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A **HOLISTIC** APPROACH FOR ASSESSING DRONE BENEFITS, SAFETY, AND SOCIETAL ACCEPTANCE

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Rains batter a region of the Midwest, saturating the ground and eventually threatening portions of the local flood control infrastructure. A buzzing can be faintly heard, slowly growing louder, entering an inaccessible flooded area. A drone launched by structural engineers comes into view, circling over a levee, assessing its condition. Nearby, another drone inspects a diversion dam to analyze how well it is holding. When risks are spotted, downstream cities and towns are warned to evacuate. The exodus begins, but before all are safe, more rains cause the structures to fail. First responders deploy multiple drones and discover new failures in real-time and locate those in peril. Flying day and night, the drones' visual and infrared video cameras allow operators to spot people in need of assistance. First responders are able to rapidly react, enable swift coordination, and save lives.

Introduction

You've seen the videos, watched the news reports, heard the stories – drones performing a variety of functions to help people, improve safety, or add convenience to our lives. A growing list of governmental and commercial drone users and stakeholders have acknowledged the positive aspects of using a drone to replace traditional methods of accomplishing a range of tasks. How can those benefits be recognized, quantified, and viewed in a holistic manner to inform safety decisions that would enable increased and purposeful use of drones with societal benefits?

Promoting and ensuring aviation safety is a primary function of the National Airspace System (NAS) regulator, the Federal Aviation Administration (FAA). The FAA's role of providing aviation safety oversight has traditionally focused on crewed and passenger-carrying aircraft. As technology and innovation evolve, new entrants to the NAS, like drones and commercial space operations, require broader, expanded safety oversight and evaluation. More informative and actionable tools are required to evaluate risk versus benefit.

WHILE EXPANDING THE PROCESS TO ENABLE AND UNLOCK BROADER DRONE POTENTIAL IN A SAFE MANNER, THE FAA CAN BENEFIT FROM A PROCESS THAT MEASURES AND EVALUATES SOCIETAL BENEFIT OF USING A DRONE IN ADDITION TO CONSIDERING AVIATION OPERATIONAL RISK. A METHODOLOGY THAT CONSIDERS SOCIETAL PERCEPTION AND ACCEPTANCE OF DRONE USE FOR A SPECIFIC PURPOSE IN A HOLISTIC MANNER.

Safety assessments are conducted by the FAA prior to approving or denying drone operators' requests to fly in the NAS. These assessments focus on the ability of the drone system to operate safely. Specifically, they consider the operation's ability to not disrupt the operations of other aircraft, to comply with required rules and directives, and to remain within established performance limitations.

There is no current means included in FAA NAS risk assessment calculations to consider the potential risks and benefits of a proposed drone operation within the context of the operator's mission safety envelope, to include quantification of comparable risks and benefits inherent in the traditional method of accomplishing the same task. When potential benefits, level of societal acceptance, and safety assurance aspects are evaluated together in a holistic manner, a clearer picture of the overall impact of the drone operation can be assessed. For example, if a drone operator desires to fly beyond the visual line of sight (BVLOS) of the remote pilot or requests to overfly a dense residential neighborhood in order to accomplish a task, the safety risks of doing so can be weighed against the benefit gained. Where benefits (most importantly, safety benefits) of drone use outweigh air and ground risk of operating the drone, societal net gain may be realized. Simply stated, where benefits are greater than the risks, enabling drones serves a broader-than-aviation societal benefit.

How does society, particularly those people directly affected by a drone operation, perceive use of a drone? Do they feel the operation is safe? Do they feel threatened? Does the drone operation improve their lives? Does the operation increase convenience or safety, or provide some other perceived benefit? If society accepts a single drone accomplishing a task, how about many drones simultaneously? Are there perceived privacy issues as the number of drones increases?

The answer to many of these questions is "it depends." In some cases, society is completely accepting, even enthusiastic, about the operations.



Some Uncrewed Aircraft (UA) operations have the potential to reduce the risk of serious injury or fatality from other causes, such as climbing towers for inspection or driving vehicles for delivery. It is in the public interest to enable such operations if the risks from the UA are lower than the risks of the activity they replace, regardless of how they would contribute to the aviation-induced ground risk.



FAA Draft White Paper "Safety Performance Objectives: Acceptable Level of Risk for Unmanned Aircraft Operations" Drone Advisory Committee (DAC) Public eBook October 27, 2021

In other cases, there is increased concern or maybe opposition. Societal acceptance depends on many factors, including the affected population's familiarity with drones, a drone operator's efforts to inform the involved population, the nature of the drone operation, and the impact – perceived or real – that the operation has on the community. Perception can also change over time and can be affected by information campaigns or events.

Applying Safety Assessment to Drone Operations Requests

Today, most commercial drone operations fall under a federal regulation: Code of Federal Regulation (CFR) Part 107 – *Small Unmanned Aircraft Systems*. This regulation allows the use of small drones (less than 55 pounds) provided they meet certain restrictions, such as staying within a distance where the remote pilot can visually observe the drone, flying in good weather, operating at or below 400 feet above the ground, and operating one drone at a time, among other restrictions. Sometimes companies, first responders and governmental organizations find uses for drones that require operations outside those allowed by current regulations. In these cases, operators will request a waiver or exemption from the FAA to allow them to operate when not in compliance with portions of the regulations.

Waiver requests are analyzed, according to the FAA's regulatory role and their drone policies, based on the safety risk they pose to other aircraft sharing the airspace, as well as to people and property on the ground. The FAA's safety assessment process involves identifying known hazards related to the proposed operation, assessing the likelihood and severity of those hazards, and developing proposed mitigations to reduce the likelihood of occurrence of those hazards to an acceptable level. Sometimes the proposed operation imposes significant enough safety risk to be denied. Most times, mitigations are applied to the operation that allow it to be conducted in a safe manner.

Many drone tasks that offer societal benefits are most effectively performed with specific waivers or exemptions from regulations. When requests for a waiver/exemption are made, the FAA applies its safety assessment process to evaluate the request. Current processes do not include assessments of benefits to society or societal acceptance.



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Creating a Holistic Process – From Methodology to Practical Framework

A multi-disciplinary team from MITRE set out with the goal of creating a holistic assessment process. The MITRE team included members from our Enterprise Program and Risk Management Department, who work with federal government sponsors (e.g., Department of Defense, Department of Homeland Security, Intelligence Community agencies) to develop, integrate, and use risk assessment processes applicable to their operations. The team also included members from MITRE departments focused on optimization and hazard identification, who are experienced in drone integration efforts and safety assessment processes both within the FAA and internationally. Completing our team was a human-centered engineer from MITRE Labs' Transportation Human-Centered Experimentation department, who is familiar with the human components and social considerations of drone systems and operations.

Collaborative and technical engagement resulted in a framework that can be used to inform FAA decision-making based on assessing air and ground safety, societal benefits, and societal acceptance for a specific drone operation. The framework allows for a more rigorous and quantitative review of the many factors that come into play for a drone

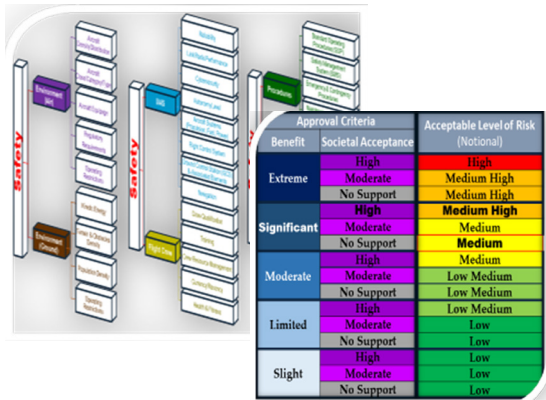


Photo Source: MITRE

operation and allows those factors to be weighted by importance.

Safety assessment is a critical aspect of the framework, and in some cases safety concerns may be weighed with other factors, such as the benefits the drone operation provides. The safety assessment process introduced in this framework evolved from the FAA's current process. It's an expanded, more comprehensive safety examination. MITRE incorporated recommendations that have emanated from multiple uncrewed aircraft system (UAS) advisory and stakeholder groups to improve safety assessment through a holistic, data-driven, and quantifiable process. The assessment focuses on characteristics that influence air and ground risk and presents a structured, transparent process that coalesces around a path to defining and including additional safety-related variables within an aviation acceptable level of risk identification.

The framework uses standardized required information that waiver applicants would normally provide, a method of quantifying the information received, and computational functions to process information to inform the existing FAA decision-making and approval process. The framework is not designed to remove human assessment or approval process of the proposed drone operation, but rather to better inform the FAA analyst and allow the decision-making process to be more streamlined and inclusive.

A Holistic Benefit/Risk Framework

Description and Key Components of the Framework.

The preliminary framework is comprised of three main components – or modules – that house sub-components that perform quantitative, computational functions that enable a holistic assessment and decision capability: approve or deny. The three modules correspond to inclusive consideration of potential benefits of using a drone for a specific operation, societal perception and acceptance (local affected population), and safety assessment (air and ground risk). The framework is data-driven, using data that is supplied to the FAA by the waiver applicant (as required today) to reduce subjectivity. Subjectivity from the regulator is not entirely removed from the decision process, but it is bounded by ranges established by the FAA and those ranges are known to drone operators. The framework employs scaling, averaging, weighting, and scoring.

Use of a Decision Matrix and Acceptable Level of Risk.

Our methodology uses a decision matrix that factors the three module outputs (benefits, acceptance, and safety) and aligns these with an acceptable level of aviation risk. Acceptable risk is a value that's understood and recognized internally by FAA and is known to the drone industry. Use of acceptable level of risk in

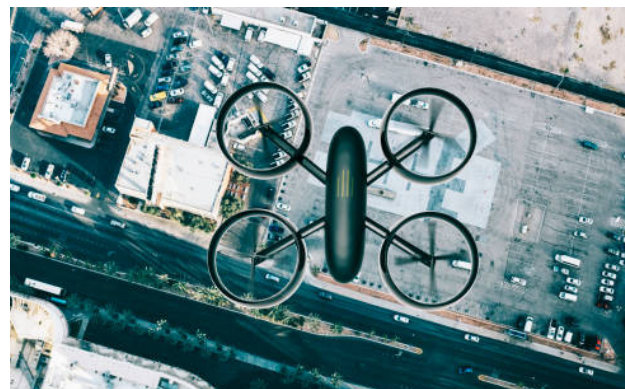


Photo Source: Getty Images

regulator decision-making potentially streamlines waiver and exemption decisions, decreases decision-making subjectivity, and provides transparency to the drone community. A decision matrix allows a holistic assessment and is constructed with the basic paradigm that in cases of high societal benefit and acceptance, greater risk may be accepted.

How the Framework Is Used. The framework is intended for regulator assessment of drone applications for waiver and/or exemption. The computational functions and calculations are designed to be contained in a web-based platform, inclusive of algorithms. This construct allows waiver applicant entry of required data, application tracking, and structured regulator assessment of an application.

Applicability Beyond Drones

While the focus of this work is on the applicability of a holistic risk assessment framework for drone use, the concepts could be expanded to incorporate other new entrants requesting access to the NAS. Areas where a more diverse assessment may be required include the concepts of Urban Air Mobility, Advanced Air Mobility, supersonic transport and the launch and re-entry operations of commercial space vehicles. These types of operations also have non-aviation benefits and varying levels of societal acceptance that are not formally considered in the current aviation risk decision process.

In addition, there are likely applications for modified versions of the framework in other modes of transportation, such as road, rail, and maritime; however, these applications would require further research.



Photo Source: NASA

Conclusion

Drones can often offer advantages over traditional methods of accomplishing a task. While their use is not wholly void of risk, their benefits can outweigh the risks under certain conditions. An assessment framework to examine benefits, risks, and societal acceptance is necessary to fully assess the advantages drones offer. MITRE's exploration of a benefit and risk framework supporting drone operations revealed it is possible to consistently and holistically assess, compare, and measure the benefit/risk relationship, thus enabling better informed decision-making.



...evolution of current FAA risk assessment methodologies is needed to integrate UAS into the National Airspace System in a timely yet safe manner. A principal driver of this conclusion is the wide variety and number of UAS operations in tandem with societal safety-related benefits that those operations can provide the public.



National Academy of Sciences, 2018

ABOUT THE AUTHORS



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