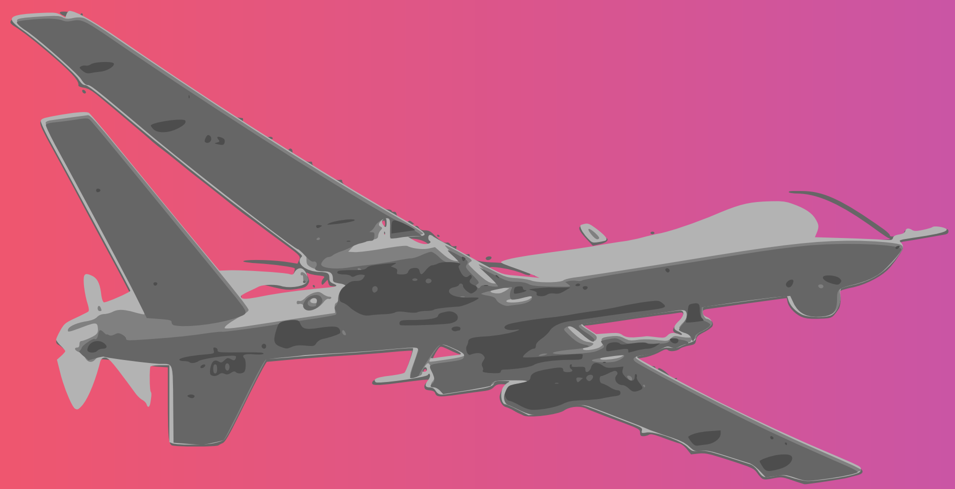
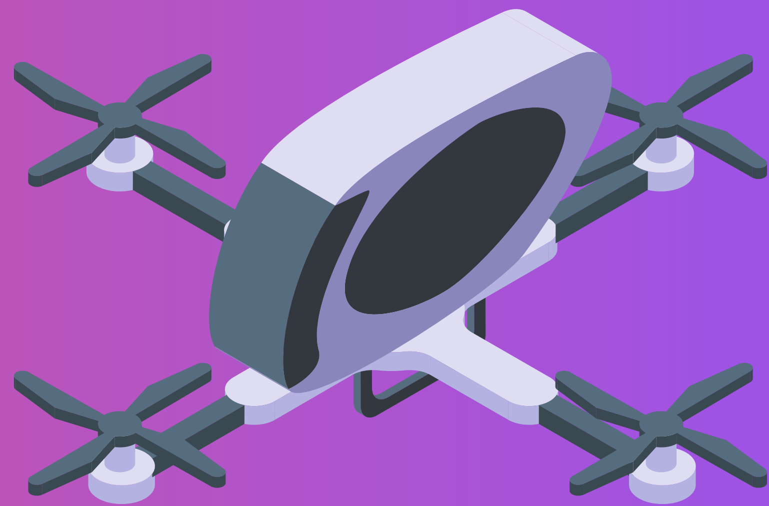
ICAO

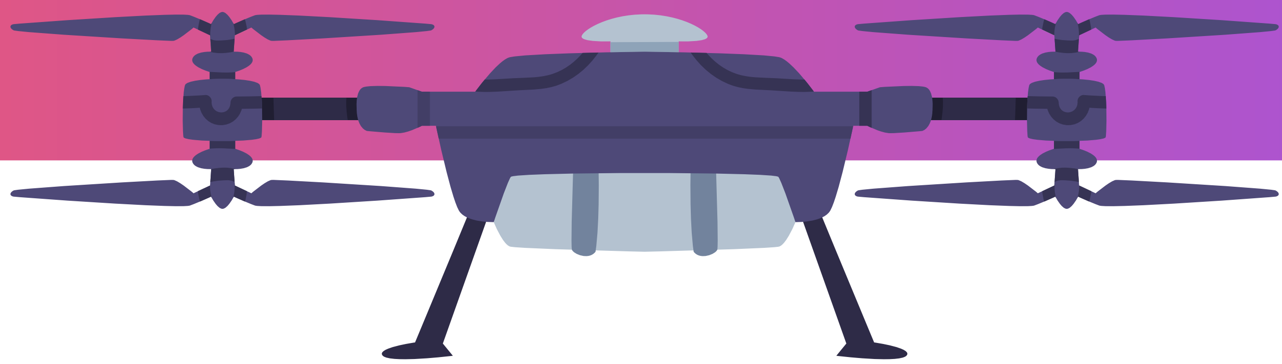
ENVIRONMENT

Environmental Impacts of Unmanned Aircraft Operations at and Around Airports

ECO AIRPORT TOOLKIT
2023







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1. INTRODUCTION

Unmanned aircraft (UA) operations have grown exponentially over the past decade. Often referred to as drones, these aircraft operate with no pilot on board. Instead, they are remotely operated via systems on-board the aircraft, and systems on the ground – usually via a remote operator. Potential use cases include aerial survey, law enforcement, package delivery, and human transportation, among others. While these developments will provide extensive societal benefits, they also bring concerns about the environmental impacts of UA operations, especially at and around airports.

Some of these new services will have important interactions with airports. These services will include air taxis, an operation where larger UA systems transport passengers. As a result, airports will need to understand how UA operations fit into their environmental management processes. The goal of this document is to provide an early assessment of the potential environmental impact of UA operations at and around airports. In order to evaluate the potential environmental effect of these new types of operations, it is important to understand:

- How UA will potentially be used;
- The types of UA that will come into service;
- How they will be propelled;
- The current state of environmental regulation regarding these vehicles;
- Future potential concepts; and
- How they might interact with current manned aviation.

Existing UA have fewer environmental impacts than traditional passenger aircraft; however, their operations also differ and will likely bring new considerations regarding community involvement and social acceptance and, as a result, require novel policies and regulations.

New UA systems, vehicles and concepts are being introduced and constantly evolving. Operational concepts are in the development stages and thus, make it difficult to evaluate the potential environmental impact of these new types of operations on the airport and the surrounding community. It is imperative that the aviation industry understand and evaluate the environmental impact of these new vehicles before they are in regular operation.

The UA industry is characterized by emerging and proprietary technologies and consequently, information on potential environmental impacts is scarce. This document represents initial efforts to track the environmental impacts of UA operations. As the industry continues to develop, information on the environmental impacts of UA operations will be updated as needed.

2. TYPES OF UNMANNED AIRCRAFT AND USE CASES

To better understand the potential environmental impact of these new types of vehicles at and around airports, the types of vehicles, their characteristics, and use cases need to be generally understood. It is then that potential environmental factors and impacts can be considered.

Types of UA can vary in terms of vehicle architecture, lift mechanism, propulsion, and power source, among other characteristics. UA may be fixed wing aircraft, rotorcraft, or a hybrid of the two. Some may be capable of vertical takeoff and landing (and hover), while others may be catapult-launched or conduct a conventional takeoff/landing roll. Propulsion may be provided via jet propulsion, a single pusher or tractor propeller, or many distributed propellers. Power sources include electricity, gas turbine or piston engine, fuel cells, or hybrid approaches (e.g., turboelectric). UA can also vary greatly in terms of size, range, and endurance. The UA types that will specifically operate at and around airports are not well known at this time, as many of these use cases and prototypes are still under development.

The environmental impact of a UA will depend on the specific vehicle characteristics and use case as well as where it is operated. The use cases can be divided into two separate categories, first, the replacement of existing operations.[1] In areas such as security, deliveries, maintenance and emergency response, legacy modes of transportation such as rail, automobiles and legacy aviation have been used for decades. However, unmanned aircraft systems present the opportunity to explore new methods of achieving positive outcomes in the aforementioned areas. Importantly, UA operations must offer a competitive advantage in these areas to be considered a viable alternative to existing operations. Even though each airport must consider its own benefit-cost for substituting legacy modes for UA, calculations should include costs to the environment and surrounding community.

The second set of use cases for UA operations is the introduction of new, previously non-existent operations. In this category, an area of particular relevance to airports is the concept of Urban Air Mobility (UAM). These types of operations would enable point to point, on-demand mobility to and around airports and in areas currently underserved by aviation or from airport to city center. Initially, these vehicles will have a pilot on board; however, as the industry gains more experience with these operations, these vehicles will be remotely piloted. At full capacity, operators envision an on-demand service of 100s or 1000s of simultaneous operations for cargo or 1-5 passengers.[2]

At least 200 designs for UAM vehicles from manufacturers are targeted to operate as electronic vertical takeoff and landing vehicles (eVTOL).[3] Despite the anticipated electrification of this industry, however, environmental impacts related to noise must be considered by airports and surrounding communities. Regardless of the use case or type of aircraft, the environmental impacts of UA operations at airports apply across all categories. From the impacts of noise and emissions to the mitigation of community concerns about environmental impacts through community engagement, the impacts of UA is an emerging field of study.

[1] See Appendix A for table of use cases
[2] Urban Air Mobility Airspace Integration Concepts (mitre.org)
[3] https://www.easa.europa.eu/sites/default/files/dfu/uam-full-report.pdf

3. UA ENVIRONMENTAL IMPACTS

Noise

Noise is unwanted sound. Aircraft noise has been regulated for decades. ICAO has acknowledged that aircraft noise is the most significant cause of adverse community reaction related to the operation of airports.[4] Since 2001, ICAO policy has focused on a balanced approach to aircraft noise management. It is not known at this time if there will ultimately be differing standards for crewed versus unmanned aircraft. For now, regulators are moving forward under the existing regulatory framework to the extent possible, but modifying and adapting regulations for these new entrants as needed. An as yet unanswered question is if existing environmental policy is appropriate to make determinations related to UA operations. As of the writing of this report, both the FAA and EASA had published consultations on noise policy related to these new types of vehicles and operations.

There is a lot of work being done on the technical aspects for certification of both large and small UAs. The ICAO Remotely Piloted Aircraft Systems (RPAS) Panel is focusing on RPAS that will cross international borders without passengers on board. Member States' regulatory authorities are working on regulations to certify small UA and larger Advanced Air Mobility (AAM) aircraft, though initial operations of AAM aircraft will be required to have a pilot on board; currently there are no ICAO noise standards as there are for traditionally manned aircraft, though it is under study by ICAO CAEP Working Group 1 - Noise. The specific noise characteristics of UA may differ from conventional aircraft due to the unique vehicle types and modes of operation. The noise-generating mechanisms may vary, e.g., due to electric propulsion, hybrid configurations, interactions between multiple lifting and propulsion rotors, ducting, etc.[5] The spectral content of UA noise may also be of concern due to the potential occurrence of multiple simultaneous tones—sometimes with dynamic, shifting frequencies—and increased sound energy in the higher frequency range due to shorter sound propagation distances and less effective atmospheric attenuation.[6]

The different nature of UA operations, and the potential closer proximity of smaller UA to people than conventional aircraft types, particularly from low altitude operations, may result in greater noise exposure. There may be reflection from buildings and the possibility of vibration and rattling caused by larger UAs with low tones. Because of such closer proximity, there may be cases of increased sensitivity to noise due to the fact that more people will "see" the nearby UA or AAM aircraft as opposed to a jet flying overhead at 30,000 ft., rather than actual noise levels exceeding current standards.

For UA operating in urban environments, there may be abrupt onsets of sound due to intermittent shielding from structures. Research is needed to fully understand the unique acoustics effects of UA, how these will impact the public, and how they might be managed.[7] UA vehicle designs vary more broadly than traditional piloted fixed wing and rotary-wing aircraft designs, making design-based noise characteristic generalizations initially more challenging.

[4] https://www.icao.int/environmental-protection/pages/noise.aspx
[5] Urban Air Mobility Noise: Current Practice, Gaps, and Recommendations (nasa.gov)
[6] https://www.volocopter.com/wp-content/uploads/Volocopter-WhitePaper-1-01.pdf
[7] Kim J. Urban Air Mobility Noise: Further Considerations on Indoor Space. Int J Environ Res Public Health. 2022 Sep 8: https://pubmed.ncbi.nlm.nih.gov/36141570/

The smallest aircraft available in existing noise models are still orders of magnitude larger than delivery drones. Additionally, drone operations are expected to be distributed throughout regions of airspace, as opposed to operating along easily definable routes or corridors.

An important aspect of UA operation noise pollution is the identification of the source of the noise by the public. As an emerging industry, the general public has little to no experience with unmanned aircraft. In a recent study conducted by EASA, the researcher concluded that drones and air taxi noise was more annoying than traditional aircraft types, such as helicopters. Although the purpose of the study was not focused on the annoyance related to specific types of aircraft, the researcher postulated that “the higher annoyance might be related to the unfamiliarity of drone and air taxi sounds in comparison to helicopter sounds.”[8] As such, education will need to play an important role in the mitigation of noise pollution at and around airports.

In addition to studies on the annoyance of UA operation noise, there is ongoing work to identify gaps and develop plans to overcome these gaps. The ICAO CAEP Impacts and Science Group (ISG) developed a white paper on the state of knowledge on so-called non-acoustic factors for CAEP/12. In October 2020, a NASA-led UAM Noise Working Group released a paper titled “Urban Air Mobility Noise: Current Practice, Gaps, and Recommendations” identifying UAM noise needs and recommendations. The paper summarizes current practices, gaps, and recommendations to close gaps and achieve high-level goals in four areas: (1) Tools & Technologies, (2) Ground/Flight Testing, (3) Human Response & Metrics, and (4) Regulation/Policy. It highlights the need for noise measurement and prediction methodologies to support impact assessment, noise mitigation, and regulation. Anticipated UAM vehicles will have novel and complex designs, operating modes, and operating environments for which acoustic data is currently lacking. Flight testing and measurement are critical to acquiring the necessary data to develop and validate modeling tools and noise reduction methods. Acoustic signature data is needed to understand the human response to UAM noise, and to develop technologies and procedures that could help mitigate adverse impacts. Regulation and policy also require specific knowledge of noise source characteristics, both for certification and environmental reporting. Overcoming these barriers will require continued information sharing and collaboration across UAM stakeholders.[9]

As a part of the AAM National Campaign, Joby Aviation and NASA performed the first acoustic flight test of a full-scale AAM aircraft over representative conditions for all phases of a typical mission profile in September 2021. The Joby aircraft is currently piloted, but Joby is developing the aircraft to operate as a UA in the future. A summary of their findings is included in Pascioni et al., 2022. This is the first step in better understanding the characteristics of noise exposure that modeling tools will need to be able to capture. The measured maximum A-weighted level (LAmax) for a 100 knots airspeed level flyover scaled to a receiver distance 1640 feet (500 meters) registered 45.2 dBA, a sound level barely noticeable in an urban environment. Such en route noise levels could be lower than typical environmental ambient levels in populated areas. Noise levels generated during approach and departure conditions were much greater than for level flyovers, meaning regions around vertiports are potentially the greatest area of interest for understanding potential noise exposure effects. More data is needed to determine if those characteristics will hold true for other manufacturers' platforms.[10]

[8] https://www.easa.europa.eu/en/downloads/137148/en
[9] https://ntrs.nasa.gov/api/citations/20205007433/downloads/NASA-TP-2020-5007433.pdf
[10] https://ntrs.nasa.gov/api/citations/20220006729/downloads/Aeroacoustics2022_Pascioni_STRIVES5.pdf

An additional topic on noise associated with UA operations at and around airports is the introduction, construction and operation of vertiports. Tied to UAM, vertiports serve as a base of operations for air taxis and similar aircraft, where passengers can board and aircraft can be charged or refueled. Vertiports may range in size and location, similar to heliports today. They may be located at airports, on top of parking garages or other city buildings or stand-alone locations. Their location will see a concentration of these vehicles and their noise footprint.

Emissions

From an emissions perspective, small UA have the potential to provide a benefit where they can be used as a lower emission alternative for a mission typically carried out by a ground vehicle or traditional manned aircraft (e.g., runway inspections, calibration of navigational aids and surveillance of the airport perimeter). On the other hand, the anticipated large number of larger UA that will be used for AAM operations raises issues on how these vehicles will be recharged and refueled between flights. While most AAMs are expected to be electric, the carbon footprint of generating the additional electricity to charge/recharge these aircraft needs to be accounted for since electricity is still generated using fossil fuel in some countries. Assessment of the emissions of UA operations should be done on a life-cycle basis to account for the different power sources across the different types of UA. eVTOL operations are anticipated to also operate at airports, on runways or at the top of a parking garage or other building. eVTOL mobility may require additional infrastructure to accommodate passengers, security, luggage, and cargo. This, in turn, may impose additional loads on the electric grid that will need to be taken into account in addition to the charging/recharging of these vehicles between flights.[11]

Impacts to Wildlife

In the EASA report titled “Study on the Societal Acceptance of Urban Air Mobility in Europe” published May 2021, researchers surveyed 3690 participants on perceptions and attitudes towards AAM and drones. Aside from noise and emissions, respondents also expressed concern for the impacts of UA operations on wildlife. Decreasing biodiversity and negative impacts on bird life and insects were tied to broader concerns around impacts to wildlife.[12] In an environment where wildlife is already stressed, such as those at and around airports, the introduction of a new and disruptive technology has the potential to further destabilize fragile ecosystems.

Despite the noise and potential emissions associated with UA operations at and around airports, early evidence suggests that these types of operations do not have a significant impact on wildlife. Between November 2021 and December 2022, the Federal Aviation Administration (FAA) conducted 15 environmental assessments of UA operations in a range of small UA operational sites, including those at and around airports. In all 15 cases, drone operations were found to have no impact on migratory birds, insects or ground wildlife. Although these studies were not solely focused on impacts to wildlife, they suggest that UA operations have minimal impact.[13]

[11] https://www.ehang.com/app/en/EHang White Paper on Urban Air Mobility Systems.pdf
[12] https://www.easa.europa.eu/sites/default/files/dfu/uam-full-report.pdf
[13] https://www.faa.gov/uas/advanced_operations/nepa_and_drones

Potential Impact of Unmanned Aircraft on Airport Operations

In December 2018, drone sightings over London-Gatwick Airport caused a closure of the airport's single runway for 33 hrs, with the cancellation of over 1,000 flights. While unauthorized UA have the potential to cause significant disruption to airport and airspace operations, UA operations have the potential to offer many benefits for the different stakeholders. Airports and Air Navigation Service Providers (ANSPs) should ensure that the impact of unauthorized UA on airport and aircraft safety and security is carefully assessed and mitigated before initiating operations of these vehicles. At airports where the airport operator desires to use UA to assist airport operations, such as for inspections, local procedures should be developed to permit their use. The ICAO RPAS Panel is working on Standards and Recommended Practices for enabling RPAS IFR operations at commercial airports. It will be up to the Member States' regulatory authorities to adopt and publish regulations governing their airspace that enable UA operations alongside piloted aircraft. AAM may improve connectivity between cities and airports; however, the impact on airport operations, both landside and airside, must be understood and managed before deployment. Necessary international regulations to enable some of these types of operations still need to be defined.

Potential Impact on Conventional Operations

The expanded use of UA and their integration into airspace will need to be carefully managed and harmonized with the needs of conventional aviation. The integration of manned and unmanned aircraft should support safe and efficient operations for all users of airspace including conventional commercial traffic and general aviation. The operations of these new entrants need to be sustainable. When operated in conjunction with conventional aircraft, new UA operations should have a reduced carbon footprint and should not introduce airspace procedures that create a negative impact on the environmental performance of conventional aviation nor limit conventional aviation's access to airports and airspace.

Initially, AAM operations will be piloted and may resemble current helicopter operations until the industry has gathered enough operational experience. The forecasted growth in the commercial use of UA indicates that segregated operations may not be sustainable in the long term. The integration of UA and conventional aircraft in the airspace introduces many questions related to the development and requirements for the ground infrastructure and aircraft equipment and integration of these systems. These questions will need to be addressed to enable these new operations before that end state is reached. For example, questions related to airspace and procedure design, airspace management, airspace system regulations and policies, communication, navigation and surveillance system performance requirements, vertiport operations, and weather need to be answered. The answers to these questions will determine how these new vehicles will operate and integrate with conventional aircraft. In 2023, the U.S. FAA released a UAM Concept of Operations 2.0 that begins to address these questions.[14] The Concept of Operations (CONOPS) will continue to evolve as the industry gains experience with these vehicles.

[14] https://www.faa.gov/air-taxis/uam_blueprint

4. MITIGATION OF CONCERNS THROUGH COMMUNITY ENGAGEMENT

The manufacturers and operators of UA are marketing the potential ubiquity of 'drones in the air', where they will potentially fly without predictable well-defined routes unlike anything the industry has seen before, including operations to/from distribution centers to individuals' homes or places of business to deliver packages and operating in city centers to pick up passengers, much like the "on demand" taxi services in operation today, except that instead of being on surface streets, these will be flying in the air. This paradigm shift will need to involve community engagement and education early in the planning process. Community engagement is critical and needs to be carefully considered. Public and political opposition to UA operations poses a significant risk to the success and growth of this industry. Community engagement around UA operations will be complex given that operations extend across municipalities, including airports and co-exist with traditional aircraft operations. The responsibility for managing resident concerns needs to be established.

As more UAs are developed and enter into service, they have unique noise characteristics that make it difficult to predict noise levels and community reaction. There are tonal and other characteristics, particularly for drones, that are not captured by traditional A-weighted metrics. In addition, the unpredictability of drone activity – in terms of both frequency and location - is likely to result in higher annoyance than more conventional aviation sources, suggesting that non-acoustic factors have the potential to play a significant role in community response.

Experience with new airport arrival and departure procedures for passenger jets has shown that when noise is introduced to neighborhoods that had not previously experienced that level of activity, it often results in opposition and controversy. Airports have discovered that early and extensive community engagement is key to gaining public acceptance for any changes. Community annoyance to UA operations will differ from annoyance to traditional aircraft operations. UAs are unfamiliar in appearance and in noise characteristics. They are flown remotely at low altitudes and within close proximity to communities. Some residents will be impacted by both traditional aircraft and UA operations that will introduce an entirely new environment for those residents.

A community engagement strategy will need to focus on addressing non-acoustic factors such as fear around safety, concern about intrusion and loss of privacy, sense of unfairness, anger around the change in the overall environment and degradation of nature. Such a strategy will require transparency around the reasons for the change, how decisions are made, how the system works, safety rules and protocols, and an accurate prediction of impact. Visualization and auralization tools will assist in conveying the changes to residents. It is also critical to include education on the environmental and economic benefits of UA operations as part of the strategy.[15]

In a recent study from the Institute of Flight Guidance at the German Aerospace Center in Braunschweig, Germany, participants' concerns related to drones significantly decreased and the "attitudes for some of the participants turned more positive" after experiencing drone flights through the experiment's virtual reality

[15] GAO-22-105844, Aircraft Noise: FAA Should Improve Efforts to Address Community Concerns

(VR) study.[16] Although this type of experiment may be difficult for every community to replicate, it reinforces the importance of early community education and engagement. By allowing the community to experience the environmental impacts of UA operations firsthand, the public can link the aircraft to the source of the noise, ultimately reducing the annoyance and stress caused by these new vehicles.

A harmonized approach to engagement is needed to properly convey the overall expectations around the airspace to community stakeholders. Best practices for early community engagement should be adopted to raise awareness of the impacts that UA operations will bring to communities. Consultation should involve residents, elected officials, municipal representatives and other relevant community stakeholder groups. A centralized resource for working with communities within a region to gain and maintain acceptance of an evolving industry may be beneficial by making use of already established mechanisms. This resource needs to include UA and AAM issues.

5. SUMMARY AND NEXT STEPS

The introduction of UA operations is constantly evolving. New information appears weekly in terms of vehicle developments and operational implementation scenarios.The number and potential uses of UA operations are highly varied and are projected to grow globally. Much of the effort to-date by international organizations, regulatory bodies, and industry have focused on safety, certification and airspace integration.

There is a limited, but growing amount of information and assessments with regard to noise or environmental impacts of the operation of unmanned aircraft at or close to airports. The specific noise characteristics of UA are not fully understood. These vehicles will be operating in closer proximity to people; therefore, research is needed to fully understand the unique acoustic effects. To predict community response to UA noise more accurately, new metrics, data and modelling that accounts for different types of UA, as well as acoustic and non-acoustic factors, need to be developed and implemented. Noise footprint analysis and modeling and psychoacoustic studies will be required to inform future development of certification requirements, and technical procedures.

It is currently unclear how UA operations will impact the public and the environment, and how this process might be managed as the forecasted number and frequency of operations are still years away. Based on experience with legacy aviation, early community engagement is key to the social acceptance of new unmanned aircraft operations. Communities around the world have shown to have reduced tolerance for the noise impact of existing conventional aircraft. Concepts for urban air mobility are maturing and some projects are underway that do take into account community acceptance and engagement. By being proactive, the industry has the possibility of ensuring sustainable principles in the development of unmanned aircraft operations. Additional work is needed with regards to community response to UA non-acoustic factors such as fear around safety, concern about intrusion and loss of privacy, sense of unfairness, anger around change in the overall environment and degradation of nature.

[16] https://elib.dlr.de/190177/1/Assessing_Social_Acceptance_of_Urban_Air_Mobility_using_Virtual_Reality.pdf

Standards and recommended practices for the certification, operation and management of unmanned aircraft are not firmly established. Furthermore, these new UA operations could have impacts on conventional traffic, as UAs have different operational performance characteristics than conventional aircraft. Stakeholder collaboration is critical to ensuring that these operations can be sustainably integrated into the community and the airport environs, as well as new urban, suburban, and rural environments where traditional aviation is not currently operating. Concept of operations definition and research projects are currently underway around the world. Hopefully, these projects will generate the environmental data and will be made publicly available to inform future decision making.

6. APPENDICES

Appendix A: Terms, Definitions, And UAS Use Cases

To better understand the potential environmental impact of these new types of vehicles at and around airports, the types of vehicles, their characteristics, and use cases need to be generally understood. It is then that potential environmental factors and impacts can be considered.

Terms and Definitions

There are a number of terms used in reference to unmanned operations. Understanding differences in these terms helps to put the types of vehicles and their operational context in perspective. This is central to understanding their environmental impacts.

AAM – Advanced Air Mobility, The vision of AAM is one in which unmanned or autonomous vehicles provide a safe, accessible, automated, and affordable air transportation system for passengers and cargo capable of serving previously hard-to-reach urban and rural locations.

DAA – Detect and Avoid, a collision avoidance process. DAA is when a UA automatically determines, through sensors or other means, if there's any danger and adjusts its flightpath to avoid a potential obstacle or other vehicle.

UA – Unmanned Aircraft, are aircraft but they have lots of different styles and capabilities that include RPA, these are sometimes referred to as drones in the common vernacular. Regulators need to be able to distinguish between the different categories.

UAS – Unmanned Aircraft System, the term some use to refer to unmanned vehicles, or drones. While the vehicles are unmanned, they generally require a person who is piloting the aircraft remotely using a communications process. Consequently, it is referred to as a "system". Many people differentiate between small and large UAS.[17]

UAM – Urban Air Mobility, the name given to AAM in dense urban areas. Buildings make tracking aircraft difficult and special precautions must be taken to ensure aircraft do not harm people or buildings. As a result, a robust control system is required.

UAV[2] – Unmanned Aerial Vehicles, similar to UAS, UAV is a term some use for small aircraft that can be remotely or autonomously controlled.[18]

RPAS – Remotely Piloted Aircraft System (RPAS). A remotely piloted aircraft, its associated remote pilot station(s), the required command and control links and any other components as specified in the type design

Vertiport – similar to a heliport, the location where unmanned aerial vehicles can land and takeoff.
For the purposes of this paper, the term Unmanned Aircraft (UA) is used to refer to aircraft without a pilot on board.

[17] For example, the US FAA defines small unmanned aircraft as an unmanned aircraft weighing less than 55 pounds on takeoff. (See Title 14 of the Code of Federal Regulations (14 CFR) § 1.1).
[18] Definitions based on ADVANCED AIR MOBILITY: WHAT IS AAM?, National Aeronautics and Space Administration. https://www.nasa.gov/sites/default/files/atoms/files/what-is-aam-student-guide_0.pdf

Table 1. **Uncrewed Aircraft Use Cases**

	USE CASES OF UNCREWED AIRCRAFT	SPECIFIC PURPOSE
REPLACEMENT OF EXISTING OPERATIONS	Monitoring or tracking	Wildlife, pest control, weather, climate research, maritime operations
	Inspection of critical infrastructure	Runways, taxiways, ramps, Foreign Object Debris on runways and taxiways, hangars, terminal buildings, tower, NAVAIDS, aircraft, ILS, pipeline, bridge, railroad, power lines.
	Calibration of critical infrastructure	NAVAIDS, ILS, PAPI
	Surveillance of critical infrastructure	Warehouses. terminal buildings, hangars, tower, rail, bridges, construction, pipelines, power lines, dams, electricity, wind turbines, oil rigs, mining, airport security, border security
	Disaster and humanitarian relief	Volcano, floods, wildfires, oil spills, search and rescue after natural disasters, aircraft crash analysis
	Flight training	Instruction, demonstrations
	Geophysical surveying and mapping	Aerial photography, obstruction analysis, advertising, filming
	Measurement	Biological, chemical, radiation, thermal isolation (buildings)
	Precision agriculture	Crop spraying, monitoring
	Parcel/Cargo deliveries	Warehouses, ships, medical transport
	Internet and communication connectivity	
	Military (outside the scope of ICAO) & surveillance	
FUTURE / NEW TYPES OF UNCREWED OPERATIONS	Urban/rural/regional air mobility	Point to point, on-demand mobility including from/to airports and in areas currently underserved by aviation or from airport to city center

Appendix B: Background to ICAO Work on Unmanned Aircraft, ICAO Activities Related to Unmanned Aircraft and ICAO UAS Webinars

ICAO Circular 328, Unmanned Aircraft Systems, defines an Unmanned Aircraft (UA) as an aircraft and its associated elements which are operated with no pilot on board. A UA can be a Remotely Piloted Aircraft (RPA) or it can have levels of automation that do not require consistent monitoring and maneuvering by a Remote Pilot in Command (RPIC). An RPA is a sub-set of a UA. Therefore, in this document, we refer to UA rather than RPA.

For years, the main use of UA was restricted to military purposes. However, over the past decade, the number of UA, and their uses, has grown considerably and is expected to continue at that pace. The ICAO RPAS Panel has been working on Standards and Recommended Practices (SARPS) for international remotely piloted aircraft operating in an instrument flight rules IFR environment flying in controlled airspace with no people onboard, focusing on SARPS for the communications link and airworthiness/certification. However, over the past number of years, as a result of the COVID pandemic, Member States with limited infrastructure have identified new use cases and requested support in using small UA for deliveries of food, blood, medicine, vaccines, supplies, personal protective equipment, dispersing sanitizing agents, monitoring public areas for compliance with social distancing requirements, making public announcements and replacing people working in agriculture (where it is no longer possible because of COVID). These Member States requested guidance from ICAO on the regulatory considerations for small unmanned operations, particularly during COVID. ICAO formed the UAS Advisory Group (UAS-AG) to help formulate regulations that Member States could use for their own regulations and ICAO hosted a series of webinars to provide educational regulatory information on small unmanned operations and examples of use cases.

The ICAO Remotely Piloted Aircraft Systems (RPAS) Panel has provided input to this e-publication. A series of eight webinars was developed by ICAO. One webinar focused on the regulatory framework being addressed by the ICAO RPAS Panel. The remainder of the webinars focused on small UA, explaining the ICAO Model Regulations that were published in February 2021, the introduction of an unmanned traffic management framework for global harmonization (analogous to air traffic management for manned operations), considerations for enabling the operation of UA beyond visual line-of-sight, the use of UA for humanitarian purposes, discussion on the operation of UA's in Rwanda and remote locations in Canada and Africa.

ICAO has also made available a public website to serve as a starting point for Member States who want to establish or approve domestic operations of UA. The ICAO UAS Toolkit is a repository of the current national UA regulations for 45 member states and provides best practices, training, education, and key safety considerations: https://www.icao.int/safety/UA/UASToolkit/Pages/default.aspx

It should be noted that absent from each of these fora has been a discussion on the environmental impacts of UA. They are considered out of scope by the RPAS Panel; however, CAEP WG1 is working on the noise impacts principally related to the certification of UA and ICAO has created a website to collect noise information on new aircraft concepts:
https://www.icao.int/environmental-protection/Pages/noise_new_concepts.aspx/.

The ICAO Remotely Piloted Aircraft Systems (RPAS) Panel has been working on Standards and Recommended Practices (SARPS) for international remotely piloted aircraft operating in an IFR environment flying in controlled airspace with no people onboard, focusing on SARPS for the communications link and airworthiness/certification. However, over the past year, as a result of the COVID pandemic, Member States have wanted to use small unmanned aircraft for deliveries of food, blood, medicine, vaccines, supplies, personal protective equipment, dispersing sanitizing agents, monitoring public areas for compliance with social distancing requirements, making public announcements and replacing people working in agriculture where it is no longer possible because of COVID. This has been requested by countries with limited infrastructure. Member States requested guidance from ICAO on the regulatory considerations for small unmanned operations, particularly during COVID. ICAO formed the UAS Advisory Group (UAS-AG) to help formulate regulations that Member States could use for their own regulations and ICAO hosted a series of webinars to provide educational regulatory information on small unmanned operations and examples of use cases.

Webinar topics include the regulatory framework being addressed by the ICAO RPAS Panel, the ICAO Model Regulations that were published in February 2021, the introduction of a unmanned traffic management framework for global harmonization (analogous to air traffic management for manned operations), considerations for enabling the operation of UAS beyond visual line of sight, the use of UAS for humanitarian purposes, and the operation of UAS in Rwanda and remote locations in Canada and Africa.

ICAO also made available a public website to serve as a starting point for Member States who want to establish or approve domestic operations of UAS. It is a repository of the current national UAS regulations for 45 member states and provides best practices, training, education, and key safety considerations.
Absent from these regulations are environmental considerations.

ICAO UAS Webinars:
https://www.icao.int/Meetings/webinar-series/Pages/ArchivedWebinars.aspx

1. RPAS International IFR Regulatory Framework
2. Enabling UAS Operations Part I
3. Enabling UAS Operations Part II - Panel Discussion
4. Introducing ICAO UAS Model Regulations
5. UAS Beyond Visual Line of Sight Operations - for Regulators
6. ICAO UTM Framework - Core Principles for Global Harmonization
7. U-AID - Humanitarian Operations using UAS
8. Safety Management System (SMS) for UAS Operations

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