NASA/CR–20230012505

Advanced Air Mobility Missions for Public Good

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September 2023

NASA STI Program . . . in Profile

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National Aeronautics and
Space Administration

Prepared under Contract 80HQTR18A0010
Order No. 80HQTR22F0102

September 2023

Available from:

NASA STI Program / Mail Stop 148
NASA Langley Research Center
Hampton, VA 23681-2199
Fax: 757-864-6500

NASA

Advanced Air Mobility

Missions for Public Good

Prepared by Deloitte.

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Acknowledgements

The authors gratefully acknowledge the guidance, support, and contributions of NASA's Contracting Officer's Representative (COR), Nancy Mendonca, and Technical Monitor, Dr. Michael Patterson, and others within NASA working to advance the Advanced Air Mobility mission.

The NASA and Deloitte team that led the effort would like to thank the many industry, government, academic, and other partners for their time and valuable input.

Executive Summary

Advanced Air Mobility (AAM) brings together novel technologies to produce innovative capabilities that have the potential to enhance the current aviation market and transportation network. However, other AAM missions may provide direct benefits to the public while also supporting the advancement of the commercial AAM market. This assessment explores AAM missions for public good, defining what public good means in the context of AAM and detailing use cases, metrics, and requirements to determine similarities to the broader AAM industry.

A repeatable approach was utilized that focuses on research, analysis, and validation to develop four deliverables and combine them into the final assessment presented here. To begin, an understanding of public good in the context of AAM was established through the development of initial characteristics common for AAM public good missions. The initial set of five characteristics developed are:

1. Sufficient availability for societal needs,
2. Available to all,
3. Fulfills a potential gap in public need,
4. Benefits society, and
5. No additional cost to the end user.

From these characteristics, a definition is proposed to clarify the meaning of AAM missions for public good while also helping to identify use cases that align with the definition in the future. This assessment defines AAM Missions for Public Good as missions leveraging Advanced Air Mobility (AAM) capabilities that benefit the public and are available to all members of society at no additional cost to the end beneficiary.

To continue exploring AAM for public good, qualitative research was performed to develop a list of application categories to which AAM capabilities could be applied to potentially enhance future operations. These 11 application categories guided the development of 42 unique use cases that provide greater detail into the expected operations and integration of AAM.

Following the development of use cases, a down selection was completed to identify 10 use cases to use for an analysis of potential benefits and impacts when utilizing AAM capabilities. To assess the impacts, a set of 13 quantitative and qualitative metrics was produced that considers a wide range of potential improvements due to implementing AAM, such as improved safety, reduced operational time, and increased access.

Shifting the focus to how AAM public good missions support and advance the commercial industry, requirements were developed for four down-selected use cases to identify similarities to requirements for commercial operations. The down-selected use cases were chosen based on alignment to four commercial AAM markets (inspection, package delivery, cargo transport, and passenger transport) that were identified as priorities across the current ecosystem and industry. These four down-selected use cases included:

1. Inspecting critical infrastructure, such as bridges or highways, to ensure safety for users,
2. Delivering essential supplies to persons in need that are not accessible except by air during and after disasters,
3. Delivering emergency supplies to an emergency scene, and
4. Rescuing a person from a dangerous event, e.g., fire, earthquake, etc.

This assessment develops core knowledge and information to provide insight on how AAM capabilities could be applied to missions to benefit the public and highlights the potential impacts and benefits of these missions. The results provide foundational information that could be applied to new applications as AAM technology and capabilities continue evolving to benefit society, communities, and the public.

1.0 Introduction

1.1 Background: Public Good and Advanced Air Mobility

Public good missions are performed to benefit the community, provide increased access to services, and improve equity. Today, these public good missions utilize aerial technology to perform a variety of tasks that may be difficult to access and/or dangerous to perform with greater efficiency. Examples include the use of helicopters to transport patients to medical centers as an air ambulance or using conventional aircraft to fight forest fires.

As technology matures, it is envisioned that there will be enhanced ways to carry out and provide aerial public services. AAM is one aspect anticipated to improve the services provided to the public by combining technologies, both near and long term, that provide advanced capabilities when transporting people and goods. Advanced Air Mobility (AAM) encompasses a wide range of innovative technologies that have the potential to transform aviation's role in public service.[1] Technologies such as novel aircraft, including small unmanned aircraft systems and electric vertical takeoff and landing aircraft, and advanced propulsion systems, including electric propulsion, could help reduce the impact on our environment while supporting new routes and operations to expand aviation markets. Innovative airspace traffic management could facilitate the integration of AAM aircraft with both the National Airspace (NAS) and other aircraft. Advanced infrastructure is envisioned to support battery charging and implementation of AAM capabilities. These technologies are anticipated to play an integral role in the efficient and safe missions for public good.

NASA defines AAM as safe, sustainable, affordable, and accessible aviation for transformational local and intraregional missions.[2] These local and intraregional missions will create new transportation operations and capabilities, while also enhancing current operations that may benefit from AAM. For example, missions such as inspection, package delivery, and transportation of passengers and cargo could utilize innovative AAM aircraft. Additionally, leveraging AAM could benefit communities and the public while also supporting the development of the emerging commercial AAM industry.

Although many challenges exist when integrating AAM into current operational and transportation networks, AAM public good missions have the potential to help support and accelerate the maturity of the industry. Developing AAM public good missions could help identify broader, cross-cutting barriers when deploying AAM operations to accelerate the development of necessary capabilities. This effort is envisioned to support and drive integration of initial AAM operations while also providing direct benefits to the public.

Additionally, demonstrating AAM capabilities through initial public good missions could help support public perception and provide communities a better understanding of the technology and how it can improve quality of life. Examples of this could be utilizing sUAS to perform a search and rescue mission during a forest fire, utilizing larger AAM aircraft to transport medical professionals to respond to a time critical medical emergency, or law enforcement utilizing sUAS to surveil a reported threat prior to dispatching police officers. While this technology has the potential to positively impact the public, the benefits of the use cases will not be equal, and a detailed understanding is needed to evaluate AAM missions based on impact.

Defining AAM missions for public good and the characteristics that comprise those missions will help the ecosystem identify possible use cases while also determining where challenges exist. The characteristics and criteria will provide a clear way to assess the potential impact that the use cases have on the public. In doing so, public good missions can be further assessed to compare requirements against similar commercial missions to support and mature the technology needed across the industry.

1.2 Goal and Objective

This final report describes, identifies, and matures the understanding of AAM missions for "public good." The goal is to provide a basis for further and more detailed discussion on applicable AAM use cases for "public good" and encourage further exploration through a common framework. Using the organizational structure proposed by NASA, this effort will successfully complete the four following tasks:

1. Propose a definition for AAM "public good" missions and highlight the characteristics of these AAM missions that make them "for public good." This step will provide a basis of understanding to then build upon as applications and use cases are considered.
2. Brainstorm, document, and describe an extensive range of AAM public good use cases, categorized by application. These missions need not only be limited by what is technically feasible or economically viable today but should also consider possibilities for new AAM missions as technologies improve.
3. Provide qualitative assessments of the potential benefits for ten of the identified "public good" use cases. The assessments will analyze key metrics that should be considered, such as impact to the public, safety to the public, and equity.
4. Analyze the high-level requirements for four of the AAM public good missions, including, the capabilities needed for the aircraft, required supporting infrastructure, or air traffic integration.

By establishing a definition of AAM missions for "public good," identifying use cases, proposing metrics, and outlining requirements, a basis for understanding how AAM can be used for "public good" can be developed. This document is divided into eight different sections that provide a basis for understanding the characteristics, use cases, metrics, and requirements for "public good" AAM missions. The framework this report proposes can be leveraged and applied to new applications for the benefit of society as new technological capabilities of AAM continue to evolve.

1.3 Approach

To achieve the project goals and mature the understanding of AAM missions for public good, a repeatable approach was employed that focused on research, analysis, and validation for each of the deliverables.

Research was conducted throughout the various stages of the assessment, beginning with a survey of existing literature to establish foundational knowledge for public good, as well as characteristics of and definitions for AAM public good missions. Additional research was performed to identify applications and use cases that AAM could enhance, and the metrics and requirements to further detail the impact and potential criteria to meet mission objectives.

Following the research efforts, the data was analyzed to ensure thoroughness and applicability to the project objectives. Over 300 sources were reviewed and analyzed to produce a robust source of applicable applications, use cases, metrics, and requirements that served as the backbone for the findings that are presented in this assessment. Additionally, applications and uses cases were also analyzed after initial development to be down selected based on criteria established by NASA and the team. This down-selection process from 42 use cases to 10 supported the development of initial metrics, and an additional down selection from 10 use cases to four informed detailed requirements that are discussed later in the assessment.

To enhance the assessment and build consensus in the ecosystem, findings were validated through external stakeholder interviews, working sessions with NASA subject matter experts (SME), and AAM Ecosystem Working Group (AEWG) presentations. Additionally, the validation efforts helped identify challenges with defining and identifying AAM public goods missions as well as prioritization of applications and use cases, which will be discussed later in the assessment.

2.0 Supporting Information

2.1 General Definitions

While serving the public provides many direct and indirect benefits, there are inherent challenges when trying to define what constitutes a mission for "public good." There is a common challenge when trying to determine what constitutes public good, as this is a subjective opinion for each individual person which was observed from the start of this project. To address this challenge and the inherent ambiguity of the term "public good" related to AAM, a thorough understanding of the general definitions for public good, a public good, and a public service were first established.

A Public Good

A *public good*[i] is a good that once produced for some, can be consumed by additional consumers at no additional cost.[3] This early technical definition is based on a mathematical model that demonstrates the concept of public goods from an economic perspective. A more recent definition asserts that a public good has one or both characteristics of being *non-excludable* (unable to prevent or exclude non-paying consumers from experiencing or using a good)[4] and *non-rivalrous* (good may be consumed by one consumer without preventing simultaneous consumption by others).[5] Examples of public goods based on this definition include roads, clean air, national security, or public parks and recreational areas.

Public goods are not easily distinguishable at times, and academics have long tried to define and categorize examples that do not meet both characteristics of non-excludable and non-rivalrous consumption to clarify the debate. These goods, that meet only one of the non-excludable and non-rivalrous characteristics, are often referred to as *toll goods* and *common pool resources*.[6] Exhibit 1 below illustrates the differences between private goods, public goods, toll goods, and common pool resources.

[i] The text that is italicized going forward will denote a term that has a formal definition not developed in the document.

Exhibit 1: Types of Goods

Exclusionary \ Consumption	Single Use	Joint Use
Feasible	**Private Goods:** Bread, shoes, automobiles, haircuts, books.	**Toll Goods:** Theater, telephone service, toll road, cable television, electric power.
Infeasible	**Common Pool Resources:** Water pumped from a ground water basin, fish taken from an ocean, crude oil from an oil field.	**Public Goods:** National defense and security, weather forecasts, infrastructure, environment, fire protection.

(Source Ostrom & Ostrom (1977) [6])

The method of consumption and ability to exclude the use of the good dictate the type of good. Toll goods are jointly used by many members of society while being feasible to exclude people who do not pay. Alternatively, common pool resources (also called common pool goods) are not jointly consumed but are available to all without being excludable.

Although a "*public good*" can be defined through different categories, such as non-excludable or non-rivalrous, it can be clearly understood since it is a recognizable and detectable good created for society to be used by all. However, defining the intent behind a mission done "for public good" is much more challenging due to the objectivity behind its representation.

For Public Good

A mission done *for public good* is generally referred to as something that benefits the largest number of people in the largest possible way.[7] From this concept, goods and assets can provide benefit to the public available to all for many years. Clearly defining "for public good" can be challenging since it mostly refers to actions and initiatives that benefit society or promote the common good. Examples of activities "for public good" are volunteering in the community, donating to a charity, or advocating for policies that aim to improve public health or safety. These examples might be considered "for public good" or might not, depending on the opinions of different individuals.

Because it is challenging to have a firm definition of something being done "for public good," current operations that mimic or represent something done for the public were further considered. Explaining public services today and similarities to the AAM missions focused on the future helps to better understand what is "for public good."

A Public Service

Today, there are organizations that support and provide benefits to the public through government-funded public services. *Public services* are generally defined as services rendered in the public interest, supplying a commodity or service to any or all members of a community.[8] These services are often attributed to government-operated agencies and employees funded by tax money, and there are many examples that demonstrate an intent to provide benefits for public good. Examples of organizations that provide public services are federal, state, and local government responsible for law enforcement, social welfare programs, public transportation, public education, and environmental protection. Other examples include non-profit organizations that provide shelter and housing for the homeless, food banks, mental health services, and disaster relief. Like the way public services are implemented and carried out today, federal, state, and local organizations are expected to have a significant role when introducing AAM technology and leveraging AAM capabilities in the future to support and enhance the public services provided today.

The core intent of current public services and future AAM missions is to benefit the public, regardless of the technology being implemented. Assessing and analyzing common characteristics of public service operations being carried out today by different government, non-profit, and private organizations provide a better understanding of how AAM capabilities can be leveraged by public service missions done today.

2.2 Public Services and their Common Characteristics

Many services that support and benefit the public are provided by government, non-profits, and, at times, private organizations. These services provide insight into the general belief or understanding of what services are considered "for public good." There is currently a range of publicly funded efforts administered by organizations that incorporate public good and public service into their daily operations. These activities, that are performed by government and non-governmental organizations, provide positive externalities that benefit those in the surrounding communities the organization serves.

After reviewing organizations that serve the public and analyzing the activities they conduct, four themes were identified. Although multiple organizations are listed throughout, this list is not intended to be exhaustive but to provide a brief overview of public services being provided today.

1) Safety and Security refers to the protection of individuals and organizations from threats, attacks, or danger likely to cause harm.[9] Administering safety and security is often considered to be for public good because the service is applicable to all of society, non-rivalrous, and non-excludable. Many of the organizations in the U.S. that comprise this category exist solely to provide the benefit of public safety to its citizens, including:

- The Department of Homeland Security (DHS) undertakes operations that prevent and respond to security threats. DHS houses many organizations that provide services focused on safety and security, such as the Customs and Border Patrol (CBP), Transportation Security Agency (TSA), and Cybersecurity and Infrastructure Security

Agency (CISA). Some example operations to ensure public safety include maintaining cybersecurity systems, protecting critical infrastructure, securing borders, and protecting the public from terrorism and homeland threats.[10]

- Local or municipal fire departments provide services that enhance safety to the public located in their communities. Fire departments perform a wide range of services, including response to fire scenes, emergency medical treatment, rescue operations, conduct inspections of fire code violations, and provide fire safety and prevention education for the public.

2) Emergency Response is a systematic response to an unexpected or dangerous event to the public that mitigates the impact of the event on people and the environment.[12] When responding to an emergency, the services provided are non-excludable, serve a critical public need that would not be met otherwise, and are generally enabled through donations or public funding. The U.S. has various organizations and agencies that act and handle emergency response. For instance:

- The Federal Emergency Management Agency (FEMA) delivers a coordinated response to disasters by providing immediate actions to save lives and meet basic human needs. After the emergency, FEMA also supports local government recovery actions including housing recovery, infrastructure planning, and community planning.[13]
- Organizations in the non-profit space also work to mobilize volunteers and donors in emergencies. Non-profits currently perform activities such as managing blood supply products, responding locally and nationally to disasters, and helping to build readiness by developing community partnerships and assisting with logistics.[14]

3) Sustainability and Conservation aims to protect and preserve natural resources for the present and future benefit of society. Maintaining natural resources increases the quality of life in a community, benefits the health of individuals, and contributes to the economic and environmental well-being of a community and a region.[15] The operations performed for sustainability and conservation are non-rivalrous, non-excludable, and provide a service that would generally not otherwise be met by the private market. The U.S. has several governmental and non-governmental organizations that conserve natural resources for public good, including:

- The Department of the Interior (DOI) manages and conserves national parks, historical sites, and ecosystems through the activities of the National Parks Service (NPS)[16] and the Fish and Wildlife Service (FWS). Operations focus on strategic planning to prevent natural resources and species from becoming depleted or endangered by using available data and science, implementing conservation laws, and partnering with tribes, private landowners, and other stakeholders.[17]
- Additionally, there are non-profits that aim to preserve and conserve natural resources, landscapes, ecosystems, and wildlife. Activities can include the active restoration of habitats, reduction of pollution through wildlife-friendly clean energy policies and projects, and mitigation of environmental threats such as climate change or invasive species.[18]

4) Mobility and Access includes the movement of passengers and goods throughout the U.S.

transportation system and infrastructure. While certain forms of mobility and access can be excludable and rivalrous, the services government agencies offer, as well as some non-profit organizations, provide essential road and public transportation infrastructure with the intent of connecting the country and its people. Examples of the organizations and activities that enhance mobility and access include:

- The Department of Transportation (DOT) promotes safety and advances the transportation system to efficiently connect passengers and goods throughout the economy. DOT oversees organizations such as the Federal Aviation Administration (FAA), Federal Transit Administration (FTA), Federal Highway Administration (FHWA), Federal Railroad Administration (FRA), and the National Highway Safety Administration (NHTSA). Specific activities include maintenance of physical infrastructure, operation management of the public transportation system, and infrastructure inspections, accident assessments, surveying of roadways and other public infrastructure, and risk identification.[19]
- State Departments of Transportation (DOT) manage state transportation systems through the planning, design, construction, operations, and maintenance of a wide range of infrastructure and travel modes. These investments made by state DOTs aim to enhance mobility through projects such as building roads, repairing existing infrastructure, enhancing public transportation, inspecting bridges, purchasing busses, improving transit maintenance facilities, and providing infrastructure for alternative modes such as walking or biking.

The example services provided by the organizations described above offer initial insight into current operations that support the public and can be used to help identify common characteristics of these public services, regardless of the technology leveraged. The following section considers common characteristics from the previous examples along with other public good operations to develop an initial list of characteristics that describe AAM missions for public good.

3.0 Characteristics of Public Good

Following the detailed research across public services, common characteristics were identified as a starting point for further validation and maturation. The common characteristics identified include benefiting society, creating no direct cost for the end user, and filling a potential gap in public need.

First, it was found that most operations or services provided by a government or non-profit organization were performed with the core intent of benefiting society and the public. While not all benefits are equal, supporting the public and improving the quality of life are at the center of the intended mission of public services. This could be done through many different operations, such as improving the safety of the community or inspecting the roads citizens use to access their food, healthcare, and work, contributing to a better quality of life for those residents.

Next, there was no additional cost for the end user or beneficiary of the service. While nothing is at zero cost, due to taxes paid as a society, many public good missions require no additional cost above the taxes and donations that fund current operations and services.

Finally, public good missions seek to fill a potential gap in public need that would otherwise go unmet. Public services are provided today to communities that would otherwise go unserved due to factors such as the market not having a strong business case or not supporting competition by private companies. AAM capabilities seek to enhance and increase the number of services that are offered to communities and society. For example, there are natural disasters year-round or high levels of non-recoupable capital investment required to establish the resources needed such as law enforcement and security.

The characteristics were then validated through stakeholder interviews to gauge their relevance and understand gaps that may exist when analyzing the initial research.

During the interviews, candidates were asked a range of questions that produced unique viewpoints regarding AAM public good missions. Examples of questions asked were:

- How public good is defined?
- What characteristics make up public good missions?
- What challenges exist when defining and categorizing public good missions, specifically for AAM?

Additionally, candidates were asked to provide their opinion on an example set of use cases to identify which examples were viewed as public good versus commercial operations.

The interview outcomes helped to validate the common characteristics identified from the initial research and produced unique insight regarding drivers for how individuals viewed and prioritized public good. For example, location is a driver that causes people living in coastal cities to consider and prioritize missions that support response to hurricanes more than avalanches. Another example would be the interview candidate's line of work that drives a considered emphasis on the providers of the services and enhancing their safety. This information started to highlight the challenges when characterizing public good missions and the subjective nature of defining and prioritizing these missions in the context of AAM.

To develop an initial set of characteristics for AAM public good missions, the commonalities researched across public services and validated through stakeholder interviews, as well as the characteristics that were defined formally to describe public goods from an economic viewpoint, were leveraged. The characteristics previously introduced to define public goods in the context of economics were *non-rivalrous* and *non-excludable.*

To provide a more straightforward, colloquial set of terms to describe attributes of AAM public good missions, unique characteristics and definitions were developed from the previous formal terms. From this point on, the document will refer to the characteristics provided here when discussing attributes of AAM missions for public good.

The exhibit below documents an initial set of characteristics intended to identify typical qualities of an AAM mission for public good. While these characteristics provide more detail regarding the core intent of public good missions, a formal definition is needed to establish a foundation for further dialogue.

Exhibit 2: Characteristics of AAM Missions for Public Good

Characteristic	Description	AAM Example
Sufficient availability for societal needs	There are enough resources to meet basic requirements in society that contributes to quality of life	Delivery of a defibrillator during an emergency event **will not deplete the availability** of an identical delivery from being accessed by another individual.
Available to all	Everyone can access and/or experience the benefits of the mission regardless of economic status	Responding to a natural disaster area to search for individuals in distress **will be for all members of society**, regardless of social and economic status.
Fulfills a potential gap in public need	Meets a societal need that otherwise would not be met through a private market	Air carriers providing their fleet to meet a need for the **transportation of service members and/or supplies during a national defense crisis**
Benefits society	Improves the quality of life of a society	Inspection of utility infrastructure before, during, or after a storm **to reduce impact to the public or recover more rapidly.**
No additional cost the end user	The end user does not have to pay an additional cost above the taxes that fund public operations or the donations that fund philanthropic private organizations.	**Publicly funded local agencies** (for example, law enforcement) leveraging low altitude sUAS operations to better protect the public

4.0 Definition

The proposed definition listed below leverages the initial characteristics documented in the previous section to broadly describe AAM missions for public good.

AAM Missions for Public Good: Missions leveraging Advanced Air Mobility (AAM) capabilities that benefit the public and are available to all members of society at no additional cost to the end beneficiary.

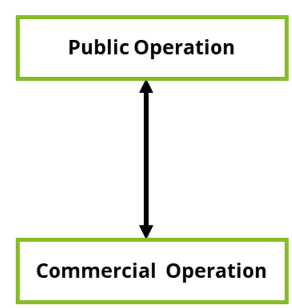
The definition developed aligns primarily with missions provided solely for the benefit of the public. However, while performing research and stakeholder engagement, more missions were identified that serve some aspect of public good without the core intent being solely for the public's benefit. During the interviews, most respondents identified missions that were performed solely for the public's benefit, but when respondents were posed with reference missions that were not performed solely for the public's benefit, it became increasingly challenging to differentiate public good and non-public good missions.

Four tiers are developed and described below in Exhibit 3 to capture the nuances between missions that can provide benefits to the public based on core intent, helping to clarify and categorize AAM missions for public good.

Exhibit 3: Proposed Tiers for AAM Public Good Missions

Tier	Description
1	Done solely for the public's benefit.
2	Done for profit but provides a public benefit during each operation.
3	Done for profit but can sometimes provide a public benefit at any one time.
4	Done for profit but now directed to be done for public's benefit.

Core Intent



Tier 1 missions are performed solely for the public's benefit without any need to generate revenues. Some examples of Tier 1 missions could include firefighting, law enforcement, and search and rescue.

Tier 2 missions are performed for profit but provide a public benefit during each operation. An example of a Tier 2 mission are cargo and logistics air carriers who provide weather data for free to government and public organizations. This mission, traditionally performed commercially for profit, could potentially provide the public greater weather data and accuracy during each operation.

Tier 3 missions are performed for profit but could sometimes provide public benefit at any one time or intermittently. These could include operations or services that are leveraged during a crisis, such as free air transportation for volunteer doctors traveling to states impacted during a pandemic or delivering medicine to rural communities to combat a communicable disease outbreak.

Tier 4 missions for public good are unique as they are performed for profit but are directed to support or serve the public during a national defense related crisis. The Civil Reserve Air Fleet established in 1951 is a cooperative program involving DOT, Department of Defense (DOD), and U.S. civil air carrier industry in a partnership that augments the DOD aircraft fleet capability during a national defense related crisis.[21] Participating members are given preference for carrying cargo and passengers for the DOD and are regularly issued contracts and task order within the program.

While these proposed tiers help clarify and categorize potential AAM missions for public good based on core mission intent, they are intended to be a foundation to build upon and mature. To comprehensively assess the amount of public good each mission provides, quantifiable metrics will be needed that demonstrate potential impacts and public benefits.

5.0 Applications and Use Cases

5.1 Applications Discussion

Consideration of current public services and activities performed today for "public good" lay the basis for discussion of how AAM can be introduced into those applications. This document refers to an application as a high-level category that is intended to provide more specificity while not describing all the potential use cases contained within. The applications researched cover many public services that are done today and would be considered for public good.

AAM is beginning to be implemented in a wide range of use cases, such as utilizing sUAS for inspection, weather, and medical applications. As AAM technology continues to evolve and larger AAM aircraft gain airworthiness, there is potential for the number of applications to expand and more effectively support the public. Two areas that leverage aviation capabilities to perform services in support of the public that AAM could enhance are conservation and disaster response.

The applications considered in this document are shown below. This list is not intended to be exhaustive but provides a basis for developing a broad range of use cases to serve as an initial foundation when referencing AAM public good missions.

- Agriculture
- Border Security
- Conservation
- Disaster Response
- Firefighting
- Inspection
- Law Enforcement
- Medical
- Search and Rescue
- Weather

5.2 Use Case Discussion

Underneath each broad application, a subset of use cases was captured. This document defines a use case as a specific operation that is being performed within the application. For example, a use case within the inspection application could be using a sUAS to inspect critical infrastructure.

Use cases give insight into how AAM is being used for public good today and can be leveraged in the future. The greater the breadth of use cases that are identified, the more insight is provided on the industry and how technology and innovation can be applied to existing and future missions. Use cases provide more information on the expected outcome, potential stakeholders, and the high-level operation.

Detailed use cases were developed through consideration of existing use of aircraft for public services, a survey of existing AAM technology that could be used for the developed applications, and further research into AAM potential capabilities in each use case.

A standardized framework was used to provide consistent information that contained the following:

- Title of the use case,
- A list of expected high-level stakeholders in general categories that may be involved in the use case, with the consideration that they may differ based on location, operations, and jurisdictions,
- Explanation and justification of need for this use case and how it may be relevant and helpful to the public good,
- Description of the benefits the use case is envisioned to provide,
- The justification for why this document considers the use case to be "for public good," and
- A high-level overview of the general envisioned operation of the AAM aircraft, noting any unique aspects of the mission.

This process was applied to create 42 standardized use cases that can be found in Appendix A. The Exhibit below provides a high-level overview of each application in alphabetical order with corresponding use cases.

Exhibit 4: Developed Use Cases for Public Good

Application	Use Cases
Agriculture	• Collecting public data on crop conditions to support production of safe and adequate food for the U.S. population. • Mapping agriculture land and terrain to manage and maintain stormwater treatment.[22] • Monitoring and sampling water quality for key metrics, such as water toxicity and contents.[23] • Surveying and managing water resources during flood or drought seasons. • Transporting supplies, pesticides, or other equipment to assist farms that have sustained pest or crop damage, to prevent far reaching negative effects on other producers.
Border Security	• Monitoring and surveilling border areas to provide security to the public.[24] • Providing border patrol agents with additional personnel or supplies in response to a time critical security need or event.[25]
Conservation	• Delivering insecticide to combat invasive environmental threats that could have far reaching detrimental effects to an ecosystem. • Mitigating Avalanches.[26]

	• Monitoring natural resources to improve natural resources management. • Obtaining water samples from ocean water to better understand ocean and coastal health. • Re-locating wildlife to preserve and support ecosystems and habitats. • Tracking wildlife to collect data such as herd migration or population to inform ecosystem conversation.
Disaster Response	• Delivering essential supplies to persons in need that are not accessible during and after disasters. • Rescuing a person from a dangerous event, e.g., fire, earthquake. • Surveying and mapping the aftermath of disasters to help inform responses.
Firefighting	• Delivering emergency supplies to an emergency scene. • Deploying AAM with firefighting capabilities to extinguish a fire. • Surveillance of a wildland or rural event, such as wildland fire.
Inspection	• Inspecting critical transportation infrastructure to ensure safety for users. • Inspecting energy infrastructure to confirm safe operational status and ensure delivery of energy and power. • Monitoring airport infrastructure for potential obstructions to ensure passenger safety for takeoff, taxi, and landings.
Law Enforcement	• Responding to a situation or threat to the public to assess the scene and inform coordinated support. • Surveilling prison compound for security purposes.[27] • Tracking and locating a suspect fleeing a crime scene. • Transporting appropriate personnel or equipment for response to time critical explosive threats.[28]
Medical	• Delivering essential medical supplies during disaster response, such as an Automated External Defibrillator (AED) to save lives. • Delivering organs for transplant. • Delivering Personal Protective Equipment (PPE) during a public health emergency. • Distributing vaccines during a public health emergency to individuals who may lack mobility to access them themselves, are in remote locations, or to individuals at public mass vaccination sites. • Patient transfers between medical facilities.

	• Transporting first responders, doctors, or patients to the scene of an accident or a medical facility. • Transporting personnel and doctors to a more remote location to improve rural medical care.
Other Applications	• Delivering food or supplies to those in need. • Operating to further research technology with potentially low Technology Readiness Level (TRL) equipment. • Transporting the public during major events to augment mass transit.
Search and Rescue	• Locating lost or stranded person(s) in distress to assess and coordinate a recovery response.[29] • Transporting personnel and equipment to a person(s) trapped in remote location.
Weather	• Monitoring weather and micro weather data to inform forecasts and data for the public. • Researching and monitoring the progression of natural disasters, such as hurricanes or tornadoes, to inform disaster response.

From this list, a wide breadth and depth of use cases were developed to provide context for how AAM can enhance and improve communities and benefit the public, today and in the future. On a broader scale, use cases may also offer benefits outside of the success in the individual mission to the broader public service and transportation network. This document identified a set of 42 use cases, which is not intended to be an exhaustive list, but a basis for further expansion. It is anticipated that the use cases will continue to evolve as technology advances.

The use cases offer an overview that could help drive forward adoption or expansion of AAM operations. While a portion of the use cases this document details are operated today, many use cases still have prohibitive barriers that must be considered before beginning operations. Therefore, understanding details and potential benefits of the use cases is important to informing communities or stakeholders who may be considering taking the first step towards incorporating AAM or expanding their already existing operations.

AAM has the potential to be leveraged in many applications and operations, but this opportunity may also present a challenge when prioritizing which use cases offer the most impact for public good applications.

6.0 Metrics Development

6.1 Introduction to Use Case Down Selection

To make an informed decision to incorporate AAM, it is important to understand and evaluate the potential benefits of each use case in practice through a set of measurable metrics prior and during operations. This section will propose, discuss, and analyze a list of potential metrics and measures, to help determine future impact of potential AAM missions for public good.

To develop the metrics and measures for AAM public good missions, 10 use cases were down selected from the complete list of use cases to use as a basis for metrics analysis. These 10 are intended to be representative of the breadth and depth of the entire public good use case selection.

The first step was to create a range of criteria to consider and organize these into a matrix to inform the use cases down-selection. This matrix created a weighted score for each of the 42 use cases, considering aspects such as safety to the public, equity, frequency of impact to the public, volume of impact to the public, time criticality of mission, and cost. The matrix produced a score that resulted in the expected aggregate impact of the previously described factors for each use case when implementing AAM capabilities.

While the matrix produced a list of the top ten use cases based on impact, further discussion and review was performed to ensure a wide breath of the researched applications and use cases for public good were represented. For example, the use cases incorporate a broad range of applications (e.g., disaster response, inspection), configurations (i.e., crewed, uncrewed), time criticalities (i.e., scheduled, on-demand), and aircraft (e.g., sUAS, electric vertical takeoff and landing (eVTOL) aircraft). This culminated in the down selection of 10 use cases that represent the 42 use cases developed while also providing significant benefit and impact to the applications when implementing AAM capabilities.

Before developing the metrics, the down-selected use cases were analyzed, and it was recognized that the ten use cases fit into three general categories: observation, delivery, and response. These categories were created to clarify the development of the metrics and align unique capabilities and impacts for each use case.

The Exhibit below lists the 10 down-selected use cases that will be used for the metrics analysis and their respective categories. Note, the order of the list does not reflect a ranking or priority of the use cases.

Exhibit 5: Ten Down-Selected Use Cases for Metrics Analysis

Category	Down-Selected Use Case
Observation	• Inspecting critical infrastructure to ensure safety for users. • Monitoring natural resources to improve natural resources management. • Surveillance of a wildland or rural event, such as wildland fire. • Researching and monitoring the progression of natural disasters, such as hurricanes or tornadoes, to inform disaster response.
Delivery	• Obtaining water samples from ocean water to better understand ocean and coastal health. • Patient transfers between medical facilities. • Delivering essential supplies to persons in need that are not accessible during and after disasters. • Delivering emergency supplies to an emergency scene.
Response	• Responding to a situation or threat to the public to assess the scene and inform coordinated support. • Rescuing a person from a dangerous event, e.g., fire, earthquake.

6.2 Development of Metrics

The ten use cases were used to develop both quantitative and qualitative metrics and example measures for each use case that provide a starting point for industry when considering, defining, and quantifying the impacts.

For stakeholders to make decisions to adopt or continue to use AAM technology, a variety of metrics or outside factors may be considered. Metrics can lay a basis for informing and helping to decide the best course of action given a stakeholder's unique priorities, goals, or funding sources. The metrics proposed are intended to be assistive to developing ways to measure impact.

With these considerations in mind, metrics were developed based on areas that AAM could provide measured benefits. Development of metrics began with a survey of existing literature and metrics for comparable public service operations. Factors considered included safety, equity, operational improvements, cost, and impact to the environment. For every metric, this document also proposed potential quantitative and qualitative measures. The measures were preliminary, not prescriptive, and may apply differently or not at all, depending on the specific use case and situation.

The chart below lists the 13 developed metrics, metric type, and potential measures for each. The developed metrics are not intended to be exhaustive or claim that each metric applies to each potential and future use case. AAM capabilities are not expected to result in a beneficial or positive result in each measure. This document acknowledges many barriers remain to implementing AAM operations and each stakeholder must weigh the outcomes of the metrics below.

Exhibit 6: Categorized Metrics

Number	Metric	Metric Type	Measure(s)
1	**Safety Risk to Public Involved in Operation**	Quantitative	Number of near misses identified, Number of employee safety ideas and hazards submitted, Number of Incidents
2	**Safety Risk to Provider**	Quantitative	Average time between worker report of a safety idea or hazard and management knowledge of the report, Number of near misses identified, Number of employee safety ideas and hazards submitted, Number of Incidents
3	**Operational Time**	Quantitative	Minutes / Hours of Operation
4	**Service Accessibility**	Quantitative	Number of services performed in underserved / rural communities
5	**Data Accuracy**	Quantitative	Lighting & Image Resolution or Ground Sample Distance (GSD), Flight Speed, Ground Control Points
6	**Operational Cost**	Quantitative	Total Cost to Complete Mission
7	**Operational Personnel**	Quantitative	Number of personnel required to perform operation
8	**Carbon Dioxide Emissions**	Quantitative	Net Carbon Emissions
9	**Noise Emissions**	Quantitative	Net Noise Emissions (Level, Amount of time, Frequency)
10	**Number of People Willing to Serve in a Higher Risk Environment**	Quantitative	Applications per Role, Recruitment Rate
11	**Workforce Equity**	Quantitative	Number of Job Opportunities Enabled by Technology to Bridge Gap of Workforce Equity
12	**Greater Access to Perform the Operation**	Quantitative	Number of Missions Carried Out Due to Technology
13	**Provides data to enhance or support tangential industries**	Qualitative	Amount of data collected

The metrics highlight the potential dimensions over which benefits may be obtained for the significant number of areas AAM capabilities may impact. Metrics also can provide a basis for evaluating the impacts of future missions. While AAM capabilities may enhance applications in the future, stakeholders will need to quantify and assess the outcomes for each metric to understand the tradeoffs associated when implementing AAM. Through the metrics, stakeholders may be able to communicate the return on investment more effectively when integrating AAM to support missions for public good.

Although the metrics demonstrate the potential impact of cases for public good, a detailed requirements analysis will help to identify capabilities that are needed for aircraft, supporting infrastructure, and airspace integration across the public good use cases.

7.0 Requirements Analysis

7.1 Introduction

The previous sections focus on defining and detailing the use cases and metrics for how AAM could be applied to and enhance public good missions. This section focuses on detailed requirements to help identify specific standards, criteria, or regulations that are needed to successfully perform the AAM mission for public good. These can include the specifics of the aircraft itself, the physical and traffic infrastructure, and airspace rules and integration. Understanding requirements is critical to ensure functional, safe, and reliable operations of the aircraft to successfully complete public good missions. The requirements developed here seek to inform and provide insight that:

- Supports a more efficient use of resources and redundancy in infrastructure,
- Accelerates adoption of technology through potential public and private collaborations,
- Builds trust and perception through demonstrating the benefits for society,
- Helps inform the regulatory framework through public good operations while identifying gaps for commercial uses, and
- Creates effective systems across all aspects of AAM to serve the needs of society.

With this information, synergies were identified between commercial operations and the four down-selected public good use cases by exploring the requirements. The four commercial markets this section included are (aerial) inspection, small package delivery, cargo transport, and passenger transport. These represent the current AAM market focus based on the research and interviews performed.

Once the commercial applications were identified, four use cases for public good were selected from the ten in Section 6.0 and are referred to as “commercial synergies.” Aligning the commercial markets with the public good missions aims to capture a breadth of requirements applicable for both sectors.

The following Exhibit details the four down-selected public good use cases aligned with their respective commercial synergies.

Exhibit 7: Four Down-Selected Use Cases

Use Case	Commercial Synergy
Inspecting critical infrastructure, such as bridges or highways, to ensure safety for users	**Inspection**
Delivering essential supplies to persons in need that are not accessible except by air during and after disasters	**Small Package Delivery**
Delivering emergency supplies to an emergency scene	**Cargo Transport**
Rescuing a person from a dangerous event, e.g., fire, earthquake	**Passenger Transport**

Maturity Level and Assumptions

To communicate the requirements effectively, an understanding of the maturity of AAM and the underlying assumptions must be established. The requirements for these use cases are envisioned to exist in the state of what NASA refers to as UAM Maturity Level 4 (UML-4), in the context of a scale that begins at initial operations at UML-1 to widespread autonomous operations at UML-6.[30] For the purpose of this analysis UML-4 consists of medium-density and medium-complexity operations with collaborative and responsible automated systems. This means automated systems do not require human oversight or mitigation of potential failures for some functions.[1]

The requirements were developed with the following set of assumptions to consistently understand and convey the information.

- Operations exist and go up to Maturity Level 4 (UML-4), as previously described.[1]
- The aircraft utilize new propulsion technologies, such as electric, hybrid-electric, or hydrogen.
- The aircraft may operate in an uncrewed configuration, based on the use case.
- The aircraft have a level of collaborative and responsible automation.[30]
- A dedicated AAM Air Traffic Management (ATM) to coordinate and manage air traffic and communications with ATC at later maturity levels.
- Airworthiness guidance and certification for AAM aircraft and autonomous systems are established.
- AAM has progressed beyond the relatively limited number of early adopter cities and has the necessary infrastructure to support the demand in a wide range of locations.[30]

7.2 Requirements Categories Overview

Three core areas were identified for categorizing the requirements: aircraft, infrastructure and community, and airspace. NASA identifies these categories as core components and drivers for the maturity of AAM.[1]

The aircraft category encompasses the aspects that constitute the development of "mission-capable" aircraft that meet all operational and functional requirement to be safely operated.[1] Infrastructure includes physical areas of focus, such as vertiports to existing airports and creating charging stations for mostly electric aircraft, and digital areas of focus, such as how aircraft will communicate with one another and with air traffic control.[31] These types of infrastructure are enabled and work in tandem with community components, such as public perception and multimodal integration. The airspace category refers to the operating rules, roles, procedures, of airspace management needed to enable safe and efficient operations.[1]

These three categories guided the build-out of the requirements. For each category, the capabilities needed to advance the AAM industry and ensure safe and operational flight were considered. From these capabilities, requirements could be considered and identified. Therefore, each requirement was grouped accordingly into one of these three overarching categories.

The following paragraphs discuss the intent for each category and provide more detail and example AAM capabilities considered to develop the requirements. These paragraphs aim to discuss the range of capabilities that may be needed to ensure a safe, efficient, cost-effective operation of AAM aircraft performed by both public and commercial stakeholders in the ecosystem to use as a basis for requirements development.

7.2.1 Aircraft

The aircraft category encompasses the aircraft and technology aspects of the AAM aircraft, including but not limited to, aircraft with innovative propulsion systems or UAS. These aircraft are anticipated to mature in the coming years and incorporate advancing levels of technology, such as increased levels of autonomy.

To mature the AAM industry, a broad range of aircraft capabilities will be needed that depend on the specific operation and compliance with the applicable regulations. Some of these capabilities are associated with the performance of the aircraft, such as range, airspeed, payload capacity, and required runway length. Other capabilities may seek to ensure operational safety and mitigate risk during flight, such as detect-and-avoid (DAA), identification or surveillance systems, and right-of-way air prioritization.

These aircraft capabilities can help unlock functionality that will be at the core of the AAM industry, provided the necessary infrastructure and airspace capabilities keep pace. Consideration of these capabilities helped to inform the development of the requirements in Sections 7.3 and 7.4.

7.2.2 Infrastructure and Community

The infrastructure and community category focuses on the physical, digital, and community capabilities vital to an AAM operation. For AAM missions, a range of infrastructure capabilities may be needed to support the operation. Physical infrastructure can include vertiports, weather surveillance systems, or electricity infrastructure. Digital infrastructure may include communications systems not associated with ATC, third service party providers, and navigation. Community aspects could include multi-modal integration or planning for how AAM can fit into transportation and other needs of a locality.

These infrastructure capabilities will drive requirements that enable AAM aircraft to support government and non-profit operations while maturing the commercial market through investments into collaborative systems. AAM infrastructure will play a significant role in unlocking operational capability for public good applications, but operations will not reach the intended levels of efficiency and safety without also airspace construct and enhanced aircraft capabilities.

7.2.3 Airspace

The airspace category considers requirements and regulations for air traffic management and airspace integration. AAM aircraft must receive clearance from ATC to enter restricted airspace and follow existing regulations, such as right of way rules. The capabilities identified to shape requirements in the airspace category seek to ensure a safe NAS and flight operations.

As the number of AAM operations increases, airspace capabilities are anticipated to develop to include traffic management and real-time planning to manage the volume of AAM operations. Managing the expected volume of traditional and AAM aircraft may drive new capabilities in Air Traffic Management (ATM), or Unmanned Aircraft System Traffic Management (UTM) in the future, changing the way approvals for restricted NAS airspace are obtained.

These categories were used as the framework to research and identify a representative list of 127 requirements that considered the operation for the four use cases.

7.3 Cross-Cutting Requirements

First, requirements were identified that were cross-cutting or applied to all four down-selected use cases. While the use cases each differed in mission intent and capabilities, the analysis found a common set of requirements that could apply to all four use cases as well as the broader AAM industry. A total of 54 cross-cutting requirements were identified. The following exhibits provide a list of these requirements, grouped into the categories: aircraft, infrastructure and community, and airspace.

7.3.1 Aircraft Cross-Cutting Requirements

This analysis begins with examining the cross-cutting requirements specific to the aircraft itself. Aircraft requirements help to guide the airworthiness, performance, reliability, maintenance, and safe operation of the aircraft. The exhibit below details the aircraft requirements found to cut across the four public good use cases.

Exhibit 8: Aircraft Cross-Cutting Requirements

Aircraft Capability	Cross-Cutting Requirements
Accessibility	• Provide adequate access to onboard systems and components to facilitate maintenance and reliability.
Airworthiness	• Demonstrate safe flight and obtain airworthiness approval.
Automation	• Automated capability to mitigate a lost link scenario.
Charging/Refuel	• Accessible interfaces to accommodate charging and/or refueling.
Communications Systems	• Provide External Communications and Data with Ancillary Services.
Compliance	• Comply with operations applicable to AAM aircraft type and operation type.
Configuration	• Operate in an uncrewed configuration.
Contingency	• Identify a hazard, the appropriate mitigation, and if necessary, make an emergency landing. • Operate in a predictable and safe manner during contingency and off-nominal situations.
Data Collection	• Ensure that the data captured is both authorized and used solely for the purpose of the mission intent. • Able to offload/share performance data or data collected during the flight. • Collect data to support safety, performance, and operations.
Detect and Avoid (DAA)	• Detect and avoid obstacles, cooperative, or non-cooperative aircraft. • Comply with right-of-way rules and ATC clearances.
Hand-Off Control	• Follow an approved AAM Aircraft control hand-off procedure that ensures continuity of control over the AAM Aircraft.
Health Monitoring	• Aircraft system provides health monitoring.
Maintenance	• Routine and as needed maintenance to retain airworthiness and ensure aircraft is functioning properly.
Navigation	• Relay aircraft position. • Redundant, multi-source positioning navigation systems in case of failure of a primary navigation system.
Payload	• Interface points to integrate payload.
Range	• Sufficient range to perform mission. • Sufficient reserve time for emergency landing if necessary.
Reliability	• Meet the applicable reliability to ensure a safe and efficient operation.
Safety and Security	• Secure and safe operations by the appropriate actors needed to complete the operation.
Takeoff/Landing	• Perform gate, taxi, takeoff and climb procedures. • Perform descent, approach, landing, go around, and clear landing hazards.

Weather Tolerance	• Flight plan can be adjusted to avoid extreme weather events and related damage.

Aircraft requirements are important to consider because they help to ensure that an aircraft is designed, manufactured, and operated safely and in compliance with regulatory standards. These requirements encompass a range of aspects including performance, reliability, safety, data and analytics, navigation, and communication.

At the core is the standard for airworthiness, which drives other aspects such as reliability assessments, inspections, and Maintenance, Repair, and Overhaul (MRO)s. Also vital to aircraft requirements are the communication systems that convey the health monitoring of aircraft, communication links, the data that are relied on, and latency of any communications.

Another set of cross-cutting requirements centers around the charging or refueling of the AAM aircraft. These requirements could help to mature the standardization of charging capabilities, considering types of battery, power, and voltage that would be required. Data and safety are other aspects of the cross-cutting requirements that could not only ensure compliance with civil aviation authority regulations but could inform decisions related to the architectures and approaches used when developing future cybersecurity protocols and encryption to protect the collection and communication of data.

The requirements could suggest a core set of aircraft requirements that could be focused on to drive the AAM industry and use cases for public good forward. These core areas include safety, with a focus on the operation of the aircraft itself and among others, and compliance with aviation, community, and local regulations, zoning, and noise ordinances.

7.3.2 Infrastructure and Community Cross-Cutting Requirements

After understanding the requirements for the aircraft, the additional surrounding and supporting infrastructure and community must also be considered to ensure safe operation of the flight. Infrastructure includes both the physical airport infrastructure, such as runways and maintenance, and the management systems in place to support the aircraft, such as navigation or third-party services. The Exhibit below details the infrastructure requirements found to cut across the four public good use cases.

Exhibit 9: Infrastructure and Community Cross-Cutting Requirements

Capability	Cross-Cutting Requirements
Third-Party Services	• Coordinate airspace allocation actions with ATC when necessary. • Discover UTM Operations information relative to an area and time of interest. • Provide information such as weather data, interaction with ground emergency services, and command centers between the ATC and the operators.
Communications Systems	• Command-and-control link with a bandwidth that supports ground station communication and data captured. • Provide functionality to autonomously submit a pre-flight plan or in-flight plan change. • In the event of an off-nominal situation, provide best course of action and send new commands to the aircraft for mitigation (i.e., diversion, emergency landing). • Communicate with a digital network of third-party service providers.
Refuel/Recharge Systems	• Accessible interfaces and sufficient energy to accommodate charging and/or refueling.
Maintenance	• Fleet Management Services shall enable safe and reliable AAM air and ground operations.
Real-Time Planning	• The fleet operations center shall have the capacity to receive and respond to Temporary Flight Restrictions (TFRs) and NOTAMs issued by the FAA.

Infrastructure and community requirements are important because they help to integrate aircraft with existing and new infrastructure and support the safe operation of aircraft. These different requirements range across different areas including physical infrastructure, management systems, and maintenance.

The infrastructure table demonstrates that across all four public good use cases, there is a set of requirements that applies to all these areas. Physical infrastructure captures the material requirements that are essential for the aircraft, but the aircraft cannot provide itself. For example, charging stations, which requires consideration of standard ports, or how much energy and power communities have and can provide. An interesting note when considering the Exhibit is that physical takeoff/landing infrastructure is not included as a cross-cutting requirement. This is because in the two down-selected UAS use cases takeoff can be from a broad range of locations, using smaller ports instead of runways or vertiports.

In addition to physical requirements, infrastructure encompasses management systems such as third-party services, communications, navigation, and real time planning. These factors are crucial because they help the aircraft communicate with ATC, other aircraft, and ground personnel to ensure safe flight operations. In addition, these services help the aircraft to respond to an off-nominal event, such as an emergency, or receiving TFR's from the FAA.

7.3.3 Airspace Cross-Cutting Requirements

While infrastructure helps to support the operation of the aircraft, airspace requirements support safe operations of all aircraft in the NAS. These requirements center on federal separation standards and prioritization. The Exhibit below details the airspace requirements found to cut across the four public good use cases.

Exhibit 10: Airspace Cross-Cutting Requirements

Capability	Cross-Cutting Requirements
Separation	• Operations shall comply with all regulations required for the airspace and type of operations it conducts. • Operator shall gain approval from ATC for missions performed in Class B, Class C, and Class D airspace. • Operator shall maintain safe separation from other air traffic.
Prioritization	• Operators shall comply with right-of-way rules.

An aircraft must comply with airspace requirements to safely enter and fly within the NAS. These requirements range across two cross-cutting key areas: separation and prioritization.

First, separation requirements allow the aircraft to enter controlled NAS airspace, avoid collisions, use the airspace efficiently, and comply with federal regulations. It is envisioned that third-party service providers may manage communication and clearance with ATC; therefore, AAM aircraft must have systems that support integration and communication with third-party providers.[32]

Prioritization is also a key factor in airspace requirements, especially for use cases for public good because it ensures that priority is given to emergency situations. Three of the four down-selected use cases in this section are either disaster or emergency situations that may be eligible for expedited airspace clearance, or priority. This is essential to understand and ensure that the aircraft has all necessary systems to interact with third-party service providers, or ATC, to gain expedited access that may have impact on delivering critical materials or saving lives.

Identifying cross-cutting requirements underscores the requirements that are critical to the core of AAM missions. Therefore, the work done on cross-cutting requirements can mature and support the AAM technology across the broader industry. By understanding which requirements apply to a broader set of applications and use cases, the ecosystem can prioritize their resources.

7.4 Unique Use Case Requirements

While cross-cutting requirements will have impact for the broader AAM industry, this analysis also identifies unique requirements for each use case.

These unique requirements help to guide and inform specific operational constraints that may present challenges to performing the public good use cases highlighted here.

To develop the requirements, the operations and key capabilities were assessed for each of the categories: aircraft, infrastructure, and airspace. This list was analyzed to identify specific and unique requirements for each use case.

The following section details the unique requirements for each of the four down-selected use cases and discusses the nuances that exist. To provide consistent information for the unique requirements, a standardized framework was developed that contains:

- Title of the use case,
- A high-level overview of the general envisioned operation of the AAM aircraft, noting any unique aspects of the mission,
- Identification of unique capabilities the AAM aircraft needs to perform this use case and discussion of what unique requirements correspond, and
- Conclusion and takeaway.

Note: All requirements developed for the use cases in this assessment can be found in Appendix C.

7.4.1 Unique Requirements for Inspecting Critical Infrastructure

The requirements for inspecting critical infrastructure are expected to be similar to those for the corresponding commercial synergy, inspection. Inspecting critical infrastructure with an unmanned AAM aircraft is anticipated to be performed in urban, suburban, and rural areas for scheduled or on-demand inspections. When a stakeholder identifies a piece of critical infrastructure needs either scheduled or on-demand inspection, an AAM aircraft can be deployed, or an aircraft can be driven to the site to launch the UAS to begin the inspection. If an inspector finds an issue that requires closer attention or maintenance, it can then be addressed with further inspection by the AAM aircraft, or additional activities informed by the AAM aircraft data. Once the mission is completed, the AAM aircraft returns to its designated landing point.

The Exhibit below details the unique capabilities identified for inspecting critical infrastructure and the requirements that correspond.

Exhibit 11: Inspection Unique Capabilities and Requirements

Mission Capabilities	Corresponding Requirements
Provide real-time information or capture and store inspection data.	• Shall provide an interface for equipment needed to capture inspection data attached or on vehicle. • Shall have sufficient payload for equipment needed to capture inspection data.
Perform a longer endurance inspection, such as a highway.	• Shall have endurance to complete the applicable mission.
Reach hard-to-access areas and inspect them from different angles, such as underneath a bridge.	• Shall obtain a BVLOS waiver or certification in case of operation underneath critical infrastructure that might cause the operator to lose sight of the aircraft for some time to complete the inspection.

The requirements unique to inspecting critical infrastructure build on the cross-cutting requirements identified in the previous section. While the use case contains the cross-cutting requirements, some may require more nuance and attention based on the specific mission performed. For example, BVLOS provides the operator a greater capability to inspect hard-to reach areas, such as inspecting the underside of a bridge. It is envisioned that BVLOS may become part of general airworthiness for UAS to enable similar operations.

This use case demonstrates the requirements to perform frequent critical infrastructure inspections in a safe manner. Understanding the requirements of this application can inform commercial inspection organizations for needed requirements and best practices for performing inspections for the public's safety.

Exhibit 16 in Appendix C summarizes the requirements developed for inspecting critical infrastructure with the purpose of identifying unique operational aspects and gaps that could support commercial inspection maturity.

7.4.2 Unique Requirements for Delivering Essential Supplies to End User

The requirements for delivering essential supplies to persons during or after a disaster are expected to be like those for the corresponding commercial synergy of delivering packages. This use case is expected to be performed using an unmanned AAM aircraft to deliver a small package to an end user in need of essential supplies during or after a disaster. For this use case, the package is anticipated to be loaded onto the AAM aircraft and is secured for flight. The AAM aircraft then departs from the designated area and flies over to the area where the individual in need is located. The UAS may hover or land to safely deliver the package to the individual. Once the package is delivered, the AAM aircraft departs from the location, and returns to its designated landing point.

The Exhibit below details the unique capabilities identified for delivering essential supplies during and after disasters and the requirements that correspond.

Exhibit 12: Small Package Delivery Unique Capabilities and Requirements

Mission Capabilities	Corresponding Requirements
Reach areas that are inaccessible by traditional means due to damage done by a natural disaster	• Shall be able to detect extreme weather conditions and adjust its flight plan to avoid damage to itself and the package
Deliver supplies that may be identified as essential for life (e.g., food, water, clothes, or medical devices such as Automated External Defibrillators (AEDs) or Portable Oxygen Concentrator)	• Shall be equipped with attachments for different sized packages that will ensure the package will be protected from physical harm, including environmental hazards • Shall have sufficient payload capacity to carry emergency supplies for at minimum one individual
Deliver a package during a disaster where it may not be able to land	• Shall have sufficient battery and reserve power to complete one roundtrip in off-nominal situations where it cannot land

Unique capabilities needed to deliver emergency supplies to the end user may drive additional requirements needed to complete the mission. To deliver to areas that cannot be traditionally accessed due to a natural disaster, a UAS may need to be able to withstand heavy weather, which could add stricter requirements on weather tolerance for the aircraft utilized. In addition, the UAS may be delivering critical medical supplies which could need more secure or controlled carrying compartments. For example, some medical supplies may require temperature-controlled containers. In some cases, the UAS may not be able to land to deliver the supplies, so it must have a function to hover and ensure that the end user can receive the package.

This use case provides understanding of the requirements and benefits of implementing AAM aircraft to perform package deliveries in either developing, dynamic, or emergency situations. This application can be utilized efficiently by organizations whose main purpose is to prepare, protect, respond, and recover against natural disasters and aid persons that are in need and not practical to reach by other means than by UAS.

Exhibit 17 in Appendix C summarizes the requirements developed for delivering essential supplies to persons affected by a natural disaster with the purpose of identifying unique operational aspects and gaps that could support commercial package delivery maturity.

7.4.3 Unique Requirements for Delivering Emergency Supplies to an Emergency Scene

The requirements for delivering emergency supplies are expected to be like those for the corresponding commercial synergy of cargo delivery. These supplies are larger in weight and volume than the previous use case of delivering essential supplies in a disaster response. Delivering supplies to an emergency scene is currently done with traditional transportation methods such as helicopters, fixed wing airplanes, boats, or cars. This use case is envisioned to transport emergency supplies, and potentially backup personnel, from an emergency services hub to the emergency scene utilizing AAM aircraft. This operation could be applied to a wide range of operations such as firefighting, law enforcement, border security, or a medical emergency. It is expected that the respective emergency services center will receive a call reporting an emergency and decide that additional supplies are needed at the scene, based on the nature of the emergency. The AAM aircraft can then be loaded with any equipment specialized to the emergency. For instance, firefighting supplies, explosive defusal supplies, or emergency medical equipment could be deployed to the emergency scene with a remote pilot in control.

The Exhibit below details the unique capabilities identified for delivering emergency supplies and the requirements that correspond.

Exhibit 13: Cargo Delivery Unique Capabilities and Requirements

Mission Capabilities	Corresponding Requirements
Carry enough payload for cargo of emergency supplies and potential additional personnel to address the emergency.	• Shall have sufficient payload capacity to support cargo needed for a myriad of emergency operations. • Shall have sufficient access in order to load, secure, and unload cargo.
Access to remote areas that may not have dedicated infrastructure.	• Shall be able to land without requiring a runway.

Unique capabilities needed to deliver emergency supplies to an emergency scene with an AAM aircraft may drive additional requirements needed to complete the mission. In the use case, the aircraft is envisioned to respond to a time critical event in the most efficient manner; therefore, it may need to be kept in a ready state and does not need a lengthy inspection before being deployed for the mission. When the aircraft arrives on the scene, it may not be able to land on dedicated infrastructure. Therefore, the aircraft must be able to access areas that may not have dedicated infrastructure, such as runways, and instead land on a road, parking lot, etc.

Another component of responding to an emergency is consideration of a range of unique payloads to address the emergency. For example, these aircraft may be carrying more traditional cargo, such as boxes of essential supplies in the aftermath of a disaster, or more specialized payload, such as fire retardant to extinguish a wildfire. Depending on the emergency event, the aircraft's payload will need to be checked and secured.

By understanding and adapting AAM aircraft used for this mission to the unique requirements of the use case, delivery of emergency supplies for public good could be adapted and drive cargo delivery in commercial industries.

Exhibit 18 in Appendix C details the requirements developed for delivering personnel, supplies, or both to an emergency scene with the purpose of identifying unique operational aspects and gaps that could support commercial cargo transportation maturity.

7.4.4 Unique Requirements for rescuing a person from a dangerous event

The requirements for rescuing a person from a dangerous event are expected share some similarities for the corresponding commercial synergy of passenger transportation. Rescuing a person from a dangerous situation is typically performed utilizing traditional helicopter operations.[33] This use case is envisioned to rescue at minimum one passenger from an emergency or critical situation, such as a natural disaster. The passenger in need of rescue could be in a range of different critical emergencies from which physical rescue by AAM aircraft is needed, such as a fire, rubble of an earthquake, or mountainous terrain. The AAM aircraft can be loaded with emergency personnel and medical equipment and then deployed to the passenger in distress. Once the individual in need of rescue is located, they may be boarded onto the aircraft and treated by the emergency professional while the AAM aircraft flies back to the point of departure, or a hospital to provide the person with additional medical treatment if applicable.

The Exhibit below details the unique capabilities identified for rescuing a person from a dangerous event and the requirements that correspond.

Exhibit 14: Passenger Transportation Unique Capabilities and Requirements

Mission Capabilities	Corresponding Requirements
Perform emergency rescue.	• Aircraft shall have the sufficient equipment to perform rescue operation. • Aircraft shall have an entrance large enough to load a person, life support equipment, and medical supplies.
Respond to and provide emergency medical treatment, if necessary, for person.	• Aircraft shall have configuration that can secure necessary medical equipment. • Aircraft shall have a separate source of power for medical devices, in the case of a malfunction to the aircraft's power source, the patient is not put at additional risk.
Respond to unique emergency where a person may be located.	• Flight plan shall be flexible and adaptable.
Rescue a person in emergency or disaster situations where aircraft cannot land.	• Aircraft shall be able to hover. • Aircraft shall have a hoist system for retrieval of a person.

Unique capabilities needed to rescue a person from a dangerous event with an AAM aircraft may drive additional requirements needed to complete the mission. Like the previous use case, the aircraft is envisioned to respond to a time critical event in the most efficient manner; therefore, it may need to be kept in a "ready-to-go" state and does not need a lengthy inspection before being deployed for the mission.

However, this case differs from the two other emergency response use cases in that a passenger could be on board and may be in critical condition. Therefore, the intended destination may be a medical center or hospital, rather than a site of delivery.

Understanding the requirements is essential to reaching operational status of these rescue missions and could save lives through increased efficiency. By understanding how AAM aircraft could be used for a critical public good operation, the requirements could be adapted and drive transportation of passengers in commercial industries.

Exhibit 19 in Appendix C details the requirements developed for rescuing a person from a dangerous event with the purpose of identifying unique operational aspects and gaps that could support commercial passenger transportation maturity.

Understanding the requirements of public good use cases is crucial for driving and sustaining operation of these new technologies. By developing clear and comprehensive requirements for AAM technologies, regulators and industry stakeholders can ensure that these aircraft are designed and operated in a safe and responsible manner.

8.0 Rough Order Ranking

Detailed requirements provide insight into operationalizing the four down-selected public good use cases. To assess the similarity between the requirements developed in this report and the focus of NASA in recent years, the four use cases were ranked in order of similarity when compared to NASA's commercial UAM passenger transportation requirements.

NASA and Deloitte defined UAM as the concept of expanding transportation networks to include short flights that transport people and goods.[34] UAM passenger transportation is envisioned to become a mobility alternative for the public, primarily serving urban areas and extending into the metropolitan periphery. NASA states that UAM has the potential to revolutionize urban transportation networks and play an integral role in future smart cities.[34] The rough order ranking will demonstrate how similar public good use cases are compared to the UAM passenger transportation use case, which has been the focus of much of NASA's AAM research.

NASA provided a developed list of UAM requirements that included 831 total requirements, which were divided into three categories: Design, Functional, and Operational. The 831 requirements provided by NASA do not represent a final list of complete requirements for UAM passenger transportation and are continuing to be developed and matured. For this analysis, the 475 functional and operational requirements were used to evaluate the use cases. From these 475 requirements, the analysis excluded any requirements that put assumptions on the future actions of regulatory bodies.

First, NASA's requirements were analyzed to ensure they could be compared at a consistent level of detail to the requirements developed and listed in Section 7.0 for the four use cases to simplify the communication of the information. These requirements were then used to compare each public good use case to the UAM passenger transportation use case. This comparison aimed to identify requirements for UAM passenger transportation that were also applicable to each public good use case.

Once the analysis was complete, the percent similarity was calculated for each of the four down-selected use cases. The percentages listed below represent the similarity between the public good use case requirements and the UAM passenger transportation requirements. The percent similarity was calculated by dividing the number of requirements from the associated public good use case that are consistent with the UAM passenger transportation requirements by the total number of UAM requirements. Therefore, 100 percent similarity would signify that the identified requirements for the associated public good use case match the requirements for the UAM passenger transportation use case. These percentages are based entirely on the requirements identified in this analysis, which are still being developed and are not considered exhaustive for potential UAM requirements at this time.

By evaluating the requirements of the public good use cases, a rough order ranking was developed based on the degree of similarity to the UAM passenger transportation requirements.

The exhibit below provides an overview of the results of the rough order ranking for each public good use case compared to the UAM passenger transportation use case.

Exhibit 15: Use Case Comparison Percent Similarity

Use Case	Commercial Synergy	Percent Similarity Compared to UAM Passenger Transportation Use Case
Inspecting critical infrastructure, such as bridges or highways, to ensure safety for users.	**Inspection**	**68%**
Delivering essential supplies to persons in need that are not accessible during and after disasters.	**Package Delivery**	**70%**
Delivering emergency supplies to an emergency scene.	**Cargo Transport**	**91%**
Rescuing a person from a dangerous event, e.g., fire, earthquake.	**Passenger Transport**	**97%**

The results are intended to provide a starting point for evaluating how NASA's UAM mission translates to public good applications. These percentages represent a high-level comparison of generalized requirements for public good use cases versus a UAM passenger transportation case.

Rescuing a person from a dangerous event had the most similar requirements when compared to NASA's UAM passenger transportation use case. This is primarily due to the methods of transportation being utilized, the aircraft concepts being employed, and the considerations required when transporting a person. Additionally, both use cases require reliable technology and systems that ensure safe operations and communications with others in the airspace. However, differences do exist due to the intent of each use case. Commercial passenger transportation will be more of a predictable, comfortable experience performed for the convenience of passengers that requires payload capacity for luggage and human factors considerations for interfacing with safety briefings. Conversely, rescuing a person from a dangerous event will be on-demand and seek to reach an individual at an unplanned location quickly and safely to provide aid.

The next public good use case most like UAM passenger transportation is delivering emergency supplies to an emergency scene, or cargo transportation. Like UAM transportation, this use case is envisioned to utilize a larger AAM aircraft. However, the configuration inside the aircraft will differ due to the intent of the cargo transportation use case. For example, space to load and attachments to secure the cargo will be required compared to interior cabin seats and comforts needed to transport passengers.

There are two public good use cases that had the most differences in requirements when compared to UAM passenger transportation. The primary driver for this was the difference in AAM aircraft concepts that would be utilized when performing the public good use cases. These use cases are envisioned to employ a UAS aircraft that would not have the capacity to carry people on board at any maturity level.

Like the use cases discussed previously, delivering essential supplies to persons in need will require flight planning and communications capabilities to complete an AAM mission. However, this use case requires different configurations that are intended to travel short distances without passengers on board. Additionally, UAS payloads are envisioned to be significantly smaller in comparison to heavier UAM aircraft.

The public good use case that is most different to UAM passenger transportation is critical infrastructure inspection. The intent for inspection is to collect data to inform decisions and monitor deterioration of infrastructure typically using sensors and cameras. Additionally, inspection UAS do not require the same infrastructure for takeoff and landing that UAM aircraft do and require less complex charging in comparison.

An important nuance to capture is that three of the four selected public good use cases are envisioned to be emergency or response operations and UAM passenger transport is not. Therefore, there are requirements that exist for these public good use cases that passenger transportation UAM is not concerned with. For example, an operator delivering emergency supplies during a disaster could request expedited airspace clearance and priority when performing the mission. Response cases may also have requirements to ensure resiliency, such as backup power or energy to facilitate the operation during a disaster event.

Comparing public good use cases to UAM passenger transportation helps identify similarities between the operational requirements and informs the industry regarding how AAM missions for public good could support the commercial industry moving forward. The results also provide a better understanding of the requirements associated with each use case, helping to demonstrate the broad applicability of UAM passenger transportation capabilities.

9.0 Conclusion

AAM capabilities have the potential to enhance the services provided to the public while also supporting the advancement of the broader AAM industry who may not pursue public service use cases initially. Benefits of adopting AAM could include improved safety, workforce equity, and access to services for the public. To reach these benefits, a more thorough understanding of AAM for public good is required.

This document provided detailed information to establish a foundation for further discussion that included:

- Unique characteristics to describe attributes of AAM public good missions,
- A definition for AAM missions for public good to help categorize future missions,
- Use cases to provide more detail on the various applications AAM capabilities can support as well as how they are integrated, and
- Requirements to understand the functional and operational requirements that are necessary to operationalize aircraft and integrate AAM into infrastructure and airspace.

Additionally, the work performed here highlights the applicability of NASA's current research and emphasis on UAM to support public good missions and the broader AAM industry in the future. While not intended to be exhaustive, this foundational information can be leveraged and applied to new applications as AAM technology and capabilities continue evolving to benefit society, communities, and the public.

10.0 Appendix A: Use Cases

The following appendix details the 42 use cases developed for AAM missions public good. The use cases are presented in alphabetical order and contain descriptions of potential stakeholders, benefits, the case for public good, and a high-level overview of operations.

10.1 Agriculture

Use Case 10.1.1: Collecting public data on crop conditions to support production of safe and adequate food for the U.S. population.

- In partnership with agricultural producers, the USDA could collect publicly available data on the crop conditions in the U.S.[35] to improve the production of safe and adequate food across the country. Agricultural producers can employ AAM aircraft to collect data such as terrain information, crop conditions, and crop stress factors. The USDA National Agriculture Statistics Service collects data such as crop progress and condition, cropland reports, land use, and disaster analysis from farmers across the country.[36] This data is publicly accessible and helpful to inform U.S. wide current agriculture production. While the agricultural production is owned by private entities and incurs a profit, ensuring that farmer's crops and produce will be sufficient to meet U.S. population needs provides public benefit that may not otherwise be met by society.
- Agricultural land of interest is identified, and a route path is established.[37] The AAM aircraft departs from designated area and flies over the agricultural area of interest while collecting data. Once the mission is complete, the AAM aircraft departs from the location, and flies back to its designated landing point. Crop and terrain data can then be analyzed and shared for public benefit.

Use Case 10.1.2: Mapping agriculture land and terrain to manage and maintain stormwater treatment.

- Stakeholders such as agricultural producers, environmental managers, farmers, contractors, and USDA can use AAM aircraft to map agriculture land to maintain stormwater treatment and management.[38] AAM aircraft can capture topographical data, conduct flow and water quality monitoring, and collect high spatial resolution data on stormwater sights.[39] Using this data, stakeholders that develop stormwater management plans can collaborate to develop the appropriate solution. Using AAM aircraft can lead to more accurate and efficient stormwater management, especially for rural farmers and remote agricultural areas that are difficult to access by traditional ground transportation and aircraft.[40] There is sufficient availability of stormwater safety mapping such that it meets societal needs. This is also a need that is available to all and provides a benefit to the public.

- Stormwater area in need of mapping and management is identified. The AAM aircraft departs from designated area and flies to the target area where it maps terrain and collects intended data. Once the mission is complete, the AAM aircraft departs from the location, and flies back to its designated landing point. At this point, data can be extracted from the AAM aircraft and analyzed.

Use Case 10.1.3: Monitoring and sampling water quality for key metrics, such as water toxicity and contents.

- Under the direction of the EPA and the Clean Water Act, State, Tribal and Federal agencies monitor lakes, streams, rivers, and other types of water bodies to determine water quality condition.[41] These activities may be replaced by an AAM aircraft to produce more efficient and accurate data collection.[42] The data generated from these monitoring activities could help water resource managers know where pollution problems exist, where to focus pollution control activities, and where progress has been made. By ensuring water quality, the EPA could keep a safe standard of water for the U.S. public and ensure communities are provided clean drinking water. Water safety is essential to all the U.S. public and there is sufficient availability of it to meet societal need. This is a good that is available to all and publicly funded.
- The AAM aircraft is equipped with the necessary equipment to monitor water quality, such as sampling materials. The AAM aircraft departs from designated area and flies over or near the surface of the target body of water to collect sufficient data for water quality sampling and analysis. Once the mission is complete, the AAM aircraft departs from the location, and flies back to its designated landing point. At this point, aerial data can be reviewed, and water drawn from the system and analyzed.

Use Case 10.1.4: Surveying and managing water resources during flood or drought seasons.

- Stakeholders such as the federal government, USDA, and contractors, can use AAM aircraft to survey and manage water resources during flood and drought seasons. Although floods and droughts cannot be stopped, data can be put into models to determine where water is likely to flow or droughts are likely to occur. This data informs what flood mitigation measures, like levies, can be built to reduce flood impact.[43] For droughts, AAM aircraft can help to determine ground water levels and detect water waste, even potentially leaks underground.[44] An AAM aircraft has the potential to improve flood and drought data, and thus, better predict and inform mitigation steps for the public. Managing water events that could have negative consequences on the public benefits society, and, if data is made available, it would be available to all.
- A flood or drought in need of risk management is identified. The AAM aircraft departs from a designated area and flies to the target area where it maps terrain and collects intended data. Once the mission is complete, the AAM aircraft departs from the location, and flies back to its designated landing point. Then, data can be analyzed by relevant stakeholders.

Use Case 10.1.5: Transporting supplies, pesticides, or other equipment to assist farms that have sustained pest or crop damage, to prevent far reaching negative effects on other producers.

- Stakeholders such as farmers, producers, contractors, or the USDA can use AAM to transport needed supplies, pesticides, or other equipment to remote agriculture locations to assist farms that have sustained pest or crop damage. Supplies and pesticides can be loaded onto an AAM aircraft and transported to remote or more rural areas with greater efficiency than using traditional ground transportation. By using AAM, stakeholders could respond more rapidly to prevent damage from having far reaching effects on other producers and the U.S. food supply. While the agricultural production is owned by private entities and incurs a profit, ensuring that threats to crops that could reach other farms are mitigated provides public benefit to the holistic U.S. food supply and health of land.
- The need for pesticides or supplies to counter crop damage is determined and the appropriate materials are loaded safely into the AAM aircraft.[45] The AAM aircraft obtains necessary clearances, takes off, and flies to the agricultural site. The AAM aircraft lands and pesticides are unloaded securely. Once the mission is complete, the AAM aircraft departs from the location, and flies back to its designated landing point.

10.2 Border Security

Use Case 10.2.1: Monitoring and surveilling border areas to provide security to the public.

- Stakeholders could include the Department of Homeland Security (DHS)'s Customs and Border Patrol (CBP), regional border patrol agents and officers, and local law enforcement.[46] These stakeholders can use AAM aircraft to improve the monitoring and surveillance of border areas to detect potential threats to the public. AAM aircraft can gather real-time data on the border including scanning for potential threats, coordinating responses, real-time reconnaissance, and providing access to remote areas.[47] The additional data and real-time information can help to provide more comprehensive and efficient information to assist responses that could protect the public from security threats. This data must be stored in a safe and secure location. AAM aircraft use for border safety can be considered a public good because safety is available to all and there is sufficient availability of it to offer to the public. Border security also fulfills a potential gap in public need and is publicly funded.
- AAM aircraft departs from designated area and is flown over the border to surveil designated areas. AAM aircraft collects real-time data and identifies threats. If a threat is identified, Border Patrol can be dispatched. When surveillance is complete, the AAM aircraft departs from the location and flies back to its designated landing point.

Use Case 10.2.2: Providing border patrol agents with additional personnel or supplies in response to a time critical security need or event.

- Stakeholders such CBP, border patrol agents and officers may be presented with time-critical or dangerous situations that require backup personnel or supplies.[48]

AAM could provide expedited transportation needed to resolve a critical situation and protect stakeholder safety. Border safety can be considered a public good because safety is available to all, fulfills a potential gap in public need and is publicly funded.

- The CBP receives an alert for a time critical event or emergency that requires additional supplies or personnel. The AAM aircraft is loaded with necessary staff and equipment, obtains clearance, departs from designated area, and flies to site of the event. The aircraft lands and unloads personnel and cargo to support the response during the event. Once the mission is complete, the AAM aircraft departs from the location, and flies back to its designated landing point.

10.3 Conservation

Use Case 10.3.1: Delivering insecticide to combat invasive environmental threats that could have far reaching detrimental effects to an ecosystem.

- Land management agencies, including the Forest Service, Bureau of Land Management (BLM), Fish and Wildlife Service (FWS), National Park Service (NPS), and non-profit conservation partners can deliver and safely release insecticides to fight off threats to forests and their surrounding ecosystems using AAM aircraft.[49] Utilizing AAM aircraft could improve the ability for stakeholders to combat invasive environmental threats by increasing efficient delivery capability and targeting technology to respond to threats faster. Depending on the case and technology available, an AAM aircraft may use insecticide sprays, baits, or slow-release diffusion to contain an insect population. Controlling invasive insect species helps to maintain and conserve ecosystems, which are available to all, there is sufficient availability for it to meet societal needs, and benefits society.
- Invasive insect species is identified, reported, and the course of action and method to control the population is determined. The AAM aircraft is equipped with the necessary insecticide and function checked to ensure capability. Then, the AAM aircraft is prepared for flight, departs from designated area, and flies to the location of the invasive species. Note, the AAM aircraft may be deployed from the scene itself. Once the AAM aircraft arrives in range of the target, the intended mission is carried out. Once the mission is complete, the AAM aircraft departs from the location, and flies back to its designated landing point.

Use Case 10.3.2: Mitigating Avalanches.

- Stakeholders such as mountain rescue teams, avalanche forecasting control teams, avalanche information centers, and State Departments of Transportation (DOTs) could employ AAM aircraft to perform avalanche mitigation efforts.[26] Instead of risking human life, AAM aircraft could deploy artillery or explosives to trigger an avalanche.[50] Depending on the topography and accessibility to the avalanche path, using AAM aircraft to set off these explosives could reduce cost, increase accuracy, and improve efficiency of using explosive charges or artillery to trigger controlled avalanches. Using an AAM aircraft could also provide increased safety to both the avalanche control teams on the mountains, and the general safety of the public in an avalanche prone area.[51] Controlling avalanches helps to maintain and conserve ecosystems, which are available to all, there are sufficient resources and availability to meet societal needs, serves a public need that would not otherwise be met, and benefits society.

- Need for avalanche control by artillery is identified. AAM aircraft is equipped with proper supplies and artillery and explosives are safely secured. AAM aircraft departs from designated area and flies to target area to trigger avalanche. Artillery is deployed until the avalanche is successfully triggered. Once the mission is complete, the AAM aircraft departs from the location, and flies back to its designated landing point.

Use Case 10.3.3: Monitoring natural resources to improve natural resources management.

- Stakeholders such as Federal Land Management agencies, including the Forest Service, Bureau of Land Management (BLM), Fish and Wildlife Service (FWS), and National Park Service (NPS), can utilize an AAM aircraft to better monitor and manage forests and other natural resources.[52] The AAM aircraft can assist with natural resource management by identifying areas that need attention and by providing real-time information. For example, in forestry management, aircraft could provide real-time information about the health of trees and other vegetation.[53] By identifying any health-related issues early, such as pest-related disease or soil contamination, forest management agencies have more time to plan a course of action and remedy the situation. Improving natural resources management ultimately conserves natural resources and vital ecosystems for the public, which can be considered a public good because natural resources are available to all, benefit society, and serve a public need that is not being sufficiently met.
- An AAM aircraft departs from a designated area and flies over the forest, identifying potential areas at risk, and collects data on the forest and ecosystem health. Once the mission is complete, the AAM aircraft departs from the location, and flies back to its designated landing point. Data from the aircraft is extracted and reviewed to assess forest health and later used for preservation strategies.

Use Case 10.3.4: Obtaining water samples from ocean water to better understand ocean and coastal health.

- Stakeholders such as the National Oceanic and Atmospheric Administration (NOAA), non-profits, and other partners can use an AAM aircraft to observe and collect samples from an ocean and coastal area to gather data, inform response to changes in climate, and identify potential hazards. By assessing ocean and coastal health, the public can be alerted to critical changes in water level or any potential hazards. Currently, NOAA uses satellites, thermometers, and tide gauges, to collect observations. AAM aircraft could be employed to make data gathering more efficient in identifying contaminants in the water, assessing environmental change, monitoring sea-level rise, or surveying the coastline and coastal sea floor.[54] The AAM aircraft could also collect samples that inform critical water data. Future AAM aircraft may have the ability to also operate in and collect data underwater.[55] Collecting samples from ocean and coastal resources is critical to informing the public as sea levels and ocean ecosystems continue to change. Monitoring ocean and coastal health is available to all, fulfills a potential gap in public need, and benefits society.

- An AAM aircraft departs from designated area and flies over the target ocean or coastal area and collects and records data and samples for the intended mission. Once sufficient data has been collected, the AAM aircraft departs from the location, and flies back to its designated landing point. Data from the AAM aircraft is extracted and reviewed to assess ocean health and later used to inform preservation planning or ecosystem risks.

Use Case 10.3.5: Re-locating wildlife to preserve and support ecosystems and habitats.

- Stakeholders such as Federal or State Fish and Wildlife Service (FWS) officials, National Parks Service (NPS), conservation partners, or non-profits can use AAM to relocate animals to improve their survival chances and combat biodiversity loss.[56] In cases of habitat loss or species facing depopulation, stakeholders may choose to relocate herds or populations to conserve their species. Transportation by AAM aircraft, especially electric or hybrid-electric aircraft, instead of helicopters could reduce the impact on the environment and the noise, which may be stressful to animals during transit.[57] Preserving the U.S.'s native species provides a public good by reducing possible depopulation and preserving essential ecosystems. Species conservation is a public good available to all and one that benefits society.
- FWS identifies a population of animals that must be relocated.[58] The AAM aircraft is equipped with all necessary materials for relocation, such as cables to suspend the animal below the aircraft and other necessary equipment to aid in transport. The AAM aircraft is cleared for takeoff and FWS officials or partnered animal conservation staff secure the animal to the aircraft. The aircraft departs from designated area and flies to the targeted location for animal relocation. At the destination, FWS officials unload the animal safely. The process is then repeated until all target animals are safely relocated. Once the mission is complete, the AAM aircraft departs from the location, and flies back to its designated landing point.

Use Case 10.3.6: Tracking wildlife to collect data such as herd migration or population to inform ecosystem conversation.

- Stakeholders such as Federal or State Fish and Wildlife Service (FWS) officials, National Parks Service officials, conservation partners, non-profits, and park rangers, can use an AAM aircraft to more efficiently track herds, gather data on native and endangered species, and monitor invasive species populations.[59] By using an AAM aircraft, wildlife officials can more accurately and efficiently fly over large areas with a birds-eye view to research and track wildlife. AAM aircraft could also minimize the noise and physical disturbances to the animals. Having accurate data on wildlife is essential to inform steps for wildlife ecosystem conservation. Supporting wildlife ecosystem conservation is a public good that is available to all, serves a public need that would not otherwise be met, and benefits society.

- An AAM aircraft departs from a designated area and loiters over the target area to find, track, or collect data on wildlife. The AAM aircraft records and collects data per the metrics it is measuring for the mission. Once sufficient data has been collected, the AAM aircraft departs from the location and flies back to its designated landing point. Data from the AAM aircraft is pulled afterwards and reviewed to assess wildlife health and discover any potential threats to conservation, and it is later used to inform preservation or risks in those areas.

10.4 Disaster Response

Use Case 10.4.1 Delivering essential supplies to persons in need that are not accessible during and after disasters.

- The Federal Emergency Management Agency (FEMA), non-profits, the Department of Homeland Security's surge capacity force for major disasters,[60] and FEMA's Resilient Nation Partnership (FEMA's network of individuals and organizations) offer a variety of programs that could leverage AAM to provide relief supplies to areas impacted by disasters and the survivors with greater efficiency. For example, FEMA offers the Individual and Households Program and the Mass Care and Emergency Assistance program. These programs rely on the delivery of physical supplies, which could be more quickly delivered to underserved or disaster aftermath locations by use of AAM delivery.[61] Items that are currently available for disaster survivors include sheltering items, hygiene kits, infant and toddler kits, durable medical equipment, and food. These kits are stored at FEMA distribution centers and could be delivered by AAM. Providing supplies in the wake of disaster helps to sustain and save lives, which is available to all, fulfills a need not otherwise met by society, and is publicly funded.
- A need for transporting disaster relief supplies by AAM aircraft is identified, and supplies are loaded onboard the aircraft. The AAM aircraft obtains all necessary clearances, departs from designated area, and flies to its intended destination. Depending on the situation, the AAM aircraft may land on a runway, vertiport, or at a mass distribution site. The supplies kits are unloaded from the aircraft to support the impact area or region. Once the mission is complete, the AAM aircraft departs from the location and flies back to its designated landing point.

Use Case 10.4.2: Rescuing a person from a dangerous event, e.g., fire, earthquake, etc.

- Emergency responders, police, firefighters, emergency medical personnel, National Guardsmen, and other rescue workers[62] in collaboration with organizations such as the

Federal Emergency Management Agency (FEMA) have the potential to use AAM to aid in disaster relief by rescuing people in hard-to-reach areas.[63] This could include rescue of people trapped in buildings due to earthquakes, stranded in houses during a flood, stuck in debris of buildings, or located in dangerous areas that need to be evacuated. The appropriate AAM aircraft could be deployed to retrieve the person in danger during or following a natural disaster. AAM rescue missions can be considered a public good because, for those in the afflicted area, emergency response is available to all, fulfills a need not otherwise met by society, and is publicly funded.

- An emergency call is initiated and if response is determined necessary, emergency responders board an AAM aircraft with necessary medical supplies. The flight route is determined, the aircraft departs from a designated area, and the aircraft travels to its destination. The aircraft hovers or lands, dependent on the situation, and the people requiring assistance board the aircraft. On board, the person is then evaluated and if additional medical attention is required, the patient is transported to the nearest hospital facility. Once the mission is complete, the AAM aircraft departs from the location and flies back to its designated landing point.

Use Case 10.4.3: Surveying and mapping the aftermath of disasters to help inform responses.

- After a disaster, Preliminary Damage Assessments (PDAs) are conducted to enable FEMA, along with State, Local, Tribal, and territorial partners, to determine the magnitude of damage and impact of disasters.[64] Deploying AAM aircraft to digitally map damage could help communities efficiently develop more consistent and accurate preliminary damage assessments, especially in damaged areas where the disaster has left public infrastructure difficult to reach. The AAM aircraft would be deployed in the aftermath of the disaster to record data and map territory and damage. Surveying disaster response is a good that is available to all, benefits the public, and is a need that would not otherwise be met by society.
- The AAM aircraft departs from a designated area and is flown over the impacted disaster area while collecting data, taking images, and mapping the damage. Once the mission is complete, the aircraft departs from the location and flies back to its designated landing point. The data is extracted and analyzed to be used to create a damage assessment and inform relief planning and recovery activities.

10.5 Firefighting

Use Case 10.5.1: Delivering emergency supplies or personnel to an emergency scene.

- Stakeholders such as the fire department, National Parks Service (NPS), or Fish and Wildlife Service (FWS) could use an AAM aircraft in a time-critical fire emergency to deliver additional supplies when responding to a fire.[63] Supplies could be loaded onto an AAM aircraft, which would then be deployed from a vertiport or runway. In the case that there is a fire in a remote location, the AAM aircraft could reach the scene of the fire more quickly than a traditional firetruck. By using AAM to deliver supplies, firefighting teams in critical situations can more quickly obtain the supplies they need to respond to an emergency, which can reduce fire damage, rescue more persons, and save more lives. Firefighting is a public good available to all, there are sufficient resources to meet societal needs, and it is done solely for the public's benefit.

- A fire incident is reported, and the emergency response begins. The necessary equipment and supplies are loaded onto the AAM aircraft. The AAM aircraft is prepared for flight, obtains all necessary clearances, departs from a designated area, and flies to the location of the fire incident. Depending on the nature of the fire, the aircraft may land at the scene or descend supplies from above. If the AAM aircraft lands, firefighters are deployed to the emergency and can use additional supplies to provide support in containing or extinguishing the fire. Once the mission is complete, the AAM aircraft departs from the location, and flies back to its designated landing point.

Use Case 10.5.2: Deploying AAM with firefighting capabilities to extinguish a fire.

- Stakeholders such as a fire department, National Parks Service (NPS), or Fish and Wildlife Service (FWS) could deploy an AAM aircraft that has firefighting capabilities, including, but not limited to, an attached water hose or fire extinguishing material, to the scene of a fire.[65] An AAM aircraft can be equipped with methods to extinguish a fire and applied to certain cases that may be preferable to sending a full fire team. For example, an aircraft can reach a wildfire that is too intense for firefighters to physically enter.[66] By deploying AAM to extinguish a fire, averting the emergency can become safer for the firefighters and may result in a faster and more efficient response, and reduce fire damage and persons. Firefighting is publicly funded, available to all, there is sufficient resources to meet a societal need, and it is done solely for the public's benefit.
- Fire incident is reported, and emergency response begins. The AAM aircraft is equipped with the necessary fire extinguishing supplies, such as fire retardant or water. The AAM aircraft may also feature a tank designed to hold water or retardant. Then, the aircraft is prepared for flight, obtains all necessary clearances, departs from a designated area, and flies to the location of the fire incident. Once the AAM aircraft arrives in range of the fire, it performs fire extinguishing activities in the air. When the fire has been extinguished, the AAM aircraft departs from the location and flies back to its designated landing point.

Use Case 10.5.3: Surveillance of a wildland or rural event, such as wildland fire.

- Stakeholders could include local fire departments, National Parks Service (NPS), and Fish and Wildlife Service (FWS). AAM aircraft collects and records live information during a fire emergency to inform fire response. Examples of this information could include monitoring the spread of the fire, surveying for available fuel near the fire, taking thermal imaging to locate persons, and surveying the fireground before and after to assess damage.[67] By using an AAM aircraft, firefighters can gain access to real time data to inform response. A more informed response could result in a reduction of fire damage and decrease in person injuries and casualties. Fire data collection aids firefighting response as a public good available to all, and it is publicly funded.

- Fire incident is reported, and emergency response begins. An AAM aircraft is prepared for flight, departs from a designated area, and flies to the location of the fire incident. Once the AAM aircraft arrives on the scene, it collects and provides the applicable information and data to the fire response team. As the firefighters arrive on the scene, they consider the AAM aircraft data and respond accordingly. Once the mission is complete, the AAM aircraft departs from the location and flies back to its designated landing point. Then, the data from the AAM aircraft can be reviewed and analyzed for future operational planning and training.

10.6 Inspection

Use Case 10.6.1: Inspecting critical transportation infrastructure to ensure safety for users.

- Stakeholders such as qualified inspectors, State Departments of Transportation (DOTs), rail companies, and local governments can use an AAM aircraft to inspect public infrastructure, such as bridges, roads, railways[68], and highways, to ensure transportation safety.[69] AAM aircraft can collect inspection data with greater efficiency by leveraging enhanced aerial camera capabilities and live video and image processing.[70] In the case of bridge inspections, an AAM aircraft also helps inspectors avoid having to place themselves in dangerous situations and removes slower manual processes. Inspection of infrastructure is critical to access and mobility within the U.S., is essential to maintaining a safe transportation system that is available to all, and is publicly funded.
- Critical infrastructure is identified by a stakeholder for regular, scheduled, or case specific inspection. The AAM aircraft departs from designated area and flies over the infrastructure, scanning and capturing applicable inspection data. The inspector receives the data while performing the inspection. Note, if an inspector finds an issue that requires closer attention or maintenance, it will then be addressed with further inspection by the AAM aircraft, or additional activities informed by the AAM aircraft data. Once the mission is completed, the AAM aircraft departs from the location and flies back to its designated landing point.

Use Case 10.6.2: Inspecting energy infrastructure to confirm safe operational status and ensure delivery of energy and power.

- Stakeholders such as utility companies, natural gas pipeline companies, and inspectors can utilize AAM aircraft to perform routine tower and line inspections. Using an AAM aircraft can allow inspectors to stay on the ground instead of climbing towers or flying in aircraft, which can improve the safety and efficiency of inspections. Detecting issues safer and more efficiently that require maintenance can help to provide a more reliable energy infrastructure. Although power and natural gas are services that can be purchased, maintaining the infrastructure provides a benefit to the public and operation of energy infrastructure is critical to society.

- Energy infrastructure is identified by a stakeholder for inspection. The AAM aircraft departs from a designated area. The AAM aircraft flies over and around the powerline or pipeline and captures the necessary inspection data to ensure acceptable and safe operation. The inspector and other relevant stakeholders receive data that can inform the successful completion of the inspection. Note, if an inspector finds an issue that requires closer attention or maintenance, it could be addressed with further inspection by the AAM aircraft or additional activities informed by the AAM aircraft data. Once the inspection is completed, the AAM aircraft departs from the location and flies back to its designated landing point.

Use Case 10.6.3: Monitoring airport infrastructure for potential obstructions to ensure passenger safety for takeoff, taxi, and landings.

- Stakeholders such as Airports, Ground Services, and Air Traffic Control (ATC) can use an AAM aircraft to document potential obstructions to airport operations to provide safety to passengers during taxi, takeoff, and landing. While towers and buildings are well-documented obstructions to airports, wildlife, trees, and other types of vegetation constantly change, which can create safety concerns for pilots.[71] By employing an AAM aircraft to inspect airports, it can efficiently capture aerial views and images of changing obstructions that airports can leverage to quickly mitigate and remove obstructions. Maintaining safe airport operations and the surrounding airport infrastructure provides a benefit to the public.
- Stakeholder schedules an inspection of airport infrastructure. The AAM aircraft departs from a designated area and flies over the airport infrastructure intended for inspection to collect the necessary data and images. The inspector receives the data that informs the results of the inspection. Note, if an inspector finds an issue that requires closer attention or maintenance, it will be addressed with further inspection by the AAM aircraft, or additional activities informed by the AAM aircraft data. Once the inspection is completed, the AAM aircraft departs from the location and flies back to its designated landing point.

10.7 Law Enforcement

Use Case 10.7.1: Responding to a situation or threat to the public to assess the scene and inform coordinated support.

- Stakeholders such as local law enforcement, the Federal Bureau of Investigations (FBI), and Department of Homeland Security (DHS), could utilize an AAM aircraft during active, dangerous situations to support tactical operations on the ground and aid law enforcement. [72] An AAM aircraft can gather more data in real time, which can, in turn, provide greater safety to law enforcement, reduce the number of individuals required to respond to an event, and de-escalate the situation faster for the safety of the public. This data must be stored in a safe and secure location. Law enforcement response to high-risk situations provides safety to the public. Law enforcement is a public good that is available to all, has enough resources available to meet societal needs, and it is publicly funded.
- A dangerous situation is reported to law enforcement and a response is determined

necessary. The AAM aircraft departs from the takeoff point and flies to the location of the incident. The AAM aircraft streams live video of the incident to report to incident command and tactical assets, such as building layout, location of persons, and location of perpetrator. The gathered AAM aircraft data supports the development of a situational strategy by police and applicable law enforcement support. After the active threat is defused, the AAM aircraft departs from the location and flies back to its designated landing point. The AAM aircraft data can be securely reviewed and analyzed for future scenario planning and training.

Use Case 10.7.2: Surveilling prison compound for security purposes.

- Prison security guards, correctional officers, and prison managers could use an AAM aircraft to better surveil the prison compound.[73] In cases of potential compound breaches, security incidents, or inmate escape, an AAM aircraft can provide enhanced aerial data and information to identify and monitor an incident to improve and accelerate the response by relevant stakeholders. By using an AAM aircraft to surveil prisons, the safety of the inmates, prison guards, and public could be improved. This data must be stored in a safe and secure location. Prison security serves a public need and benefits society.
- Prison security becomes aware of an incident or need to deploy an AAM aircraft, such as an attempted escape. The AAM aircraft departs from a designated area and flies to the scene of the incident. The AAM aircraft remains in air capturing data, such as live video, until the situation is resolved, or it has provided sufficient information for the prison to prepare a response to the incident. Once the mission is complete, the AAM aircraft departs from the location and flies back to its designated landing point. Data can be reviewed afterwards to improve future operations.

Use Case 10.7.3: Tracking and locating a suspect fleeing a crime scene.

- Law enforcement such as police, state troopers, or FBI can utilize an AAM aircraft to track a suspect fleeing a scene that may otherwise not be easily located. When a suspect flees a scene, an AAM aircraft can offer a view from above that provides critical information and can enable law enforcement to position themselves appropriately on the ground and track the suspect.[74] By tracking and locating suspects fleeing a crime with AAM, law enforcement could better secure the area, alert the public to potential danger more reliably, and provide enhanced public safety. This data must be stored in a safe and secure location. Tracking fleeing suspects provides safety to the public that is available to all, meets a need that would not otherwise be met, and it is publicly funded.
- Suspect flees the scene of a crime and law enforcement decides that an AAM aircraft would be preferable to locate and track the suspect.[75] The AAM aircraft departs from a designated area to scan an area while broadcasting live video to locate the suspect. Once the AAM aircraft has located the suspect, it follows the individual and continues to send live information to law enforcement about the suspect's position. Law enforcement then utilizes the data to plan their countermeasures and strategic positioning accordingly. Once the suspect has been apprehended, the AAM aircraft departs from the location

and flies back to its designated landing point. The data is securely stored.

Use Case 10.7.4: Transporting appropriate personnel or equipment for response to time critical explosive threats.

- Stakeholders such as law enforcement, security personnel, specialized bomb disposal units, first responders, police, or SWAT teams may use AAM to respond to time critical explosive threats.[76, 77] Once a threat has been reported and response is coordinated with all stakeholders, it may be determined that utilizing an AAM aircraft to transport the proper responders and equipment to disarm or contain the explosive is more efficient or faster than traditional methods. Using AAM could provide a more efficient and timely response, which can be critical to ensuring fast containment of the potential explosive in question. Explosive threat aversion provides safety to the public, is available to all, has enough resources available to meet societal needs, meets a need that would not otherwise be met, and is publicly funded.
- A bomb threat is reported to stakeholders and AAM aircraft is determined to be necessary to contain or disarm the threat. The AAM aircraft is loaded with explosive de-escalation supplies and personnel, gains clearances for takeoff, and flies to the emergency location. The aircraft lands, and the bomb threat response stakeholders and materials are delivered. Once the emergency is averted, the AAM aircraft departs from the location and flies back to its designated landing point.

10.8 Medical

Use Case 10.8.1: Delivering essential medical supplies during disaster response, such as an Automated External Defibrillator (AED), to save lives.

- Stakeholders such as non-profits, FEMA, emergency medical services, emergency medical responders, and FEMA partners could use AAM in cases of medical emergency in disaster. In times of medical emergency, providing the necessary medical supplies can be critical to the survival of community members, for example if an AED is needed. During a disaster, an AAM aircraft could reach a person in medical need faster than traditional road-based vehicles or aircraft, which may need infrastructure that may be damaged or blocked due to the disaster.[78] The potential time saved by utilizing AAM could make the difference in saving a person's life. AAM disaster relief can be considered a public good because, to those in the afflicted area, emergency response is available to all and fulfills a need not otherwise met by society.
- Emergency call is initiated and if delivery of medical supplies is determined critical, the AAM aircraft is loaded with medical supplies and any necessary staff or stakeholders. The AAM aircraft receives a clearance, departs from a designated area, and flies to the medical emergency location. The aircraft hovers or lands to deliver the medical supplies. If additional medical attention is required, the patient can be transported to a hospital facility. After delivering the medical supplies, the AAM aircraft departs from the location and flies back to its designated landing point.

Use Case 10.8.2: Delivering organs for transplant.

- Stakeholders such as non-profits, hospitals, and organ procurement partners could use AAM to deliver time critical organs needed for transplant.[79] In addition to finding a match, time is one of the most critical factors in delivery of organs from donors to recipients.[80] AAM aircraft may have the potential to move organs directly from point to point in the air.[81] This may make the organ transplant network faster, safer, and more cost-effective. AAM organ transplant could be considered a public good because it benefits society.[81]
- Organ match for transplant is located. The AAM aircraft is loaded with the medical supplies needed to preserve, store, and safely contain the organ during flight, plus any necessary staff or stakeholders. The AAM aircraft departs from a designated area and flies to the organ delivery location. The aircraft hovers or lands to deliver the organ. After the organ is delivered, the AAM aircraft departs from the location and flies back to its designated landing point.

Use Case 10.8.3: Delivering Personal Protective Equipment (PPE) during a public health emergency.

- Stakeholders such as non-profits, federal organizations, the Department of Health and Human Services (HHS), and other health organizations can use AAM to transport PPE.[82] During a public health emergency, stakeholders track transmission and public health data. AAM aircraft could be used to deliver PPE by loading it as cargo and flying it to areas of high transmission or areas lacking sufficient supply or access.[83] AAM delivery can help to reach typically underserved or remote communities more efficiently to better supply the public with essential goods and supplies. The effects of a public health emergency can be far reaching, and actions taken to mitigate the negative effects, such as providing PPE, are available to all, fulfills a potential gap in public need, benefits society, and the end user does not have to pay an additional cost above the taxes that fund public operations.
- Flight and delivery routes are determined based on need for PPE during a public health emergency. The PPE is loaded as cargo onto AAM aircraft, and the AAM aircraft receives all necessary clearances, departs from a designated area, and flies to the delivery location(s). The AAM aircraft lands and the PPE supplies are unloaded. Once the mission is complete, the AAM aircraft departs from the location and flies back to its designated landing point or the next delivery site.

Use Case 10.8.4: Distributing vaccines during a public health emergency to individuals who may lack mobility to access them themselves, are in remote locations, or public mass vaccination sites.

- Stakeholders such as non-profits, federal organizations, and the Department of Health and Human Services (HHS),[84] can use AAM to transport vaccines for distribution and administration. During a public health emergency, if a vaccine is made free and available to the public through federal funding, such as during the COVID-19 Pandemic, the government could partner with stakeholders to transport and deliver vaccines. AAM delivery of vaccines can help to reach typically underserved populations or remote communities. Additionally, for vaccines that may have specific conditions for transport or varying shelf lives, the efficiency AAM could offer could help to save lives.[85] [86] Vaccines are available to all, there are enough resources to serve the public need, and it is done for the public's benefit.

- Flight and delivery routes are determined based on need for vaccine supply during a public health emergency. Vaccines are acquired and loaded as cargo onto AAM aircraft. The AAM aircraft is equipped with proper storage to ensure that vaccines are stored and transported at the correct temperatures and conditions. The AAM aircraft receives all necessary clearances, takes off, and flies to delivery location(s). The AAM aircraft lands, and vaccination supplies are unloaded and taken to be distributed. Once the mission is completed, the AAM aircraft departs from the location and flies back to its designated landing point.

Use Case 10.8.5: Patient transfers between medical facilities.

- Stakeholders such as hospital management could use AAM to provide efficient patient transportation between medical facilities. Medical facilities may need to transport patients between medical facilities due to lack of capacity or lack of capability.[87] AAM could be used to bridge these gaps and challenges for healthcare, by providing a more efficient method of transportation between medical facilities. This could, in turn, enhance access and quality of treatment of medical care for patients and the public by balancing patient counts or more efficiently transporting patients to medical facilities with the capabilities needed for treatment. Patient transfer provides a benefit to society.
- Capacity imbalance or capability at another medical facility for patient is identified. The AAM aircraft is loaded with medical supplies and any necessary doctors or stakeholders. The AAM aircraft receives clearance, departs from a designated area, and flies to the second medical facility. Staff unload and treat patients at the medical facility destination. When the schedule of patients and care is finished, the AAM aircraft receives clearance, departs, and flies back to its designated area.

Use Case 10.8.6: Transporting first responders, doctors, or patients to the scene of an accident or a medical facility.

- Stakeholders such as first responders, doctors, non-profits, and emergency medical services could use AAM in cases of medical emergency to provide care at the scene of an accident requiring medical attention. For time-critical medical cases, AAM air transport could offer more efficient transport and bring the critical care skills and resources of the trauma resource hospital directly to the bedside or accident scene.[88] AAM's potential to bring more efficient and better care to time-critical medical emergencies provides a time and resource benefit to the patient that could make the difference in saving patients' lives. Transportation of first responders to an accident has sufficient availability for societal needs to contribute to quality of life, is available to all, and meets a need that may not otherwise be met by society.

- Emergency call is initiated and if medical responders are needed on a critical emergency scene, the AAM aircraft is loaded with medical supplies and any necessary doctors or stakeholders. AAM aircraft receives clearance, departs from designated area, and flies to the medical emergency location. The aircraft hovers or lands to deliver the medical treatment and care. If additional medical attention is required, the patient can be transported to a hospital facility. After the response is complete, the AAM aircraft departs from the location and flies back to its designated landing point.

Use Case 10.8.7: Transporting personnel and doctors to a more remote location to improve rural medical care.

- Stakeholders such as doctors, nurses, non-profit partners, and hospital management, could use AAM to provide efficient transportation from urban to rural hospitals. Many rural American population groups experience significant health disparities that may be caused by rural risk factors such as geographic isolation, lower socioeconomic status, higher rates of health risk behaviors, limited access to healthcare specialists and subspecialists, and limited job opportunities.[89] AAM could be used to bridge these gaps and challenges for rural healthcare, by providing a more efficient method of transportation for doctors to reach rural patients. This could, in turn, enhance access and quality of treatment of medical care for patients and the public located in rural areas. Transportation of doctors to rural locations meets a societal need that may not otherwise be met by the private market.
- A rural area in need of doctors is identified. An AAM aircraft is loaded with medical supplies and any necessary doctors or stakeholders. The AAM aircraft receives clearance, departs from a designated area, and flies to the hospital or medical care rural location. Doctors and staff unload and treat patients in the rural area. When the schedule of patients and care is finished, the AAM aircraft receives clearance, departs, and flies back to its designated area.

10.9 Other Applications

Use Case 10.9.1: Delivering food or supplies to those in need.

- Stakeholders such as non-profits, volunteers, and food banks could leverage AAM to perform delivery of essential food and supplies to underserved and in-need populations.[90] In 2021, 6.4 percent of U.S. households had what the USDA defines as low food security, and 3.8 percent of households had very low food security.[91] There are a variety of non-profits and organizations that could leverage AAM to meet food insecurity needs more efficiently. Food and supplies could be loaded onto an AAM aircraft and transported from the supply location to the destination to decrease delivery time. In addition, the efficiency that AAM offers could help to reach more rural and remote areas that are typically underserved. Using AAM to deliver food and supplies to those in need fulfills a potential gap in public need, benefits society, and is available with no additional cost to the end user

- Stakeholder identifies need for efficient AAM delivery of food and supplies to underserved population. An AAM aircraft is loaded with food, supplies, and any necessary stakeholders. The AAM aircraft receives clearance, departs from a designated area, and flies to the site of food and supplies distribution. Stakeholders and staff unload and distribute supplies to target benefiters. When the supplies have been properly distributed, the AAM aircraft receives clearance, departs, and flies back to its designated area.

Use Case 10.9.2: Operating to further research technology with potentially low Technology Readiness Level (TRL) equipment that is not certified to operate in FAA designated airspace.

- Operating AAM concepts with potentially low TRL could be utilized by NASA and the DOD to perform research and test novel technology. This could accelerate the maturity of AAM technology and the identification of solutions for challenges regarding the systems and their use. These operations could be performed at a test site location that has restricted airspace, reducing risk and making other aircraft operators aware of the operations and their purpose. Further researching and testing low TRL technology will help accelerate the development and implementation of equipment, infrastructure, and AAM aircraft that could be utilized by the public in the future. This is considered a public good use case because there is no additional cost to the end user, and it has the potential of benefitting the public.
- Stakeholder identifies technology to be tested and test location. An example of this could be development of Detect and Avoid (DAA) operational concepts and technologies. Stakeholder deploys multiple AAM aircraft with communication, navigation, and surveillance (CNS) capabilities into the restricted airspace and tracks the detection of unmanned air traffic. Operators collect data and identify challenges in the operation. The AAM aircraft return to base and land. After testing is complete, the aircraft depart from the location and fly back to their designated landing points.

Use Case 10.9.3: Transporting the public during major events to augment mass transit.

- Flexible augmentation of mass transit during major events could be offered by the DOT, public transportation agencies, and airline providers of AAM. This service has the potential of dispersing large crowds while helping support rapid response to disruptions for emergency transport, if needed. This could be done by deploying AAM aircraft to transport people within an urban area during events such as concerts, music festivals, sport tournaments, or conventions. In this case, the public and first responders would benefit from reduced travel time due to a reduction in traffic. Transportation of people to a major event fulfills a gap in public need, is available to all, and benefits society.
- Major event in urban area is identified. Flight routes are determined across possible major congested road routes. An AAM aircraft is on standby to perform multiple short routes for transporting the public. Passengers are loaded into the AAM aircraft. The AAM aircraft receives clearance and departs from a designated area. The AAM

aircraft flies across the pre-determined route, performs a landing, and releases passenger at the destination. The AAM aircraft loads passengers from the destination and flies back to the original departure location to transport a second group of passengers. AAM aircraft performs same route multiple times throughout the duration of the major event.

10.10 Search and Rescue

Use Case 10.10.1: Locating lost or stranded person(s) in distress to assess and coordinate a recovery response.

- Stakeholders, such as search and rescue units and National Parks Service (NPS) park rangers, could use AAM aircraft to search for and rescue people in remote locations.[92] Deploying an AAM aircraft for search and rescue can improve the ability to locate lost persons and provide a faster, potentially life-saving response. In remote locations, such as mountainous or heavily forested terrain, the AAM aircraft can reach areas faster than traditional ground transportation, map terrain to pinpoint places where the missing person may be located, and use thermal imaging to search for the lost person(s). In cases where response time may be a critical factor for survival, the AAM aircraft provides an available-to-all service that fulfills a potential gap for public in need of rescue.
- A search and rescue team are alerted of a missing person. Information is gathered from caller or report of last seen whereabouts and estimated location.[29] The AAM aircraft departs from a designated area and flies to scan and map the last known area of the lost person, gathering data on the terrain to determine where the person may be located. Leveraging real-time images and video, the status and location of the person can be assessed. If a person needs physical rescue due to injury, the rescue team is deployed to the location of the person. While waiting for the rescue team to arrive, certain AAM aircraft may be equipped with loudspeakers that will allow communication, alerting the lost person that rescue is on the way or providing lifesaving instructions. In less critical cases, the AAM aircraft could provide light to guide the lost individual back to a trail or to safety. Once the search and rescue efforts are completed, the AAM aircraft departs from the location and flies back to its designated landing point.

Use Case 10.10.2: Transporting personnel and equipment to a person(s) trapped in a remote location.

- Stakeholders could include search and rescue units, National Parks Service (NPS) park rangers, emergency medical responders, and volunteers. In cases where physical rescue of a person is required, the AAM aircraft would transport necessary personnel and equipment to a safe landing location near the trapped person. The AAM aircraft could then be used to transport personnel following the retrieval of the person(s) or to transport the person(s) to a medical facility for care. In cases where response time may be a critical factor for survival, AAM provides an available-to-all service that fulfills a potential gap for public in need of remote search and rescue.
- Search and rescue team is alerted of a person trapped in remote location in need of

rescue. Information is gathered from caller or report of last seen whereabouts and estimated location. If additional personnel or equipment is necessary, the AAM aircraft is loaded to support rescue. The AAM aircraft departs from designated area, flies to the person in need of rescue, and hovers or lands dependent on the circumstance. Once the person(s) has been rescued, the AAM aircraft departs from location and flies back to designated landing point, or the closest medical facility for the person(s) to receive care.

10.11 Weather

Use Case 10.11.1: Monitoring weather and micro weather data to inform forecasts and data for the public.

- The National Oceanic Atmospheric Administration (NOAA) and the National Weather Service (NWS) could utilize AAM to improve daily weather forecasting. AAM offers the possibility of collecting weather data from the lower and middle atmosphere through high-resolution and direct measurements of temperature, humidity, air pressure and wind.[93] These data points can then be incorporated into weather model calculations to improve weather forecasts. Using AAM could help to provide more accurate and detailed weather forecasts to the public. In addition, more accurate weather data can be crucial for other daily societal operations such as air traffic operations at airports, or to be able to warn of tornadoes or hurricanes at an early stage. Weather forecasting is a public good because it fulfills a potential gap in public need, is at no additional cost to the end user, and is available to all.
- Need for AAM weather monitoring is identified and the AAM aircraft departs from a designated area and is flown over or through the weather area.[96] The AAM aircraft collects imagery and weather data to be used by the forecast centers. This data will help weather forecast centers and scientists better predict weather and anticipate any potential hazards. Once information is collected, the AAM aircraft departs from the location and flies back to its designated landing point.

Use Case 10.11.2: Researching and monitoring the progression of natural disasters, such as hurricanes or tornadoes, to inform disaster response.

- The National Oceanic Atmospheric Administration (NOAA) monitors the progression of natural disasters such as hurricanes or tornadoes to inform disaster response to public. The data may be shared with private industry, the academic research community, and the public.[94] These AAM aircraft flights allow forecasters to collect critical data that reveals how a storm is moving and changing. AAM aircraft in severe storms, such as hurricanes, can send real-time data back to the National Hurricane Center, which uses the information to produce hurricane tracking and intensity forecasts.[95] The information allows for a more refined and accurate forecast, which could improve disaster response and save lives of individuals in the affected area. Using an AAM aircraft in natural disasters can be considered a public good because it fulfills a potential gap in public need, is at no additional cost to the end user, and is available to all.
- A weather event is identified and the AAM aircraft departs from designated area and is flown over or through the weather event. The AAM aircraft collects imagery and weather

data to be used by the forecast centers.[96] This data will help weather forecast centers and scientists better estimate storm intensity and potential hazards with information observed from the AAM aircraft. Once information is collected, the AAM aircraft departs from the location and flies back to its designated landing point.

11.0 Appendix B: Metrics Analysis

The following appendix details the metrics developed for the ten down-selected use cases. The use cases are presented in three distinct categories: observation, delivery, and response.

11.1 Observation

Utilizing AAM for monitoring, surveilling, and inspecting could provide significant benefits for the public and communities. An AAM aircraft can quickly fly over hard-to-reach areas and provide high-quality aerial images and real-time footage. Not only can this help improve inspection of critical infrastructure and management of natural resources and natural disasters, but it can also help reduce the safety risk of the individuals responsible for providing these services. The following sections identify key metrics pertaining to use cases focused on observation operations while discussing the aspects of the current operation that could be improved through the implementation of AAM.

11.1.1 Inspecting critical infrastructure to ensure safety for users.

Critical infrastructure, such as roads and bridges, is required to be inspected and evaluated for safety against national and state standards.[97] State Departments of Transportation have an inventory of critical infrastructure that they track for age, deterioration, bridge damage or other concerns. When a piece of infrastructure is scheduled for inspection, a crew size is determined and then sent to the location with all necessary manual tools and equipment.[98] The inspection is conducted, and if any safety issues or structural concerns are identified, action is immediately taken to post weight limits, detour traffic, and repair these structures. The impact of new AAM capabilities will be described in the following metrics.

Metric 11.1.1.1: Safety Risk to Provider

- Safety is one of the top concerns in performing bridge inspections and maintenance activities.[99] In order for inspections to comply with the required criteria, inspectors must collect manual data on all the critical structural components of physical infrastructure, potentially posing a risk to their safety. For example, bridge inspection entails inspecting the bridge deck, superstructure, and substructure, including the abutments and piers. It can be challenging to reach many of these areas, especially those that are high above and underneath bridge decks. Using AAM aircraft such as UAS to inspect bridges allows inspectors to remain on the ground while gaining visualization to collect data. AAM aircraft could offer increased safety for the provider by reducing the risk traditionally encountered during infrastructure inspection operations.

Metric 11.1.1.2: Operational Time

- A leading problem contributing to the backlog of infrastructure inspections is the time it takes to perform them. With a well-equipped UAS, the operator may be able to complete the inspection of critical infrastructure more quickly due to the aircraft's ability to maneuver around the areas of interest. Additionally, an AAM aircraft could remove or reduce the need to set up and use heavy machinery by flying to the hard-to-reach places, such as under bridges, to take images and assess any structural deficiencies more quickly than with a traditional crew.[100]

Metric 11.1.1.3: Service Accessibility

- Across the U.S., there are many communities that have aging or inaccurately inspected infrastructure, such as country roads or remote bridges located in underserved or rural communities. Using AAM to conduct inspections could provide more efficient and accurate data collection, leading to greater detail and more precise inspection reports. By leveraging AAM, underserved communities could increase the number of inspections performed in their area, obtain better data on neglected infrastructure, and identify more areas of concern.

Metric 11.1.1.4: Data Accuracy

- Manual inspections are susceptible to human error when examining infrastructure due to reliance on human perception. This can lead to inaccurate or inconsistent inspections that could overestimate the safety of a structure. AAM aircraft can provide data through high-resolution photos, videos, thermal images, and even 3D models that significantly increases inspection accuracy in comparison to traditional methods.

Metric 11.1.1.5: Operational Cost

- Transporting the required inspection crews and materials can be costly and time consuming. Additionally, manual bridge inspections are often slow processes that require the service provider to reposition multiple times to ensure adequate exposure to the infrastructure. Alternatively, AAM aircraft can be piloted from the ground and maneuvered around the infrastructure of interest, reducing operational cost.[101]

Metric 11.1.1.6: Net Carbon Emissions

- Inspections require specialized vehicles to transport materials such as snooper trucks, which are used to perform inspections under bridges.[102] These snooper trucks and other heavy inspection machinery have low gas mileage, which can contribute to carbon emissions.[103] AAM aircraft could replace snooper trucks and other heavy inspection machinery, which could lower carbon emissions when performing inspections. It is estimated that using AAM aircraft, such as UAS, to supplement the inspection of only a small subset of the bridges in the U.S. may be equivalent to removing thousands of cars from the road, improving climate resilience.[103]

Metric 11.1.1.7: Number of People Willing to Serve in a Higher Risk Environment

- Currently, the qualifications for becoming an infrastructure inspector include a bachelor's degree, years of experience, and additional specialized on-site training. Due to the physicality requirements of the inspection occupation, especially for more high-risk inspection operations, there may be a risk-averse portion of the labor market that self-selects away from this profession. Because AAM allows inspectors to perform operations from the ground, risks that exist during some inspections can be reduced, creating opportunities for people to join who otherwise would not.[104]

Metric 11.1.1.8: Workforce Equity

- Inspecting critical infrastructure often requires the inspector to perform activities such as heavy physical work, work in confined spaces, climbing and descending ladders, lifting, carrying, pushing, or pulling heavy materials and objects.[105] These factors could create barriers and provide physical obstacles that limit job functionality. Utilizing AAM aircraft such as UAS could provide opportunities to eliminate the need for a person to perform these strenuous physical activities. UAS can be utilized to perform inspections in confined spaces or high-rise areas where climbing might be needed. In the future, UAS might also be able to carry heavy weight material or equipment that might decrease the physical job performance requirements. AAM could be leveraged to enable an equitable workforce by providing more job opportunities without physical barriers.

Metric 11.1.1.9: Greater Access to Perform the Operation

- A traditional infrastructure inspection typically involves setting up work zones, detouring traffic, and using heavy equipment to gain access to the area where the inspection needs to be performed.[106] These factors can limit the number of missions that can be performed. AAM aircraft have the potential to increase the number of missions performed in areas that may have previously been too time consuming or dangerous, such as underneath high areas of bridges.

Metric 11.1.1.10: Provides Data to Enhance or Support Tangential Industries

- The infrastructure inspection industry is closely tied to the construction and construction material industry. For example, when a road is determined to need repair, construction crews are brought in and the necessary materials are contracted.[107] Inspecting critical infrastructure with AAM could increase the amount of data collected, such as high-resolution images, videos, thermal images, and 3D models. Construction companies could benefit from this by having increased data about types of asphalt or concrete that remained in good condition or how well different architectural designs performed over a period of time. The amount of data AAM could provide could help improve the development of infrastructure and construction materials that are utilized.

11.1.2 Monitoring natural resources to improve natural resources management.

Natural resources such as forestry, wetlands, wildlife, and ecosystems are closely monitored today by a range of stakeholders who employ various methods including manned aerial surveillance, manual sample data collection, and satellite imaging. Examples of metrics collected, according to the National Parks Service (NPS), include weather and climate, water chemistry, land cover and use, invasive species, wet and dry deposition, and mammals. The goal is to enhance natural resource monitoring and improve wildlife, biodiversity, vegetation, and forestry conservation. The impact of the new AAM capabilities will be described in the following metrics.

Metric 11.1.2.1: Safety Risk to Provider

- Traditional methods of collecting natural resource data are a collective effort between scientists, resource specialists, park managers, and data managers.[108] Although satellite imaging and helicopters have become more popular, there are still many natural resource stakeholders who collect data manually at the location. These stakeholders travel to the site and manually measure key metrics by collecting water, air, and soil samples or placing GPS tracking on mammals. In these physical cases, there is risk for potential dangerous and unpredictable safety incidents. AAM aircraft can reduce operational risks by replacing the need for physical collection in dangerous terrain or near potentially harmful species. UAS could be equipped to conduct soil analysis in real-time using multispectral cameras, or fly above the wildlife herd to track them, instead of having a person on the ground that could be at risk for an incident.[108]

Metric 11.1.2.2: Service Accessibility

- The Environmental Protection Agency (EPA) states that there persists disproportionate environmental inequity for underserved communities, such as those in rural areas, indigenous communities, and communities of color. Many of these communities lack the access and services to adequately manage their natural resources. For example, there are typically higher concentrations of toxic air pollution and water pollution near communities of color.[109] AAM has the potential to provide access to services unavailable to historically underserved communities through reduced operational costs and more efficient natural resource monitoring. For instance, a rural community that is hard to reach or monitor may receive monitoring services from AAM aircraft that could more easily access the areas.

Metric 11.1.2.3: Data Accuracy

- Data accuracy when monitoring natural resources is very important when attempting to understand the health of forests, lakes, and rivers, for example. Data collected manually does not require complex technology but human error may be present, and images captured by satellites have limitations on their resolution.[110] AAM aircraft can be deployed with high-resolution sensors to map forests, sample vegetation, or monitor and manage the health of forests at a level that satellites cannot capture. UAS can also fly at significantly lower altitudes than satellites, which decreases the impact of certain atmospheric conditions compared to satellites, such as cloud cover.[111]

Metric 11.1.2.4: Operational Cost

- A challenge when collecting data on natural resources, such as forests or land, is the sheer size of the U.S. Forests in the U.S. cover millions of acres of land, which can be time consuming and costly to monitor. Current technology used includes satellites that can be limited by resolution and LiDAR (remote sensing technology that analyzes reflected light) that can be costly, especially for large forest areas. AAM aircraft have the potential to offer a more affordable and accurate solution when monitoring large natural resources. For forest monitoring, it is estimated that using a UAS costs less than a tenth the cost of some equivalent flights by traditional methods.[112]

Metric 11.1.2.5: Carbon Emissions

- Conventional airplanes and helicopters are currently used to travel to sites to collect natural resource data. Fuel is the main source of carbon emissions throughout a conventional aircraft's lifecycle.[113] However, AAM vehicles are leveraging alternative energy sources, such as electricity and hydrogen, for propulsion and power, which may produce fewer carbon emissions than traditional aircraft. By utilizing AAM aircraft, carbon emissions can be reduced during the monitoring of natural resources.

Metric 11.1.2.6: Workforce Equity

- Currently, collecting data to monitor natural resources is performed through satellite imaging and traditional aircraft, but there are still many natural resource stakeholders who collect data manually at the location. Scientists manually measure key metrics by collecting water, air, and soil samples or placing GPS tracking on mammals in environments that might be difficult to navigate such as forests, lakes, swamps, and caves to name a few. These environments present a limitation on the data collector and can sometimes provide physical obstacles that limit job functionality. AAM aircraft offer the capability of flying over areas to survey and collect data without the need for a person to obtain the data manually. AAM could be leveraged to enable an equitable workforce by providing more job opportunities to gather data in physically hard to navigate environments.

Metric 11.1.2.7: Greater Access to Perform the Operation

- The U.S. Department of Agriculture Forest Service manages millions of acres of land, which includes areas such as mountains, bodies of water, and forests that can be difficult and expensive to reach using conventional helicopters or planes.[114] AAM aircraft such as UAS can quickly take off and fly over hard-to-reach areas to capture data. The accessibility that AAM aircraft provide could allow natural resource managers to cover and monitor areas that may not have been sufficiently monitored or accessed before.

Metric 11.1.2.8: Provides Data to Enhance or Support Tangential Industries

- Natural resource data is an essential part of daily operations and conservation efforts for U.S. agencies, such as the Fish and Wildlife Service (FWS), Forest Service (FS), National Parks Service (NPS), and Environmental Protection Agency (EPA), but could also have broader applications for non-profits and companies in the conservation space.[115] The amount of data collected is important because it informs research, education, and future conservation efforts. Certain research areas, such as wildlife monitoring, are still being performed manually. AAM aircraft offer the capability to survey a larger area and collect more data.[116] For example, a study on applying UAS to sea turtle conservation found that AAM was better at monitoring and counting sea turtles and provided more significant data than traditional methods. This increased data due to AAM could support tangential industries, non-profits, or businesses interested in improving conservation efforts.

11.1.3 Surveillance of a wildland or rural event, such as wildland fire.

Tracking and monitoring wildland and rural events, such as wildfires, requires the most accurate, live information available.[117] Today, wildfire monitoring is conducted with satellites by stakeholders such as NASA and NOAA. In addition, NASA has a fleet of research aircraft carrying the latest sensor technologies that can be used for Earth observations.[118] The more accurate the data of wildland or rural events, the better informed a response can be and could result in a reduction of fire damage, prevention of firefighter incidents, and decrease in person injuries and casualties. The impact of the new AAM capabilities will be described in the following metrics.

Metric 11.1.3.1: Safety Risk to Public Involved in Operation

- Each year thousands of wildfires burn many acres of land and can cause injury and fatalities. A couple of the driving factors in casualties and injuries from fire are the unpredictable spread and average response time, where every second counts.[119] AAM aircraft allow responders to scan large areas quickly to identify spot fires that may be at a short distance from the main fire. This enables firefighters to use an AAM aircraft with fire suppression capabilities to suppress those hot spots before they grow, reducing response time and increasing the survivability rate for the public.[120]

Metric 11.1.3.2: Safety Risk to Provider

- Wildfire response requires physical undertaking and exertion from the provider that may put their life at risk.[121] AAM aircraft could provide support to firefighters to help improve their safety. During a fire, when firefighters are engaged in extinguishing a fire, AAM aircraft can send an “early warning” to firefighters if they are in danger or if local winds shift and divert the fires toward personnel. AAM aircraft can also help in search and rescue missions using infrared imaging. These important pieces of data could help improve the safety of firefighters and reduce number of incidents.

Metric 11.1.3.3: Operational Time

- The Forest Service uses planes of many types and sizes to manage wildland fires. Some are owned by the Forest Service while many are leased or contracted, and during times of high fire activity, military aircraft may be activated. These planes require long onboarding of supplies, crews, pilots, and clearance before taking off to collet aerial data.[122] In the time it takes to prepare a wildfire fighting plane to gain better visual, a AAM aircraft could be deployed more quickly. Current AAM used for wildfire monitoring can take off in a lower amount of time and fly at sufficient speeds to perform the mission efficiently. As technology progresses, these AAM aircraft can be programmed to fly on their own, which could further increase efficiency.[123]

Metric 11.1.3.4: Service Accessibility

- Environmental disasters in the U.S. often have disproportionately negative effects on minority groups. A 2018 study demonstrated that racial and ethnic minority groups faced greater vulnerability to wildfires compared with primarily white communities.[124] Additionally, Native Americans are more likely than other groups to live in areas prone to wildfires.[125] AAM aircraft could help expand access to wildfire management in underserved communities, leading to an increase of services to these communities through faster response and improved fire monitoring.[125]

Metric 11.1.3.5: Data Accuracy

- While satellites and sensors have improved wildfire data collection, there are still various limitations. For example, thick smoke from fires can obstruct data collection by distorting satellite imaging and grounding manned aircraft due to diminished visibility. AAM can bridge these gaps and provide accurate data such as high-resolution imagery, infrared cameras, wind data, sub-centimeter data in smoke and at night. In addition, AAM aircraft can detect small fires as they are starting. Once the AAM aircraft has found this information, it can transmit in real time to a fire crew to prepare response, or to authorities to transmit important emergency information to take precautions and inform response.[126]

Metric 11.1.3.6: Operational Cost

- Between the Forest Service, Department of Interior and other federal agencies, suppressing wildfires is an expensive and costly task.[127] AAM aircraft could be used to collect data that would inform and support fire suppression efforts more efficiently while reducing costs during prolonged wildfire monitoring.

Metric 11.1.3.7: Net Carbon Emissions

- Currently, manned aerial aircraft such as helicopters and satellite remote sensing systems are commonly used by different agencies and industries to monitor and detect wildfire events. AAM has the potential to reduce emissions for missions that use helicopters. Surveillance operations that would be traditionally performed by helicopter could be replaced with an electric or hybrid-electric AAM aircraft, reducing the amount of emissions released into the environment during the monitoring of wildfires.

11.1.4 Researching and monitoring the progression of natural disasters, such as hurricanes or tornadoes, to inform disaster response.

The monitoring of natural disasters evaluates the event in terms of its intensity, location, scale, and the vulnerability of the population affected.[128] This monitoring requires the collection of critical data that reveals how a disaster is moving and changing. Methods used today include weather satellites to track floods, tsunamis, hurricanes and tornadoes, seismographs to monitor earthquakes, and in certain cases, manned aircraft.[129] The impact of the new AAM capabilities will be described in the following metrics.

Metric 11.1.4.1: Service Accessibility

- While a disaster is indiscriminate with whom it affects, the Department of Health and Human Services reports that the medically underserved, especially in rural areas, bear a greater burden.[130] One of the causes of this disparity is inadequate mapping and surveying when responding to the needs of those affected by a natural disaster. Manned aircraft are often too expensive to use, satellite mapping does not meet high-resolution needs, and both take time that those impacted by the disaster may not have. AAM aircraft have the capability to be deployed quickly, generate high-resolution and 3D maps, identify hotspot areas that are at higher risk, and monitor areas that have sustained the most damage to guide response efforts. Therefore, AAM has the potential to improve access to services for underserved communities during natural disasters by leveraging more cost-effective surveying capabilities while responding to sites faster than traditional aircraft used today.

Metric 11.1.4.2: Data Accuracy

- Monitoring disasters is performed to create forecasts and alert the public of a need to evacuate or move to a safer location. This places a high importance on the accuracy of data for natural disasters such as storms, hurricanes, or tornadoes. Currently tornado warning systems have a high false-positive rate, and predictions can be inaccurate.[131] Current research is being conducted on how unmanned AAM aircraft can fly into these potential natural disasters and collect humidity, air pressure, temperature, wind speed, and wind direction data from an array of instruments.[131] By leveraging AAM to collect these measurements, smaller-scale structures in thunderstorms that are thought to trigger tornadoes can be identified, providing more accurate data and predictions.

Metric 11.1.4.3: Operational Cost

- Rotorcraft and fixed-wing aircraft currently perform disaster response missions, such as overhead damage assessments, reconnaissance, and missing person searches. These resources are often costly to operate on a per-hour basis. Unmanned AAM could offer an opportunity to perform many conventional aerial missions in a more cost-effective manner, depending on the operation.[132]

Metric 11.1.4.4: Workforce Equity

- The National Oceanic and Atmospheric Administration (NOAA) has aircraft pilots whose job is to fly with specially equipped aircraft directly into the eye of the storm to collect crucial data that helps protect lives and property.[133] This job requires the capability to fly a plane into a high-risk scenario. AAM aircraft such as UAS are being developed and implemented to fly into hurricanes and collect important data such as 3D wind sensing, temperature, pressure, and moisture.[134] These can be remotely piloted from the ground and potentially be flown Beyond Visual Line of Sight (BVLOS) over the water with a waiver from the FAA.[135] By leveraging AAM aircraft, opportunities with fewer physical barriers are created that enable a more equitable workforce.

Metric 11.1.4.5: Provides Data to Enhance or Support Tangential Industries

- The amount of data currently collected from surveying and monitoring natural disasters can be used afterwards to inform the appropriate response.[136] For example, stakeholders involved in rebuilding in the aftermath could include power, construction, or utility companies that may benefit from an increase in the amount of data. A challenge after natural disasters such as tornadoes or hurricanes is restoring damaged utility lines to restore power to homes.[137] AAM has the capability to take high resolution aerial photography that helps inform the necessary response materials needed for aftermath. If this aerial mapping was shared with powerline or utility companies, then they could potentially locate key outage areas or those suffering the most damage to rebuild and restore power more efficiently. Increased data showing the aftermath of the disaster such as communities mapped with aerial images enhance the response and better inform the industries affected.

11.2 Delivery

This section focuses on developing metrics and describing improvements for use cases focused on delivery. Both manned and unmanned AAM aircraft could be used to transport goods and people between two places more efficiently. The main benefits of using AAM for delivery could include reduced operational times when transporting supplies, personnel, or patients in critical conditions. The impact of the new AAM capabilities will be described in the following metrics.

11.2.1 Obtaining water samples from ocean water to better understand ocean and coastal health

- Obtaining samples from ocean water can be labor-intensive, and it is difficult to ensure the samples are representative of the environment intended for study and are not contaminated.[138] Traditionally, teams take samples from the shoreline or use a boat to obtain samples from open water. These teams may require a boat, captain, crew, and extensive equipment to collect the samples from open water. Coastal and ocean water samples could be obtained to test for bacteria, chemicals and compounds associated with oil, or toxicity in the water. Obtaining water samples from the ocean and coastal water can ensure that the public is alerted and aware of potential hazards and critical changes in the water. The impact of new AAM capabilities will be described in the following specific metrics.

Metric 11.2.1.1: Safety Risk to Provider

- Obtaining water samples from the coast or from a boat can present many safety risks and incidents to the teams obtaining the water samples, such as hypothermia.[139] As water flows from land to coastal waters, it can be contaminated by untreated sewage from boats, pets, and failing septic systems; fertilizers; and spills from hazardous substances. High levels of bacteria and other chemicals in the water can cause gastrointestinal illnesses in those who swim directly in the water. There is also the presence of Harmful Algal Blooms (HABs) (popularly referred to as red tides), which are dense populations or "blooms" of algae that form in coastal waters. A small percentage of these blooms can be toxic to marine animals and humans.[140] New AAM capabilities can reduce the need for personnel to interact with potentially contaminated water, which could reduce the number of incidents and the risk to the provider. AAM aircraft can be deployed from a launching facility and away from the water which reduces or eliminates the risk of personnel drowning or putting themselves at risk for hypothermia. Furthermore, these AAM aircraft can obtain water samples from the coast or the ocean without people having to use a boat or go into the water, which reduces or eliminates the risk of people touching hazardous water or getting infections due to bacteria or toxicity in the water.

Metric 11.2.1.2: Operational Time

- Traditionally, teams take samples from the shoreline or use a boat on the open water. A significant amount of time is required to prepare the boat, ensure all safety equipment is present, brief the staff, and navigate from site to site to collect water samples. Leveraging AAM has the potential to reduce the operational time through more efficient technology that requires less personnel and preparation time. Preparation for the AAM aircraft collecting the water sample can be as simple as inserting a sampling bottle into a bottle holder attached to the AAM aircraft and launching it. The operation can be carried out without spending time briefing safety to multiple individuals since the operation can be performed by one person and no safety equipment is needed for multiple individuals. Finally, the AAM aircraft can fly to multiple sites in a short amount of time, reducing the time needed for the total operation and increasing the number of samples taken in a window of time. Private companies utilizing water sampling AAM aircraft have claimed that AAM aircraft can reach locations efficiently and reduce the operational time.[141]

Metric 11.2.1.3: Service Accessibility

- Coastal regions often house diverse populations at the frontline of ecological and social transformation. Social scientists who evaluate coastal research have found that attention to racial, ethnic, economic, and other social inequities is underrepresented in coastal planning efforts and coastal research fails to discuss or analyze equity considerations.[142] AAM has the potential to provide a more cost-effective method to obtain a larger range of data by leveraging aircraft that are better suited to support the mission objective. Therefore, AAM could be utilized to increase the access to ocean water sampling for underrepresented areas along the coast, leveraging more data to improve planning efforts.

Metric 11.2.1.4: Operational Cost

- Water sampling techniques can be time consuming, logistically complex, labor intensive, and heavily dependent on the use of boats and boat crews. If these operations are done at a large-scale, it can be expensive to perform due to the amount of personnel in the field required to complete the operation. For certain missions such as a large-scale sampling project, operating an AAM aircraft can cost less compared to using an open-water boat due to less personnel in the field and sampling more area in a shorter amount of time.

Metric 11.2.1.5: Net Carbon Emissions

- Emissions from boats come primarily from burning fuel in their engines. These emissions contribute to the total impact on the environment from the transportation capabilities currently required to obtain water samples. To maintain the ability to sample and access locations on the water, AAM aircraft could be used. Leveraging AAM aircraft could reduce or even eliminate the need to use additional transportation modes, such as boats, which reduces the amount of carbon emissions released into the environment during the operation.

Metric 11.2.1.6: Workforce Equity

- Obtaining water samples from the ocean can be labor intensive, requiring a person to get into a boat and/or the water to obtain a sample. These requirements present physical barriers to the provider of the service needing to perform their job. Utilizing AAM aircraft could allow water samples to be obtained remotely without the need to access the location, reducing the physical requirements that traditionally exist during the operation. By leveraging AAM aircraft, opportunities with fewer physical barriers are created that could enable a more equitable workforce.

Metric 11.2.1.7: Greater Access to Perform the Operation

- Obtaining water samples can be time consuming and complex, depending on the number of samples that are required and where they are located. Large scale operations generally require a large amount of personnel to successfully complete the sampling over a designated area. Sampling may also be needed in areas that are challenging to access for several reasons, such as water toxicity or tides. Using AAM aircraft to obtain water samples could increase the number of sampling missions carried out due to the aircraft's agility covering sampling areas and need for less personnel. Multiple AAM aircraft can be deployed from shore to quickly obtain water samples across different areas at the same time. These aircraft could perform remote water sampling that could reduce or eliminate the need for a person encounter toxic water.

11.2.2 Patient transfers between medical facilities

Patients may be transferred between medical facilities due to lack of capability, lack of capacity, insurance, or simply at the patients' request.[144] Transporting patients from one facility to another is traditionally performed by ground ambulances or helicopters. Air ambulances comprise a small minority of the most critical medical case transportation, compared to ground transportation, due to the historically high cost and risk of airborne operations.[145] The impact of new AAM capabilities will be described in the following specific metrics.

Metric 11.2.2.1: Safety Risk to Provider

- According to a study performed, helicopter air ambulances have twice the fatal accident rate compared with all other forms of aviation.[146] One of the benefits of some AAM aircraft designs is multiple rotors to continue operating safely if one motor fails.[147] However, this may not be widespread. It is important to acknowledge that the accidents that occur in helicopters often are caused by weather, and emerging AAM aircraft may not operate in severe weather, decreasing their availability and not providing a significant advantage.

Metric 11.2.2.2: Operational Time

- In a situation where seconds matter, helicopter operational capabilities are critical to a patient's outcome. Today's helicopters require a warm-up and cool down time that are significant. Electric motors used by fully electric aircraft are expected to have shorter warm-up and cool-down periods compared to traditional combustion engines. This capability allows AAM aircraft to potentially respond faster, as well as provides the ability load and unload patients without the presence of spinning rotors, reducing the total operational time for patients.

Metric 11.2.2.3: Service Accessibility

- Currently, most of the continental U.S. population is located within a flight radius to have the potential to receive air emergency medical services (EMS). However, gaps in air EMS persist, primarily in rural areas. In these regions, advanced EMS, hospital infrastructure, and even ground ambulances are often limited in availability due to the challenging economics of providing service in low-demand areas.[148] The ability to reach these areas faster can make an impact on rural communities and potentially increase the number of services provided. New AAM aircraft may provide additional capabilities to air EMS operators in some rural areas and have the sufficient range to reach most populations. Cost of operations for electric aircraft is expected to decrease, which could enable greater availability of air ambulance services for patient transportation to and from underserved communities.

Metric 11.2.2.4: Operational Cost

- Air EMS may have high-cost barriers for patients due to the cost of operations needed to sustain 24/7 staffed medical and pilot services. Costs associated with insurance, facilities, and staffing the aircraft are all fixed costs. Variable costs for each transport depend on the mission duration and consist of aircraft maintenance costs, depreciation, and fuel. Fixed costs usually account for most of the total costs, which means the relative cost of operating the aircraft compared with the cost to establish the service is low. An increase in the number of missions performed by the air EMS aircraft may reduce the per-mission total cost significantly. By leveraging AAM, the number of air EMS missions could scale to a volume that decreases the total operational cost for completing the mission while potentially reducing personnel required. Due to the projected low cost of operations for new AAM aircraft, cost of operations may reduce through greater scale and less need for personnel.[148]

Metric 11.2.2.5: Net Carbon Emissions

- To transfer patients between medical facilities, fuel-based air ambulances or ground vehicles are typically used. These transportation modes account for different levels of carbon emissions released into the environment.[149]AAM aircraft that are fully electric or hybrid-electric could emit a lower volume of carbon emissions per operation. Therefore, AAM could reduce net carbon emissions when used for transporting patients, particularly as an alternative method for a traditional air ambulance.

Metric 11.2.2.6: Noise Emissions

- One of the most significant issues in the helicopter industry is the community complaints regarding helicopter noise.[150] This impacts community perception and can even cause these services to be reduced or halted after a certain time at night. While AAM may have the potential to reduce the noise of a combustion engine, there will still be noise associated with the aerodynamics of the aircraft, such as rotors.[147] Therefore, it is uncertain whether noise emissions from AAM aircraft will be a differentiating metric or have an additional benefit.

11.2.3 Delivering essential supplies to persons in need that are not accessible during and after disasters

Delivering essential supplies such as food, medicine, sanitation supplies, and other basic items during and after disasters could help save lives and support communities in need. It is difficult to access people affected by a disaster, both during and after, due to damaged infrastructure and inability to communicate. Multiple methods are used to deliver emergency supplies such as utilizing traditional fixed-wing aircraft, helicopters, and boats. The impact of new AAM capabilities will be described in the following metrics.

Metric 11.2.3.1: Safety Risk (Benefit) to the Public Involved in the Operation

- Delivering emergency supplies to critical patients after a disaster could be a major challenge due to inaccessibility, and this metric seeks to capture the benefits of improved supply delivery to the safety of the public. People that live in communities that have been affected by a natural disaster are usually hard to reach. Helicopters and boats might be the only available transportation modes if roads are destroyed; however, these may be limited as well. The ability to reach persons in difficult areas plays a critical role regarding their survivability. Although EMS stations are placed in locations to optimize access for the population they serve, response time can be considerably more than the average in rural, remote, geographically challenged, or high-traffic urban areas.[151] During or after a natural disaster, this response time may be even longer. Utilizing AAM aircraft to bring emergency supplies to people in need could save lives due to their ease of accessibility into hard-to-reach areas and the reduction in delivery time. One example could be AAM aircraft delivering medical supplies rapidly and reliably while awaiting EMS arrival. Also, sUAS may be small and agile enough to fit within an enclosed area that would not otherwise be reachable, such as a collapsed building, to search, locate, and deliver to people.

Metric 11.2.3.2: Safety Risk to Provider

- Delivering emergency supplies to persons after disasters can pose a high risk to first responders. Challenges such as damaged infrastructure may make conditions difficult for relief workers to access areas and provide aid.[152] These conditions could be collapsed buildings after an earthquake, unsteady land after avalanches, or hazardous chemical spills that result in a higher number of incidents. AAM aircraft might offer the ability for first responders to reach individuals in distress and provide guidance to safety or deliver emergency medical supplies from a safer location, ultimately reducing their risk of injury during the operation.

Metric 11.2.3.3: Operational Time

- Emergency supply delivery is a time critical operation. Many of these operations after a disaster could be extensive and require significant time when done with traditional transportation methods, such as a helicopter, boat, road vehicle, or fixed-wing aircraft. Accessibility and loss of communication might significantly delay the process of delivering supplies to persons due to damaged infrastructure. Due to their agility and size, AAM aircraft could be used to deliver essential supplies in a quick, efficient manner to persons in need. AAM aircraft deliveries of emergency medical supplies and kits might support emergency response organizations in multiple humanitarian contexts that require the provision of life-saving materials.[153] Electric motors on fully electric AAM aircraft are expected to allow for shorter warm-up and cool-down times compared to current combustion engines, which could facilitate faster response times. AAM aircraft could also help communicate to persons that are unreachable for situational awareness and to understand their needs when providing supplies, further improving operational efficiency.

Metric 11.2.3.4: Service Accessibility

- Rural and remote communities usually suffer the most due to inaccessibility to services or supplies that are common in urban cities with higher populations. Emergency response entities, such as the Federal Emergency Management Agency, Air National Guard, and

U.S. Coast Guard, can leverage lower-cost AAM aircraft, most notably sUAS, to increase the number and geographic coverage of deliveries that can be made. Additionally, air EMS services and supply chains of other essential supplies, such as food, might have gaps in coverage, which could be primarily located in rural areas. In these regions, EMS services, hospital infrastructure, ground ambulances, and even some essential supplies can be limited in availability due to the challenging economics of providing services in low demand areas.[154] During a disaster, these communities are the most vulnerable and the ability to reach these areas faster could increase the number of services provided to rural communities. AAM aircraft could enhance the ability for persons in communities to be reached following a disaster by employing a smaller, tailored platform to the missions, potentially without needing a first responder to ever reach the person physically. By removing the need for a first responder, costs associated with delivering supplies and the number of personnel required for a delivery could be reduced, making them more widely accessible.

Metric 11.2.3.5: Net Carbon Emissions

- To deliver emergency supplies, multiple modes of transportation are leveraged such as fixed-wing aircraft, traditional helicopters, and emergency ground vehicles. These transportation modes account for different levels of carbon emissions released into the environment. Fuel is the main source of carbon emissions throughout a helicopter's lifecycle. A boat's carbon footprint results primarily from burning the fuel in its engine and generator.[143] Emergency response aircraft often leave their engines on idle to maintain systems and equipment in standby mode, and these engines could release a significant amount of pollution into the environment.[155] Additionally, fixed-wing aircraft also emit gases and particles that alter the atmospheric concentration of greenhouse gases.[156] AAM aircraft with lower carbon footprints, specifically UAS, could be utilized to transport medicine, food, sanitary supplies, as well as medical equipment to save lives. Different fixed-wing electric aircraft could be used to transport medical personnel or emergency supply cargo. Therefore, AAM aircraft may reduce the carbon emissions during the delivery of emergency supplies that are common when using traditional aviation, ground, and water vehicles.

Metric 11.2.3.6: Workforce Equity

- Emergency responders are often required to perform strenuous physical activities to deliver emergency supplies to persons. These requirements might include being able to lift supplies or equipment, climb stairs, ramps, or ladders, and enter confined spaces. AAM aircraft could be used to transport equipment and reach areas that are difficult to access such that the emergency responder would not have to meet those requirements to perform the job. AAM could therefore be used to enable an equitable workforce by providing more job opportunities without harsh physical barriers for people who want to help after a disaster.

Metric 11.2.3.7: Greater Access to Perform the Operation

- During a disaster, demand for emergency response and services can surge due to higher volume of time sensitive responses and supplies needed. This can lead to inadequate care or ability to reach persons in need of potentially life-saving medical supplies.[129] Emergency medical services are vital during all phases of disaster response, with key roles including mass-casualty triage, on-scene treatment, communication, evacuation, coordination of patient transport, and patient tracking.[157] Whereas the number of emergency responders, aircraft, and manned aircraft can be limited and calls must be prioritized, AAM could help to bridge the gap and increase the number of missions carried out.[158] In specific, unmanned AAM could increase the frequency and speed of emergency responses in situations where larger, manned aircraft are not required, making more missions possible.

11.2.4 Delivering emergency supplies or personnel to an emergency scene

Every day, emergency calls are received for a variety of time critical situations that could require additional materials sent to the scene of the emergency.[159] This could include delivering essential equipment to support a law enforcement emergency, fire emergency, or medical emergency.[160] These situations often require time critical operations that can make a difference in successfully accomplishing the mission at hand, whether it be averting a threat to the public or saving a life. Multiple methods are used to deliver emergency supplies such a utilizing traditional fixed-wing aircraft, helicopters, and emergency response ground vehicles. The impact of new AAM capabilities will be described in the following specific metrics.

Metric 11.2.4.1: Safety Risk to Provider

- The geography of remote areas can pose significant challenges when delivering emergency supplies by ground transportation methods. In cases where a critical response is needed, factors such as limited accessibility, terrain, lack of infrastructure, and distance can greatly hinder the efficient delivery of supplies during critical situations. AAM aircraft have the capability to avoid ground transportation hazards or reach remote locations that ground transportation may not be able to. In addition, when remote pilot operations are enabled, advanced automation technology could allow supplies to be delivered remotely, therefore reducing the risk of the pilot.

Metric 11.2.4.2: Operational Time

- One of the most critical factors when responding to an emergency scene is response time. However, when using ground emergency response vehicles, such as an ambulance, traffic and roads may cause delays in reaching the emergency scene. For example, traffic congestion in an urban area may prevent an ambulance from reaching an emergency scene in a timely manner. An AAM aircraft has the capability to fly over congestion or areas where a ground transportation vehicle may be delayed. For example, if medical supplies are needed for an emergency response, an AAM aircraft could carry these supplies, such as a defibrillator, blood and blood products, and rescue medications, to the site of an emergency.[162] Additionally, using an AAM aircraft with electric motors may enable decreased warm-up and cool-down times compared to current EMS helicopter engines. This capability could facilitate faster response times, as well as provide the ability to load and unload patients without the presence of spinning rotors.[163] Using an AAM vehicle could reduce operational response time and may improve response outcomes at an emergency scene.

Metric 11.2.4.3: Service Accessibility

- Rural areas and communities have historically experienced greater response times to emergency scenes. For example, the National Highway Safety Administration (NHTSA) reports that approximately over a third of fatal crashes in rural areas had response times greater than an hour, compared to only a tenth in urban areas. Additionally, the median EMS arrival times in the U.S. for all call types are between seven and eight minutes, and the median time could increase to more than 14 minutes in rural settings.[161] Generally speaking, AAM may provide more communities with more affordable rapid-response capabilities, which can increase the service accessibility. Although rural emergency scenes may be located a further distance from emergency response service providers, AAM aircraft could be used to reach the scene in a more efficient manner. For example, medical supplies from a hospital or warehouse could be directly delivered via a small unmanned AAM aircraft alongside of first responders who may reach an emergency scene via a different AAM aircraft or other means of transport that originates from a different location than the supplies. Therefore, AAM may enhance emergency response operations by more effectively reaching rural emergencies, increasing the accessibility of the service for communities.

Metric 11.2.4.4: Operational Cost

- While saving lives is the focus when responding to an emergency, improving the operational cost for the mission can lead to more available resources and support. AAM aircraft are envisioned to reduce the operational cost for several missions by employing smaller, less expensive platforms to provide sufficient capabilities to meet the objectives. These cost reductions may be realized in lower energy costs for delivery and/or by reducing the number of personnel required to physically move the cargo. Deploying smaller AAM aircraft to deliver supplies to an emergency scene may result in reduced costs compared to operating traditional manned aircraft or even ground vehicles in some instances.

Metric 11.2.4.5: Net Carbon Emissions

- To deliver supplies to the scene of an emergency, a range of transportation modes, such as helicopters, fixed-wing aircraft, and emergency ground vehicles, can be used. These modes of transportation each account for different levels of carbon emissions released into the environment. For example, conventional emergency response aircraft often leave their engines on idle to maintain systems and equipment in standby mode, which can produce significant amounts of pollution for the environment.[155] Additionally, fixed-wing aircraft can emit gases and particles that alter the atmospheric concentration of greenhouse gases.[156] AAM aircraft that are fully electric or hybrid-electric are envisioned to emit a lower volume of carbon emissions per operation. Therefore, AAM could reduce net carbon emissions when used for transporting supplies to the scene of an emergency instead of traditional aviation and ground vehicles.

Metric 11.2.4.6: Workforce Equity

- Emergency responders are often required to perform strenuous physical activities to deliver emergency supplies to a scene. These requirements might include being able to lift multiple materials or equipment, climb stairs, ramps, or ladders, and enter confined spaces. AAM aircraft could provide the ability for first responders to reach persons and deliver emergency supplies from a safe location. AAM aircraft can carry and transport heavy materials or equipment to areas that are challenging for emergency responders to access. AAM could therefore be used to enable an equitable workforce by providing more job opportunities that have less significant physical barriers for first responders.

11.3 Response

The previous section focused on delivery of goods and people that can make a significant impact during critical and non-critical operations. AAM can be used to support tactical operations happening on the ground and search and rescue missions to respond more quickly and efficiently. The following section highlights use cases and metrics focused on response and discusses public good mission improvement characteristics that can be accomplished using AAM.

11.3.1 Responding to a situation or threat to the public to assess the scene and inform coordinated support

To law enforcement, security, and military professionals, threat assessment refers to the process of identifying potential and immediate threats such as active assailants or people carrying concealed weapons.[169] Identifying threats can sometimes take time since police officers must first assess the environment and determine a pattern of consistent behavior.[169] These can be done in person and in locations that are full of moving people. These situations could become highly volatile and can compromise the safety of police officers and the public who are in the direct line of fire. The impact of new AAM capabilities will be described in the following metrics.

Metric 11.3.1.1: Safety Risk to Provider

- Responding to the scene of a potential threat to the public may put responding provider personnel in dangerous situations. Without AAM, a provider may arrive at a scene without background knowledge or assessment of the threat at play. However, AAM aircraft could enable insight into assessing the level of danger and identifying the appropriate response before responders arrive at the scene. For example, if a threat is reported, a UAS could be flown to assess the situation before the responder arrives on the scene. The data collected can provide a more detailed brief to the responders, potentially decrease response time, and help identify the appropriate response.

Metric 11.3.1.2: Operational Time

- Responding to a threat can be time critical, especially in a remote or rural location that is difficult to reach by ground. The average helicopter takes around 2-5 minutes to start the engines and get the instruments and systems working and tested before the helicopter is ready for takeoff. Also, the colder the helicopter is, the longer it takes for the oil and hydraulic fluids to get to optimum temperatures before liftoff.[171] Given these limitations, utilizing an electric AAM aircraft could reduce the start-up time of the aircraft, which can lead to faster response times. In specific, electric motors do not have the same warm-up period requirements, or required cool-down period.[172]

Metric 11.3.1.3: Service Accessibility

- When emergencies occur in remote or rural communities, the demands on local response agencies can quickly consume available resources, and many areas can be hard to reach in time sensitive situations.[173] Utilizing AAM aircraft to respond to a threat in a remote or rural community could result in faster aid and a more effective response.[174] AAM aircraft could be used to reach rural areas where surveillance is needed for a possible threat to better understand the situation, geography, and accessibility to the location. AAM aircraft with loudspeakers could also address crowds, such as directing them to safety or to perform behaviors directed by emergency personnel staff.[174]

Metric 11.3.1.4: Data Accuracy

- Identifying active threats can be difficult for humans due to factors such as the number of people in the location.[175] Utilizing AAM aircraft could help assess a situation to identify a threat more efficiently than from the ground. AAM aircraft could provide high resolution photos, videos, thermal images, and 3D models, even initiating specific actions if dangerous objects, weapons, perimeter intrusions, or anomalous behavior are detected.[176] Additionally, AAM aircraft could cover larger areas than traditional means that increase law enforcement's ability to monitor crowds while also being equipped with technology that gathers and compares data against police files to identify threats.[176] An example of this could be gathering data on license plates to help identify stolen or unauthorized automobiles.

Metric 11.3.1.5: Operational Cost

- Responding to a potential public threat, such as police response to a fleeing suspect, can become costly for police departments, especially if a police helicopter is needed.[166] If a suspect escapes from a scene and a helicopter is needed to surveil and track, the cost can quickly add up. This is because traditional helicopters, including police helicopters, can be expensive to operate. Manned aircraft are large, complex machines requiring expert ground crews, multiple shifts of pilots and co-pilots, and (unlike smaller AAM aircraft which can be hand-launched) runways or helipads. Such expenses mean there are inevitably going to be far fewer of them— which in turn means the police are likely to use them only where they are most needed.[177] Some AAM aircraft are expected to require much lower capital and operating expenditures compared to traditional police air support helicopters.[167] A trial and evaluation study, including a cost-benefit analysis of implementing a full AAM aircraft program, was conducted, which identified that hourly operating costs of AAM aircraft were significantly less than operating a traditional helicopter and brought considerable return on investment.[178] In the case of a fleeing suspect, law enforcement could reduce costs by deploying a UAS to survey the area, rather than a police helicopter.

Metric 11.3.1.6: Net Carbon Emissions

- In certain situations, emergency aircraft may leave their engines on idle to maintain lighting, communications equipment, computers, refrigeration for medication, and life-support equipment, as well as the aircraft's heating and cooling systems. These engines produce significant carbon emissions and other air pollution that can exacerbate respiratory or cardiovascular problems in sensitive populations.[155] AAM aircraft that are fully electric might emit less carbon into the environment during operations due to the lack of hydrocarbon combustion. AAM could reduce the net carbon emissions by eliminating the need to idle emergency aircraft, enabling more efficient aircraft, and providing a cleaner source of energy for operations.

Metric 11.3.1.7: Number of People Willing to Serve in a Higher Risk Environment

- Law enforcement agencies across the United States are struggling to recruit and hire police officers.[179] One factor for driving the recruitment difficulties is the safety of police officers or line-of-duty death and injury. Utilizing AAM aircraft could allow for police officers to surveil, gain critical information, and perform tactical operations without being subjected to a high-risk environment. Using new technology could create an interest and entice the public to join the police force by minimizing the risk in response operations to dangerous situations.

Metric 11.3.1.8: Greater Access to Perform the Operation

- During active threats, it is often difficult for police officers to have full knowledge, visibility, and accessibility to the scene. Small AAM aircraft, such as UAS, could identify a person of interest, including during night-time hours, aiding police officers as they locate and assess a threat from a safe distance.[178] Additionally, when a threat is happening in a location that is enclosed or hard to reach by ground, small AAM aircraft could be utilized to access the scene without being detected or even break through windows to inspect the area for possible threats.[180] AAM aircraft that can operate inside buildings could allow law enforcement to inspect a situation inside a location that is too dangerous to enter.

Metric 11.3.1.9: Workforce Equity

- While responding to a situation or a threat to the public, first responders, such as law enforcement officers, might be put in a position to defend themselves and others. They are also required to be physically capable of controlling the suspect in question if they were to pose a threat to the public. To assess a scene and inform coordinated support, the first responder might be required to withstand various environments, such as cold weather, rain/snow, or heat or stand, walk, or run for long periods of time. AAM aircraft could offer the capability of surveilling a potential threat from a distance, enduring the different environments and covering large areas for monitoring and surveillance. AAM could therefore be used to enable an equitable workforce by providing more job opportunities without harsh physical barriers for all first responders.

11.3.2 Rescuing a person from a dangerous event, e.g., fire, earthquake.

Search and Rescue (SAR) is a service which renders aid to persons or property in distress. Most SAR missions are performed by manned aircraft such as helicopters.[181] When a disaster hits an area, accessibility may become challenging for law enforcement and first responders due to roads being blocked or power lines being down.[182] AAM could provide a significant impact to disaster response operations. The impact of new AAM capabilities will be described in the following metrics.

Metric 11.3.2.1: Safety Risk to Provider

- Search and rescue missions can pose a major risk to the individuals responding to the scene. Due to dangerous environments, they could face unique health risks that increase the probability for line-of-duty injury or death, such as burns, heat exhaustion, high noise levels, and chemically toxic air.[187] Utilizing AAM aircraft, particularly unmanned aircraft, could improve the risk associated with performing a search and rescue mission and reduce the number of incidents common for first responders who must enter dangerous environments.

Metric 11.3.2.2: Operational Time

- Response time is critical when performing rescue missions because the more quickly rescuers can reach and aid those in need, the higher the chances of saving lives and minimizing injuries. However, geography and terrain may pose a barrier to certain rescue missions for traditional aircraft or ground vehicles. AAM aircraft have the capability to be quickly deployed to more remote or difficult-to-navigate areas without the need of extensive developed infrastructure. In addition, electric AAM aircraft have the capability to start-up and shut down more quickly than traditional helicopters.[189] In a critical rescue situation, this difference of minutes may be critical to more successful rescue outcomes.

Metric 11.3.2.3: Service Accessibility

- Search and rescue missions in rural and remote communities face a variety of challenges due to the limited number of resources, such as essential equipment or fully staffed workforce. Utilizing ambulances and firefighting trucks might be difficult for persons in rural communities after a disaster since roads might be blocked and communication systems might be down. For this reason, helicopters are usually utilized to perform search and rescue operations in remote areas. However, helicopters might require a longer idle time to properly prepare the engine and might have difficulty landing in unestablished landing zones. Current helicopters may reject improvised landing zones because of obstacles, uneven terrain, or poor visibility.[190] Dispatching AAM aircraft, particularly sensor-equipped UAS, to remote, hard-to-reach locations could enhance the ability to reach persons in distress after a natural disaster. AAM aircraft with loudspeakers can also address crowds, such as directing them to safety or to perform tasks directed by emergency personnel staff. Additionally, the speed and vertical takeoff and landing capabilities of eVTOL aircraft may enable them to effectively serve additional underserved or rural communities than traditional aircraft.[191]

Metric 11.3.2.4: Workforce Equity

- Search and rescue missions require first responders to endure operations and environments that can pose significant risk to health. Additionally, these first responders are often required to perform strenuous physical activities to complete search and rescue missions, such as navigating unsteady or collapsed terrain and entering confined spaces. Utilizing AAM to enhance search and rescue missions reduces risk to the first responder by placing the aircraft in difficult environments, not the first responder. Because of this, AAM could enable a more equitable workforce by providing more job opportunities without harsh physical barriers for search and rescue missions.

Metric 11.3.2.5: Greater Access to Perform the Operation

- Sufficient accessibility to people is a major challenge first responders face during search and rescue missions. First responders may face challenges when attempting to reach individuals following an avalanche or earthquake that can impede the normal transportation routes. AAM aircraft could support search and rescue missions by leveraging smaller aircraft to access enclosed or structurally unsound buildings following an earthquake or to quickly reach an avalanche site to provide a location to emergency medical personnel and supplies to those on the mountain. These AAM capabilities could enhance search and rescue operations that are time-critical while also increasing the accessibility to people who require assistance.

12.0 Appendix C: Requirements Analysis

12.1 Inspection Requirements

Inspecting critical infrastructure, such as bridges or highways, to ensure safety for users.

The exhibit below summarizes the requirements developed for inspecting critical infrastructure with the purpose of identifying unique operational aspects and gaps that could support commercial inspection maturity.

Exhibit 16: Requirements Analysis for Inspecting Critical Infrastructure

Characteristic	Capability	Requirement
Aircraft	**Configuration**	The system shall operate in an uncrewed configuration.
	Altitude	The system shall operate no greater than 400 feet above ground level unless operated within a 400-foot radius of a structure.[194] The system shall operate no less than 500 feet below and 2000 feet horizontally from clouds. [198]
	Max Takeoff Weight (MTOW)	The system max-takeoff-weight (MTOW), including everything that is on board or otherwise attached to the aircraft, shall be no greater than 55 pounds on takeoff and throughout the duration of each operation.
	Payload	The system shall provide standard interface points to integrate payload equipment for the inspection operations.
	Accessibility	The system shall provide adequate access to onboard systems and components to facilitate maintenance and reliability.
	Reliability	The system shall meet the applicable reliability to ensure a safe and efficient operation.
	Automation	The system shall have the autonomous capability to mitigate a lost link scenario (e.g., hover, emergency landing, or return to takeoff location). The system shall be capable of flying a pattern autonomously that would allow it to collect the necessary data.
	Speed	The system ground speed shall be no greater than 100 mph (87 knots).[195] However, if the inspection requires it, the operator shall request a FAA waiver to go past 100 mph (87 knots) ground speed.[195]
	Identification System	The system shall provide remote identification data in flight that includes the identity, location, and altitude of the UAS and its control station or takeoff location.[196] The system shall provide a method for identifying the location if power is lost.

	Detect and Avoid	The system shall detect and avoid obstacles, cooperative aircraft, and non-cooperative aircraft.[197] The system and equipment shall comply with 14 CFR 91.113 right-of-way rules.[198] The system shall comply with ATC clearances and regulations, and the impact of such operations.[199]
	Beyond Visual Line of Sight (BVLOS)	The aircraft and system shall have sufficient capabilities to always know the unmanned aircraft's location; determine the unmanned aircraft's attitude, altitude, and direction of flight at all times; identify all air traffic or hazards through DAA technology; yield to right-of-way air traffic; and ensure that the unmanned aircraft does not endanger the life or property of another.[200]
	Takeoff/Landing	The system shall take off and land in areas other than No UAS Zones and other than areas restricted by state, local, territorial, or tribal government agencies.[201]
	Navigation Systems	The system shall be able to relay aircraft position. The system shall have redundant, multi-source positioning navigation systems in case of failure of a primary navigation system.
	Refuel/Recharge Systems	The aircraft shall have an onboard/integrated charging system that contains the necessary battery voltage/amp capacity to reach the flight time needed to perform the inspection on site. If the system cannot perform the inspection within one charge, it shall have the capability to recharge.
Infrastructure	**Communication Systems**	The system shall have a command-and-control link with a bandwidth that supports ground station communication and data captured. The system shall have a redundant communication capability to automatically switch between the applicable command-and-control links to ensure communication and data transfer.
Airspace	**Real-Time Planning**	The system shall have the capacity to receive and respond to Temporary Flight Restrictions (TFRs), NOTAMs, or UAS NOTAMs (referred to as DROTAMS),[203] that may alter the flight and are issued by the FAA. [204] The system shall be able to assess data collected in real time for required fidelity to act on results if more data is needed.
	Third-Party Services	The system shall have capacity to support additional third-party services including applications that assist with flight plans, weather, risk assessment support, authorizations, submitting DROTAMS, or repair and maintenance services.[205]
	Air Traffic Management	The system shall have capacity to communicate with ATC for operations when required for entering Class B, C, D, or E National Airspace System (NAS).[206] When Unmanned Traffic Management (UTM) is operational, the aircraft and system shall adapt to accommodate communications requirements.[207]
	Prioritization	The system shall yield the right of way to all aircraft, airborne vehicles, and launch and reentry vehicles. The system shall yield the right of way to the aircraft or vehicle and may not pass over, under, or ahead of it unless well clear. [208]

Visual Line-of-Sight	Minimum visibility, as observed from the control station, shall be up to 3 statute miles per 14 CFR 107.51.[209] If the inspection requires it, the operator shall request a BVLOS FAA waiver.
Separation	The operator shall gain approval from ATC for operations performed in Class B, Class C, and Class D airspace. The operator shall gain approval from ATC to operate in Class E or Class G airspace that starts at surface level.[210] The minimum separation distance shall be appropriate to ensure safe operations with collaborative and non- collaborative actors in the airspace while considering aircraft size, speed, and weather during the operation.[210]

12.2 Small Package Delivery Requirements

Delivering essential supplies to persons in need that are not accessible during and after disasters.

The exhibit below summarizes the requirements developed for delivering essential supplies to persons during or after a disaster with the purpose of identifying unique operational aspects and gaps that could support commercial small package delivery maturity.

Exhibit 17: Requirements Analysis for Small Package Delivery

Characteristic	Capability	Requirement
Aircraft	Configuration	The system shall operate in an uncrewed configuration.
	Altitude	The system shall operate no greater than 400 feet above ground level unless operated within a 400-foot radius of a structure.[209] The system shall operate no less than 500 feet below and 2000 feet horizontally from clouds.
	Payload	The aircraft shall be able to secure the package from physical harm and from falling throughout the duration of each operation.
	Weather Tolerance	The aircraft shall be able to adjust flight plan as needed to avoid weather related damage.
	Accessibility	The system shall provide adequate access to onboard systems and components to facilitate maintenance and reliability.
	Reliability	The system shall meet the applicable reliability to ensure a safe and efficient operation.
	Speed	The system ground speed shall be no greater than 100 mph (87 knots).[195]
	Navigation Systems	The system shall be able to relay aircraft position. The system shall have redundant, multi-source positioning navigation systems in case of failure of a primary navigation system.
	Identification System	The system shall provide remote identification data in flight that includes the identity, location, and altitude of the UAS and its control station or takeoff location. [196]
	Detect and Avoid	The system shall detect and avoid obstacles, cooperative, or non-cooperative aircraft.[197] The system and equipment shall comply with 14 CFR 91.113 right-of-way rules.[199] The system shall visually comply with ATC clearances and regulations, and the impact of such operations.
	Beyond Visual Line of Sight (BVLOS)	The aircraft and system shall have sufficient capabilities to always know the unmanned aircraft's location; determine the unmanned aircraft's attitude, altitude, and direction of flight at all times; identify all air traffic or hazards through DAA technology; yield to right-of- way air traffic; and ensure that the unmanned aircraft does not endanger the life or property of another.[200]

	Takeoff/Landing	The aircraft shall be able to hover, in situations where it cannot land, for the recipient to collect the delivery safety. The aircraft shall have an emergency landing method to safely land with a package
	Communication Systems	The system shall have a command-and-control link with a bandwidth that supports ground station communication and data captured. The system shall have the capacity to register when the delivery has been safely collected by recipient. The system shall have the capacity to communicate with the recipient
	Refuel/Recharge Systems	The aircraft shall have onboard, accessible ports to accommodate charging.
Infrastructure	**Payload**	The system shall provide interface points into which the package can be loaded and from which the package can be received and removed from aircraft.
Airspace	**Real-Time Planning**	The system shall have the capacity to receive and respond to Temporary Flight Restrictions (TFRs), NOTAMs, or UAS NOTAMs (referred to as DROTAMS),[203] that may alter the flight and are issued by the FAA.[204]
	Third-Party Services	The system shall have capacity to support third-party services, including applications that assist with flight plans, authorizations, submitting DROTAMS, or repair and maintenance services.[205]
	Air Traffic Management	The system shall have capability to communicate with a third-party service provider entity that manages communication with ATC for operations when required for entering Class B, C, D, or E National Airspace System (NAS) to comply with instructions.[1]
	Prioritization	The system shall yield the right of way to all aircraft, airborne vehicles, and launch and reentry vehicles deemed to have higher priority. The system shall yield the right of way to the aircraft or vehicle and may not pass over, under, or ahead of it unless well clear.[208] The aircraft shall have priority over non-essential, non- emergency UAS operations.
	Visual Line-of-Sight	The aircraft shall have necessary certification to fly BVLOS.
	Separation	The system shall be able to obtain expedited clearance to enter No UAS Zones and other areas restricted by state, local, territorial, or tribal government agencies.[201] The operator shall gain emergency approval from third-party service provider entity that manages communication with ATC for deliveries performed in Class B, Class C, and Class D airspace. The operator shall gain approval from third-party service provider entity that manages communication with ATC to operate in Class E or Class G airspace that starts at surface level.[210]

12.3 Cargo Delivery Requirements

Delivering emergency supplies to an emergency scene.

The exhibit below summarizes the requirements developed for delivering emergency supplies to an emergency scene with the purpose of identifying unique operational aspects and gaps that could support commercial cargo delivery maturity.

Exhibit 18: Requirements Analysis for Cargo Delivery

Characteristic	Capability	Requirement
Aircraft	Configuration	The system shall operate in an uncrewed configuration.
	Range	The aircraft shall be capable of operating with a minimum range of 50 miles. The aircraft shall have sufficient reserve time for emergency landing from highest altitude above ground expected following the exhaustion of energy. The aircraft shall have sufficient power, energy, or fuel to complete the range of the mission.
	Weather Tolerance	The aircraft shall be able to operate safely in instrument meteorological conditions. The aircraft shall be able to avoid extreme weather conditions such that the flight plan can be adjusted as needed to avoid weather related damage.
	Payload	The aircraft's payload shall be sufficient to carry a minimum of one emergency personnel, one patient, and carry-on equipment such as supplies or medical equipment.
	Accessibility	The system shall provide adequate access to onboard systems and components to facilitate maintenance and reliability.
	Reliability	The system shall meet the applicable reliability to ensure a safe and efficient operation.
	Surveillance System	The aircraft shall have ADS-B out and ADS-B in transponders to transmit information such as the aircraft ID, GPS position, and altitude as radio signals to correctly broadcast location.[211]
	Navigation Systems	The system shall be able to relay aircraft position. The system shall have redundant, multi-source positioning navigation systems in case of failure of a primary navigation system.
	Detect and Avoid	The aircraft shall have a system that can detect and avoid obstacles, cooperative, or non-cooperative aircraft.[197]
Infrastructure	Takeoff/Landing	The point of departure and landing location shall have sufficient infrastructure (e.g., vertiport, short take off runway) to support the operations. The emergency response station or location shall have sufficient feet of runway to support the aircraft's vertical, short, or conventional takeoff and landing capacities.

Airspace	**Communication Systems**	The system shall have a link to control the aircraft from the mission control center located on the ground. The system shall have an alternative communication network to provide a redundant system in the event of a lost link. The system shall be capable of submitting a flight plan. In the event of an off-nominal situation, a mission command and control system shall provide best course of action and send new commands to the aircraft for mitigation (i.e., diversion, emergency landing).[212]
	Real-Time Planning	The mission control system shall have the capacity to receive and respond to Temporary Flight Restrictions (TFRs), NOTAMs issued by the FAA.[203]
	Third-Party Services	The system shall have capacity to support additional third-party services such as maintenance, correspondence with ATC, receiving weather data, and interaction with a service-provider network.
	Air Traffic Management	The system shall have capability to communicate with a third-party service provider entity that manages communication with ATC for operations when required for entering Class B, C, D, or E National Airspace System (NAS) to comply with ATC instructions. [1]
	Separation	The mission control system shall gain approval to enter Class B, Class C, Class D, Class E and Class G airspace.[213]

12.4 Passenger Transportation Requirements

Rescuing a person from a dangerous event, e.g., fire, earthquake.

The exhibit below summarizes the requirements developed for rescuing a person from a dangerous event, e.g., fire, earthquake, with the purpose of identifying unique operational aspects and gaps that could support commercial passenger transportation maturity.

Exhibit 19: Requirements Analysis for Passenger Transportation

Characteristic	Capability	Requirement
Aircraft	**Configuration**	The system shall operate in an uncrewed and remotely piloted configuration.
	Range	The aircraft shall be capable of operating with a minimum range of 50 miles. The aircraft shall have sufficient reserve time for emergency landing from highest altitude above ground expected following the exhaustion of powerplant energy. The aircraft shall have sufficient fuel/battery to account for hovering while performing Search and Rescue missions.
	Weather Tolerance	The aircraft shall be able to operate safely in instrument meteorological conditions. The aircraft shall be able to avoid extreme weather events such that the flight plan can be adjusted as needed to avoid weather related damage.
	Accessibility	The system shall provide adequate access to onboard systems and components to facilitate maintenance and reliability.
	Reliability	The system shall meet the applicable reliability to ensure a safe and efficient operation.
	Payload	The aircraft's payload shall be sufficient to carry a minimum of one emergency personnel, one passenger, and carry-on equipment such as medical equipment or supplies.
	Automation	The aircraft shall have an autonomous flight system that can execute taxi, takeoff, flight, navigation, and landing procedures.[212] The system shall have the autonomous capability to mitigate a lost link scenario. (i.e., maintaining last directed flight path until telemetry data is reacquired, identification of alternative landing sites)
	Speed	(Class C Airspace) Unless otherwise authorized or required by ATC, no person may operate an aircraft at or below 2,500 feet above the surface within four nautical miles of the primary airport of a Class C airspace area at an indicated airspeed of more than 200 knots (230 mph).[214] (Class D Airspace) Unless otherwise authorized or required by ATC, no person may operate an aircraft at or below 2,500 feet above the surface within 4 nautical miles of the primary airport of a Class D airspace area at an indicated airspeed of more than 200 knots (230 mph). Unless otherwise authorized by the Administrator, no person may operate an aircraft below 10,000 feet MSL at an indicated airspeed of more than 250 knots (288 mph).[215]

	Surveillance System	The aircraft shall have ADS-B out and ADS-B in transponders to transmit information such as the aircraft ID, GPS position, and altitude as radio signals to correctly broadcast location.
	Navigation Systems	The system shall be able to relay aircraft position. The system shall have redundant, multi-source positioning navigation systems in case of failure of a primary navigation system.
	Detect and Avoid	The aircraft shall have a system that can detect and avoid obstacles, cooperative, or non-cooperative aircraft.[198]
	Charging/Refueling	The aircraft shall have the capability to identify and utilize charging/refueling ports closest to its flight path.
Infrastructure	**Takeoff/Landing**	The point of departure and landing location shall have specialized infrastructure (i.e., vertiport, short takeoff runway) to support the operations. The emergency response station or location shall have sufficient feet of runway to support the aircraft's vertical, short, or conventional takeoff and landing capacities. The aircraft must be able to take off within the available runway of the emergency services departure point.
Airspace	**Communication Systems**	The system shall have the capability to provide a secure real-time video stream to the operator. The system shall have a link to control the aircraft from the mission control center located on the ground. The system shall have an alternative communication network to provide a redundant system in the event of a lost link. The system shall be capable of submitting a flight plan. The system shall have the ability to communicate with a digital network of service providers.[1]This aircraft shall be equipped with a communication system such that the emergency personnel can communicate with ground medical support exclusive from the air traffic control system. The aircraft shall have an intercommunications system that should be provided for medical personnel to communicate with each other aboard the aircraft. In the event of an off-nominal situation, a mission command and control system shall provide best course of action and send new commands to the aircraft for mitigation (i.e., diversion, emergency landing).[212]
	Real-Time Planning	The mission control system shall have the capacity to receive and respond to Temporary Flight Restrictions (TFRs), NOTAMs issued by the FAA.[203]
	Third-Party Services	The system shall have capacity to support additional third-party services such as maintenance, correspondence with ATC, receiving weather data, and interaction with a service-provider network.
	Air Traffic Management	The system shall have capability to communicate with a third-party service provider entity that manages communication with ATC for operations when required for entering Class B, C, D, or E National Airspace System (NAS) to comply with ATC instructions.[1]

	Separation	The system shall be able to obtain expedited clearance to enter no fly zones or airspace areas restricted by state, local, territorial, or tribal government agencies in the event of an emergency.[201] The mission control system shall be able to gain priority to enter Class B, Class C, Class D, Class E and Class G airspace in case of emergency.

13.0 Bibliography

[1] National Aeronautics and Space Administration. (2020). UAM Vision Concept of Operations UML-4 v1.0. https://ntrs.nasa.gov/api/citations/20205011091/downloads/UAM%20Vision%20Concept%20of%20Operations%20UML-4%20v1.0.pdf

This document provides a concept of operations for UAM and establishes a more detailed discussion and basis for the development and integration of UAM as part of the broader transportation system.

[2] Garrow, Laura, et al. (April 22, 2022). NASA Technical Reports Server (NTRS). A Proposed Taxonomy for Advanced Air Mobility. Retrieved from https://ntrs.nasa.gov/citations/20220006225

This paper describes advanced air mobility (AAM) and provides a framework based on demand and supply concepts that can be used for developing a taxonomy for AAM with a focus on passenger applications.

[3] Samuelson, Paul A. "The Pure Theory of Public Expenditure." *The Review of Economics and Statistics* (1954): 387-389.

In this paper, Samuelson outlines a pure theory of government expenditure on collective consumption, or public goods. These public goods have the property that an individual's consumption of the good does not reduce some other individual's consumption of the good. In contrast, a private good is one which, once consumed or utilized as an input, can no longer be of service to others. This paper is known as the foundation of the modern theory of public goods.

[4] Cornes, R., Sandler, T. (1986.) *The Theory of Externalities, Public Goods, and Club Goods*. Cambridge University Press.

This book presents a theoretical treatment of externalities, public goods, and club goods, including the difference between rivalrous and non-rival goods. In specific, it defines goods considered non-rivalrous or non-rival if, for any level of production, the cost of providing it to an additional individual is zero.

[5] Musgrave, Richard A. "Provision for Social Goods." *Public Economics* (1969): 124-144

In this paper, Musgrave defines the difference between private and public goods. He defines public goods as non-excludable goods, which every individual can access. The opposite being excludable goods, which refers to private goods, or goods that restrict some people from using them. These definitions set the foundation for understanding and applying the concepts of public and private goods.

[6] Ostrom, V., & Ostrom, E. (1977). *Public Goods and Public Choices*. In Alternatives for Delivering Public Services: Toward Improved Performance (pp. 7-49).

This paper expands the discussion of public goods and provides analysis for dealing with the organization and delivery of public goods and services. Ostrom defines a public good as one which is not subject to exclusion and is subject to jointness in its consumption or use.

[7] Merriam-Webster. (n.d.). For the common/public good. In *Merriam-Webster.com dictionary*. Retrieved from https://www.merriam-webster.com/dictionary/for%20the%20common%2Fpublic%20good

Merriam-Webster defines for the common/public good as "in order to help or benefit everyone."

[8] Merriam-Webster. (n.d.). Public service. In *Merriam-Webster.com dictionary*. Retrieved from https://www.merriam-webster.com/dictionary/public%20service

Merriam-Webster defines public service as "The business of supplying a commodity (such as electricity or gas) or service (such as transportation) to any or all members of a community."

[9] Oxford Learner's Dictionary. *Security Definition*. Retrieved from https://www.oxfordlearnersdictionaries.com/definition/american_english/security

Oxford Learner's Dictionary defines security as "the activities involved in protecting a country, building, or person against attack, danger, etc."

[10] Department of Homeland Security. (2022, October 4). *About the Department of Homeland Security: Mission.* Department of Homeland Security Official Website. Retrieved from https://www.dhs.gov/mission

This article describes the mission of the DHS to ensure safe, secure, and prosperous security to the U.S. In addition, the site details the underlying core values, guiding principles, and the six overarching homeland security missions that make up their strategic plan.

[11] Civil Air Patrol. *Civil Air Patrol's Three Primary Programs: What We Do.* Civil Air Patrol U.S. Airforce Auxiliary Official Website. Retrieved from https://www.gocivilairpatrol.com/

This webpage gives an overview of the Civil Air Patrol, which is America's premier public service organization for carrying out emergency services and disaster relief missions nationwide. The site explains that as an auxiliary of the U.S. Air Force, CAP citizen volunteers work to keep the U.S. safe and promote aviation and related fields through aerospace education.

[12] Safeopedia. (2018, November 8). *Emergency Response Best Practices.* Safeopedia Dictionary. Retrieved from https://www.safeopedia.com/definition/195/emergency-response

This article explains the components of an emergency response. It defines emergency response as "any systematic response to an unexpected or dangerous occurrence."

[13] Federal Emergency Management Agency. (2022, September 7). *National Disaster Recovery Framework.* The Federal Emergency Management Agency Official Website. Retrieved from https://www.fema.gov/emergency-managers/national-preparedness/frameworks/recovery

The webpage explains how the National Disaster Recovery Framework (NDRF) enables effective recovery support to disaster-impacted states, tribes, territorial and local jurisdictions. The NDRF focuses on how best to restore, redevelop, and revitalize the health, social, economic, natural and environmental fabric of the community and build a more resilient nation.

[14] U.S Centers for Disease Control and Prevention. (2022, April 29). *Mission, Role, and Pledge.* Centers for Disease Control and Prevention. Retrieved from https://www.cdc.gov/about/organization/mission.htm

The webpage explains how CDC works to protect the U.S. from health, safety, and security threats. The CDC aims to save lives and protect people from health threats through conducting critical science and providing health information when health threats arise.

[15] U.S Centers for Disease Control and Prevention. (2022, April 29). *Why Parks and Recreation are Essential Public Services.* Centers for Disease Control and Prevention. Retrieved from Parks and Recreation as Essential Public Services (nrpa.org)

This document asserts that parks and recreation have three values that make them essential services to communities: economic value, health and environmental benefits, and social importance. The document provides further detail into how each of these categories contributes to serving and enhancing communities.

[16] Wallace, R. (2020, February 20). *Oversight of the U.S. Fish and Wildlife Service*. U.S. Department of the Interior Office of Congressional Affairs. Retrieved from Department of the Interior | FWS Mission

This webpage contains the testimony of Robert Wallace, the former Assistant Secretary for Fish and Wildlife and Parks in the Department of the Interior. His statement addresses the Senate Committee on Environment and Public Works and discusses the mission, work, and priorities of the U.S. Fish and Wildlife Service.

[17] Department of the Interior. (2021). *Budget Justifications and Performance Information*. Department of the Interior Office of Budget Official Website. Retrieved from https://www.doi.gov/sites/doi.gov/files/fy2022-nps-budget-justification.pdf.

This webpage is the official Budget Justification of the Department of the Interior National Parks Service (NPS) for Fiscal Year 2022. The justification contains a detailed breakdown of NPS activities and current and past funding levels that support the mission of preserving and maintaining U.S. natural resources.

[18] The National Wildlife Federation. *Our Work.* National Wildlife Federation Official Website. Retrieved from National Wildlife Federation.

The NWF's website provides an overview of their mission to build a better future for both people and wildlife through our hands-on programs, policy work, and community outreach. Areas of focus include preserving habitats, waters, wildlife, preventing environmental threats, and natural lands.

[19] Department of Transportation. (2022, April 7). *Fiscal Year 2022-2026 U.S. DOT Strategic Plan.* Department of Transportation Official Website. Retrieved from DOT Strategic FY22-26 Plan.

This article provides an overview of the Department of Transportation (DOT)'s strategic plan for the Fiscal Years 2022-2026. The DOT establishes five key goals in the upcoming years to improve the transportation system including safety, strength and global competitiveness, equity, climate and sustainability, transformation, and organizational excellence.

[20] Intelligent Transportation Society of America. *About: A better future transformed by intelligent mobility*. Intelligent Transportation Society of America Official Website. Retrieved from About ITSA.

ITSA's mission statement explains how the organization aims to advance the research and deployment of intelligent transportation technologies by convening leaders from across the private and public sector, promoting a legislative and regulatory environment that supports investment in and the deployment of intelligent systems, conducting research, and building awareness of advancements in smart transportation technologies.

[21] Department of Transportation. (2020, November 20). ***Civil Reserve Airfleet.*** U.S. Department of Transportation Official Website. U.S. Department of Transportation Official Website. Retrieved from Civil Reserve Airfleet | US Department of Transportation.

This webpage provides an overview of the Civil Reserve Air Fleet, which is a cooperative, voluntary program involving the DOT, DOD, and the U.S. civil air carrier industry in a partnership to augment DOD aircraft capability during a national defense related crisis.

[22] Forsner, M., Brunt, D., & Wasteson, E. (2019). Environmental aspects of antibiotics and antibiotic-resistant bacteria-a brief review. Current Opinion in Environmental Science & Health, 11, 72-77. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4491066/

This article examines the environmental impact of antibiotics and antibiotic-resistant bacteria and discusses the various ways in which antibiotics and antibiotic-resistant bacteria can enter the environment and affect ecosystems and human health.

[23] United States Environmental Protection Agency. (n.d.). Water Quality Data. Retrieved from EPA Water Quality Data.

This website provides information on water quality data collected and links to several databases, tools, and maps that users can access to obtain information on water quality parameters such as temperature, pH, dissolved oxygen, and nutrients, as well as information on pollutants and their sources.

[24] U.S. Customs and Border Protection. (n.d.). CBP Small Unmanned Aircraft Systems Program. Retrieved from https://www.cbp.gov/frontline/cbp-small-uas-program

This website provides information on the CBP's use of sUAS for border security and other law enforcement purposes. The webpage explains the various types of sUAS used by the CBP, their capabilities, and the benefits they provide, such as improved situational awareness and enhanced border surveillance.

[25] U.S. Customs and Border Protection. (2022). Interim critical incident response guidance. Retrieved from https://www.cbp.gov/sites/default/files/assets/documents/2022-Feb/Interim-Critical-Incident-Response-Guidance_%2822-40128%29.pdf

This article outlines the guidance for CBP personnel in responding to critical incidents, details the roles and responsibilities of CBP personnel involved in critical incident response, and lists the steps to be taken in preparing for and responding to such incidents.

[26] Washington State Department of Transportation. (n.d.). Avalanche control. Retrieved from https://wsdot.wa.gov/travel/operations-services/avalanche-control

This resource explains the methods used by WSDOT to control avalanches, such as avalanche forecasting and monitoring, explosives and artillery fire, and the use of snow sheds and other physical barriers. The webpage also provides information on the tools and equipment used in avalanche control operations, such as snowplows, snow blowers, and other specialized vehicles.

[27] 911 Security. (2022, January 11). 6 Benefits of Using AAM Vehicle Detection Technology for Prisons. Retrieved from https://www.911security.com/blog/6-benefits-of-using-aam-vehicle-detection-technology-for-prisons

The article discusses the benefits of using AAM vehicle detection technology for prisons, including reducing the risk of escape.

[28] National Institute of Justice. (2007). Law Enforcement and Security Officers' Guide to Responding to Bomb Threats. Retrieved from https://www.ojp.gov/ncjrs/virtual-library/abstracts/law-enforcement-and-security-officers-guide-responding-bomb-1

The article provides a comprehensive guide for law enforcement and security officers on how to respond to bomb threats.

[29] FlytNow. (2022, February 23). AAM Vehicles for Search and Rescue. Retrieved from https://flytnow.com/AAM-vehicles-for-search-rescue/

The article describes how AAM vehicles can provide faster transportation to remote areas, allowing first responders to quickly reach persons in need of medical attention.

[30] Goodrich, K. and Theodore, C. (2021). Description of the NASA Urban Air Mobility Maturity Level (UML) Scale. AIAA SciTech 2021 Forum, AIAA 2021-1627. Retrieved from https://www.researchgate.net/publication/348245490_Description_of_the_NASA_Urban_Air_Mobility_Maturity_Level_UML_Scale

The research paper presents a description of the NASA Urban Air Mobility Maturity Level (UML) Scale. The UML Scale is a framework developed by NASA to assess the maturity of technologies and systems related to urban air mobility (UAM).

[31] NASA. (2021, February 17). Building the Infrastructure for Advanced Air Mobility. Retrieved from https://www.nasa.gov/feature/building-the-infrastructure-for-advanced-air-mobility

This webpage discusses the efforts being made to develop the necessary infrastructure for AAM and provides insights into NASA's role in conducting research, testing, and validation to support the implementation of AAM infrastructure.

[32] Federal Aviation Administration. (2021). UTM Concept of Operations (Version 2.0). Retrieved from https://www.faa.gov/researchdevelopment/trafficmanagement/utm-concept-operations-version-20-utm-conops-v20/

The UTM Concept of Operations published by the FAA, (Version 2.0) provides a comprehensive framework for the implementation of UTM.

[33] National Ag Safety Database. (n.d.). Rescues at Sea: A Guide to Helicopter Rescues & Dewatering Pumps. Retrieved from https://nasdonline.org/7434/v001639/rescues-at-sea-a-guide-to-helicopter-rescues-dewatering-pumps.html

The article is a guide to helicopter rescues in maritime operations.

[35] US Department of Agriculture. (2020, November 18). Safe Agricultural Data Collection and Delivery. Retrieved from https://www.usda.gov/media/blog/2020/11/18/safe-agricultural-data-collection-and-delivery

This article highlights the importance of safe and secure data practices in agriculture and provides practical guidance for stakeholders to ensure the protection of sensitive information.

[36] National Agricultural Statistics Service. (n.d.). Home page. United States Department of Agriculture. Retrieved from https://www.nass.usda.gov/index.php

This website provides access to a wide range of the USDA's statistical data and reports on topics such as crops and livestock, economics and prices, and environmental management.

[37] National Park Service. (2021). Search and Rescue (SAR) Library Resources. MyLearning. Retrieved from https://mylearning.nps.gov/library-resources/search-rescue-sar/

This website provides current and relevant information on best practices in SAR, as well as updates on new developments in the field.

[38] Walter McDonald (2019) UAS in urban stormwater management: a review and future perspectives, Urban Water Journal, 16:7, 505-518, Retrieved from DOI: 10.1080/1573062X.2019.1687745

This paper presents a review of UAS studies that have applications for urban stormwater management and provides future perspectives on their role as an emerging technology.

[39] TraceAir. (2021, May 12). How to Use AAM Vehicles for Stormwater Pollution Prevention Planning (SWPPP). Retrieved from https://www.traceair.net/whats-new/how-to-use-aam-vehicles-for-stormwater-pollution-prevention-planning-swppp

This article discusses the use of AAM vehicles for stormwater pollution prevention planning (SWPPP).

[40] Cuyahoga Soil & Water Conservation District. (2015, August 11). AAM Vehicles and Stormwater Management. Retrieved from https://www.cuyahogaswcd.org/blog/2015/08/11/aam-vehicles-and-stormwater-management

This website provides an overview of how AAM vehicles can be used to assess stormwater runoff and identify potential sources of pollution.

[41] U.S. Environmental Protection Agency. (n.d.). Water Quality Data. Retrieved from https://www.epa.gov/waterdata/water-quality-data

This website provides data on water quality throughout the United States.

[42] Oosterhuis, F., van der Meer, F. D., & Wielemaker, R. (2022). The Role of Augmented Reality in Enhancing Resilience of Critical Infrastructure. Safety Science, 146, 105594. Retrieved from https://doi.org/10.1016/j.ssci.2022.105594

This article explores the potential role of augmented reality (AR) technology in enhancing the resilience of critical infrastructure. The authors argue that AR can be used to provide real-time information and situational awareness to infrastructure operators, helping them to identify and respond to threats or disruptions more effectively.

[43] Geonadir. (2019, November 8). Using AAM Vehicles for Flooding Management. Retrieved from https://geonadir.com/using-AAM-vehicles-flooding-management/#:~:text=AAM%20vehicle%20mapping%20and%20photogrammetry%20can,built%20to%20reduce%20flood%20impact.

This article discusses the use of AAM vehicles for flooding management.

[44] Consortiq. (n.d.). AAM Vehicles: The Latest Tools in Drought Management. Retrieved from https://consortiq.com/uas-resources/AAM-vehicles-the-latest-tools-in-drought-management/

This article discusses the use of AAM vehicles for drought management.

[45] University of Nebraska-Lincoln. (n.d.). Tips for Staying Safe When Transporting Pesticides. Retrieved from https://cropwatch.unl.edu/tips-staying-safe-when-transporting-pesticides#:~:text=The%20best%20way%20to%20transport,wood%20and%20the%20pesticide%20container.

The article provides practical guidance for safely transporting pesticides, such as using appropriate containers, securing containers to prevent movement, and avoiding transport during extreme weather conditions.

[46] U.S. Customs and Border Protection. (n.d.). Home page. Retrieved from https://www.cbp.gov/

The website for the U.S. Customs and Border Protection (CBP) provides information on the agency's mission, operations, and services.

[47] U.S. Customs and Border Protection. (n.d.). CBP Small Unmanned Aircraft Systems Program. Retrieved from https://www.cbp.gov/frontline/cbp-small-UAS-program.

This article discusses the Small Unmanned Aircraft Systems (sUAS) Program implemented by the U.S. Customs and Border Protection (CBP).

[48] U.S. Customs and Border Protection. (2022). Interim Critical Incident Response Guidance. Retrieved from https://www.cbp.gov/sites/default/files/assets/documents/2022-Feb/Interim-Critical-Incident-Response-Guidance_%2822-40128%29.pdf

This document provides a detailed framework for CBP for identifying and reporting critical incidents, assessing the situation, and initiating an appropriate response.

[49] U.S. Government Accountability Office. (2022). Managing Federal Lands and Waters: Opportunities to Improve the Use of AAM vehicles for Resource Management (GAO-22-425SP). Retrieved from https://www.gao.gov/assets/gao-22-425sp.pdf

This report discusses the opportunities to improve the use of AAM vehicles for resource management on federal lands and waters.

[50] The Inertia. (2019, January 11). AAM vehicles are changing avalanche control for the better. The Inertia. Retrieved from https://www.theinertia.com/mountain/AAM vehicles-are-changing-avalanche-control-for-the-better/

This article discusses how AAM vehicles can be used to trigger controlled avalanches without putting people at risk.

[51] Kallgren, B. (2021, February 15). AAM vehicles changing the game in avalanche safety. GearJunkie. Retrieved from https://gearjunkie.com/winter/skiing/avalanche-safety-AAM vehicles

This article explains how AAM vehicles are changing how avalanche safety is handled in the skiing and snowboarding industry due to new technological advancements.

[52] U.S. Government Accountability Office. (n.d.). Managing Federal Lands and Waters. Retrieved from https://www.gao.gov/managing-federal-lands-and-waters/

This website provides information on federal land and water management operations.

[53] Your AAM vehicle Reviews. (n.d.). AAM vehicles for Forestry. Retrieved from https://youraamvehiclereviews.com/aam-vehicles-for-forestry/

This website details how the use of AAM vehicles in forestry can help reduce the environmental impact of logging and other forestry operations.

[54] National Oceanic and Atmospheric Administration. (n.d.). Monitoring. NOAA's National Ocean Service. Retrieved from https://oceanservice.noaa.gov/observations/monitoring/

NOAA's website provides information on monitoring the ocean and coastal areas.

[55] Institute of Industrial Science, The University of Tokyo. (21 November 2022). "Exploring the deep: UAS offer new ways to monitor sea floor." ScienceDaily. Retrieved from <www.sciencedaily.com/releases/2022/11/221121105258.htm>.

This article details how researchers have developed a novel method for measuring the earth's crust on the seafloor. The mobility of this new system will enable rapid, efficient collection of real-time deep seafloor information, which is critical for understanding earthquake risk, as well as various other oceanographic observations.

[56] Carrington, D. (2016, April 20). More than 1,000 species have been moved due to human impact. The Guardian. Retrieved from https://www.theguardian.com/environment/2016/apr/20/more-than-1000-species-have-been-moved-due-to-human-impact

This report highlights the effects of human activity on biodiversity.

[57] Florida Fish and Wildlife Conservation Commission. (n.d.). Relocating wildlife. Retrieved from https://myfwc.com/conservation/you-conserve/wildlife/relocate/

The Florida Fish and Wildlife Conservation Commission provides information on the relocation of wildlife.

[58] WLWT Digital Team. (2020, January 16). Once nonexistent, elk are making a major comeback in Kentucky. WLWT5. Retrieved from https://www.wlwt.com/article/once-nonexistent-elk-are-making-a-major-comeback-in-kentucky/30547595#

This article gives an overview and explains the successful reintroduction of elk in Kentucky.

[59] Noar Technologies. (n.d.). How to use UAS in wildlife conservation. Retrieved from https://www.noartechnologies.com/how-to-use-UAS-in-wildlife-conservation/#:~:text=Monitoring%20Wildlife%20with%20UAS&text=This%20is%20done%20by%20using,their%20populations%20and%20their%20habitats.

This article discusses the use of UAS in wildlife conservation and highlights the potential for further use of this technology in the future.

[60] FEMA. (2023). Disaster Survivors. Federal Emergency Management Agency. Retrieved from https://www.fema.gov/assistance/individual/disaster-survivors

This webpage describes how FEMA works closely with state and local governments, non-profit organizations, and other partners to ensure that disaster survivors receive assistance needed.

[61] FEMA. (2019). Commonly used sheltering items catalog. Retrieved from https://www.fema.gov/sites/default/files/documents/fema_commonly-used-sheltering-items-catalog.pdf

The Commonly Used Sheltering Items Catalog provides a list of essential items that are necessary for setting up and maintaining temporary shelters for disaster survivors.

[62] U.S. Department of Veterans Affairs. (2022). Disaster Response Work. National Center for PTSD. Retrieved from https://www.ptsd.va.gov/professional/treat/type/disaster_response_work.asp

This article describes roles that mental health professionals may take in disaster response work.

[63] NASA. (2019, August 14). AAM for Emergencies: Unmanned Aircraft Offers Lifeline from Above. Retrieved from https://www.nasa.gov/centers/armstrong/features/aam-for-emergencies.html

The article highlights the potential of AAM in emergency response and how NASA is contributing to its development.

[64] FEMA. (n.d.). Preliminary damage assessments. FEMA. Retrieved from https://www.fema.gov/disaster/how-declared/preliminary-damage-assessments

This article describes how FEMA works with state, tribal, and local officials to assess the damage and the resources required to address it.

[65] Learmount, D. (2021, August 24). AAM role seen battling wildfires. Aviation Week & Space Technology. Retrieved from https://aviationweek.com/business-aviation/aam-role-seen-battling-wildfires

This article discusses the potential role of AAM vehicles in fighting wildfires.

[66] National Interagency Fire Center. (n.d.). Helicopters. Retrieved from https://www.nifc.gov/resources/aircraft/helicopters

This article provides an overview of the use of helicopters in wildland firefighting.

[67] No author. (n.d.). Fire Department AAM vehicles. Adorama. Retrieved from https://www.adorama.com/alc/fire-department-AAM vehicles/

The article explains how AAM vehicles can be useful for fire departments in surveying the landscape, detecting fires, and planning their response to an emergency.

[68] U.S. Department of Transportation. (n.d.). Federal Railroad Administration. SafetyFirst. Retrieved from https://www.transportation.gov/briefing-room/safetyfirst/federal-railroad-administration

This website provides an overview of the FRA's responsibilities, including inspection.

[69] U.S. Department of Transportation. (2018). Highway Bridge Inspections [Testimony]. Retrieved from https://www.transportation.gov/testimony/highway-bridge-inspections

This excerpt of a testimony discusses the importance of bridge inspections in preventing accidents, maintaining the safety of the public and the need for continued investment in bridge infrastructure.

[70] Flyability. (n.d.). AAM Vehicle Inspections. Flyability. Retrieved from https://www.flyability.com/AAM vehicle-inspections

This website describes Flyability's AAM vehicle, the Elios 2, that is specifically designed for the inspection of complex and hazardous environments, such as mines, power plants, and offshore oil rigs.

[71] Bartlett, R. (2016, May 11). Students Create System to Manage Airport Runway Obstructions. Informed Infrastructure. Retrieved from https://informedinfrastructure.com/16012/students-create-system-to-manage-airport-runway-obstructions/

The article discusses a system developed by students at Ohio State University for managing airport runway obstructions using UAS.

[72] Miles, S. (2021, March 31). More AAM Vehicles Please: Why Police Departments Need to See Everything. Security Magazine. Retrieved from https://www.securitymagazine.com/articles/97963-more-AAM vehicles-please-why-police-departments-need-to-see-everything

This article explains how the use of AAM vehicles in law enforcement is increasing and how these vehicles provide aerial surveillance capabilities to police departments.

[73] 911Security. (2019, May 17). 6 benefits of using AAM vehicle detection technology for prisons. 911 Security. Retrieved from https://www.911security.com/blog/6-benefits-of-using-UAS-detection-technology-for-prisons/.

The article highlights the benefits of using AAM vehicle detection technology for prisons and how it could help reduce the risk of escape, enhance prison security, and reduce costs.

[74] Winstead, T. (2022, January 14). North Carolina police use UAS to patrol from the sky. Government Technology. Retrieved from https://www.govtech.com/products/north-carolina-police-use-UAS-to-patrol-from-the-sky

This article describes how the police department in Winston-Salem, North Carolina, have started using UAS to provide real-time aerial footage of the area under surveillance and respond to criminal activities.

[75] Nesbitt, L. (2021, February 4). How unmanned aerial systems can assist police pursuits. Police1. Retrieved from https://www.police1.com/police-products/police-AAM vehicles/articles/how-unmanned-aerial-systems-can-assist-police-pursuits-4s3K7BXNHqOKyp6V/

This article discusses the use of UAS in police pursuits and potential limitations.

[76] National Institute of Justice. (2007). A law enforcement and security officer's guide to responding to bomb threats. Retrieved from https://www.ojp.gov/ncjrs/virtual-library/abstracts/law-enforcement-and-security-officers-guide-responding-bomb-1

This document provides guidance for law enforcement and security officers in responding to bomb threats.

[77] MPDC. (n.d.). Bomb Threats and Explosive Devices. Metropolitan Police Department of the District of Columbia. Retrieved from https://mpdc.dc.gov/page/bomb-threats-and-explosive-devices

This website provides information and guidelines for responding to bomb threats and explosive devices.

[78] Sharma, M., & Singh, G. (2018). Role of telemedicine in bridging the gap between doctors and patients. Journal of family medicine and primary care, 7(5), 1328–1331. Retrieved from https://doi.org/10.4103/jfmpc.jfmpc_283_18

This article contains information on healthcare disparities, particularly for individuals living in rural or remote areas.

[79] LifeSource. (n.d.). How Are Organs Transported for Transplant? Retrieved from https://www.life-source.org/latest/how-are-organs-transported-for-transplant/#:~:text=The%20transportation%20of%20organs%20for,recipient(s)%20transplant%20surgeons.

This article outlines the steps involved in organ transportation, starting with the identification of a potential donor, the evaluation of organ suitability for transplantation, the process of organ procurement, then preservation, and finally packaging.

[80] GE Reports. (2019, May 2). Special Delivery: First Time UAS Flies Donor Kidney to Patient for Successful Transplant. Retrieved from https://www.ge.com/news/reports/special-delivery-first-time-UAS-flies-donor-kidney-patient-successful-transplant#:~:text=A%20medical%20and%20aviation%20breakthrough,human%20kidney%20from%20Baltimore's%20St.

This article highlights the successful transportation of a human kidney from Baltimore's St. Agnes Hospital to the University of Maryland Medical Center using a UAS.

[81] United Network for Organ Sharing (UNOS). (n.d.). High-Flying Hopes: Are UAS the Future of Organ Transportation? Retrieved from https://unos.org/news/innovation/high-flying-hopes-are-UAS-the-future-of-organ-transportation/#:~:text=By%20keeping%20transplant%20surgery%20teams,more%20frequently%2C%E2%80%9D%20he%20said.

This article explores the advantages of using UAS in organ delivery, such as their ability to bypass traffic and reduce transportation time. It also highlights a successful trial in which a UAS transported a kidney for transplant, demonstrating the feasibility of this approach.

[82] Xwing. (2020, July 10). Delivering PPE and school supplies to the Navajo Nation autonomously. Medium. Retrieved from https://medium.com/@xwinginc/delivering-ppe-and-school-supplies-to-the-navajo-nation-autonomously-9111f5c543d7

This article describes a project undertaken by Xwing to deliver personal protective equipment (PPE) and school supplies to the Navajo Nation in response to the COVID-19 pandemic.

[83] ASPR. (2022, January 25). Deploying PPE from SNS. U.S. Department of Health & Human Services. Retrieved from https://aspr.hhs.gov/SNS/Pages/Deploying-PPE-from-SNS.aspx

The article discusses the Strategic National Stockpile (SNS) program, which provides critical medical supplies, including personal protective equipment (PPE), to communities in need during emergencies.

[84] U.S. Department of Health and Human Services. (n.d.). Deploying PPE from SNS. ASPR - Office of the Assistant Secretary for Preparedness and Response. Retrieved from https://aspr.hhs.gov/SNS/Pages/Deploying-PPE-from-SNS.aspx

The article discusses the deployment of Personal Protective Equipment (PPE) from the Strategic National Stockpile (SNS) during a public health emergency.

[85] APIC. (2021, March 30). FDA extends shelf life of Pfizer COVID-19 vaccine. Association for Professionals in Infection Control and Epidemiology. Retrieved from https://apic.org/advocacy_update/fda-extends-shelf-life-of-pfizer-covid-19-vaccine/#:~:text=The%20FDA%20approved%20a%20request,90%20to%20%2D60%20degrees%20Celsius.

This article contains information on the shelf life and temperature storage of the Pfizer-BioNTech COVID-19 vaccine.

[86] Centers for Disease Control and Prevention. (2016). Fast facts. Immunization prevents death worldwide. Retrieved from https://www.cdc.gov/globalhealth/immunization/data/fast-facts.html

The Centers for Disease Control and Prevention (CDC) provides fast facts on immunization and its life-saving impact globally.

[87] About Healthcare. (2021, March 11). Why do hospitals transfer patients? Retrieved from https://www.abouthealthcare.com/insights/blog/why-do-hospitals-transfer-patients/

This article discusses the reasons why hospitals transfer patients to other healthcare facilities.

[88] Smith, T. (2014). Air medical transport: When taking flight with trauma patients makes sense. ED Management, 26(4), 37-39. Retrieved from https://www.reliasmedia.com/articles/116468-air-medical-transport-when-taking-flight-with-trauma-patients-makes-sense

The article discusses the advantages of air medical transport for trauma patients, particularly those who are in critical condition and require immediate treatment.

[89] Rural Health Information Hub. (2022, February 2). Rural Health Disparities. Retrieved from https://www.ruralhealthinfo.org/topics/rural-health-disparities

This article states that rural communities often have limited access to healthcare in the US due to shortage of healthcare professionals, transportation barriers, and limited healthcare facilities.

[90] Gonzalez, A. (2022, October 2). Hunger, poverty hitting communities of color disproportionately. NPR. Retrieved from https://www.npr.org/2022/10/02/1125571699/hunger-poverty-us-dc-food-pantry

This article highlights the increase in hunger and poverty among low-income communities of color in the United States.

[91] US Department of Agriculture. (2021, September 8). Key statistics & graphics. Economic Research Service. Retrieved from https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-u-s/key-statistics-graphics/

This article provides data from the Economic Research Service of the US Department of Agriculture on food insecurity statistics in the United States.

[92] FlytBase. (2021, June 28). AAM vehicles for search and rescue. FlytNow. Retrieved from https://flytnow.com/AAM-vehicles-for-search-rescue/

This article discusses the potential use of AAM vehicles in search and rescue operations.

[93] Meteomatics. (2022). MeteoAAM vehicles Weather AAM vehicles. Meteomatics. Retrieved from https://www.meteomatics.com/en/meteoAAM vehicles-weather-AAM vehicles/

The article discusses how Meteomatics is using AAM vehicles to collect and analyze weather data.

[94] National Oceanic and Atmospheric Administration. (n.d.). Big Data Project Frequently Asked Questions. NOAA. Retrieved from https://www.noaa.gov/big-data-project-frequently-asked-questions.

This webpage details NOAA's Big Data Project, which seeks to serve its stakeholders, including the scientific community, decision-makers, and the public.

[95] NOAA scientists used AAM vehicles to take measurements inside the most dangerous part of Hurricane Ian. (2021, September 9). KCRA 3. Retrieved from https://www.kcra.com/article/noaa-scientists-used-AAM vehicles-to-take-measurements-inside-the-most-dangerous-part-of-hurricane-ian/41504444#

This article explains how AAM vehicles were used to take measurements inside Hurricane Ian.

[96] National Oceanic and Atmospheric Administration. (2022, January 25). AAM vehicles are helping scientists understand major weather events. NOAA. Retrieved from https://research.noaa.gov/article/ArtMID/587/ArticleID/2687/AAM vehicles-are-helping-scientists-understand-major-weather-events

The article discusses the use of AAM vehicles in the field of atmospheric research by NOAA.

[97] Virginia Department of Transportation. (n.d.). Bridges and structures. VirginiaDOT. Retrieved from https://www.virginiadot.org/info/Bridge.asp

This webpage details how the Virginia Department of Transportation (VDOT) is responsible for inspecting all bridges and structures in the state of Virginia.

[98] Federal Communications Commission. (n.d.). Bridge inspections using unmanned aircraft systems (UAS). Retrieved from https://www.fcc.gov/sites/default/files/bridge2bridgeinsp_new.pdf

The report provides information on the use of UAS technology for inspecting bridges and the benefits of using this technology.

[99] Bridge Masters Inc. (2022). Bridge inspection & safety. Retrieved from https://bridgemastersinc.com/bridge-inspection-safety/#:~:text=With%20all%20this%20activity%20also,of%20Transportation's%20Federal%20Highway%20Administration.

The article discusses the importance of bridge inspections to ensure safety.

[100] The UAS Life NJ. (2021, May 28). UAS Bridge Inspection: Pros and Cons. Retrieved from https://theUASlifenj.com/UAS-bridge-inspection/

The article discusses the advantages and drawbacks of using UAS for bridge inspection.

[101] Boozman, J. (2022, August 4). Improving Infrastructure Inspections with UAS. Retrieved from https://www.boozman.senate.gov/public/index.cfm/2022/8/improving-infrastructure-inspections-with-UAS

The article discusses a new legislation introduced by Senator John Boozman that aims to improve infrastructure inspections with the help of UAS.

[102] Under Bridge Platforms. (n.d.). Why You Need a Snooper Truck. Retrieved from https://underbridgeplatforms.com/why-you-need-a-snooper-truck/

This article explains how snooper trucks are designed to inspect and maintain bridges, allowing engineers to easily examine the underside of bridges without shutting down traffic or requiring complex rigging systems.

[103] Stanton, G., & Graves, S. (2021, September 15). Stanton, Graves Introduce Bipartisan Bill to Encourage Use of UAS for Infrastructure Inspection. Retrieved from https://stanton.house.gov/2021/9/stanton-graves-introduce-bipartisan-bill-to-encourage-use-of-UAS-for-infrastructure-inspection

This article details the bill introduced by Representatives Greg Stanton and Sam Graves to encourage the use of UAS for infrastructure inspections.

[104] Under Bridge Platforms. (2020, August 14). Will UAS replace under bridge inspection units? Under Bridge Platforms. Retrieved from https://underbridgeplatforms.com/will-UAS-replace-under-bridge-inspection-units/

The article discusses the possibility of UAS replacing under bridge inspection units (UBI) for bridge inspections.

[105] Whitestown Indiana (2022). Utility infrastructure inspection. Retrieved from https://whitestown.in.gov/wp-content/uploads/2022/08/Utility-Infastructure-Inspection-REV-8.3.22.pdf

The document discusses the process of inspecting utility infrastructure, including the potential risks.

[106] Cleveland, A. (2021, March 29). UAS now inspecting bridges and roadways near you. Fleet Owner. Retrieved from https://www.fleetowner.com/perspectives/trucks-at-work/article/21693557/UAS-now-inspecting-bridges-and-roadways-near-you.

This article discusses the increasing use of UAS for bridge and roadway inspections.

[107] Midwest Industrial Supply. (2021, February 9). Why road maintenance is important and how to get it done. Midwest Blog. Retrieved from https://blog.midwestind.com/why-road-maintenance-is-important-and-how-to-get-it-done/.

This article emphasizes the importance of road maintenance and provides practical advice for communities and transportation agencies to maintain their road infrastructure.

[108] Consortiq. (n.d.). How UAS are growing the agricultural industry with soil analysis. Retrieved from https://consortiq.com/uas-resources/how-UAS-are-growing-the-agricultural-industry-with-soil-analysis#:~:text=In%20a%20simple%20flyover%2C%20UAS,scanned%20%E2%80%93%20not%20just%20representative%20samples.

This article emphasizes the growing role of UAS in the agricultural industry and suggests that their use for soil analysis is likely to become more widespread in the future.

[109] Fleming, M. (2019, May 8). The nature gap. Center for American Progress. Retrieved from https://www.americanprogress.org/article/the-nature-gap/.

This article discusses the lack of access to nature and green spaces in low-income and minority communities in the United States.

[110] SkyWatch. (n.d.). 5 benefits of using satellite imagery over UAS. Retrieved from https://skywatch.com/5-benefits-of-using-satellite-imagery-over-UAS/#:~:text=High%2Dresolution%20satellites%20can%20give,which%20an%20image%20is%20captured.

This article outlines the advantages of using satellite imagery for remote sensing applications and suggests that it is a powerful tool for monitoring and managing the environment.

[111] Wingtra. (n.d.). Surveying & GIS. Retrieved from https://wingtra.com/UAS-mapping-applications/surveying-gis/.

This article highlights the potential of UAS to improve the field of surveying and GIS and suggests that their use can lead to significant improvements in accuracy, efficiency, and safety.

[112] University of California, Santa Cruz. (2018, March 22). Drones could make forest conservation monitoring significantly cheaper. Retrieved from https://envs.ucsc.edu/news-events/news/karen-holl-UAS.html#:~:text=In%20total%2C%20the%20UAS%20and,open%20%E2%80%93%20to%20field%20based%20measures.

This article discusses the use of UAS for environmental monitoring and research.

[113] United States Environmental Protection Agency. (n.d.). Greenhouse gas emissions from a typical passenger vehicle. Retrieved from https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle.
This article provides information on the amount of greenhouse gases emitted by a typical passenger vehicle and explanation of the calculation.

[114] U.S. Department of Agriculture Forest Service. (n.d.). Meet the Forest Service. Retrieved from https://www.fs.usda.gov/about-agency/meet-forest-service.

The article provides information on the USDA's Forest service mission and the stakeholders with which it works.

[115] National Park Service. (n.d.). Reports and data. Retrieved from https://www.nps.gov/im/reports-nrr.htm.

This webpage provides access to various reports and data related to the management of national parks and other public lands.

[116] Simulyze. (2021, January 12). UAS & conservation: Taking to skies to protect natural resources & wildlife. Retrieved from https://www.simulyze.com/blog/UAS-conservation-taking-to-skies-to-protect-natural-resources-wildlife.

This article describes the use of UAS in conservation efforts to monitor and observe to protect natural resources and wildlife.

[117] NASA Applied Sciences. (n.d.). Monitoring fires with fast-acting data. Retrieved from https://appliedsciences.nasa.gov/our-impact/story/monitoring-fires-fast-acting-data.

This article describes how NASA is using satellite data to detect fires and track their spread and could allow for more effective response.

[118] NASA. (2021, February 17). Missions: NASA's Fire Detection and Management Activities. Retrieved from https://www.nasa.gov/mission_pages/fires/main/missions/index.html.

The website explains that NASA is using a range of technologies and approaches to monitor and respond to wildfires, including satellite data, computer models, and on-the-ground measurements.

[119] Fire and EMS Fund. (2019, October 1). Three Things to Know About Fire Department Response Times. Retrieved from https://www.fireandemsfund.com/three-things-to-know-about-fire-department-response-times/#:~:text=When%20measuring%20the%20effectiveness%20of,effectively%20serve%20and%20protect%20communities.

This article details the importance of response times in measuring the effectiveness of fire departments.

[120] Wildfire Today. (2022, October 5). UAS are playing an increasingly important role in fighting wildfires. Retrieved from https://wildfiretoday.com/2022/10/05/UAS-are-playing-an-increasingly-important-role-in-fighting-wildfires/#:~:text=With%20UAS%2C%20fire%20managers%20and,new%20starts%20before%20they%20grow.https://wildfiretoday.com/2022/10/05/UAS-are-playing-an-increasingly-important-role-in-fighting-wildfires/#:~:text=With%20UAS%2C%20fire%20managers%20and,new%20starts%20before%20they%20grow

This article describes the potential benefits of using UAS in wildfire management.

[121] Adams, E. (2022, February 15). COVID was the Leading Cause of Wildland Firefighter Deaths in 2021. Montana Public Radio. Retrieved from https://www.mtpr.org/montana-news/2022-02-15/covid-was-the-leading-cause-of-wildland-firefighter-deaths-in-2021

This article discusses the challenges that wildland firefighters faced during the pandemic, including limited access to testing and personal protective equipment.

[122] USDA Forest Service. (2022). Planes. Retrieved from https://www.fs.usda.gov/managing-land/fire/planes

This website provides information about the use of planes in wildland firefighting, including to drop water and fire retardant.

[123] VPM News. (2020, May 1). UAS: A Tool For Early Wildfire Detection. Retrieved from https://vpm.org/news/articles/13739/UAS-a-tool-for-early-wildfire-detection

This article describes how the Virginia Department of Forestry is using UAS in their efforts to monitor and prevent wildfires.

[124] López-Granados, F., Torres-Sánchez, J., Serrano-Pérez, A., & Peña-Barragán, J. M. (2018). An assessment of the accuracy and consistency of canopy height measurements of UAS using photogrammetric methods. Retrieved from PloS one, 13(10), e0205825.

The article explores the use of UAS in collecting high-resolution images to assess the accuracy and consistency of UAS-based canopy height measurements.

[125] The Nature Conservancy. (2021, August 11). Wildfires Disproportionately Impact Communities of Color. The Nature Conservancy. Retrieved from https://www.nature.org/en-us/about-us/where-we-work/united-states/washington/stories-in-washington/wildfires-impact-minorities/

This article discusses how wildfires in the United States disproportionately affect communities of color.

[126] Johnson, B. (2022, October 5). UAS are playing an increasingly important role in fighting wildfires. Wildfire Today. Retrieved from https://wildfiretoday.com/2022/10/05/UAS-are-playing-an-increasingly-important-role-in-fighting-

wildfires/#:~:text=With%20UAS%2C%20fire%20managers%20and,new%20starts%20before%20they%20grow.https://wildfiretoday.com/2022/10/05/UAS-are-playing-an-increasingly-important-role-in-fighting-wildfires/#:~:text=With%20UAS%2C%20fire%20managers%20and,new%20starts%20before%20they%20grow.

This article describes how UAS are currently being used in mapping wildfires, monitoring fire lines, and detecting new fires.

[127] National Interagency Fire Center. (2022). Suppression Costs. National Interagency Fire Center. Retrieved from https://www.nifc.gov/fire-information/statistics/suppression-costs

This website details the National Interagency Fire Center's data set, which provides information on the costs associated with fighting wildfires in the United States.

[128] United Nations Office for Disaster Risk Reduction. (2022, March 16). Monitoring and evaluation for disaster recovery. PreventionWeb. Retrieved from https://www.preventionweb.net/news/view/82785

The article describes the United Nation's approach to monitoring and evaluation, including the collection and analysis of data on various aspects of recovery efforts, such as infrastructure, livelihoods, and social support.

[129] NASA Armstrong Flight Research Center. (2019, August 26). Advanced Air Mobility for emergencies. NASA. Retrieved from https://www.nasa.gov/centers/armstrong/features/aam-for-emergencies.html

This article highlights the potential uses of AAM in emergency situations and notes the challenges associated with implementation.

[130] Davis JR, Wilson S, Brock-Martin A, Glover S, Svendsen ER. The impact of disasters on populations with health and health care disparities. Disaster Med Public Health Prep. 2010 Mar;4(1):30-8. Retrieved from doi: 10.1017/s1935789300002391. PMID: 20389193; PMCID: PMC2875675.

This paper reviewed the literature on the combined effects of a disaster and living in an area with existing health or health care disparities on a community's health, access to health resources, and quality of life.

[131] UASBelow. (2019, May 15). Into the Eye of the Storm with UAS. Retrieved from https://UASbelow.com/2019/05/15/into-the-eye-of-the-storm-with-UAS/#:~:text=Researchers%20will%20gather%20information%20on,are%20thought%20to%20trigger%20tornadoes.

This article discusses how UAS are being used to study severe weather, particularly tornadoes.

[132] Kespry. (2018, August 21). What to Charge for UAS Services. UASblog.com. Retrieved from https://www.UASblog.com/what-to-charge-for-UAS-services/#:~:text=Commercial%20UAS%20service%20providers%20can,being%20about%20%24150%20per%20hour.

This article discusses the pricing strategies for commercial UAS services.

[133] National Weather Service. (n.d.). The Price of Being a Hurricane Hunter. National Oceanic and Atmospheric Administration (NOAA). Retrieved from https://www.weather.gov/ctp/HurricaneHunterPriceArticle.

This article discusses the challenges, costs, and risks associated with hurricane hunting.

[134] Fox Weather. (2021, August 18). Hurricane UAS Research Could Revolutionize Hurricane Hunting. Retrieved from https://www.foxweather.com/extreme-weather/hurricane-UAS-research-hurricane-hunter.

This article discusses the limitations and risks associated with traditional hurricane hunting methods and explains how UAS could offer a safer and more cost-effective alternative.

[135] Federal Aviation Administration. (2022). Report of the Unmanned Aircraft Systems (UAS) Beyond Visual Line of Sight (BVLOS) Aviation Rulemaking Committee (ARC). Retrieved from https://www.faa.gov/regulations_policies/rulemaking/committees/documents/media/UAS_BVLOS_ARC_FINAL_REPORT_03102022.pdf.

This report provides an overview of the current regulatory framework for UAS operations and highlights the need for new rules to support safe and effective BVLOS operations.

[136] UNDRR. (2021, January 7). How GIS can help communities prepare for disaster. PreventionWeb. Retrieved from https://www.preventionweb.net/news/how-gis-can-help-communities-prepare-disaster.

This article discusses the benefits of using GIS technology to collect and analyze data, such as identifying vulnerable populations and mapping critical infrastructure.

[137] Custom Truck One Source. (2019, April 19). Getting the Job Done: Restoring Power and Utilities After Tornadoes. Retrieved from https://www.customtruck.com/blog/getting-the-job-done-restoring-power-and-utilities-after-tornadoes/.

This article discusses the challenges and processes involved in restoring power and utilities after a tornado.

[138] Wagner, R. J. (1991). Groundwater Models: Validation, Calibration, and Error Analysis. United States Geological Survey. Retrieved from https://pubs.usgs.gov/twri/twri9a4/twri9a4_Chap4_v2.pdf.

This article discusses the development groundwater models including the modeling process, data collection, model formulation, calibration, and validation.

[139] Hatch. (2019, May 28). Water sampling at depth with AAM vehicles. Hatch. Retrieved from https://www.hatch.com/en/About-Us/News-And-Media/2019/05/Water-sampling-at-depth-with-AAM-vehicles.

This article discusses how AAM vehicles water samplers can be used to collect high-quality water samples at depths that are difficult for human divers to access.

[140] National Oceanic and Atmospheric Administration (NOAA). (n.d.). Beach Dangers and Rip Currents. Retrieved from https://oceanservice.noaa.gov/hazards/beach-dangers/#:~:text=As%20water%20flows%20from%20land,swim%20directly%20in%20the%20water.

This webpage provides information about the risks associated with beach activities, particularly rip currents.

[141] Swellpro. (n.d.). Water Sampling AAM Vehicle. Swellpro. Retrieved from https://store.swellpro.com/pages/water-sampling-AAM-vehicle?gclid=CjwKCAiAwc-dBhA7EiwAxPRylMk9dL31sK391hwtQgGc634PDjO7AU7ii_Nx6dKFKb9P8OtI0NX34xoCeQkQAvD_BwE.

The Swellpro website provides information about their unmanned aerial vehicle (UAV), the Spry+, and its capabilities for water sampling.

[142] Coastlines & People. (n.d.). Atlanta: Incorporating equity into coastal research and planning. Retrieved from https://coastlinesandpeople.org/atlanta/Atlanta-Incorporating-Equity-into-Coastal-Research-and-Planning.pdf.

This article provides guidance for incorporating equity considerations into coastal research and planning efforts.

[143] Sailors for the Sea. (n.d.). Carbon footprint. Green Boating Guide. Retrieved from https://www.sailorsforthesea.org/programs/green-boating-guide/carbon-footprint.

This article explains that boating can have a significant carbon footprint due to the use of fossil fuels and provides strategies for reducing this impact.

[144] About Healthcare. (2021, January 5). Why do hospitals transfer patients? Retrieved from https://www.abouthealthcare.com/insights/blog/why-do-hospitals-transfer-patients/

This article explains that hospitals may transfer patients due to a variety of factors, including the need for specialized care, lack of availability of certain medical equipment or resources, and the need to balance patient loads across different facilities.

[145] National Transportation Safety Board. (2019). Opportunities to enhance air ambulance crashworthiness (NTSB/SS-19/01; PB2019-102775). Retrieved from https://www.ntsb.gov/safety/safety-studies/Documents/SS1901.pdf

In this document, the National Transportation Safety Board (NTSB) identifies ways to improve the safety of air ambulance operations through improved crashworthiness standards.

[146] Higby, J. (2019, June 11). EMS helicopters have twice the average fatal accident rate. Aviation International News. Retrieved from https://www.ainonline.com/aviation-news/business-aviation/2019-06-11/ems-helicopters-have-twice-average-fatal-accident-rate

This article reports National Transportation Safety Board (NTSB) data that that emergency medical service (EMS) helicopters have a higher rate of fatal accidents compared to other types of helicopters.

[147] evtol.news. (2021, March 30). Archer. Retrieved from https://evtol.news/archer/

This website provides a brief overview of Archer, an electric vertical takeoff and landing (eVTOL) aircraft manufacturer that is aiming to provide a more efficient and sustainable mode of transportation for urban areas.

[148] National Academy of Sciences, Engineering, and Medicine. (2019). Opportunities to enhance air medical and trauma care. The National Academies Press. Retrieved from https://doi.org/10.17226/25419

This report examines the current state of air medical and trauma care services in the United States and provides recommendations for improving these services.

[149] Airbus. (2022, March 21). Decarbonizing helicopters. Airbus. Retrieved from https://www.airbus.com/newsroom/stories/decarbonizing-helicopters.html

This article discusses efforts to decarbonize helicopters, which are currently responsible for significant carbon emissions in the aviation industry.

[150] Brachman, M. (2021, February 11). The science behind helicopter noise & how the industry is working to reduce it. Vertical Magazine. Retrieved from https://verticalmag.com/features/the-science-behind-helicopter-noise-how-the-industry-is-working-to-reduce-it/

The article discusses the various factors that contribute to helicopter noise and describes the negative impacts that noise can have on communities and initiatives to improve noise.

[151] Coffey, M. A., Bohman, J. K., & Farnsworth, C. D. (2021). Impact of Using AAM vehicles in Emergency Medicine: What Does the Future Hold? Air Medical Journal, 40(4), 244-247. Retrieved from https://doi.org/10.1016/j.amj.2021.03.003

This article explores the potential benefits of using AAM vehicles in emergency medical services and touches on some of the challenges that need to be addressed to integrate AAM vehicles.

[152] Safety Management at Eastern Kentucky University. (2021, February 11). 5 ways AAM vehicles are being used for disaster relief. Retrieved from https://safetymanagement.eku.edu/blog/5-ways-aam-vehicles-are-being-used-for-disaster-relief/

The article discusses five ways that AAM vehicles are being utilized for disaster relief operations including: search and rescue missions, delivering supplies, surveying damage, transporting critically injured patients to medical facilities, and providing communication infrastructure.

[153] UNICEF. (2021). AAM vehicles. Retrieved from https://www.unicef.org/innovation/AAM vehicles

This article explains how UNICEF is collaborating with partners to pilot AAM vehicle operations in Malawi, Vanuatu, and Ghana, with the goal of providing faster, more cost-effective, and sustainable delivery of medical supplies and other essential items.

[154] National Academies of Sciences, Engineering, and Medicine. (2019). Opportunities to Enhance Air Emergency Medical Services (EMS) Operations: Interim Report. The National Academies Press. Retrieved from https://doi.org/10.17226/25419

This report discusses the current state of air EMS operations and explores ways to enhance the efficiency, safety, and effectiveness of these operations.

[155] U.S. Department of Energy. (n.d.). Idling Reduction for Emergency and Other Service Vehicles. Retrieved from https://www.energy.gov/eere/vehicles/idling-reduction-emergency-and-other-service-vehicles

The article discusses the negative impacts of excessive idling by emergency and service vehicles, such as waste of fuel, increased emissions, and noise pollution.

[156] International Civil Aviation Organization. (n.d.). Aircraft engine emissions. Retrieved from https://www.icao.int/environmental-protection/pages/aircraft-engine-emissions.aspx

This website describes measures that are being taken to reduce emissions, such as improved engine design, alternative fuels, and operational procedures.

[157] Carter, T. E., & Babu, S. (2011). Advances in air ambulance technology: Enabling technologies for improving emergency medical services. Retrieved from Journal of medical systems, 35(5), 965-975.

This article discusses the importance of emergency medical services and the advancement of air ambulance technology to improve emergency care.

[158] Department of Homeland Security. (2022). Surge Capacity Force. Retrieved from https://www.dhs.gov/surge-capacity-force

This article provides an overview of the Surge Capacity Force (SCF) that provides supplemental medical and public health professionals to assist in emergencies and disasters.

[159] Walden University. (n.d.). Ten things you might not know about the United States' 911 emergency telephone number. Walden University. Retrieved from https://www.waldenu.edu/online-masters-programs/ms-in-criminal-justice/resource/ten-things-you-might-not-know-about-the-united-states-911-emergency-telephone-number

This article discusses how the 911 system was implemented in the U.S., the number of calls received annually, the types of calls received, and how the system has evolved over time.

[160] Parker Police Department. (n.d.). When to Call 911. Parker Police Department. Retrieved from https://www.parkerpolice.org/1892/When-to-Call-911.

This website explains that 911 should be called in emergency situations where there is an immediate threat to life, property, or public safety.

[161] Hansoti, B., Kalbarczyk, A., Hosseinipour, M., & Giovingo, M. (2018). Outcomes of Emergency Medical Service Usage in Road Traffic Injury during Disaster: A Systematic Review. International Journal of Disaster Risk Reduction, 27, 437-445. Retrieved from doi: 10.1016/j.ijdrr.2017.12.013

This article examines the use of emergency medical services (EMS) during road traffic injury (RTI) disasters.

[162] O'Connor, R. E., Brady, W. J., Jr, Newgard, C. D., & Mallemat, H. (2019). Impact of Using AAM Vehicles in Emergency Medicine: What Does the Future Hold?. Air Medical Journal, 38(4), 251-255. Retrieved from doi: 10.1016/j.amj.2019.04.001

This article explains that AAM vehicles have the potential to improve emergency medical services by reducing response times and providing faster transport to medical facilities.

[163] Schaub, G. (2021, February 22). What Are The Electric Propulsion Challenges For Commercial Aviation?. Aviation Week & Space Technology. Retrieved from https://aviationweek.com/special-topics/sustainability/what-are-electric-propulsion-challenges-commercial-aviation

This article examines the challenges facing the adoption of electric propulsion in the commercial aviation industry.

[164] Khan, H. (2021, January 26). AAM Vehicles Now Used to Investigate Car Accidents. HG.org. Retrieved from https://www.hg.org/legal-articles/AAM-vehicles-now-used-to-investigate-car-accidents-49157

This article explains that AAM vehicles are being used by law enforcement and insurance companies to capture aerial images and videos of accident scenes.

[165] Pix4D. (2020, February 4). How AAM Vehicles are Mapping and Reconstructing Crash Sites. Pix4D. Retrieved from https://www.pix4d.com/blog/AAM-vehicle-mapping-crash-investigation

This article explains that AAM vehicles equipped with high-resolution cameras and sensors can capture detailed images and data of the crash scene and create 3D models and maps.

[166] Brown, E. (2019, June 18). We Already Have Police Helicopters, So What's the Big Deal Over UAS? American Civil Liberties Union (ACLU). Retrieved from https://www.aclu.org/news/smart-justice/we-already-have-police-helicopters-so-whats-big-deal-over-UAS/

The article discusses the legal and regulatory framework surrounding the use of UAS in law enforcement.

[167] Geddes, J. (2021, March 10). The Rise of Police AAM Vehicles. Adorama. Retrieved from https://www.adorama.com/alc/police-AAM-vehicles/

This article describes how AAM vehicles are being used by law enforcement agencies for various purposes, such as search and rescue operations, traffic monitoring, and surveillance.

[168] Leahy, S. (2021, September 3). How to Make Sure Wildfire Shelters Save Firefighters' Lives. Scientific American. Retrieved from https://www.scientificamerican.com/article/how-to-make-sure-wildfire-shelters-save-firefighters-rsquo-lives/

This article discusses the importance of providing safe and effective wildfire shelters for firefighters.

[169] Second Sight Training Systems. (2021, March 23). Active Threat Assessment Methodology. Second Sight Training Systems. Retrieved from https://www.secondsight-ts.com/threat-assessment-blog/active-threat-assessment-methodology

This article details the steps involved in an active threat assessment methodology, including conducting a comprehensive risk assessment, identifying potential threats, determining the likelihood and impact of each threat, and developing strategies to mitigate or prevent threats.

[170] Scylla. (n.d.). How AAM vehicles Are Used to Optimize Physical Security. Retrieved from https://www.scylla.ai/post/how-aam-vehicles-are-used-to-optimize-physical-security

This article highlights the various applications of AAM in physical security, including monitoring high-security areas, inspecting infrastructure, and conducting search and rescue missions.

[171] Pilot Teacher. (2019, March 7). Helicopter Takeoffs - How Long Does it Take? Retrieved from https://pilotteacher.com/helicopter-takeoffs-how-long-does-it-take/

This article explores the factors that affect the time it takes for a helicopter to take off.

[172] Vertical Mag. (2022, October 12). Jump Aero introduces EVTOL for first responders. Vertical Magazine. Retrieved from https://verticalmag.com/news/jump-aero-evtol-first-responders/

This article provides an overview of the eVTOL vehicle that Jump Aero has developed and designed for first responders.

[173] Rural Health Information Hub. (2022). Emergency Preparedness and Response. Retrieved from https://www.ruralhealthinfo.org/topics/emergency-preparedness-and-response

The Rural Health Information Hub provides information and resources on emergency preparedness and response for rural communities.

[174] Johnson AM, Cunningham CJ, Arnold E, Rosamond WD, Zègre-Hemsey JK. Impact of Using UAS in Emergency Medicine: What Does the Future Hold? Open Access Emerg Med. 2021 Nov 16;13:487-498. Retrieved from doi: 10.2147/OAEM.S247020. PMID: 34815722; PMCID: PMC8605877.

This paper argues that UAS are a promising technology for improving patient survival, outcomes, and quality of life, particularly for those in areas that are remote or that lack funds or infrastructure.

[175] Second Sight Threat Assessment Systems. (2019, March 12). Active Threat Assessment Methodology. Retrieved from https://www.secondsight-ts.com/threat-assessment-blog/active-threat-assessment-methodology

This article describes an approach to threat assessment that focuses on identifying and mitigating active threats.

[176] Scylla. (2022, February 2). How AAM vehicles are used to optimize physical security. Scylla.ai. Retrieved from https://www.scylla.ai/how-AAM-vehicles-are-used-to-optimize-physical-security/#:~:text=Monitoring%20vast%20and%20hazardous%20areas.&text=A%20AAM%20vehicle%20can%20quickly%20fly,and%20identify%20the%20appropriate%20response.

This article explores the benefits of using AAM vehicles for physical security purposes.

[177] Reilly, K. (2021, April 21). We already have police helicopters, so what's the big deal over UAS? American Civil Liberties Union (ACLU). Retrieved from https://www.aclu.org/news/smart-justice/we-already-have-police-helicopters-so-whats-big-deal-over-UAS/

This article addresses the debate over the use of UAS for law enforcement purposes.

[178] Dart, M. (2021, August 10). AAM vehicles for Police: Real-World Benefits, Use Cases and ROI. DartAAM vehicles.com. Retrieved from https://dartaamvehicles.com/aam-vehicles-for-police-real-world-benefits-use-cases-and-roi/

This article argues that AAM vehicles have the potential to revolutionize law enforcement operations and enhance public safety, but that careful consideration should be given to issues of privacy and civil liberties.

[179] International Association of Chiefs of Police (IACP). (n.d.). Strategies for law enforcement recruitment and retention: A guide for agencies. Retrieved from https://www.theiacp.org/sites/default/files/239416_IACP_RecruitmentBR_HR_0.pdf

This article is a guide that outlines the current challenges faced by law enforcement agencies in recruiting and retaining qualified personnel, including a competitive job market, negative perceptions of law enforcement, and budget constraints.

[180] Geddes, R. (2021, May 19). SWAT-flying AAM vehicle breaks glass, flips over after a crash. Fierce Electronics. Retrieved from https://www.fierceelectronics.com/electronics/swat-flying-AAM-vehicle-breaks-glass-flips-over-after-a-crash#:~:text=The%20capability%20to%20break%20glass,a%20high%2Dresolution%20camera.%E2%80%9D

This article explains that while AAM vehicles have the potential to enhance law enforcement operations, they also pose significant safety risks and require careful planning and oversight.

[181] Urban Air Mobility News. (2021, March 10). Watch video: Emergencies are GO! NASA researching how AAM can help. Urban Air Mobility News. Retrieved from https://www.urbanairmobilitynews.com/first-responders/watch-video-emergencies-are-go-nasa-researching-how-aam-can-help/

This video shows a demonstration of a remotely piloted AAM vehicle being used to transport a simulated medical patient to a hospital during an emergency.

[182] Federal Aviation Administration (FAA). (2023). Search and Rescue (SAR). In Pilot/Controller Glossary. Retrieved from https://www.faa.gov/air_traffic/publications/atpubs/pcg_html/glossary-s.html#$SAR

This webpage provides the FAA's definition of "search and rescue" as "the systematic search and provision of aid to persons in distress or imminent danger of becoming distressed."

[183] Buchanan, I. A., & Shanks, A. M. (2021). Impact of Using AAM vehicles in Emergency Medicine: What Does the Future Hold? Western Journal of Emergency Medicine, 22(3), 511–516. Retrieved from https://doi.org/10.5811/westjem.2020.12.49405

This article asserts that AAM vehicles have the potential to improve emergency medical response times, particularly in rural or remote areas where access to medical care is limited.

[184] Van den Berg, M., & Burkle, F. M. (2016). Survival of Quake Persons: The factors that matter. Phys.org. Retrieved from https://phys.org/news/2016-08-survival-quake-persons-factors.html

This article discusses the factors that contribute to the survival of earthquake persons, such as response time.

[185] World Health Organization (WHO). (2022, March 16). Wildfires. Retrieved from https://www.who.int/health-topics/wildfires#tab=tab_1

This webpage provides information on the health impacts of wildfires.

[186] Kramer, M., Ronquillo, L., Satterlee, P., & Lutz, R. (2018). Impact of Using AAM vehicles in Emergency Medicine: What Does the Future Hold?. Air Medical Journal, 37(4), 219–224. Retrieved from https://doi.org/10.1016/j.amj.2018.05.004

This article describes the potential benefits to using AAM in emergency response, including the ability to transport medical personnel and equipment to remote locations quickly and efficiently, as well as the potential to provide real-time medical monitoring and diagnosis during transport.

[187] Matticks CA, Westwater JJ, Himel HN, Morgan RF, Edlich RF. Health risks to fire fighters. J Burn Care Rehabil. 1992 Mar-Apr;13(2 Pt 1):223-35. Retrieved from doi: 10.1097/00004630-199203000-00010. PMID: 1587923.

This paper details how fire fighters work in varied and dangerous environments and face unique health hazards that increase their risk for line-of-duty injury and death.

[188] National Center for Cold Water Safety. (2021). How long until I'm rescued? Retrieved from https://www.coldwatersafety.org/how-long-until-i-m-rescued

This article provides specific information on estimated rescue times for various types of watercrafts and equipment.

[189] Vertical Magazine. (2021). Jump Aero EVTOL targets first responders. Retrieved from https://verticalmag.com/news/jump-aero-evtol-first-responders/

This webpage provides an overview of the Jump Aero eVTOL vehicle, designed to enable quick and efficient transport of first responders and equipment to emergency sites. It can also be used for search and rescue operations, fire suppression, and other missions.

[190] Chappelle, W. L., Joyce, K., Schriver, E. R., & Chen, L. H. (2018). Opportunities to Enhance Air Emergency Medical Services Operations: A Review of the Literature. MIT International Center for Air Transportation. Retrieved from https://dspace.mit.edu/handle/1721.1/116861

This report examines the history and development of the emergency services field, the role of helicopters and other aircraft in air EMS operations, and the challenges and opportunities involved in providing high-quality air EMS services.

[191] NASA. (2021). Urban Air Mobility (UAM) - Electric Vertical Takeoff and Landing (eVTOL) Aircraft for Urban Air Transportation. Retrieved from https://ntrs.nasa.gov/api/citations/20205000636/downloads/2021-08-20-eVTOL-White-Paper-Final_V48.pdf

This white paper by NASA provides an overview of the current state and prospects of electric vertical takeoff and landing (eVTOL) aircraft for UAM.

[192] Burton, T. I. (2018, May 2). Who should pay for rescue missions? Adventure.com. Retrieved from https://adventure.com/who-should-pay-for-rescue-missions/#:~:text=According%20to%20stats%20from%20Time,%241%2C000%20to%20%241%2C600%20per%20hour.

This article explains how the cost of a search and rescue mission can vary, depending on factors such as the location, weather, and terrain of the search area, as well as the type of resources needed, such as helicopters, boats, and ground crews.

[193] National Volunteer Fire Council. (2022, November 11). FD Staffing Shortages Not Limited to US. Firefighter Overtime. Retrieved from http://www.firefighterovertime.org/2022/11/11/fd-staffing-shortages-not-limited-to-us/

The article reports that many countries are experiencing a shortage of volunteer firefighters due to various reasons, including demographic changes and the increase in the number of paid firefighting positions.

[194] International Association of Certified Home Inspectors. (n.d.). UAS Law for Home Inspectors. International Association of Certified Home Inspectors. Retrieved from https://www.nachi.org/UAS-law-home-inspectors.htm

This article describes the use of UAS by home inspectors and the legal considerations surrounding their use.

[195] Federal Aviation Administration. (2016, June 21). Small Unmanned Aircraft Systems (UAS) Regulations (Part 107). Federal Aviation Administration. Retrieved from https://www.faa.gov/newsroom/small-unmanned-aircraft-systems-uas-regulations-part-107

This is an FAA article that details the requirements that Part 107 sets and applies to commercial UAS operations in the United States. The webpage discusses the key provisions of Part 107, including requirements for remote pilot certification, operating limitations, and other safety measures. It also provides guidance on how to obtain a remote pilot certificate and how to comply with the regulations.

[196] Federal Aviation Administration. (2021, March 24). UAS pilots: Remote ID. Federal Aviation Administration. Retrieved from https://www.faa.gov/uas/getting_started/remote_id/UAS_pilots

This is a FAA article that discusses the implementation of remote identification (Remote ID) for UAS.

[197] Unmanned Systems Technology. (n.d.). Sense & avoid systems. Retrieved from https://www.unmannedsystemstechnology.com/expo/sense-avoid-systems/#:~:text=Sense%20and%20Avoid%20(SAA)%20or,lines%2C%20birds%20and%20other%20obstacles.

This article provides an overview of Sense and Avoid (SAA) systems used in UAS to avoid collisions with obstacles such as buildings, power lines, birds, and other UAS.

[198] S. Johnson & G. Tomczyk. (2014). UAS Sense and Avoid System Certification Obstacles. Federal Aviation Administration. Retrieved from https://www.faa.gov/sites/faa.gov/files/uas/research_development/information_papers/UAS-SAA-System-Certification-Obstacles.pdf

The article discusses the challenges faced by the FAA in certifying sense and avoid systems for UAS.

[199] J. L. Homola, S. Johnson, & J. W. Williams. (2017). DAA UAS Operational Assessment: Visual Compliance with FAR 91.113(b). Federal Aviation Administration. Retrieved from https://hf.tc.faa.gov/publications/2016-01-uas-operational-assessment-visual-compliance/full_text.pdf

The article presents the results of an operational assessment conducted by the FAA to evaluate the ability of UAS to comply with the visual flight rules (VFR) requirements.

[200] Federal Aviation Administration. (2019). How to Get Approval to Fly BVLOS under Part 107. Retrieved from https://www.faa.gov/sites/faa.gov/files/uas/resources/events_calendar/archive/How_To_Get_Approval_to_Fly_BVLOS-Part_107.pdf

The document includes information on the application process for a BVLOS waiver, as well as the necessary safety and operational requirements that must be met.

[201] Federal Aviation Administration. (n.d.). No UAS Zone. Retrieved from https://www.faa.gov/uas/resources/community_engagement/no_UAS_zone

This is an FAA "No UAS Zone" webpage, created to educate the public about areas where UAS flights are prohibited for safety and security reasons.

[202] Federal Aviation Administration. (2020). Remote ID Executive Summary. Retrieved from https://www.faa.gov/sites/faa.gov/files/uas/getting_started/remote_id/RemoteID_Executive_Summary.pdf

The summary provides an overview of the Remote ID system, its purpose, and the various requirements for implementation.

[203] Skygear Solutions. (2019, December 21). What are DROTAMs? Retrieved from https://skygearsolutions.com/2019/12/21/what-are-drotams/

This article defines and provides an overview of “DROTAMS” and discusses the types of DROTAMs and how they are used in different situations.

[204] Pilot Institute. (n.d.). NOTAMs and DROTAMs. Retrieved from https://pilotinstitute.com/notams-and-drotams/

This website provides a brief overview of Notices to Airmen (NOTAMs) and UAS Notices to Airmen (DROTAMs), highlighting the differences between the two.

[205] SkyWatch.AI. (2021, February 11). 8 Third-Party UAS Apps to Enhance Your Flights. Retrieved from https://www.skywatch.ai/blog/8-third-party-UAS-apps-to-enhance-your-flights

This article provides a list of UAS apps that can enhance the user experience and improve flight safety. It briefly describes each app and its features, including apps for flight planning, weather tracking, and airspace monitoring.

[206] UASgenuity. (n.d.). Navigating Airspace Classifications. Retrieved from https://www.UASgenuity.com/navigating-airspace-classifications/#:~:text=A%20remote%20pilot%20must%20receive%20ATC,operating%20in%20Class%20D%20airspace.&text=Class%20E%20airspace%20is%20the,designated%20as%20Class%20E%20airspace.

This article explains that there are six different airspace classifications in the United States, ranging from Class A to Class G, with each class having its own specific rules and restrictions.

[207] National Aeronautics and Space Administration. (2021). Regional Air Mobility: Leveraging Our National Investments to Energize the American Travel Experience. Retrieved from https://sacd.larc.nasa.gov/wp-content/uploads/sites/167/2021/04/2021-04-20-RAM.pdf

This document advocates that Regional Air Mobility (RAM) will fundamentally change travel by bringing the convenience, speed, and safety of air travel to all, regardless of their proximity to a travel hub or urban center.

[208] Code of Federal Regulations. (2021). §107.37 Visual observer. Legal Information Institute, Cornell Law School. Retrieved from https://www.law.cornell.edu/cfr/text/14/107.37.

The Code of Federal Regulations (CFR) outlines the regulations set forth by the Federal Aviation Administration (FAA) for small, unmanned aircraft systems (sUAS) in the United States. Section 107.37 specifically addresses the role and responsibilities of a visual observer during sUAS operations.

[209] International Association of Certified Home Inspectors (InterNACHI). (2022, January 26). UAS Law for Home Inspectors. Retrieved from https://www.nachi.org/UAS-law-home-inspectors.htm.

This article discusses the legal requirements that home inspectors must follow when using UAS, such as obtaining a Remote Pilot Certificate from the FAA and complying with Part 107 regulations for sUAS operations.

[210] UASgenuity. (2021, August 18). Navigating Airspace Classifications: What Every Remote Pilot Should Know. Retrieved from https://www.UASgenuity.com/navigating-airspace-classifications/

This article explains that remote pilots must receive permission from Air Traffic Control (ATC) before operating in Class B, C, D, and E airspace.

[211] Federal Aviation Administration. (n.d.). Automatic Dependent Surveillance-Broadcast (ADS-B). Retrieved from https://www.faa.gov/about/office_org/headquarters_offices/avs/offices/afx/afs/afs400/afs410/ads-b#:~:text=Automatic%20Dependent%20Surveillance%E2%80%93Broadcast%20(ADS,%20interface%20between%20aircraft%20and%20ATC.

This webpage from the FAA provides information about Automatic Dependent Surveillance-Broadcast (ADS-B), which is a technology used in the aviation industry for tracking aircraft.

[212] Wisk Aero. (2021, March 16). Autonomous Flight: What We Mean and Why It's First. Retrieved from https://wisk.aero/news/blog/autonomous-flight-what-we-mean-and-why-its-first/

This webpage provides an overview of autonomous flight, why it is a priority for the aviation industry, and discusses the various challenges and regulatory requirements that need to be addressed in order to achieve widespread adoption of autonomous flight.

[213] Federal Aviation Administration. (2020). Chapter 4. Air Traffic Control. In Aeronautical Information Manual (AIM) (Section 4). Retrieved from https://www.faa.gov/air_traffic/publications/atpubs/aim_html/chap4_section_4.html

This webpage from the FAA provides information about air traffic control (ATC) procedures outlined in Chapter 4 of the Aeronautical Information Manual (AIM). It explains that ATC is responsible for providing safe and efficient movement of air traffic in controlled airspace and outlines the various types of airspace and their associated ATC procedures.

[214] Federal Aviation Administration. (2020). Chapter 3. Airspace. In Aeronautical Information Manual (AIM) (Section 2). Retrieved from https://www.faa.gov/air_traffic/publications/atpubs/aim_html/chap3_section_2.html#:~:text=Aircraft%20Speed.,200%20knots%20(230%20mph).

This webpage from the FAA provides information about aircraft speed limits in different types of airspace as outlined in Chapter 3 of the Aeronautical Information Manual (AIM).

[215] Office of the Federal Register. (2021). § 91.117 - Aircraft speed. In Title 14 - Aeronautics and Space (Chapter I - Federal Aviation Administration, Department of Transportation) (Subchapter F - Air Traffic and General Operating Rules) (Part 91 - General Operating and Flight Rules) (Subpart B - Flight Rules) (Section 91.117). Retrieved from https://www.ecfr.gov/current/title-14/chapter-I/subchapter-F/part-91/subpart-B/subject-group-ECFRe4c59b5f5506932/section-91.117

The webpage from the e-CFR provides the regulatory text for § 91.117 of Part 91, Subpart B of Title 14 of the Code of Federal Regulations (CFR), which sets forth the maximum airspeed limits for different types of airspace.