitoring: Gas and Oil																							
New 10: Wildlife Conservation and Anti-Poaching	**0**																						
New 11: Waste Management for Remote Locations	**0**																						
New 12: Electromagnetic and Radiation Monitoring	**0**																						
New 13: Reef and Marine Life Protection	**0**																						
New 14: Communication Network Restoration as Temporary Communication Relays	**0**																						
New 15: Infrastructure Damage Assessment after Natural Event or	**0**																						

Man-Made Disaster																						
New 16: Monitoring sewage and drainage systems to prevent flooding and contaminati on.	**0**																					
New 17: Identifying fire risks by monitoring vegetation density and dryness	**0**																					
New 18a: Disaster Early Warning Systems	**0**																					
New 18b: Disaster Early Warning Systems	**0**																					
New 19: Biodiversity Mapping	**0**																					

B.2 Pugh Matrix Evaluation

As discussed in Section 2, we conducted a Pugh Matrix evaluation of each application to compare to its current baseline to understand the additional benefit that the use of AAM technologies per each use case may bring to identified end users. The following table displays our final analysis of the Pugh Matrix categories and use cases, where the categories are defined in Section 2.

Table B-2 displays a single application (Patient Transport) to show how the Pugh Matrix Evaluation is populated with content. Our Excel spreadsheet allows for the selection of application that the review wants to explore, with all fields populated based on our extensive research into each application.

Table B-2. Pugh Evaluation Matrix for Patient Transport Application

Application	Description	Stakeholders	Mission Type	Potential Improvements
10.8.7b: Transport to Rural Areas	Bridge the health disparity gap seen in rural areas through the use of efficient transport	Doctors, nurses, non-profits partners, hospital management	Transportation	Increase efficiency in transport

Criteria Type	Evaluation Criteria	Description	Mission Requirement	AAM Concept Capability	Baseline Capability	Weight	AAM Concept Rating	Baseline Rating	Justifications
				eVTOL	Ground Transporta-tion		eVTOL	Ground Transporta-tion	
Operational	Distance Covered per Operation	Quantitative Range/Area Coverage	System should cover medium to long distances efficiently ~50-500 miles connecting rural areas to medical hubs	*Believed to have an intermediate range (max. ~50 miles)*	*Ground transportation can cover almost any distance on the road*	4	0	0	The effectiveness of ground transportation in rural area depends on the state of the infrastructures. We assume that in good conditions, both system can reach rural area

	Speed of Deployment	Quantitative Time to Response Includes Time to Operational Readiness and Time to reach mission operation area	System should be quickly deployed in case of emergency situations to ensure timely transport of medical teams, eventually patients	*Believed to necessitate more time to startup than a traditional ground vehicle. Believed to reach >100mph*	*Immediately operational but limited at ~90mph *depending on state and road/road conditions Exceeds ~30 min*	**3**	1	0	Assumed that the medical equipment is already in the vehicle, or that it takes the same amount of time to get it inside LEI Zhong. Flight Performance Estimation of eVTOL Aircraft Using Synthesis of Aerodynamics Theories of Rotorcraft and Fixed-Wing Aircraft. Transactions of Nanjing University of Aeronautics & Astronautics, 2024, (1):35-42
	Access to Remote Location and Coverage Capabilities	Qualitative Assessment of travelable areas of the system considered Includes Maximum Operational Elevation when relevant	System should effectively access rural and secluded areas, overcoming geographical and infrastructural challenges	*Believed to be able to access extensive locations in urban areas*	*Dependent on Road Infrastructure*	**5**	1	0	Road infrastructures may be lacking for a last-mile transport to under-served and remote areas. Stringer, Thomas, and Amy M. Kim. 2023. "Transportation Access Index for Remote Communities That Considers Modal Seasonality." Findings, July.
	Payload Capacity	Quantitative Volume, Weight, or Units Transported Sensors…	System should effectively accommodate essential medical equipment ~500 lb	*Believed to be able to carry ~500 lb*	*~5000 lb*	**2**	0	0	Assumed that the medical equipment does not exceed the payload capacity of either system
	Passenger Payload	Quantitative Number of passengers	System should effectively accommodate medical personnel, eventually patients	*Believed to carry up to 4 passengers*	*Driver, EMT*	**3**	0	0	Assumed that both systems can carry the required number of passengers

	Infrastructure Requirements	Qualitative Physical support structure needed (e.g., take-off/landing area, charging/refueling stations, etc.)	System should operate effectively within the existing infrastructure of rural areas or require minimal additional infrastructure	*Believed to require small, flat areas to VTOL (vertiport). Believed to need access to charging facilities when not in use to maintain operations*	*Dependent on Road Infrastructures*	**4**	1	0	Ground transportation depends on existing road infrastructure that may be lacking for under-served and remote areas. Community Facilities Programs Rural Transportation Infrastructure: Information and Guidance, USDA
	Availability of the System	Qualitative Complexity of the maintenance on the system, time to refuel…	System should be manageable in remote areas with limited access to maintenance services	*Believed to need less maintenance than traditional aircraft but probably will need as much/more maintenance than Baseline*	*Require routine checks*	**4**	-1	0	Ground vehicles are believed to be generally more robust and benefit from established service networks. Goyal, R.; Cohen, A. Advanced Air Mobility: Opportunities and Challenges Deploying eVTOLs for Air Ambulance Service. Appl. Sci. 2022, 12, 1183.
Performance	Energy and Resources Efficiency	Quantitative	System should minimize energy consumption and environmental impact	*Believed to be energy / resources-efficient thanks to its electric propulsion*	*Traditional ground vehicles consume fossil fuels and emit greenhouse gases. Relies on extensive infrastructure.*	**3**	1	0	Assuming direct routing to destination and potential for lower emissions associated with advanced propulsion systems.

	Mission Duration	Quantitative How long the system can operate (e.g., Endurance, Runtime)	System should be capable of prolonged operations	*Believed at ~60 min*	*Can perform over a long period of time*	**2**	0	0	LEI Zhong. Flight Performance Estimation of eVTOL Aircraft Using Synthesis of Aerodynamics Theories of Rotorcraft and Fixed-Wing Aircraft. Transactions of Nanjing University of Aeronautics & Astronautics, 2024, (1):35-42 Hagag, Nabil & Toepsch, Felix & Graf, Simon & Büddefeld, Michael & Eduardo, Hugo. (2021). Maximum total range of eVTOL under consideration of realistic operational scenarios.
	Stationary Capability	Quantitative Can the system remain static during operation (e.g., hover)	N/A	*Believed to be able to hover*	*N/A*	**0**	0	0	
Environmental	Noise Emission	Quantitative Noise Emission during use	System should operate with minimal noise emissions to avoid disturbing rural communities and wildlife	*Believed to be quieter than traditional helicopters, concerns exist regarding noise impact in urban area.*	*Emit noise but will generally be accepted in rural areas*	**1**	1	0	Noise is assumed to be less of a concern over rural areas compared to urban areas Civil Aviation Authority. Emerging Technologies: The effects of eVTOL aircraft noise on humans. 2023
	Carbon Footprint	Quantitative Environmental Impact during use	System should minimize environmental impact	*Believed to benefit from the use of electric propulsion*	*Traditional trucks contribute significantly to greenhouse effects*	**4**	1	0	

	Weather Resilience	Qualitative	System should be operated safely in adverse weather conditions	*Believed to have lower wind tolerance than Baseline, may struggle in heavy wind or downpour conditions*	*Able to operate in adverse weather conditions*	**3**	-1	0	Assuming no disaster-type weather
Safety	Public and Operator Safety	Quantitative Number of near misses identified, Number of employee safety ideas and hazards submitted, Number of Incidents / Average time between worker report of a safety idea or hazard and management knowledge of the report	System should minimize the safety risk for both the general public and operators when in use	*Not believed to be safer than Public Transportation*	*Ground vehicles present significant safety risks on rural roads compared to urban areas*	**4**	0	0	No clear argument for both systems as eVTOLs are still under development https://www.nhtsa.gov/rural
Cost	Operational Cost	Quantitative	N/A	*N/A*	*N/A*	**0**	0	0	
	Initial Acquisition Cost	Quantitative	N/A	*N/A*	*N/A*	**0**	0	0	
Mission-Specific	Level of Data Acquisition Accuracy needed	Quantitative Lighting & Image Resolution or Ground Sample Distance (GSD), Flight Speed, Ground Control Points	N/A	*N/A*	*N/A*	**0**	0	0	
	Data Gathering Capabilities	Quantitative/Qualitative	N/A	*N/A*	*N/A*	**0**	0	0	
Human Factor	Operational Personnel	Quantitative/Qualitative Number and type of personnel required	System should minimize the number of personnel	*Require a certified pilot*	*Driver*	**3**	-1	0	eVTOL requires more technical operational personnel

	Training Complexity	Qualitative	System should minimize the training complexity	*Believed to be more complex than Baseline*	*Basic training needed*	**2**	-1	0	FAA regulations for eVTOL training or evolving and training programs are still at early stages
	Ergonomics and Comfort	Qualitative Comfort for passenger	System should maximize comfort for passengers	*Designed with ergonomics and comfort in mind*	*Requires a well-designed and ergonomic cabin for the driver*	**1**	1	0	García, U., Pelaez, S., Alvarado, P. (2023). Ergonomic evaluation involved in an eVTOL vehicle design process for the application of future transport operations in urban ecosystems. In: Gesa Praetorius, Charlott Sellberg and Riccardo Patriarca (eds) Human Factors in Transportation. AHFE (2023) International Conference. AHFE Open Access, vol 95. AHFE International, USA.
Technological	Level of Autonomy	Qualitative Fully autonomous, remote controlled, piloted	System should prioritize autonomy to maximize operations and reduce safety risk	*Believed to be able to benefit from autonomous systems integration*	*Necessitates a driver*	**2**	1	0	

In each application reviewed, results were generated for the Pugh Matrix, and collected in a final table, seen as Table B-3. The use cases that have final scores supported the follow-on TOPSIS analysis.

Table B-3. Pugh Matrix Results

		Mission Criteria																					
Public Good Applications ↓	**TOT-AL**	Distance Covered per Operation	Speed of Deployment	Access to Remote Location and Coverage Capabilities	Payload Capacity	Passenger Payload	Infrastructure Requirements	Availability of the System	Energy and Resources Efficiency	Mission Duration	Stationary Capability	Noise Emission	Carbon Footprint	Weather Resilience	Public and Operator Safety	Operational Cost	Initial Acquisition Cost	Level of Data Acquisition Accuracy Needed	Data Gathering Capabilities	Operational Personnel	Training Complexity	Ergonomics and Comfort	Level of Autonomy
10.1.1: Crop Data	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.1.2: Stormwater Management	**2**	1	-1	1	1	0	1	1	-1	-1	0	-1	0	-1	-1	-1	-1	1	1	-1	-1	0	0
10.1.3: Water Monitoring	**-4**	-1	0	1	0	0	-1	1	-1	-1	1	-1	1	1	-1	-1	1	-1	1	-1	0	0	0
10.1.4: Flood and Drought Management	**11**	-1	0	1	0	0	1	1	-1	1	1	0	0	1	1	1	1	-1	1	-1	-1	0	0
10.1.5a: Supply Transport	**11**	-1	0	1	-1	0	1	-1	1	0	1	0	1	-1	1	0	1	0	0	0	-1	0	1
10.1.5b: Supply Transport	**-12**	-1	1	1	-1	0	1	-1	1	-1	0	1	1	-1	-1	-1	-1	0	0	0	-1	1	1

10.2.1: Surveillance Operations	**6**	-1	1	1	0	0	-1	1	-1	-1	0	-1	1	-1	0	1	-1	1	1	1	-1	0	0
10.2.2a: Quick Reaction Force	**3**	-1	1	1	0	-1	-1	1	1	-1	0	1	1	-1	1	1	-1	0	0	0	-1	1	0
10.2.2b: Quick Reaction Force																							
10.3.1: Combat Invasive Species	**28**	-1	-1	1	-1	0	1	1	1	-1	1	1	1	-1	1	0	1	0	0	0	1	0	1
10.3.2a: Avalanche Mitigation	**15**	-1	1	1	-1	0	1	1	1	-1	0	1	1	-1	1	1	1	0	0	1	0	0	1
10.3.2b: Avalanche Mitigation																							
10.3.3: Natural Resource Management																							
10.3.4: Ocean Samples	**21**	-1	1	1	-1	0	1	1	1	-1	1	-1	1	1	-1	1	1	1	1	0	1	0	0
10.3.5: Wildlife Relocation	**11**	-1	1	1	-1	-1	0	-1	1	-1	1	1	1	0	1	1	-1	0	0	0	1	1	0
10.3.6a: Herd Tracking																							
10.3.6b: Herd Tracking																							
10.4.1a: Provide Relief Aid																							
10.4.1b: Provide Relief Aid																							
10.4.2: Difficult to Reach Rescue																							
10.4.3: Post-Disaster Damage Assessment																							
10.5.1a: Supply and Personnel Transport																							
10.5.1b: Supply and Personnel Transport																							
10.5.2a: Firefighting capabilities																							

10.5.2b: Firefighting capabilities																							
10.5.3: Coordinating Emergency Operations																							
10.6.1a: Infrastructure Inspections																							
10.6.1b: Infrastructure Inspections																							
10.6.2a: Routine Tower and Line Inspections																							
10.6.2b: Routine Tower and Line Inspections																							
10.6.3: Airport Surveillance																							
10.7.1a: Tactical Support Coordination	**17**	1	-1	1	0	0	0	0	0	-1	0	-1	0	-1	1	1	1	1	1	-1	-1	0	0
10.7.1b: Tactical Support Coordination																							
10.7.2: Prison Surveillance																							
10.7.3: Suspect Tracking																							
10.7.4: Bomb Threat Response																							
10.8.1: Emergency Medical Supplies Transport																							
10.8.2a: Organ Transport	**29**	0	1	1	0	0	1	1	1	0	1	1	1	-1	1	0	0	0	0	1	0	1	1
10.8.2b: Organ Transport																							

10.8.3a: Personal Protective Equipment Transport	**20**	-1	1	1	-1	0	1	1	1	0	1	1	1	-1	1	0	0	0	0	0	0	1	1
10.8.3b: Personal Protective Equipment Transport	**-3**	0	1	1	0	0	0	-1	1	0	0	-1	1	-1	0	0	0	0	0	-1	-1	1	1
10.8.4a: Vaccine Transport	**16**	-1	1	1	-1	0	1	1	1	0	0	1	1	-1	1	0	0	0	0	0	-1	0	1
10.8.4b: Vaccine Transport	**0**	0	1	1	0	0	0	-1	1	0	0	-1	1	-1	0	0	0	0	0	-1	-1	1	1
10.8.5: Patient Transport	**18**	0	1	1	-1	0	0	1	1	0	0	1	1	-1	1	0	0	0	0	0	-1	1	1
10.8.6: On-scene care to an accident site	**8**	0	1	1	0	0	0	0	1	0	0	-1	1	-1	0	0	0	0	0	-1	-1	1	1
10.8.7a: Transport to Rural Areas	**-10**	0	-1	0	0	0	-1	-1	1	0	0	0	1	-1	0	-1	-1	0	0	-1	-1	0	1
10.8.7b: Transport to Rural Areas	**11**	0	1	1	0	0	1	-1	1	0	0	1	1	-1	0	0	0	0	0	-1	-1	1	1
10.9.1: Supply Delivery to Rural Areas	**17**	0	0	1	-1	0	1	0	1	0	1	0	1	-1	1	0	0	0	0	0	-1	1	1
10.9.2: TRL Testing																							
10.9.3: Event Mass Transportation	**-17**	-1	1	1	-1	-1	1	-1	0	-1	0	-1	0	-1	-1	-1	-1	0	0	-1	-1	1	0
10.10.1: Remote Area SAR	**17**	-1	1	1	0	-1	1	1	1	-1	0	1	1	-1	1	1	1	1	0	1	1	0	1
10.10.2: Remote Location Transportation	**14**	-1	1	1	-1	0	1	1	1	-1	0	1	1	-1	1	1	-1	0	0	0	-1	1	1
10.11.1: Improve Daily Forecasting	**-5**	-1	1	-1	0	0	0	1	1	-1	0	-1	1	-1	0	0	0	0	0	0	-1	0	0
10.11.2: Natural Disaster Monitoring	**-10**	-1	-1	-1	0	0	0	1	0	-1	0	0	0	-1	1	0	0	1	0	-1	-1	0	0
New 1: Traffic and Congestion Monitoring																							

New 2: Environmental and Air Quality Monitoring																						
New 3: Renewable Energy and Utility Management																						
New 4a: Seeds Distribution and Reforestation																						
New 4b: Seeds Distribution and Reforestation																						
New 5: Archaeological and Historical Site Monitoring																						
New 6: Crowd Management at Large Public Events																						
New 7: Aerosol Dispersal for Solar Radiation Management (SRM)																						
New 8: Geoengineering & Cloud Seeding for Increased Albedo																						
New 9a: Leak and Spillage Monitoring: Gas and Oil																						
New 9b: Leak and Spillage Monitoring: Gas and Oil																						
New 10: Wildlife Conservation and Anti-Poaching																						
New 11: Waste Management for Remote Locations																						

New 12: Electromagnetic and Radiation Monitoring	**0**																						
New 13: Reef and Marine Life Protection																							
New 14: Communication Network Restoration as Temporary Communication Relays																							
New 15: Infrastructure Damage Assessment after Natural Event or Man-Made Disaster																							
New 16: Monitoring sewage and drainage systems to prevent flooding and contamination.																							
New 17: Identifying fire risks by monitoring vegetation density and dryness																							
New 18a: Disaster Early Warning Systems	**0**																						
New 18b: Disaster Early Warning Systems																							
New 19: Biodiversity Mapping	**0**	0	0	1	-1	0	1	-1	1	0	1	0	1	-1	1	0	1	0	0	0	-1	0	1

B.3 TOPSIS Evaluation Criteria

As the final step in our down-selection process, and leveraging the results of the Pugh Matrix for comparisons of baseline operations across the full list of applications reviewed, we developed a TOPSIS evaluation to determine the most ideal use cases for this effort. Table B-4 displays the evaluation criteria and the assigned scores for each use case reviewed. From these rankings, we were able to adjust the ranks to understand which applications would become top choices for our investigation, based on SME input and additional references captured after the initial analysis was completed. The final rankings used for this table for the chosen applications defined in this report are listed in Section 2. A TOPSIS scale and Rank were applied to generate Figure 2.

The rankings listed in Table B-4 represent the final tallies with the following weights for each of the TOPSIS criteria, for example, but can be adjusted to meet any requirement or scenario:

- **Adopter Potential:** 8/10
- **Difference to Other Commercial Applications:** 2/10
- **AAM Technologies Leveraged:** 2/10
- **Timeline Required:** 2/10
- **Cost Savings:** 6/10
- **Amount of Public Good Achieved:** 6/10

Table B-4. TOPSIS Analysis Ranking Table

Use-Case	Early Adopter Potential	Difference to Other Commercial Applications	AAM Technologies Leveraged	Timeframe Required	Amount of Public Good Achieved	Cost Savings
10.1.1: Crop Data					2	1
10.1.2: Stormwater Management	2	3	2	3	1	1
10.1.3: Water Monitoring	-4	2	2	3	2	1
10.1.4: Flood and Drought Management	11	1	3	3	2	1
10.1.5a: Supply Transport	11	2	3	3	2	1

10.1.5b: Supply Transport	-12	2	2	2	2	1
10.2.1: Surveillance Operations	6	1	2	4	3	1
10.2.2a: Quick Reaction Force	3	2	2	2	2	1
10.2.2b: Quick Reaction Force						
10.3.1: Combat Invasive Species	28	2	2	3	3	2
10.3.2a: Avalanche Mitigation	15				1	1
10.3.2b: Avalanche Mitigation					1	1
10.3.3: Natural Resource Management					2	1
10.3.4: Ocean Samples	21				1	1
10.3.5: Wildlife Relocation	11				1	1
10.3.6a: Herd Tracking					1	2
10.3.6b: Herd Tracking						
10.4.1a: Provide Relief Aid					2	2
10.4.1b: Provide Relief Aid						
10.4.2: Difficult to Reach Rescue					3	1
10.4.3: Post-Disaster Damage Assessment					2	1

10.5.1a: Supply and Personnel Transport					2	2
10.5.1b: Supply and Personnel Transport						
10.5.2a: Firefighting capabilities					3	1
10.5.2b: Firefighting capabilities						
10.5.3: Coordinating Emergency Operations					2	1
10.6.1a: Infrastructure Inspections					2	1
10.6.1b: Infrastructure Inspections						
10.6.2a: Routine Tower and Line Inspections					2	1
10.6.2b: Routine Tower and Line Inspections						
10.6.3: Airport Surveillance					2	1
10.7.1a: Tactical Support Coordination	17				2	2
10.7.1b: Tactical Support Coordination						

10.7.2: Prison Surveillance					1	1
10.7.3: Suspect Tracking					1	1
10.7.4: Bomb Threat Response					1	1
10.8.1: Emergency Medical Supplies Transport					3	2
10.8.2a: Organ Transport	29	2	2	3	3	2
10.8.2b: Organ Transport						
10.8.3a: Personal Protective Equipment Transport	20	1	2	3	2	1
10.8.3b: Personal Protective Equipment Transport	-3	2	3	2	2	1
10.8.4a: Vaccine Transport	16	2	2	3	2	1
10.8.4b: Vaccine Transport		3	3	2	2	2
10.8.5: Patient Transport	18	1	3	2	2	2
10.8.6: On-scene care to an accident site	8	1	2	2	2	1
10.8.7a: Transport to Rural Areas	-10	2	1	2	2	1
10.8.7b: Transport to Rural Areas	11	2	2	2	2	1

10.9.1: Supply Delivery to Rural Areas	17	2	2	3	2	1
10.9.2: TRL Testing		3			1	1
10.9.3: Event Mass Transportation	-17	1	2	2	2	1
10.10.1: Remote Area SAR	17	2	2	3	1	1
10.10.2: Remote Location Transportation	14	2	3	2	2	2
10.11.1: Improve Daily Forecasting	-5	2	3	4	2	1
10.11.2: Natural Disaster Monitoring	-10	1	3	3	2	1
New 1: Traffic and Congestion Monitoring					3	1
New 2: Environmental and Air Quality Monitoring					2	1
New 3: Renewable Energy and Utility Management					1	2
New 4a: Seeds Distribution and Reforestation					1	1
New 4b: Seeds Distribution and Reforestation						
New 5: Archaeological and Historical Site Monitoring					1	1

New 6: Crowd Management at Large Public Events					2	2
New 7: Aerosol Dispersal for Solar Radiation Management (SRM)					1	1
New 8: Geoengineering & Cloud Seeding for Increased Albedo					1	1
New 9a: Leak and Spillage Monitoring: Gas and Oil					3	3
New 9b: Leak and Spillage Monitoring: Gas and Oil						
New 10: Wildlife Conservation and Anti-Poaching					2	2
New 11: Waste Management for Remote Locations					2	2
New 12: Electromagnetic and Radiation Monitoring					1	1
New 13: Reef and Marine Life Protection					1	1
New 14: Communication					1	2

Network Restoration as Temporary Communication Relays						
New 15: Infrastructure Damage Assessment after Natural Event or Man-Made Disaster					3	2
New 16: Monitoring sewage and drainage systems to prevent flooding and contamination.					2	2
New 17: Identifying fire risks by monitoring vegetation density and dryness					3	1
New 18a: Disaster Early Warning Systems					2	1
New 18b: Disaster Early Warning Systems						
New 19: Biodiversity Mapping		2	5	3	2	1

Appendix C – Details of VA Transport Policies and Procedures for Patient Transport

C.1 VA Transportation Mode Selection Framework for Patient Transfers

The VA medical system handles patient transport requests through a structured process that evaluates eligibility, clinical urgency, and available resources to select the most appropriate VA-provided mode: VTS van, VA-managed volunteer ride, ambulance/special mode, or contracted rideshare. At a high level, these are the steps followed:

- ***Step 1 – Eligibility Determination*:** Upon receiving a request, VA staff first verify the patient's eligibility for VA transport, which is codified under 38 Code of Federal Regulations (CFR) Part 70 and Veteran Health Administration (VHA) Directive 1695(1) [74], [75]. All persons eligible for Beneficiary Travel under 38 CFR §70.10 (such as veterans with service-connected conditions, low-income or pensioners, and those unable to defray travel costs) are eligible for VTS transport. In practice, all veterans enrolled in the VA healthcare system qualify for transport for any scheduled or urgent VA healthcare visit (including inpatient discharges or procedures) and even unscheduled or walk-in visits. Non-enrolled veterans may also use the VTS under limited conditions (e.g., a scheduled "Compensation & Pension" exam or urgent care). Other eligible riders include servicemembers on duty, VA-certified family caregivers, necessary attendants, the Civilian Health and Medical Program of the Department of Veterans Affairs (CHAMPVA) inpatients, and even a veteran's escort or guest (one per patient) if resources permit. In short, eligibility status (i.e., service connection, income, enrollment, etc.) determines whether a patient can use VA transport at all, and enrolled veterans carry the highest eligibility priority (as discussed below).

- ***Step 2 – Qualifying clinical urgency*:** The next step is assessing clinical urgency. Requests are triaged into urgent/same-day versus routine scheduled transport. "Urgent" transport needs include emergency or same-day clinic visits, inpatient discharges requiring immediate follow-up care, or any situation in which delay could harm the patient. In these urgent cases, VA staff can expedite arrangements.

- ***Step 3 – Determining transportation mode:*** A VA clinician determines if the patient needs a special mode (e.g., ambulance or wheelchair van) due to a medical condition or mobility limits. Special-mode transports (SMTs) require clinical authorization (i.e., a VA clinician must certify the need) and pre-authorization unless truly emergent, requiring immediate transport without delay.
    - If the patient is ambulatory (i.e., able to walk) and stable, the facility next checks availability of VTS vans for immediate pickup. If a VTS vehicle is available on short notice, the ride is scheduled. If no VA van is immediately free, staff will fall back on the quickest alternative – often a contracted rideshare (e.g., Uber Health) booked on-demand to meet the urgent need. AAM services may provide high utility to such urgent transfers especially for remote and rural transfers. For example, AAM may not only provide faster transport options but could also enable new operational models, such as regional air hubs serving multiple rural spokes and integrated scheduling platforms that coordinate air-ground transfers in near real time. These two components will need to work together to improve efficiency (i.e., the air hubs provide strategic staging points) while the scheduling platforms seamlessly coordinates across modes. This is primarily an operational advancement enabled by AAM rather than a purely vehicle technology advantage.
    - For routine/non-emergency appointments, the staff schedules transportation in advance. The normal workflow is to book the patient on a VTS multi-passenger

van when possible. If the patient is eligible and a VTS seat can be arranged reasonably, the VTS van is the preferred mode of transportation.
  - If VTS capacity is insufficient (e.g., no vans or drivers available at the needed time), then other VA options are explored: first checking the local Volunteer Transportation Network (e.g., the Disabled American Veterans (DAV) program) and then resorting to contracted rideshare if needed. Throughout, the patient's medical needs (e.g., oxygen, gurney) and self-transport capability (e.g., blindness, paralysis) are considered; higher-need patients take precedence.
  - Finally, staff check if the patient is eligible for mile reimbursement or other common carriers under alternative funding means, such as the Beneficiary Travel program.

C.2 Ride Prioritization Criteria & Triggers

VHA Directive 1695(1) provides guidance on how to prioritize rides when demand exceeds supply [76]. Key criteria include (in order):

- ***Eligibility Tier:*** Enrolled veterans are the highest priority, followed by other veterans (non-enrolled), active duty servicemembers, approved caregivers, persons in counseling/training programs, and CHAMPVA In-House Treatment Initiative (CITI)/CHAMPVA beneficiaries [77]. A person who qualifies under multiple categories is slotted into the highest applicable tier.
- ***First-Requested:*** Among those in the same eligibility tier, staff consider the timestamp of the request (first-come, first-served).
- ***Clinical Need:*** Patients with greater medical need (e.g., recent surgery, mobility limitations) are prioritized. This ensures, for example, that a patient needing an escort or gurney is served before a fully mobile patient.
- ***Self-Transport Capability***: Patients who cannot self-transport (e.g., due to blindness, paralysis, severe illness) take precedence over those who could drive or use public transit.
- ***Other Benefits/Services:*** If a patient is eligible for alternative VA or community transportation programs (e.g., veterans' service organizations or public transit) that can cover the trip, VTS may defer transport to prioritize resources for those without such options.
- ***Resource Maximization:*** Finally, local availability of assets influences assignment. The facility seeks to make the best use of each resource (e.g., VTS van, volunteer vehicle, rideshare funds) in context. Fleet and staffing constraints routinely limit VA transportation capacity. VA-owned vans (especially wheelchair-accessible vehicles) are a fixed resource and often fully booked for regular routes, and the volunteer network is shrinking.[12] AAM services could provide a new capacity buffer to currently constrained VA transportation systems.

The VHA Directive incorporates 38 CFR Part 70 requirements by reference. For example, 38 CFR 70.10 lists all beneficiary travel eligible persons (service-connected veterans, low-income, pensioners, etc.). Subsection 70.4(d) codifies special-mode transport rules, which include that the VA will pay for an ambulance or wheelchair van if it is medically required, the veteran cannot afford it, and the trip was approved in advance (or was an emergency) [75]. In practice, VA's

[12] The US Government Accountability Office (GAO) notes a ~50% drop in volunteer drivers per facility from FY2018 to FY2023. [26]

Mobility Managers use these rules to guide decisions (e.g., ambulance rides are only assigned when a VA clinician documents medical necessity). All VTS transport is governed by 38 United States Code (USC) 111A, which lists permitted trip types (including door-to-door service between VA facilities and medical appointments) and directs usage of both VA-operated vans and VA-managed volunteer transport under the VTS umbrella. The Directive delegates responsibility to local VTS Mobility Managers to coordinate all patient transportation, including liaising with volunteer networks and other agencies, such as the Department of Transportation (DOT), General Services Administration (GSA), or State agencies that oversee transportation policy. Program management, directed by VA Directive 1695(1) requires guidance, oversight, and certification of the driver of a VTS vehicle to be complementary to that of other agencies' policies on transporting of passengers. Therefore, it is assumed that an updated directive that would support AAM patient transfers would also require similar compliance and liaising with other agencies.