

An Overview of Advanced Air Mobility (AAM) Public Good Applications

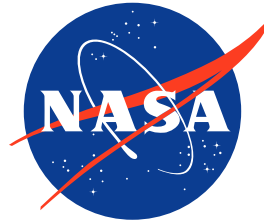
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- Scope of Effort
- Application Down Selection Methodology
- Results
 - Patient Transport
 - Organ Transport
- Conclusions and Recommended Next Steps

Scope

Our focus was to understand how AAM capabilities may be used for **“public good” applications**. Public good refers to benefiting the public and being available to all members of society at no additional cost to the end beneficiary.¹

Objectives:

1. 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
2. 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
3. Discuss key assumptions, constraints, enablers, and non-aviation systems needed
4. Perform an initial cost assessment

Timeframe:

Near Term (3-5 Years)
until implementation

[1] T. Zimbelman, L. Dailey, D. Oriach, N. Flom, and M. Metcalfe, “Advanced Air Mobility Missions for Public Good,” Deloitte Consulting, LLP, Arlington, VA, Technical Report NASA/CR-20230012505, Sep. 2023.

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Down Selection Methodology



Step 1: Application Identification

Create a comprehensive list of AAM applications by augmenting Deloitte use cases and characterize each use case based on funding and execution mechanisms



Step 2: Filter Applications

Shortlist applications that are funded or directly executed by a federal government entity



Step 3: TOPSIS Analysis

TOPSIS: Technique for Order of Preference by Similarity to Ideal Solution

Multi-attribute decision making technique assigns each use case with AAM vehicle that can meet mission requirements, assess benefit of using AAM as compared to baseline using a set of weighted evaluation criteria, deployment timelines, etc.

Key Outcomes:

- ❑ **New applications** – Identified 19 new AAM applications combined with 40 from a previous NASA study conducted by Deloitte
- ❑ **Ranking of each application** – Each application that can be executed or funded by public entity was evaluated and ranked based on uniqueness, technologies leveraged, timeline, public good achieved, and cost savings

Application 1

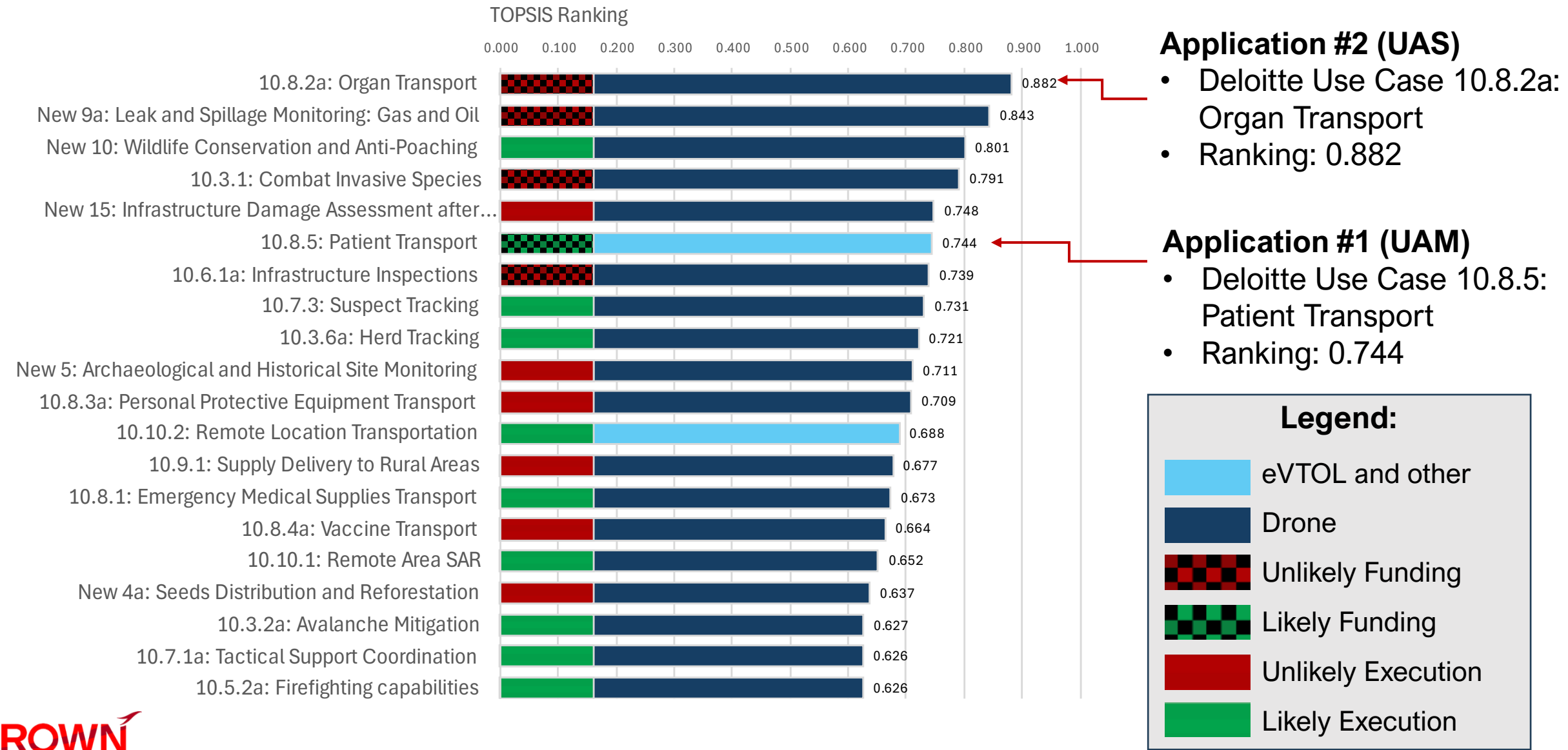
Patient
Transport

Application 2

Organ
Transport

Down Selection of Two Applications

NASA and Crown selected two applications based on TOPSIS scores and analysis of funding/execution models for public entities



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Application 1: Patient Transport

We defined two missions within the patient transport application to support various needs based on currently established protocols for veteran patient transportation conducted by the Department of Veterans Affairs (VA).

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

Key Points:

- 1 patient, 2 – 3 medical professionals
- Could also include the transfer of medical professionals to VA rural clinics and facilities during staffing shortages
- Potential to either reduce the cost of the operation (as compared to a helicopter) or reduce the response time (as compared to an ambulance)

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

This mission involves inter-hospital transfers within the VA medical network, including both transferring patients and medical professionals

Key Points:

- Inter-hospital facility transfers within the VA medical network
- Transferring medical patients and professionals
- As with Mission 1, the benefit mechanisms are reduced costs and response times, compared to current air and current ground operations, respectively

Application 1: Cost Assessment Key Points

➤ Acquisition

- Bell 407 (conventional helicopter) is in the range of \$2.5M - \$3M
- Jump Aero's JA1 Pulse anticipated purchase price is \$1.6M - \$2.5M
- Archer Aviation's aircraft is expected to cost \$5M
- Electra claims its EL9 eSTOL vehicle has over 2,200 provisional orders at an implied price of around \$5M - \$6M

➤ Basing

- Development of a new vertiport expected to be \$3.5M - \$12M, varying for a ground-based vertiport versus developing on top of an established VA medical facility.
- Vertiports utilized for various mission profiles could support urgent and non-emergency patient transport missions; therefore, costs associated with the use of the vertiport are likely to be comparable to current airport parking, fueling, and leasing fees.

➤ Operating and Maintenance

- In general, electric vehicles will be less expensive to operate and maintain due to fewer moving parts and increased reliability
- Beta claims that hourly operating costs for their eVTOL will be up to 40 percent lower relative to comparable non-electric VTOLs. The operating costs for their eCTOL are claimed to be up to 67 percent lower relative to a comparable non-electric conventional aircraft.
- JA1 Pulse direct operating costs estimated at \$424 per flight; indirect costs are estimated to be \$685,000 per vehicle per year.

Cost Estimates for Patient Transport

Cost Category	Range of Estimates
Acquisition	\$1.6M - \$4.5M (competitive with existing helicopters)
Basing	Existing helipads: \$1.4M for electrification New vertiports: \$3.5M - \$12M
Operating & Maintenance	Potentially 40% - 60% lower relative to conventional aircraft

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Application 2: Organ Transport (UAS)

Our interpretation of organ transport to various VA medical facilities comprises two mission examples to enable faster organ transport, reducing the cold ischemic time (CIT).

Mission 1: “first-mile” and/or “last-mile” legs

A UAS replaces a ground vehicle in fulfilling the first-mile and/or last-mile stage (nominally 5 – 50 miles) in the regional or cross-country delivery (≥ 150 miles between donor and recipient) of the organ.

Key Points:

- Would deliver organ to near-by airport for continental flight on charter or commercial aircraft
- Would help eliminate at least one leg of ground transportation in the overall organ delivery
- Bypassing busy urban surface traffic, the CIT is potentially shortened and thus the viability of the organ is increased

Mission 2: moving an organ within a medical network

A UAS completes the round-trip delivery of the organ within a medical network (nominally 5 – 150 miles), substituting for a ground vehicle.

Key Points:

- 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 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

Application 2: Cost Assessment Key Points

- Direct cost of transporting organs is a small fraction of overall organ procurement costs, so primary advantage for drone transport relates to time rather than cost savings
- Analysis assumes minimum range of at least 20 miles and payload capacity of at least 50 pounds; estimates based on four examples of heavy-lift drones (1 from U.S., 1 from Switzerland, 2 from China)
 - **Average Flight Duration/Distance:** 60 minutes / 60 miles
 - **Annual Number of Flights:** 200 (out and back for 100 organ transports)
- **Realization:** There are over 2,000 donor sites where organs are harvested, and most of these sites send out less than 50 organs per year. This means that the geographic distribution of organ transport services is extremely sparse and dispersed, which suggests potentially very low utilization rates if AAM vehicles are to be dedicated only to organ transport. Entry into other markets besides organ transport may be required to adequately cover the economic costs of providing AAM services.

Life Cycle and Per Unit Cost Estimates

Cost Variable	4-Year Lifecycle (800 Flights): Low End of Costs	2-Year Lifecycle (400 Flights): High End of Costs
Acquisition	\$200,000	\$400,000
Electricity	\$9,600	\$9,800
Insurance	\$70,000	\$50,600
Maintenance	\$24,000	\$36,000
Total Lifecycle Cost	\$303,600	\$496,400
Direct Cost per Flight	\$380	\$1,240
Other Overhead	25%	25%
Total Cost per Flight	\$500	\$1,600
Total Cost per Roundtrip	\$1,000	\$3,200

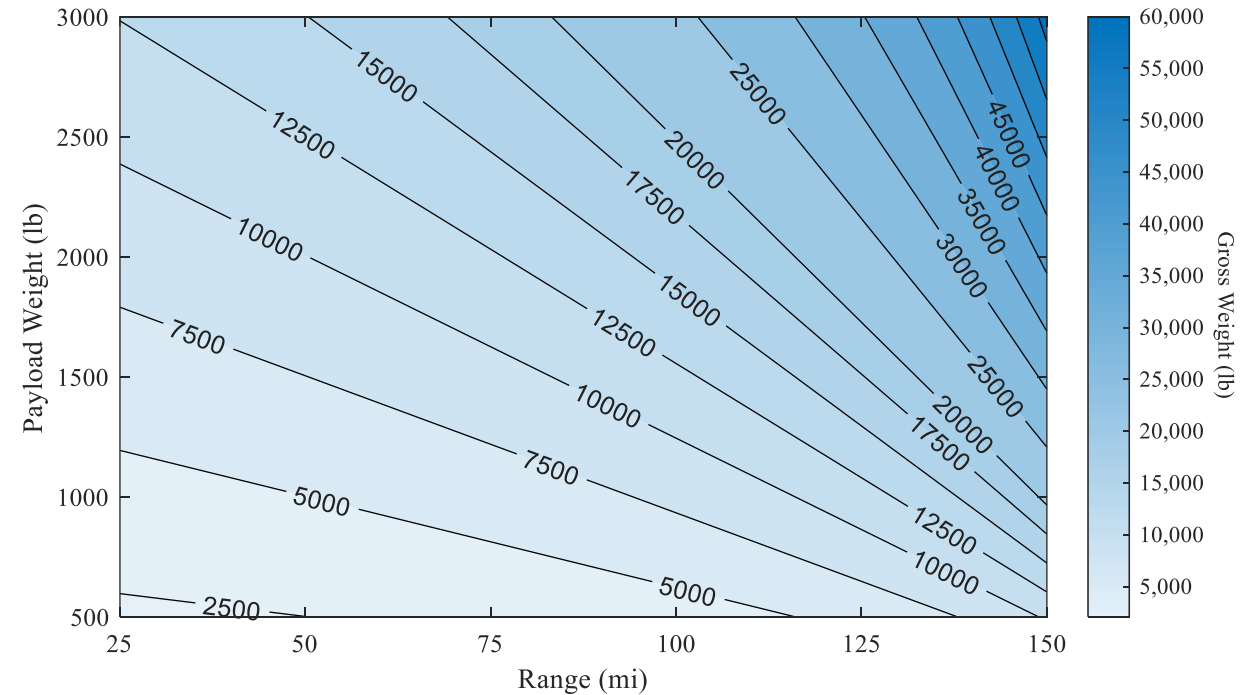
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Conclusions and Recommended Next Steps

- AAM can **potentially fill VA patient transport gaps** in rural and inter-hospital missions
- **Pilot programs** with select VA networks can validate operational and financial viability
- **Partnerships across VA, OEMs, and private hospitals** will be critical for scaling
- Federal **legislative and funding support** (FAA/DOT, VA) will accelerate adoption

- **Technology enablers** such as battery advancements, autonomous flight systems, noise reduction technologies, digital infrastructure, and *vehicle sizing studies* could be areas **where NASA can contribute**



Sizing estimates for a national eVTOL aircraft over a variety of payload and range requirements

Summary, Discussion and Q&A

➤ **Selected Public Good Applications**

- *Patient Transport*: AAM-enabled rural urgent transfers (100 miles) and inter-hospital transfers (50 miles) within Department of Veterans Affairs (VA) networks
- *Organ Transport*: UAS round-trip (5-150 miles) and first-/last-mile (5-50 miles) use to reduce cold ischemic time (CIT)

➤ **Current Challenges**: Reliance on fragmented ground/air logistics, delays (increased CIT of organs), limited rural access, high MedEvac/HEMS costs

➤ **Expected Benefits**

- *Patient Transport*: Faster transfers, competitive aircraft acquisition costs and reduced operating costs compared to conventional air transport (though more costly than ground transport)
- *Organ Transport*: Reduced CIT, fewer handoffs, costs less than or comparable to existing air transport

➤ **Recommended Next Steps**: Pilot programs at select VA networks and transplant hubs, leveraging existing helipads/airports first, scaling to dedicated AAM infrastructure as technology and regulation mature

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Terminology Hierarchy

1. **Application Category:** The high-level mission/domain above the specific application, implying high-level operational characteristics (e.g., *UAM, RAM, LAM*)
- ➡ 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*)

