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Ocean Savior From Above: Small Unmanned Aircraft Systems (sUAS) Operations During Near-Shore Ocean Rescues

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Small Unmanned Aircraft Systems (sUAS) Operations During Near-Shore Ocean Rescues

Phase I: Legality, Public Opinion, and Practical Utility

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Abstract

The United States possesses 12,383 miles of ocean shoreline across all territorial boarders, which includes the U.S. mainland, Alaska, Hawaii, and non-state possessions. The vast shorelines offer great opportunities for both recreational and commercial exploration. However, the shoreline environment also presents a challenging and ever-present public safety hazard: drowning in open water. To combat the drowning threat, the United States Coast Guard and local governments along the nation's shorelines have developed protection measures to prevent drowning. These protection measures include beach lifeguards, rescue boats, and manned rescue aircraft. Yet 50-75% of the approximately 4,000 annual drowning deaths in the United States happen in oceans and other open waters (Branche & Stewart, 2001). This paper discusses the implementation of a new tool to protect visitors of the United States' near-shore ocean waters: small unmanned aircraft systems (sUAS). The contained study focuses on how sUAS can be used for near-shore ocean rescue, the legality of the proposed solution, and how the population of Volusia County, Florida views the government using the technology for public safety use, and more specifically ocean rescue. The study postulates that the sUAS can be used for a quicker aviation asset response than manned aircraft during rescues and fly in non-favorable conditions. The proposed solution also appears to be legal, and possess public favor.

Introduction & Literature Review

General

Drowning is an emergency that is near impossible to completely prevent, and it causes two very large problems: loss of life and economic damage. The causes of drowning are diverse, but the proper usage and development of lifeguard capabilities over the years has brought overall fatalities down since the early twentieth century, which was as high as 9,000 people per year according to the American Red Cross (Branche & Stewart, 2001). However, history has shown that lifeguards are not always effective. Like any other system dependent on human detection, recognition, and intervention, lifeguards will occasionally fail. This paper proposes the utilization of small unmanned aircraft systems (sUAS) technology to enhance drowning recognition and expedite emergency response to drowning events.

The investigation leading up to this publication serves as the beginning of a feasibility study, which worked to define legality of the proposed solution, public perception of the use of sUAS technology by government agencies for ocean rescue and other public safety missions, and how sUAS can be a better solution than manned aircraft for ocean rescue within Volusia County, Florida.

The Problem: Loss of Life and Economic Impacts

Approximately 4,000 people lose their lives due to downing accidents in the U.S. annually, with 50-75% of deaths happening in oceans and other open waters (Branche & Stewart, 2001). During 2012 alone, Florida experienced 783 downing incidents, of which 440 were fatal. Open water drownings accounted for 111, approximately 25% of the drowning deaths in Florida during 2012, with roughly 7-14 drowning incidents in Volusia County per 100,000 residents (Florida Department of Health).

Loss of life is not the only issue associated with drowning incidents; there is a steep economic cost involved with it as well. In 1997, the National Safety Council valued the economic cost of an unintentional injury death at $790,000 (Branche & Stewart, 2001). That is $1,205,800.19 in today’s currency according to the United States Department of Labor’s Bureau of Labor Statistics. This means that the economic cost of Florida's open water drowning deaths in 2012 alone amount to $133,843,821. However, it has been noted that numbers this high are almost too big to be useful for policy-makers at the local level (Branche & Stewart, 2001). This can largely be attributed to speculation on many variables, such as loss of productivity from the individual.

Yet there is another statistic that is more reasonable for decision-makers to look at involving the economic costs of drowning, the average cost of non-fatal hospitalizations caused by drowning. On average the cost of a non-fatal drowning is roughly $16,000 within the state of Florida (Florida Department of Health). Enormous amounts of the economic costs from these events are also passed along to various levels of government. Of the 343 non-fatal drowning hospitalizations in Florida during 2012, roughly 50% of patients were insured by Medicaid (Florida Department of Health), a health insurance program backed by state and federal governments. This means that the federal and state governments paid significant percentages of the medical bills for half of all non-fatal drowning hospitalizations in the state of Florida in 2012. However, local governments can be left with a large amount of financial exposure as well. In Florida, local governments have a discretionary power to operate designated swimming areas at beaches, but when they decide to operate a swimming area, they have a common-law duty to operate it safely. Florida courts look at previous knowledge of danger, presence of lifeguards, and adequate warnings to determine liability (Branche & Stewart, 2001). Volusia County does have an adequate hazard warning system in place and a robust lifeguard corps. However, the proposed solution would further reduce the county's liability because of the presence of additional protective measures.

Brief History of Lifeguarding

Prior to the early 1900s, lifeguarding as we know it today was non-existent. Early attempts at preventing drowning included lifelines, which struggling swimmers were meant to hold. However, swimmers were not always capable of holding onto them. Some municipalities began using police officers for water rescue operations, but this took away resources from law enforcement duties. Eventually municipal governments began employing individuals who were specially trained and equipped for water rescue, whom we now know as "lifeguards" (Branche & Stewart, 2001).

However, standardization of lifeguard training did not begin until 1912 when the YMCA established a national lifesaving service. Similarly, the American Red Cross established their own lifesaving division in 1914. Early training of lifeguards focused on prevention of emergencies and protecting oneself during an emergency. Non-swimming rescues like throwing a rope or life-preserver were encouraged and swimming rescues were viewed as a final resort in an emergency, largely because of the dangers posed by a panicking swimmer in the water (Branche & Stewart, 2001). These tactics had many shortcomings because swimming rescues were often impossible for beach lifeguards to avoid, which lead to the invention of technologies such as the rescue buoy, rescue tube, and rescue board (Branche & Stewart, 2001).

Today lifeguards have other tools at their disposal as well, such as motorboats and personal water craft, otherwise known as "jet-skis," to quickly reach swimmers in distress who are far from shore. However, lifeguards are commonly also required to complete other duties such as law enforcement and emergency medical services. This creates a need for a new tool to help enhance the overall situational awareness of lifeguards and decrease response times between becoming aware of an emergency and reaching the victim(s).

Why Lifeguards Fail to Stop Drowning

The number of people who perish due to drowning annually has fallen by more than half since the early 1900s. This in large-part can be attributed to the use of lifeguard services. However, with around 4,000 drowning deaths in the United States still happening annually, one can deduce that lifeguards are not a one-hundred percent effective solution. One of the main reasons is that municipalities cannot keep lifeguards on duty around the clock, it would be too expensive. In fact, three-quarters of drowning deaths that happen at beaches that are protected by lifeguards occur when the lifeguards are not on duty (Branche & Stewart, 2001).

Even though most drownings at protected beaches happen when lifeguards are not on duty, there are still many instances where people still drown while lifeguards are on duty. In a study that analyzed drowning deaths at swimming pools protected by lifeguards during the 2000-2008 time period, the lifeguard realized the drowning was taking place only 22% of the time. The other 78% of cases were recognized by by-standers and reported to the lifeguard (Pelletier & Gilchrist, 2011). One might argue that these statistics are not valid when applied to the effectiveness of lifeguards at beaches because the environment is different. However, one must consider that the environmental conditions at a pool are generally more favorable than at the beach, which means that lifeguards could potentially notice an even smaller percentage of drownings on their own at beaches.

The next question that one must ask is why lifeguards fail to notice drownings. Research conducted by Dr. Frank Pia in the 1980s introduced the concept of the RID factor, which stands for recognition, intrusion, and distraction. Today it is universally recognized as the formula for why swimmers drown when lifeguards are present (Katchmarchi, 2013). Recognition is being able to identify the signs of a drowning in progress, such as anxious expressions, lack of progress toward shore, head low in the water, low strokes, “climbing the ladder” motions, and waves breaking over head (Volusia County Beach Patrol, 2008). If a lifeguard fails to identity these signs, they are not going to recognize a drowning event. Intrusions are duties that interfere with a lifeguard’s duty to surveille the water, such as law-enforcement and non-drowning related EMS. Distractions are conditions that take a lifeguard’s attention off their surveillance duties. These distractions are a part of human nature and can come in many forms. Some distractions often encountered are: daydreaming, boredom, illness, environmental discomfort, and cellular devices.

Another factor in why lifeguards may miss drowning events is that they are unable to maintain maximum vigilance. There have even been articles written stating that lifeguards can only maintain vigilance for a maximum of 30 minutes (Katchmarchi, 2013). However, even that statistic has some less than favorable variance. In Adam Katchmarchi's study on lifeguard behaviors, he observed lifeguards for a period of 30 minutes during their shift to classifiy their behaviors while on duty. The avergage amount of time that lifeguards actively scanned the water was 27.70 minutes. However, some lifeguards scanned for as little as 23 minutes and were distracted for 5.17 minutes (Katchmarchi, 2013). The distractions leave plenty of time for an individual to begin drowning without a lifeguard taking notice.

Introduction & History of UAS Technology

Unmanned aircraft systems (UAS) have evolved greatly since their introduction during the 1930s, where their use was primarily for military applications. In fact, they were originally used as target practice for anti-aircraft gunners during World War II. This eventually developed into UAS operations for reconnaissance during the Vietnam War with the Ryan Firebee, which flew over 34,000 operational missions in Southeast Asia (PBS, 2002). However, UAS technology did not become popularly known among the public until the 1990s with the development of the Predator Unmanned Aerial Vehicle (UAV), which allowed for high resolution imagery of situations on the ground while being controlled from thousands of miles away.

It is important to note that many of the above-mentioned uses of UAS describe aircraft that are roughly the same size as many manned aircraft. However, there is another classification of UAS known as small UAS (sUAS), which are smaller than full-sized aircraft and generally preform missions in a local area near a ground control station. These are the type of UAS that will be considered during this course of research. Examples of these include catapult-launched military sUAS platforms such as AAI's Shadow and Insitu's ScanEagle, along with popular commercial platforms that are roughly the same size as miniature radio-controlled models, such as the DJI line of sUAS.

In recent history UAS usage has also expanded beyond strictly military application and into the civilian sector, particularly for missions that are too long, dull, or dangerous for manned aircraft to conduct. A quick search on any web browser for “Civilian UAS” will return a myriad of results on how they are currently being used. Some of the most notable are aerial imagery, communications relays, and emergency services/public safety. Given the nature of the project, emergency services/public safety usage will be the only one discussed in this paper.

Emergency Services Usage of sUAS

The earliest known usage of sUAS technology for emergency services was during Hurricane Katrina in 2005, where UAS systems were extensively used for mission reconnaissance and mapping (Murphy, 2014). There have also been 10 other known deployments of sUAS around the globe for large scale disasters (Murphy, 2014). However, there are many lesser known examples of sUAS deployments for smaller natural and man-made disasters. One example within Volusia County was the use of a sUAS platform after Hurricane Matthew to perform initial damage assessments in the City of Daytona Beach Shores on the city’s high-rise condos and hotels. The task was completed in a matter of only a couple hours when it could have taken upwards of a day on foot.

Outside of disaster response, there are also many other usages for sUAS during more ‘routine’ emergency services, such as search and rescue, law enforcement, and firefighting. Remarkably, as of 2016, sUAS are already being used by public service agencies in 43 out of 50 states in the U.S. (Kelley, 2017). However, the technology used and concept of operation for search and rescue sUAS are the best suited for adaptation to drowning detection and intervention in the ocean rescue environment.

Search & Rescue sUAS: General Usage, Payloads, and Ocean Rescue Application

sUAS platforms can be categorized into two overarching categories, fixed-wing (airplane-like) or rotor-wing (helicopter-like) aircraft (Murphy, 2014). Both categories of sUAS aircraft play important roles in the search and rescue field. Fixed-wing sUAS with long flight endurances are generally best used for coverage of large search areas, such as looking for a missing person in the wilderness (Murphy, 2014). Whereas rotor-wing sUAS are better suited for quickly checking out a local area (Murphy, 2014).

There have also been studies conducted on ideal search and rescue payloads for sUAS platforms. The payload of a sUAS is what allows it to be useful during missions and differentiates it from a radio-controlled aircraft operated for amusement. Most payloads consist of a camera or another kind of sensor, which is why UAS platforms in general are known for their surveillance abilities. However, there was one study developing a search and rescue payload for the Desert Hawk III, a military fixed-wing sUAS platform that performed more comprehensively. The LASSIE payload developed by students at the University of North Dakota went beyond simple sensory capabilities. Not only was LASSIE able to search for subjects of search and rescue cases, it also made efforts to communicate with them. LASSIE consisted of a camera and GPS timestamp device like many other UAS platforms. However, what made LASSIE unique was the way that it could communicate with subjects using an MP3 player with pre-recorded messages, siren, and strobe light.

There is a gap in the literature on the use of rotor-wing sUAS payloads that can be directly related to ocean rescue operations. However, there are a few working examples of rotor-wing sUAS platforms being used for ocean rescue. One example is in Spanish Catalonia where lifeguards are using a quad-copter sUAS to drop life vests for distressed swimmers. News reports indicate that the sUAS platform can reach a drowning swimmer within a minute, whereas a regular lifeguard can take up to three minutes to reach the distressed individual (Ruptly, 2016). Another similar example of rotor-wing sUAS is being used off the coast of Australia to rescue swimmers in distress and track the location of sharks (euronews, 2016). The system in Australia, known as the Little Ripper Lifesaver, also made headlines around the globe on January 18, 2018 after it completed what is possibly the first ever confirmed ‘save’ by a sUAS in an ocean rescue environment (Kwai, 2018). These examples bring credibility to this feasibility study for sUAS usage at Volusia County beaches because the concept has worked somewhere else.

Federal Regulations Pertaining to sUAS Operation

In 2016 the Federal Aviation Administration (FAA) published a series of rules to govern sUAS operations within the United States National Airspace System. These regulations are known as the FAR Part 107, not to be confused with airport security regulations that were under the same number previously. The rules within FAR Part 107 allow for the use of sUAS platforms for commercial and other non-recreational usage and all sUAS platforms that fly under Part 107 rules must weigh under 55 pounds and be registered with the FAA. Operators of sUAS flying under the rules of Part 107 must also obtain a remote pilot certificate, which is obtained by passing a written knowledge exam; unlike other certifications issued by the FAA that require both knowledge and practical examinations. This can be attributed the vastly different modes or operation for sUAS platforms flying under the Part 107 rules, which makes identifying flight standards difficult. However, like any other FAA governed flight activities, there are certain operational rules that must be adhered to:

- sUAS must fly only in Class G airspace (uncontrolled airspace)
- The operator must keep the aircraft in sight (visual line-of-sight)
- sUAS must fly under 400 feet above ground level
- sUAS must fly only during the daytime
- sUAS must fly at or below 100 mph
- sUAS must yield right of way to manned aircraft
- sUAS must NOT fly over people
- sUAS must NOT be flown from a moving vehicle

These rules may seem restrictive at first because they severely limit what can be done with sUAS platforms. Fortunately, all the operational rules are subject to wavier by the FAA, but operators must prove to the satisfaction of the FAA administrator or their designee that they can operate outside of specific rules safely, but it is difficult to get waivers to fly sUAS in controlled airspace.

However, the FAA has developed a means to allow public entities, governments or their representative agencies, to operate sUAS within controlled airspace for specific purposes. They are known as Certificates of Authorization (COAs). COAs grant the ability for public entities to conduct specific missions using sUAS within controlled airspace, but they must satisfy the requirements of the FAA for performance characteristics, airworthiness, procedures, equipment, air-traffic control communication, aircrew qualification, and flight operations planning among other things.

Florida Statutes Pertaining to sUAS

The State of Florida has its own laws pertaining to the operation of UAS platforms within the state, Florida Statute Section 934.50, commonly known as the "Freedom from Unwarranted Surveillance Act." This act prohibits the use of "drones" (UAS) from being used for surveillance purposes where there is a "reasonable expectation of privacy" by law enforcement and groups such as political parties and private investigators. Surveillance within the statute is defined as:

1. With respect to an owner, tenant, occupant, invitee, or licensee of privately owned real property, the observation of such persons with sufficient visual clarity to be able to obtain information about their identity, habits, conduct, movements, or whereabouts; or

2. With respect to privately owned real property, the observation of such property's physical improvements with sufficient visual clarity to be able to determine unique identifying features or its occupancy by one or more persons.

However, the reasonable expectation of privacy is also defined differently in this statute compared to others within Florida:

> A person is presumed to have a reasonable expectation of privacy on his or her privately owned real property if he or she is not observable by persons located at ground level in a place where they have a legal right to be.

The law even prohibits surveillance activities that are traditionally allowable when conducted from a manned aircraft, such as game code enforcement by the Fish and Wildlife Commission. However, there are exceptions to section 934.50 where UAS systems can be used for surveillance. Some of the exceptions explicitly mentioned are if a law enforcement agency obtains a warrant to use a UAS for an evidence search, countering a high-risk terrorist attack, reasonable suspicion of imminent danger to life or severe damage of property, preventing the imminent escape of a suspect or destruction of evidence, or searching for a missing person.

Proposed Solution

This project proposes the utilization of two sUAS platforms to help supplement current lifeguard capabilities for drowning prevention within Volusia County, FL.

One platform would be a long endurance fixed-wing aircraft equipped with cameras and other sensors that transmit to a ground control station, where a computer with motion recognition software analyzing the feed will alert the sUAS operator of hazardous conditions or possible persons in distress. Additional payload items similar to the University of North Dakota's LASSIE could also be particularly useful in an ocean rescue scenario because it would allow the operator to relay instructions to a victim to help him or her stay afloat and alert lifeguards on shore with visual and auditory alarms, while giving the exact position of the victim using real-time GPS data.

The second sUAS, a multi-rotor based platform, would be utilized to aid lifeguards during rescues by flying out to distressed persons with a life preserver to stabilize the victim in the water until lifeguards can arrive. This sUAS would also have a radio transceiver so that the operator can communicate with the victim.

sUAS technology could become part of the way that we address the RID factor and the inability to maintain vigulance. Modern computing techology is capable of visual intelligence, which means computers are able to detect pre-programed paterns or anomalies (Kelley, 2017). We can program this technology to detect the signs of a drowning victim by using footage collected by a sUAS's sensors. Machines like sUAS platforms also cannot be distracted in the sense that a human can because they don't get bored, tired, sick, or uncomfortable, which means they can always maintain vigilance. Granted, the operator of a sUAS can still become distracted, but the system can alert the the operator of trouble through the use of an alarm stimuli if the sensors detect signs of drowning.

The utilization of sUAS in beach environments can provide an additional layer of protection that reduces fatalities and potential liability for municipalities during drowning-related lawsuits.

Research Methodologies

To begin a feasibility assessment of using sUAS for ocean rescue within Volusia County, the study contained in this paper investigates three key elements to help determine if continued study on the implementation of the proposed solution is worthwhile: legality of the proposed solution, public opinion of sUAS public safety use, and fatal drowning cases where a sUAS would have been beneficial. Legality was important to look at because if the proposed solution did not fit within the limits of the law, it could create greater liability for agencies using sUAS technology to face a costly lawsuit. The public's opinion of sUAS usage in public safety is also a central aspect to a feasibility assessment because if the public doesn't approve of sUAS use, the proposed solution could meet a lot of resistance and cause a public relations nightmare for an implementing agency. Looking at real life cases of drowning where sUAS could have been used to potentially save the victim is also critical to the assessment because it helps determine if the proposed solution is needed and possesses a significant practical utility.

Legality

The legality of the sUAS solution that is proposed by this paper was assessed by reviewing applicable statutes from both the federal government and the State of Florida. The review of the federal statutes in 14 CFR Part 107, better known as FAR 107, examines if the proposed usage is allowable within the FAA's current sUAS operating rules. Meanwhile, the review of Florida statutes focuses on the allowable applications of sUAS by public agencies within the State of Florida.

Public Opinion

To gauge the public's opinion on government use of sUAS for public safety and more specifically the proposed ocean rescue application of this study, a survey instrument was used. The instrument and the procedure used to collect data received approval from the Embry-Riddle Aeronautical University's Institutional Review Board prior to the collection of any data.

Any individuals at Volusia County beaches over the age of 18 were eligible to participate in the survey. Respondents were recruited by the approaching the respondent in person and making a scripted statement that explained the purpose of the survey and asked the respondent to participate. All collected responses were anonymous, and informed consent was obtained by having the respondent read a statement on the first page of the survey, which informed the respondent that completion of the survey implied consent.

The survey was administered in a digital format using a tablet device, or during equipment failures, delivered via a paper form, and consisted of nine multiple choice questions. The first six questions were meant to collect demographic information on the respondent, such as age group, gender, area of residence, and familiarity with sUAS (First thought when they hear the word 'drone,' level of knowledge, and where they learned about sUAS). The final three questions were designed to capture the respondent's opinion of sUAS use by the government for public safety. The first question covered their opinion to generalized use of sUAS by the government for public safety. The second question provided different perceivable missions for a public safety sUAS with specific examples and asked the respondent to choose the sUAS applications they would most likely approve. The final question gives a detailed description of the proposed ocean rescue application this feasibility assessment is studying and asked if the respondent would support it. Two of the questions, general opinion of government public safety use and the feasibility study specific question, had comment sections to capture "why" if they recorded a disapproval or "with reservation" response. Once the survey was complete, the respondent returned the tablet or paper to the survey administrator. Respondents were then thanked for their participation and any questions they might have had were answered on the spot, ending the procedure.

Due to the possibility of personally identifiable information being left in the comment sections that could compromise the respondent's anonymity, all responses were screened at the end of each day during the survey period and those that left personally identifiable information were destroyed.

After the survey period, the responses to the multiple-choice questions were analyzed to determine statistically what percentages of the population supported or opposed public safety sUAS use and determine which demographics were more likely to support or disapprove of sUAS in public safety. Whereas the comments sections provided qualitative data on why respondents might not support sUAS in public safety, which can be used to make changes to the proposed ocean rescue sUAS solution to make it more palatable to the population if possible. The survey data will also be helpful for future projects to study the potential implementation of sUAS in other regions of the United States and see how public opinion of sUAS changes within Volusia County as the technology becomes more prevalent in society over time.

Necessity Case Studies

To establish the necessity of sUAS technology for ocean rescue within Volusia County, drowning incident reports from the Volusia County Beach Safety Division between January 2012 and June 2017 were analyzed. The records were obtained via a public information request to the Volusia County government. During the time frame examined, 40 drowning incident reports were generated by Volusia County's Beach Safety division. The reports were narrowed by an initial screening of all the report narratives. Incidents that were recognized by lifeguards and the victim was successfully recovered by the lifeguard without the assistance of aviation assets were eliminated first. Incidents where there was a false alarm and no person was in distress were also then eliminated. This left only incidents where the victims were not recovered by lifeguards alone and aviation assets were requested to aid in the search for the victim. After the elimination process was complete, only nine of the reports remained for further analysis.

The remaining drowning reports had their narratives closely examined for a better understanding of events that unfolded during each drowning case. After closer examination, the nine remaining cases were classified into a typology with three categories: aircraft arrived and located the victim, aircraft arrived but failed to locate the victim, and aircraft failed to arrive. Once classification of the cases was complete, the researcher then analyzed the events and conditions of each case. The factors that were noted in each case's analysis other than its classification was time of day, prevailing atmospheric and ocean conditions, when an aircraft arrived, reason why an aircraft did not arrive, if the aircraft left the search early and why, and how the drowning emergency occurred.

Findings

Legality of sUAS Near-Shore Ocean Rescue Solution

The proposed sUAS solution is governed by two bodies of law within Volusia County, FL: 14 CFR Part 107 and Florida Statute 934.50. For the solution to be legally acceptable, it must satisfy the requirements of both bodies of law.

Due to the nature of using sUAS at beaches for ocean rescue a waiver from the FAA would be required for flying over people, which means the agency operating the platform must prove that their remote pilots are competent enough to fly over people and that safeguards to protect people on the ground in the event of a technical failure are in place. Also, since much of Volusia County's beaches are near airports, a waiver for operation in controlled airspace would be required as well. This can be done by an agency using the ocean rescue sUAS through certificate of authorization to conduct their specific mission. Otherwise, the solution can fit within the parameters of 14 CFR Part 107. Visual line of sight can be maintained of the patrol aircraft by using a technique known in the sUAS community known as "daisy chaining," which is a process where the pilot-in-command of the sUAS uses observer assistants to maintain line of sight beyond that of the main operator, which in the case of near-shore ocean rescue could be lifeguards during their normal scanning routine. The sUAS platforms would never need to exceed an altitude of approximately 100 feet, which is well below the minimum legal altitude of manned aircraft, thus reducing the likelihood of needing to give right-of way to manned aircraft. Operations would only be conducted during daylight hours when beach visitors are normally present and it would be unpractical to conduct the mission of the proposed solution from a moving vehicle or using a sUAS that can travel over 100mph.

The proposed solution also appears to be legal under FS 934.50. However, the solution would have to remain separate from any law enforcement mission that an agency utilizing the solution is chartered to complete, unless a warrant was obtained from a judge first or if specific exigent circumstances mentioned in the statute are met. Also, the operating agency would need to keep all private real property out of view of sUAS sensors, which includes hotels, condos, homes, and businesses along the beach front, which can be done via flight planning considerations and through design controls that direct all sensors toward the water. This is incredibly important to consider in Volusia County where all agencies that currently utilize sUAS or are responsible for near-shore ocean rescue have a law enforcement component to them.

Public Opinion

The initial survey of public opinion on the proposed sUAS solution taken during this study show favorable results in support of the sUAS solution, the summary results of which can be seen in attachments 1 & 2, but it is difficult to determine the accuracy of the results relative to the population due to a fairly small sample size and only conducting a single sample. However, it is important to note that of the eight percent of respondents that stated they would not support the proposed solution, all were from the 18-40-year-old age group. This could possibly be because the younger adult population is more aware of the capabilities and potential for abuse of sUAS platforms, but it is purely speculative at this time. However, to ensure that the public opinion data is reliable enough for actual implementation decisions, multiple samples of a larger size than the 100 responses collected during the study must be obtained.

Most of comments left on the survey question regarding if respondents would support the specific sUAS solution, 12 out of 18, were related to privacy. Efforts must be made to educate the public about the limits of their privacy in public places and make the sUAS solution minimally invasive for actual implementation. Other comments revolved around issues of safety, the need to test any life-saving technology, cost of operation, and a lack of knowledge. While another comment stated that the respondent would trust the government to use sUAS technology appropriately.

Also, comments made by respondents regarding their opinion of if they would support the proposed solution's brief description questioned why recognition software was needed. The recognition software implied in the question was for motion to detect movements typically associated with drowning, but the word motion was not explicitly stated. The population in this survey appears to associate the term recognition software in the context of personal identification, which is typically how recognition software is portrayed in popular culture. If this study were to be repeated, it would be interesting to see if response outcomes would change by inserting the word 'motion' in front of 'recognition software.'

Practicality of sUAS Over Helicopters in a Near-Shore Ocean Rescue Environment

Analysis of the nine drowning cases that utilized aviation assets between January 2012 and June 2017 highlighted several points where a sUAS might have an advantage over using a helicopter in the near-shore ocean rescue environment (See attachment 3 for charts explaining details). The principle points revolve around response time, flight in adverse weather, and cost of operation. For the cases that noted when a drowning incident began and when a helicopter asset arrived, the minimum amount of time it took a helicopter to arrive was 21 minutes, which is a fatal amount of time for a distressed person in the water. There were also several occasions where the helicopter either did not arrive or was forced to leave early due to poor weather conditions. This is understandable because the risk of losing a multi-million dollar machine and the lives of the crew on board would be too high if the weather deteriorated while searching for a drowning victim. Additionally, in only one of the analyzed cases did the helicopter locate the drowning victim successfully, but helicopters like the ones used in the case studies cost at least $600 an hour to operate depending on the aircraft and operator.

The sUAS platforms in my proposed solution have an advantage over helicopters in response time because the patrol sUAS would be loitering over the water all the time during the beach's protected hours, while the multi-rotor rescue platform can be launched and on scene with the victim within approximately a minute in the hands of a trained operator, which has been achieved by a working example in Australia (Kwai, 2018). sUAS platforms can also fly in more inclement weather than helicopters because the consequence of losing a sUAS in bad weather is far less catastrophic than that of a helicopter. When a helicopter crashes, like the Bell 407s operated by Volusia County's Air One, an approximately 2.5 million dollar aircraft is lost along with the almost certain fatalities of the flight crew on board; whereas if a sUAS is lost in a crash due to poor weather, only the cost of a significantly cheaper machine will be lost. sUAS will also work out to be cheaper to operate than helicopters in a near-shore ocean rescue environment because they do not require expensive aviation fuels, operators are cheaper to train, and cost less to maintain.

Conclusions and Next Steps

The proposed sUAS solution appears to be legal according to FAA regulations and statutes of the State of Florida, is favored in the public's opinion, and demonstrates a practical utility that gives sUAS an advantage over helicopters. The results of phase one of this feasibility assessment (legality, public opinion, and practical utility) warrant the project moving onto a second phase, which will encompass selection of the best sUAS platforms and ground support equipment for the mission and estimating the cost of implementation and operation. After phase two of the assessment is complete and if the cost of implementation and operation of the sUAS has been proven to not be too burdensome for use in Volusia County, a limited deployment will be made to test the solution's effectiveness before full implementation across the county.

This study can be repeated in other locations throughout the country to begin feasibility assessments of implementing sUAS solutions for near-shore rescue at beaches, lakefronts, and other natural aquatic locations throughout the nation. There will also be opportunities for the expansion of sUAS capabilities within the drowning prevention mission, such as detection of rip currents and tracking locations of sharks, with the development and improvement of on-board sensors. There could even be opportunities to utilize the technology for missions outside of ocean rescue and drowning prevention during disaster situations, including the assessment of beach erosion after hurricanes.

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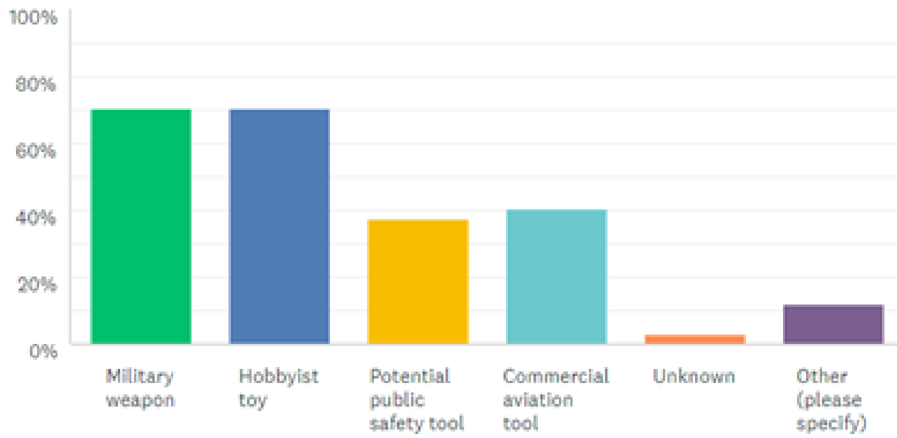
Attachment 1: Public Opinion Survey Statistics

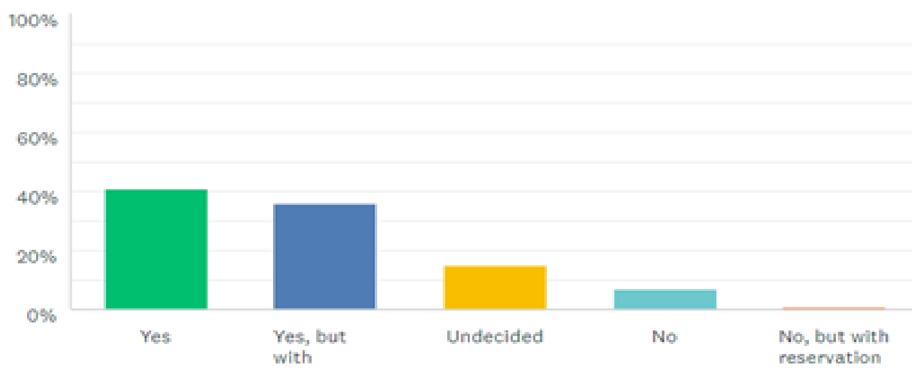
What do you think of when you hear the words 'drone, UAV, or UAS' ? (Check all that apply)

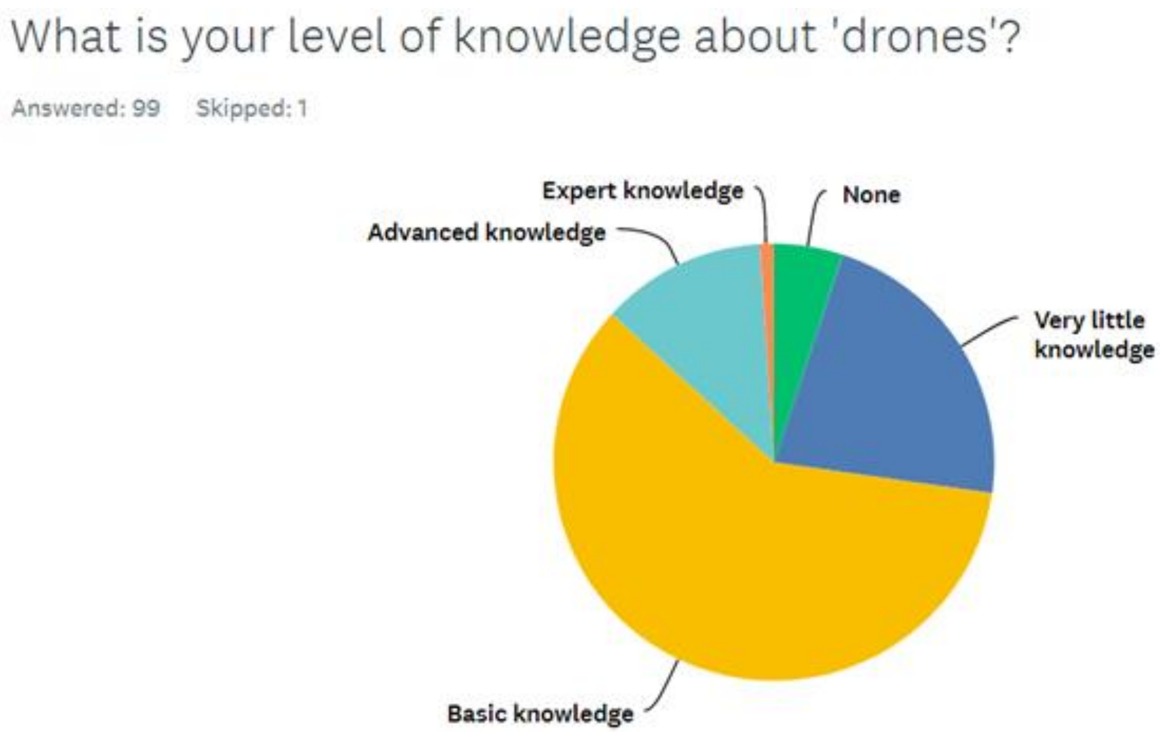
Answered: 99 Skipped: 1

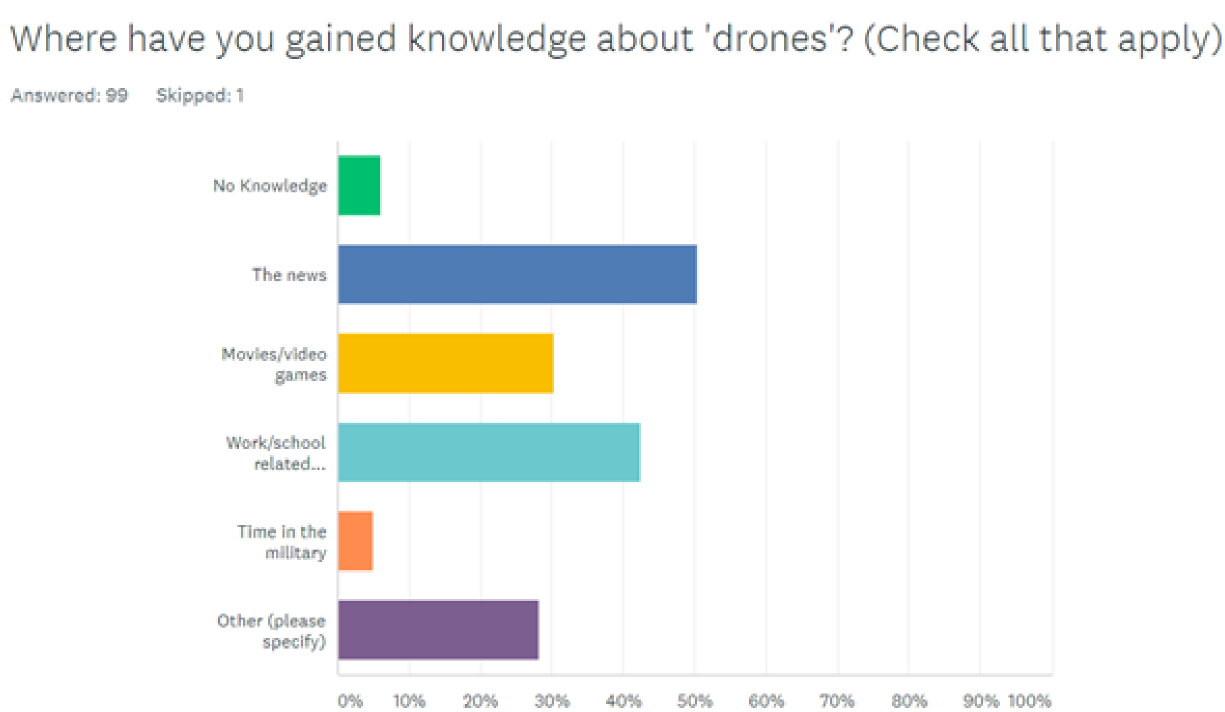


Would you support the use of a 'drone' that is equipped with a camera and recognition software for constant surveillance of beaches for swimmers/boaters in distress and to assist in rescue operations?

Answered: 100 Skipped: 0




What is your level of knowledge about 'drones'?
Answered: 99 Skipped: 1
Expert knowledge
None
Advanced knowledge
Very little knowledge
Basic knowledge


Where have you gained knowledge about 'drones'? (Check all that apply)
Answered: 99 Skipped: 1
No Knowledge
The news
Movies/video games
Work/school related...
Time in the military
Other (please specify)
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Attachment 2: Public Opinion Survey Comments

(Grouped by Category)

Q: Would you support the use of a 'drone' that is equipped with a camera and recognition software for constant surveillance of beaches for swimmers/boaters in distress and to assist in rescue operations?

Privacy / Harassment

Comment:	Survey Response:
Why does it need recognition software?	Yes, but with reservation
As long as it's being used properly for the above reasons. Some people could see it as invasion of privacy even though it's not necessarily directed at them.	Yes, but with reservation
Not sure how invasive the technology can/will get in the future	Yes, but with reservation
I support the use of drones. However, I do recognize potential privacy issues that may arise and need to be addressed.	Yes, but with reservation
I believe in privacy.	Undecided
Only use recognition during distress or rescue operation. Do not use recognition for patrolling purposes or during regular operations.	Yes, but with reservation
That it is a pretty big violation of privacy	No
It has to be regulated so that authority is not abused of.	Yes, but with reservation
The surveillance constantly may abuse the right to privacy. If this surveillance goes into effect, limits may push further. Limitation on what normal if the drone was used + equipped w/ a camera. If called for individuals or any distress signals, the UAV may assist in rescue operations. Plus, if there is a lifeguard he may notify the UAS/UAV/Drone while doing what needs to help individuals to the extent that the lifeguard can.	No
This could be an easy tool for sexual harassment	No
It would have to be strictly for the reason listed	Yes, but with reservation
To preserve human rights	Yes, but with reservation
I believe that the equipment technology has to be used very responsibly. So there would need to be extra security precautions put in place in the software and for the users so it is not abused.	Yes, but with reservation

Other

Comment:	Survey Response:
I've had one crash down on me + injure me. Also- they're loud.	Yes, but with reservation
Anything we can do to help prevent death should be at least publicly tested for viability	Yes
Trust in the proper/fair use of the technology.	Yes
I do not have enough knowledge to decide	Undecided
These are real costs ($$ and equipment) to maintaining constant surveillance. Suggesting "demand surveillance" during peak crowds or key weather / water periods to that program. Once costs in equipment (fine before maintenance, life-cycle of drone) personnel to monitor / service ... [illegible]	Yes, but with reservation

Attachment 3: Drowning Cases Information Chart

	Incident Date/Time	Type*	Ocean/Atmospheric Conditions + Situation Notes	When Did Aircraft Arrive & Depart?	Why Did Aircraft Not Arrive/Leave Early?	How Did Drowning Event Occur?
1	05-28-2012 @ 1755	2	3-4 Foot surf, overcast sky, Inclement Weather from tropical storm	Air One 1819A, 1902D	Deteriorating weather conditions	Victim separated from friend in the surf
2	06-17-2012 @ 1543	2	No description provided	Air One Unknown	N/A	Rip Current
3	09-21-2012 @ 1627	3	Apx. 3-foot surf, mostly cloudy sky, "Red Flag" conditions, East-South-East wind Apx. 1-2MPH	Air One Failed to Arrive	Poor Area Weather Conditions	Rip Current
4	05-14 -2013 @ 1402	1	2-3 foot surf, clear sky, "Red Flag[1]" conditions, East wind 10-15MPH	Air One Apx. 1430A	N/A	Rip Current
5	06-22-2014 @ 1237	2	0-1 foot surf, Clear sky, Slight southbound current, directly west of tower 410, lifeguards recognized incident but could not see what they were going after	Air One Apx. 1300A, 1321D USCG 1526A	Air One Deteriorating Weather	Weak Swimmer
6	04-19-2015 @ 0307	2	1-2 foot surf, night, current unknown	Air One Unknown	N/A	Rip Current
7	05-31-2015 @ 1645	2	3.6 foot surf, partly cloudy sky, "Red Flag" conditions, East wind 14MPH, northbound current, last seen 2,167 feet south of nearest open lifeguard tower, lifeguard did not witness the event	Air One Unknown USCG Unknown	Air One Low Light Conditions	Rip Current
8	05-02-2016 @1524	2	2-3 foot surf with choppy waves, Mostly sunny sky, Southeast wind 11 Knots, 676' away from nearest lifeguard tower (south), 1036' (north)	Air One 05-02 Unknown 05-03 0914A	N/A	Unknown/missing swimmer
9	04-15-2017 @ 1518	2	4-5 foot surf with choppy waves, swift northbound current, initial incident could barely be seen through binoculars from tower 410 body was recovered 1.5 miles off-shore by U.S. Army Corps of Engineers (4-20)	Air One 04-15: 1539A 04-17: 0947A, 1052D USCG 04-15: 1758A	N/A	Non-swimmer caught in surf

*1: Aircraft arrived and located the drowning victim was located, 2: Aircraft arrived but failed to locate the victim, 3. Aircraft failed to arrive.