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PEER-REVIEWED ARTICLE

OPERATIONAL ORGANIZATION OF SMALL UNMANNED AERIAL SYSTEM PHYSICAL AIRSPACE

Dr. Daiheng Ni
Associate Professor of Civil Engineering at the University of Massachusetts Amherst

Mr. Jared Geller
Undergraduate Student in Department of Civil and Environmental Engineering
at the University of Massachusetts Amherst

ABSTRACT

Surging demand for public and civil applications of small unmanned aerial systems (sUAS) has urged the government, the industry, and the academia to explore ways to integrate such vehicles into already crowded national airspace. With research actively on-going at the high level which concerns about policies and regulations and at the low level which addresses sense and avoid, A wide gap has been identified in between. Hence, this paper aims at the middle-level sUAS operational organization problem. The objective of this paper is to integrate ideas presented by the FAA, NASA, Amazon, and academia regarding airspace organization with successful experiences of traffic operation in other modes of transportation in order to design safe and efficient operation modes for sUAS traffic.

Keywords: small unmanned aerial systems (sUAS), traffic operation, airspace design, modes of operation

Introduction

Due to surging demand for public and civil applications of small unmanned aerial systems (sUAS), which are unmanned aerial vehicles (drones) that weigh less than 55 pounds, academia and government agencies have been extensively studying how the United States could incorporate such vehicles into an already crowded airspace. In studying the methods to control the proliferation of sUAS, there are three different fields of study to consider. Firstly, there is the high level focus, which includes topics such as sUAS policies, regulations, and traffic management. This arena has already been extensively studied by NASA, which has presented a concept of operations for unmanned aerial system traffic management (UTM), by the FAA, which has proposed rules and policies for sUAS, and by Amazon, which has created a rudimentary physical airspace design (NASA, 2015) (De Los Santos & Rios, 2015) (Dillingham, 2015) (Golson, 2015). Secondly, there is the low level focus, which includes modeling interactions between sUAS that are equipped with sense-and-avoid (also referred to as detect-and-avoid or detect, sense, and avoid) technology. Numerous academic papers have attempted to address definitions of well-clear as well as how computer algorithms would separate aircraft, both of which are crucial in developing sense-and-avoid for sUAS (Munoz, Narkawicz, Chamberlain, Consiglio, & Upchurch, 2015) (Hottman, Hanson, & Berry, 2015).

However, there is a wide gap in between the high level and low level arenas: the mid-level focus. Very few have considered the mid-level focus, which is meant to address how sUAS traffic is organized and separated within the airspace (NASA's unmanned traffic management concept does not address this in great detail). The motivation behind this paper is to fill this gap in order to make upcoming low-altitude sUAS operations safer and more efficient. Our vision is to allow high-speed, beyond-visual-line-of-sight sUAS traffic to operate seamlessly within an airspace which includes many different vehicles. The objective of this paper is to integrate ideas presented by the FAA, NASA, Amazon, and academia regarding airspace organization with successful experiences of traffic operation in other modes of transportation in order to design safe and efficient operation modes for sUAS traffic. In order to achieve this, our approach will be 1) to incorporate ideas and successful experiences from other modes of transportation, and 2) to consider realistic designs which take privacy and safety concerns into serious consideration.

Recent sUAS Developments

While not much literature currently exists about organizing the airspace for small unmanned aerial systems (sUAS), which are best described as drones weighing less than 55 pounds, two entities have taken a keen interest in the topic. Firstly, NASA has delved into the subject out of necessity. In 2013 and 2014, 128,000 and 430,000 sUAS were sold in the U.S., respectively. 2015 is on pace to reach over 700,000 drone sales (CBSNews, 2015). Several incidents have occurred where sUAS, currently under regulated, have interfered with manned aircraft operations. Recently, hobbyists flying sUAS over California's wildfires have prevented firefighters from flying helicopters and planes over certain areas to drop water and flame retardant. The U.S. Forest Service has recorded 13 wildfires in 2015 in which sUAS interfered with manned aerial firefighting operations, 11 of which occurred from late June through the end of July (CBSNews, 2015). There are also reports of sUAS causing emergency landings for both recreational and commercial aircraft. On August 2, 2015, a commercial airline pilot approaching New York's JFK Airport reported a sUAS in the vicinity of the aircraft. On August 9, only a few days later, 4 commercial airline pilots reported a drone on approach to Newark International Airport while flying between 2000 and 3000 feet (CBSNews, 2015). Clearly, the government needs help establishing laws, rules, and regulations that restrict drones to safe flying environments while not being too overbearing. While the FAA is focused on administration and public policy, NASA is focused on the technical elements of organizing sUAS airspace. NASA has already shared its plan for airspace organization, which it calls unmanned aerial system traffic management (UTM). UTM, according to NASA, would allow for "safe and efficient low-altitude airspace operations by providing services such as airspace design, corridors, dynamic geo-fencing, severe weather and wind avoidance, congestion management, terrain avoidance, route planning and re-routing, separation management, sequencing and spacing, and contingency management (De Los Santos & Rios, 2015)."

Secondly, Amazon has also put some effort into airspace organization, motivated by the potential for reduced delivery costs and increased profits. The company plans on using sUAS through its *Amazon Prime* service to allow for package deliveries that take less than one day. This service is currently referred to as *Prime Air*. In spite of Amazon's profit-driven and aggressive push to allow for sUAS package deliveries, the company's engineers and researchers have theorized and presented their own well-thought-out plan for airspace organization which builds upon ideas presented by NASA. Amazon's plan includes altitude stratification, otherwise known as separating the airspace into vertical layers for different aircraft. From ground-level to 200 feet, "low-speed localized traffic" would operate. This would be the zone where package delivery drones would ascend and descend to make the actual deliveries. This is also where hobbyists, photographers, and other operators involved in low-speed, low-altitude flights would use their vehicles. From 200 to 400 feet, "high-speed transit" vehicles would operate. This would include package delivery and emergency vehicles which seek to reach a destination as quickly as possible. Airspace between 400 and 500 feet would be a no-fly zone, used to provide a buffer between unmanned and manned aircraft, which are required to be above 500 feet for the plan to function properly. Importantly, drones would not be able to fly within a certain radius of airports. *Figure 1* includes Amazon's diagram of the plan (Golson, 2015).

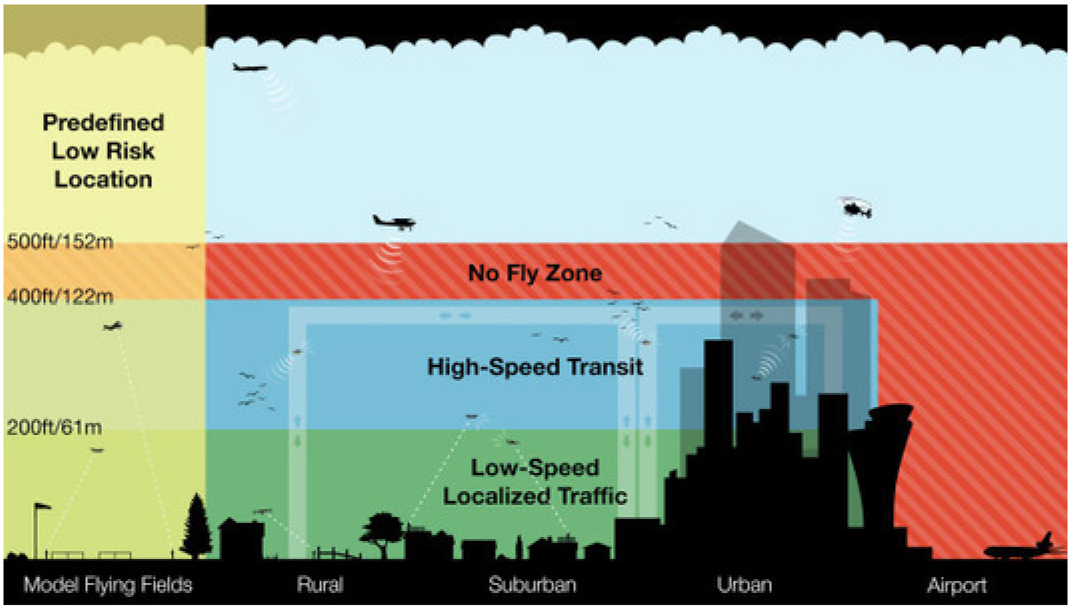

Figure 1: Amazon's Proposed sUAS Airspace Organization

Organizational Methods

3.1 Overview

In order to design an airspace model for sUAS, it is necessary to have an understanding of what objectives sUAS have. Firstly, there are sUAS which need to reach a destination as efficiently as possible, most likely to make a delivery. These high-speed, beyond visual-line-of-sight sUAS will be referred to as **destination sUAS**. Other sUAS will operate sporadically within a relatively small volume of airspace, such as those used for photography, agriculture, infrastructure monitoring, and more. These will be referred to as **proximity sUAS**. Some sUAS might even fall under both categories.

Every owned parcel of land is expected to have exclusive air rights within the land's property lines and up to 83 feet, barring certain exceptions (Henn, 2014). This will be known as **private airspace**. Property owners will be able to operate proximity sUAS as they please within the volume that is their private airspace. Local regulations will dictate how closely proximity sUAS operating within private airspace can approach the boundaries of other properties or private airspace. Properties which include tall buildings will have **tailored airspace**, private airspace with adjusted boundaries, to prevent other sUAS from operating too closely. Property owners can waive their **exclusive right** to their private airspace for any period of time, and this ability will mostly be used to allow package deliveries.

Above altitudes of 83 feet, marking the point at which private airspace tops out, is **free airspace**. Free airspace will also exist at points below 83 feet in portions of airspace above public property, and local regulations will dictate how far below 83 feet sUAS pilots can operate over public land, if at all. Any free airspace below 83 feet and above public land will be known as **extended free airspace**. Only operators with permission from some government overseer of sUAS

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operations will be able to enter free airspace from private airspace, which would most likely consist of package delivery companies or other destination sUAS (NASA, 2015) (De Los Santos & Rios, 2015). The speed limit in free airspace is expected to be low due to the freedom of operation allowed in this sector. In addition, sense-and-avoid technology would be required.

Some operators may request **reserved airspace** from the overseer of sUAS operations (NASA, 2015) (De Los Santos & Rios, 2015). Reserved airspace consists of some 3-D volume of free airspace allocated exclusively to a certain operator for some period of time, so long as other operators would not be adversely affected by not being able to operate in that particular area. **Temporarily reserved airspace** would be appropriate for operators who need access to a certain part of free airspace for proximity sUAS operations for periods such as an hour or day. **Permanently reserved airspace** would be appropriate for airspace above properties which disperse many destination sUAS, such as package delivery hubs. The rights for permanently reserved airspace would likely need to be renewed after certain intervals of time, such as a year, to prevent "senior rights" operators from dominating the airspace.

In areas of high destination sUAS traffic, such as the airspace between a package delivery hub and a large suburb, **corridors** could be set up to shuttle sUAS safely and efficiently back and forth. Corridors would be high-speed virtual tubes which sUAS could merge in and out of so long as they follow safety protocols. Speed limits would be higher to encourage operators to utilize the safer corridors instead of navigating through free airspace for the entire duration of the operation. *Figure 2* includes a visual overview of this airspace organization. As mentioned earlier, the delivery company operating the sUAS delivery hub should have the ability to reserve airspace permanently so that delivery sUAS can reach high-speed corridors from the delivery hub's preordained private airspace (all properties have automatic air rights up until a certain height). Corridors will exist to funnel traffic safely and efficiently through high traffic areas, usually between delivery hubs and suburbs and cities. Vehicles may exit corridors as they please into free airspace, or they can travel to the end of a corridor, which empties into free airspace. Within free airspace, other operators can reserve airspace for so-called proximity sUAS operations, which are those that require a 3-D area for spontaneous yet leisurely motions, such as photography or inspections.

Private residences will most likely have air rights up until 83 feet, and in order to receive deliveries, property owners must waive their exclusive access to their own airspace. Taller structures, especially infrastructure which requires monitoring for deficiencies, such as a water tower, will have private airspace tailored to a non-standard area to keep other aircraft away and to uphold safety and privacy. Over land that is not private, local ordinances will determine how low vehicles can fly. sUAS are expected to take off and land from commercial properties, like farms, delivery hubs, third-party headquarters, etc., or government-owned sUAS headquarters, all of which will be allowed to operate in their own airspace or reserve airspace in free airspace if necessary. Again, all of this is presented in *Figure 2* below.

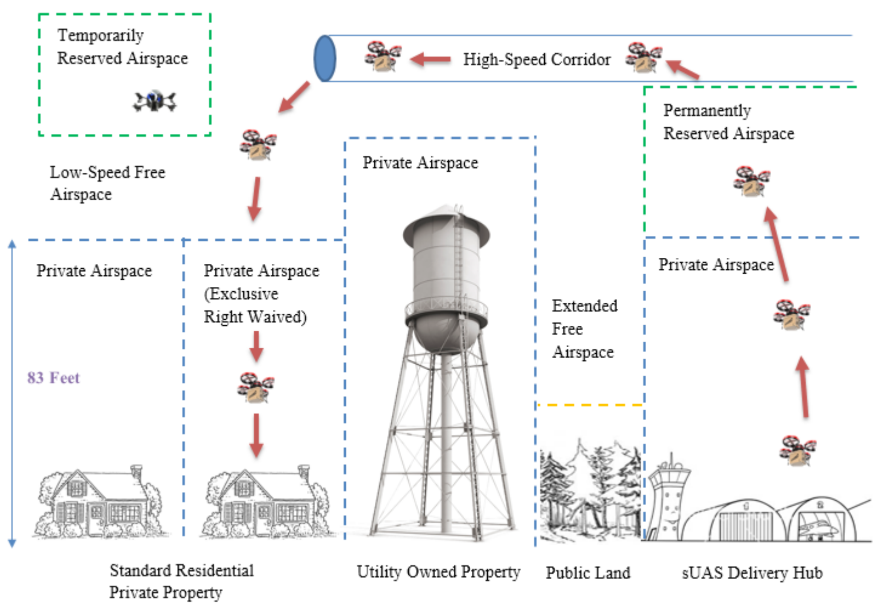

Figure 2: Airspace Organization Overview

3.2 Private Airspace

Airspace immediately above commercial or residential properties is private, since property owners are guaranteed air rights. However, property owners should be able to waive their airspace rights to other operators, whether temporarily, indefinitely, or permanently. Emergency vehicles would likely be exempt from requiring special permission to operate in private airspace, though this will depend on local ordinances. In addition, how high air rights stretch above a property before bordering free airspace needs to be determined by regulators, whether on the local, state, or federal levels. Based on a Supreme Court case dating back to World War II, the accepted number for the minimum elevation for which aircraft should fly over private property is 83 feet (Henn, 2014). The lateral boundaries will not be vertical extensions of the property lines, but rather a smaller outline of the property. The distance by which the perimeter is reduced for private airspace will likely be determined by local ordinances as to protect the privacy of adjacent property owners. Based on these boundaries, we can assume that free airspace exists from 83 feet up until 400 or 500 feet, where the cap for sUAS is expected to be, and that any airspace below 83 feet and above private property is private airspace. Other land, such as public land, would be subject to further ordinances. In some cases, the height restrictions above public land might be lower than 83 feet based on local ordinances, and portions less than 83 feet would be known as extended free airspace. *Figure 3* portrays the boundaries between private and free airspace as well as a portion of extended free airspace, which would exist above public land.

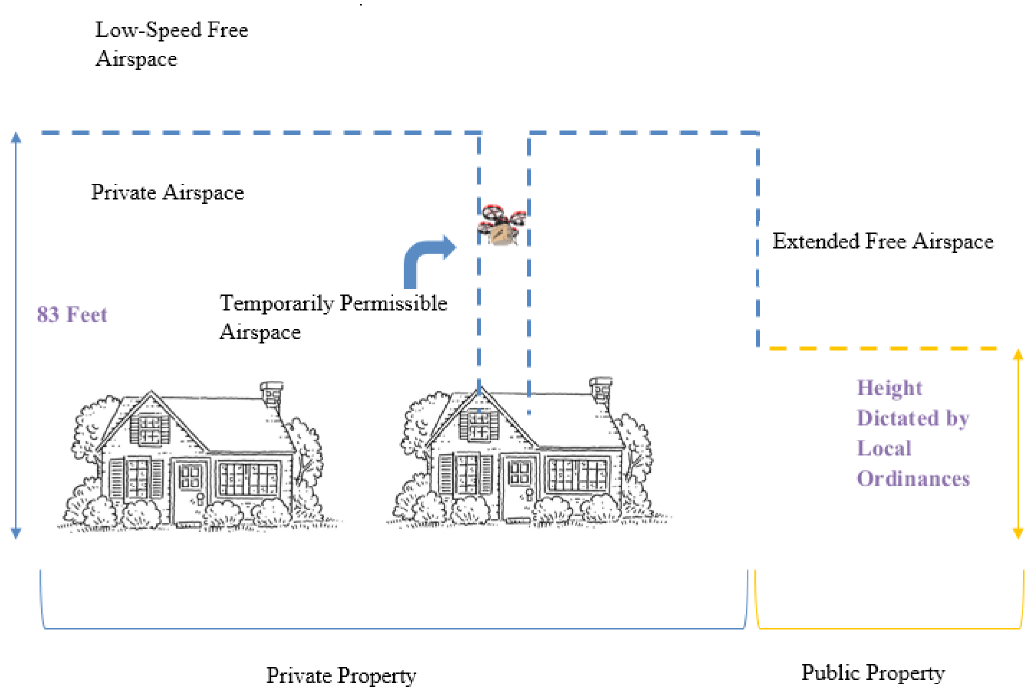

Figure 3: Private Airspace Boundaries and Extended Free Airspace

3.3 Free Airspace

As briefly stated before, free airspace will be open to all sUAS, though speed limits will be lower than in corridors to account for the unpredictable nature of the trajectories of vehicles in this portion of airspace. Free airspace is a transitional zone between corridors and private airspace. Again, private airspace is where sUAS will land and take off from, so long as the private airspace is above the property owned by or affiliated with the sUAS operator. Based on the randomness of this sector, sUAS operators who wish to operate in free airspace must have their vehicles equipped with sense-and-avoid technology. Operators and vehicles which operate here also should be licensed and registered, respectively. In addition, free airspace can be reserved for some period of time, so long as the operational area does not negatively impact other operators or those on the ground. Above residential properties free airspace is expected to begin at 83 feet. Local ordinances will dictate how far extended free airspace will exist below the 83 foot mark above public lands. For buildings or structures taller than 83 feet, free airspace will be tailored around the private airspace required to keep unwanted vehicles away from such structures both horizontally and vertically. *Figure 4* shows what such a tailored free airspace would look like to protect the air rights of high-rises.

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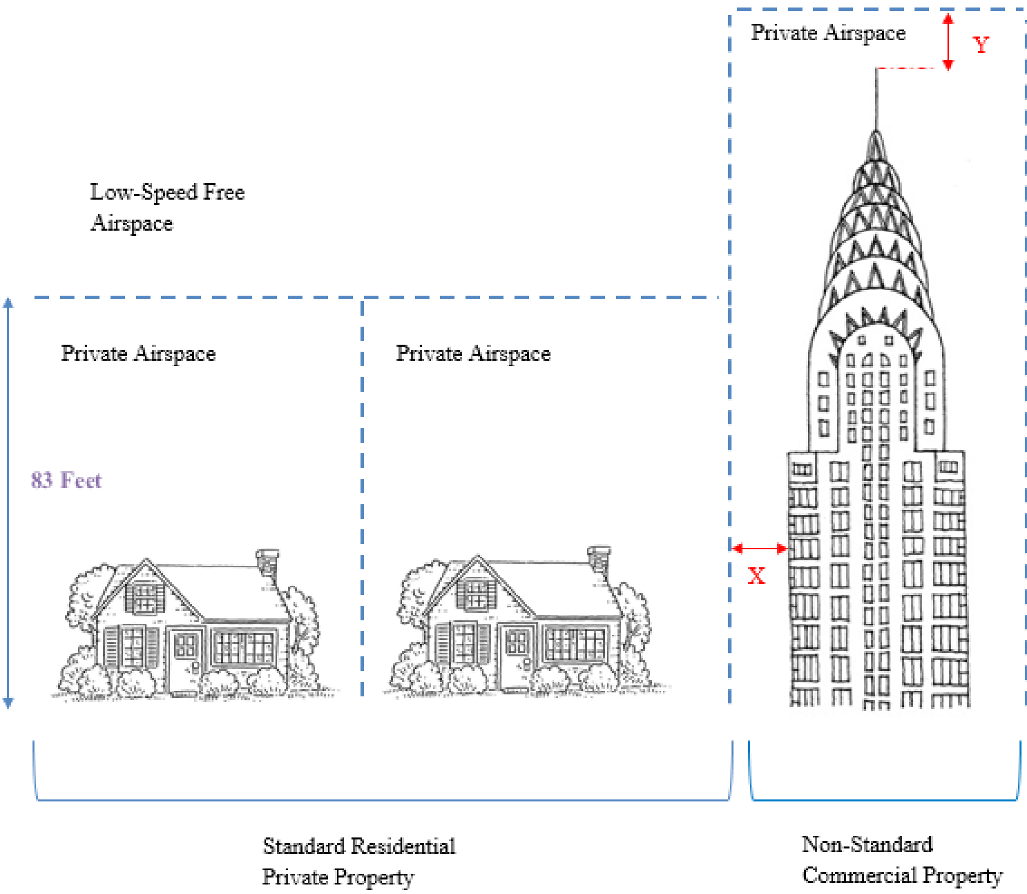

Figure 4: Tailored Free Airspace for Nonstandard Properties

3.4 Reserved Airspace

Reserved airspace would be beneficial for proximity sUAS, those that require a 3-D area for hovering along a slow and unknown trajectory (for photography, inspections, etc.). If companies need to reserve airspace outside of their own boundaries that will either benefit or have little effect on the public or other users, or if public operators or third parties hired by government need to utilize free airspace for some purpose, they should be able to reserve free airspace for the duration which their operation would require. This time span could be anywhere from one day to permanently or indefinitely. The overseer of the airspace would decide which applications for reserved airspace are necessary or unbothersome, and which ones would impair safety or privacy. *Figure 5* shows how reserved airspace could be implemented. Suppose that a local fire department wants to survey a nearby forest for brush fires. If the forest is public land, the department would legally be allowed to use their sUAS up until a height specified by local ordinances, such as 40 feet. Airspace above that would be free airspace. However, the team might need to hover well above the treetops at 70 feet to see signs of smoke. In order to ensure that no other sUAS interferes with this operation, the fire department can reserve the airspace from the overseer of the airspace to conduct the mission.

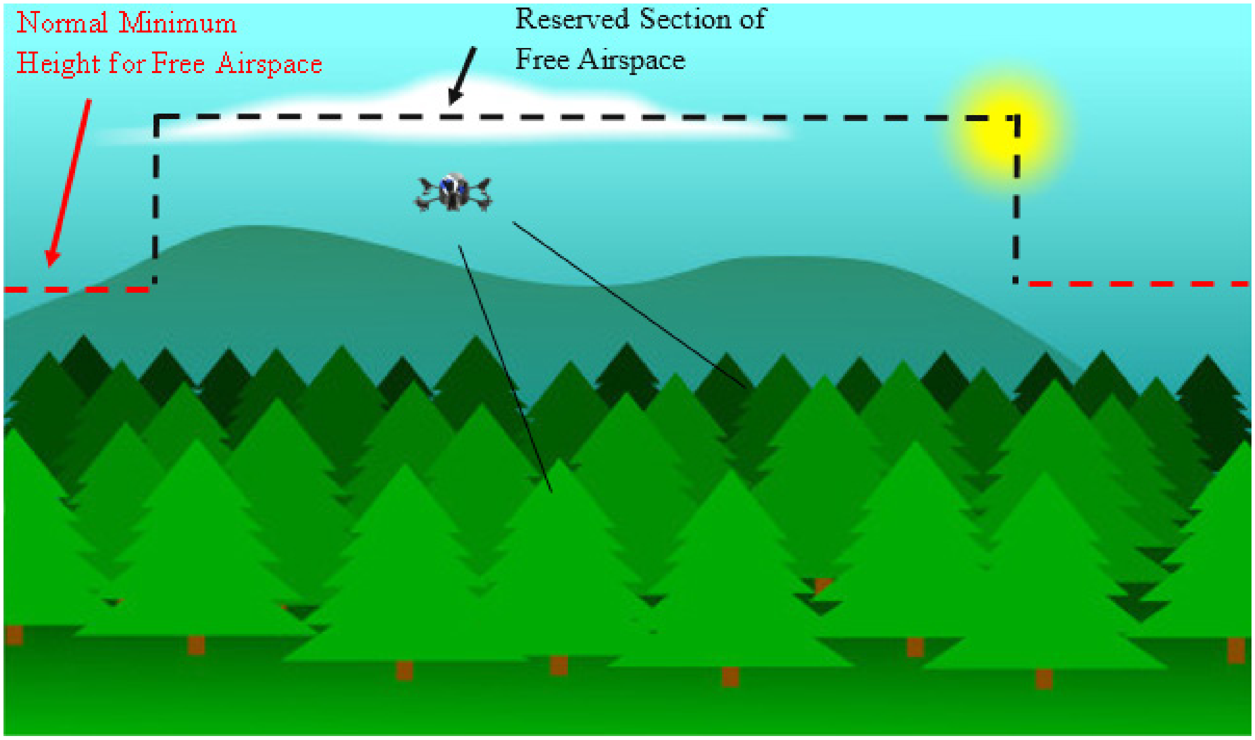

Figure 5: Reserved Airspace Example

3.5 Destination sUAS and Corridors ("Air Highways")

Package delivery sUAS are expected to be high-speed, beyond-visual-line-of-sight vehicles (destination sUAS). As such, they need to be separated from other types of sUAS used for applications which are not meant to allow the vehicle to move from an origin to a destination as quickly as possible (proximity sUAS). In addition, corridors might be necessary before the proper wide-spread autonomous vehicle-to-vehicle separation technologies allow vehicles to fly quickly and freely in any direction while avoiding one another, like ideal gas particles. Therefore, air corridors will provide a safe 3-D pathway for delivery vehicles in relatively high traffic air space.

To describe how air corridors could be useful, we can begin with an illustrative example of a package delivery. A customer first orders a product online and expects that product to be delivered to his or her front door within the next 24 hours. That package must travel from a distribution center or delivery hub. A vertical cylinder could be geo-fenced around the delivery hub to give ascending and descending delivery vehicles exclusive access to that airspace. Up until 83 feet, this would be a given, but in the portion of free airspace between the private airspace and the corridor, the company would have to reserve exclusive air rights. At an altitude high enough to not interfere with low-altitude sUAS operations, but low enough to be well-away from manned aircraft operations, this cylinder could intersect with a corridor. This geo-fenced cylinder could also be an upside-down cone so that delivery drones would not have to ascend or descend in a perfectly vertical manner. *Figure 6* includes a possible rendering for how the airspace could be designed above a package delivery hub.

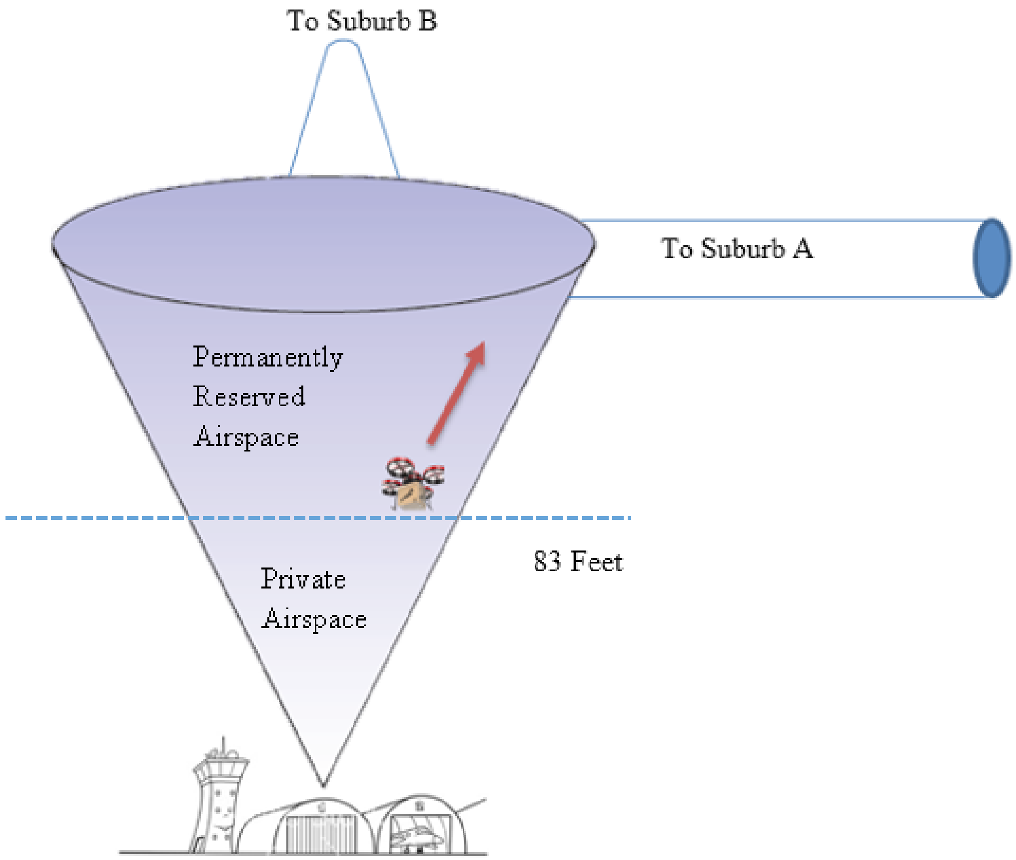

Figure 6: Airspace Diagram for Package Delivery Hub

Corridors could link the airspace above the delivery hub with suburban areas. Once the delivery drone reaches a section of the corridor near the destination, it could exit the corridor and enter free airspace, where maximum allowed speeds are lower due to the spontaneity of vehicles in this portion of airspace. Once above the correct property, the delivery drone could descend vertically towards the property of the recipient of the package. A vertical column above the property would be set up to allow temporary access to reach the recipient's property from free airspace. Once the package is delivered, the delivery drone would need to ascend vertically back to free airspace, where it can then move horizontally and vertically back to the corridor to return to the delivery hub. The reason for vertical take-offs and landings is to protect property rights and the privacy of those not involved in the delivery. *Figure 7* illustrates how package delivery drones would reach their destinations from corridors.

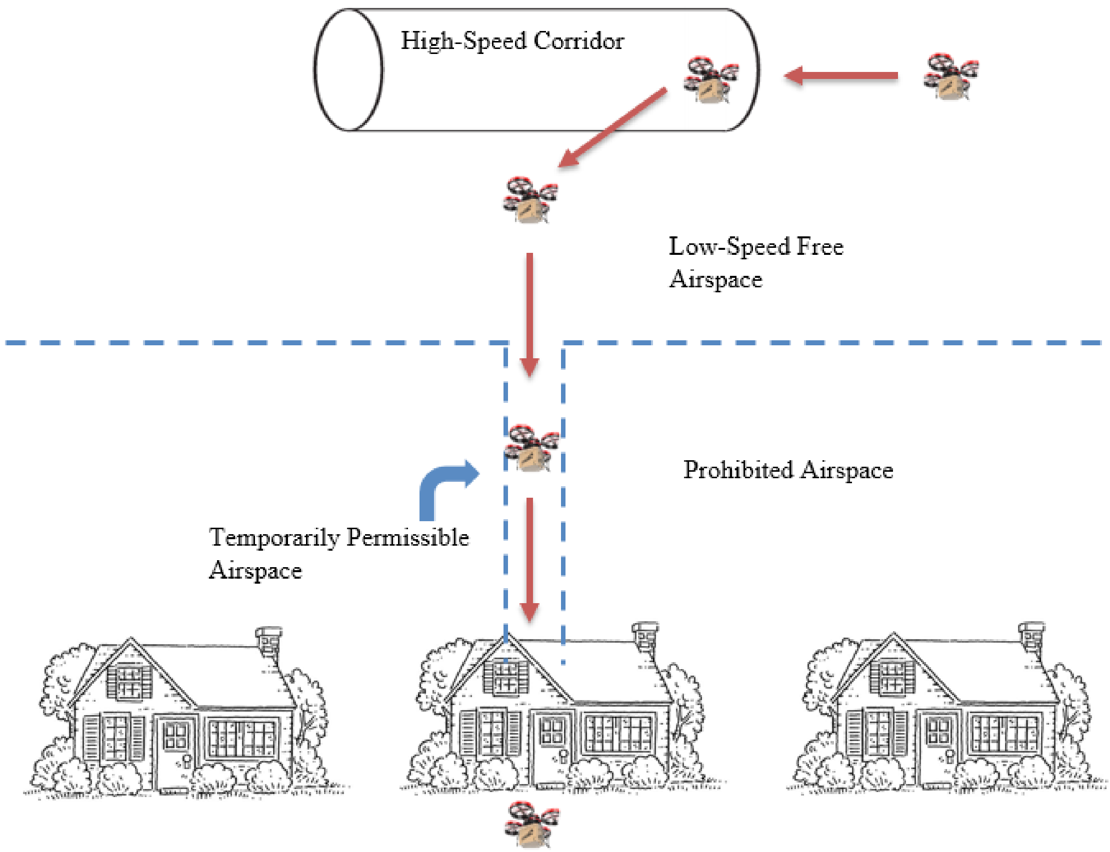

Figure 7: From Corridor to Delivery

One issue that arises from such a setup includes drones safely emerging from and entering high-speed corridors. One solution is to include a set outer radius for merging into corridors from low-speed free airspace or for slowing to appropriate speeds for free airspace from corridors. These would function similar to highway on-ramps and off-ramps, which allow vehicles to reach highways speeds safely before entering and to safely slow to local traffic speeds from highway speeds, respectively. *Figure 8* shows a cross-sectional area of a corridor which helps to illustrate how corridors, merging and exit zones, and free airspace could be designed.

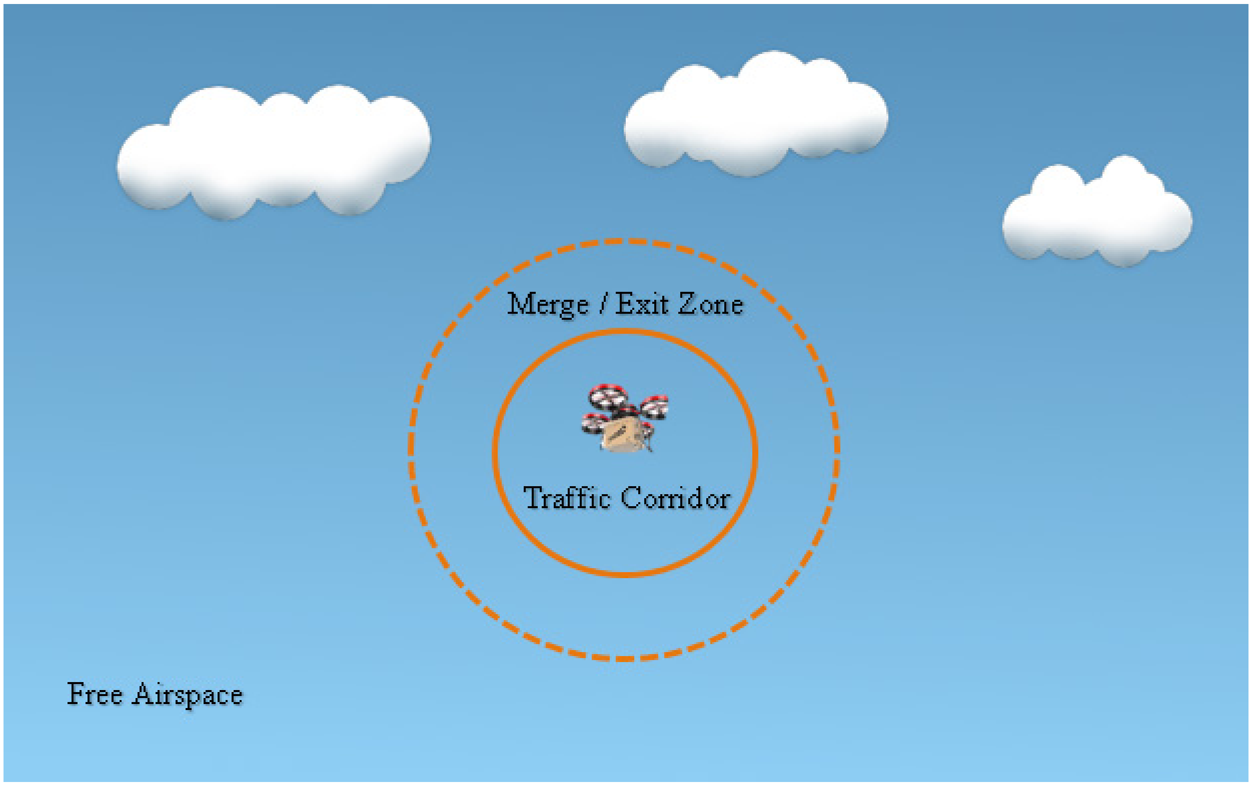

Figure 8: Cross-sectional Area of Corridor

Corridors would function similar to highways, and traffic volumes and densities could be calculated if necessary. However, if extra capacity is needed, the geo-fenced area could be expanded as necessary. Corridors could be viewed as arterial roads or freeways in the sky, while the free airspace surrounding them could be considered the local streets. Also as with highways, corridors should have buffer space between the opposing directions of travel. Of course, delivery drones need to return to the delivery hub as efficiently as they arrived at their current destination, so the returning route should be much the same as the original. One possible solution is to have a sizeable space between forward and reverse corridors where no traffic is allowed under any circumstances. *Figure 9* shows what this might look like.

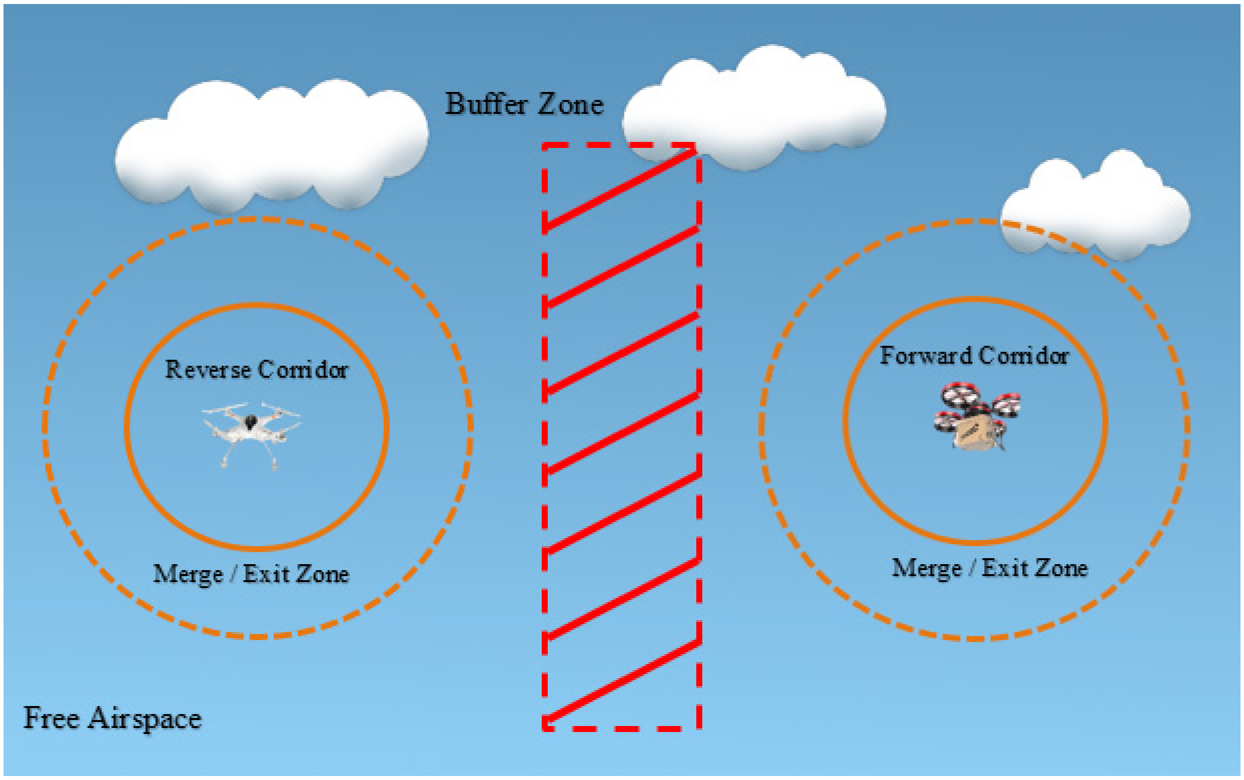

Figure 9: Cross-Sectional Area of Bi-Directional Corridor

The buffer zone between each direction of a corridor would serve to alleviate concerns of head-on collisions. The boundaries of the buffer zone would be geo-fenced to ensure that sUAS do not deviate from the small portions of free airspace between merge/exit zones and buffer zones and accidentally enter the buffer zones. Yet another issue that arises is the ability to pass within corridors. While establishing single lane corridors with set speed requirements (exact speeds to travel at, rather than speed limits) in each direction would be the obvious solution, this also presents more problems. Since there are expected to be a wide variety of sUAS models using the corridors, there will be many variations in top speed and overall maneuverability. From a policy perspective, only vehicles which meet certain requirements could be allowed to use corridors. However, companies which pay additional money for vehicles with higher top speeds should be given the ability to pass. Furthermore, emergency vehicles could be able to use a "passing lane" to reach a destination quickly without much disturbance to other vehicles in the airspace (this could prevent an "all-land" scenario to give way to emergency vehicles). Other vehicles in the corridor would simply shift to the "right lane" to allow emergency vehicles to pass. This setup has been proven to work well for vehicular traffic on four lane highways (two lanes in each direction).

For sUAS corridors with multiple lanes, it makes sense to stack the lanes vertically, rather than horizontally, since vehicles are not limited to a 2-D plane. In order to reach a passing lane, sUAS would enter an acceleration and ascend zone (or a deceleration and descend zone for returning to the normal traffic lane) and accelerate in order to match the speed of traffic. The passing lanes and ascend/descend zones would be surrounded by no-fly zones so that sUAS can only reach them from the standard lane ("right lane") of the corridor. Therefore, sUAS would not be able to enter the passing lane from free airspace, much like cars typically do not enter interstate highways into the left lane. *Figure 10* shows what corridors with several lanes could look like.

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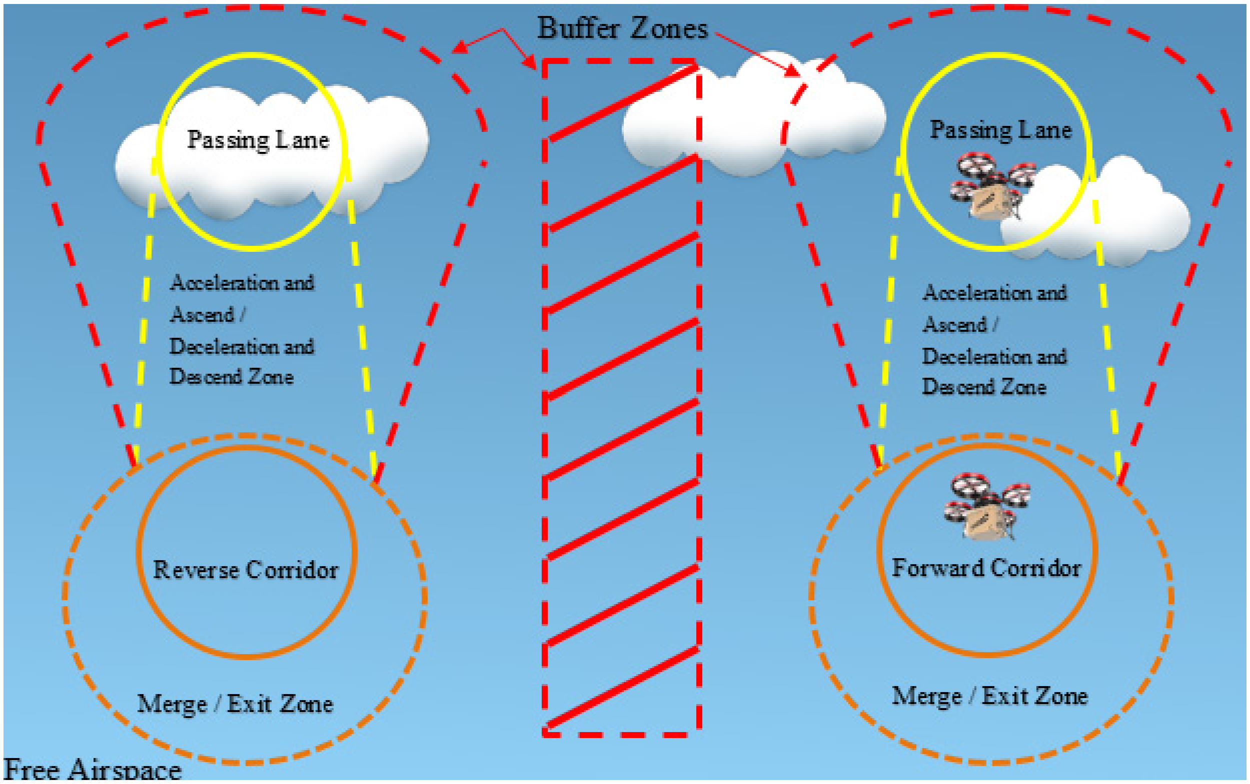

Figure 10: Multi-lane Corridors

We should note that corridors do not need to require defined speeds of all sUAS. Since all sUAS are expected to have their own geo-fences, following vehicles would autonomously slow down to the speed of the leading vehicle or enter the passing lane. This is very similar to adaptive cruise control in cars, which, when enabled by the driver, sets the vehicle at a constant speed and slows to the speed of the leading vehicle if sensors detect that their own vehicle is approaching the leading one too quickly. As a result, each lane of a corridor could either have a defined speed that all vehicles must travel at, or a bare minimum speed. In the defined speed scenario, the normal lane would require all vehicles to travel at 40 mph, and the passing or fast lane would require all vehicles to travel at 60 mph, for example. For the bare minimum speed scenario, the normal lane would require vehicles to travel at least 40 mph. When a vehicle traveling at 50 mph approaches a vehicle traveling at 40 mph from the rear, it could ascend into the passing lane and descend back to the normal lane once a safe clearance is established. Passing lanes could also have a minimum speed limit and a maximum speed limit.

Lastly, since free airspace is able to be reserved by those operating sUAS for purposes other than reaching a destination as quickly as possible, certain zones must not be able to be reserved as to limit the effectiveness of so-called destination sUAS. For example, free airspace surrounding corridors must always be open to all destination sUAS. Residential airspace, above private residences, is off-limits as to ensure the privacy and safety of residents. It is unclear how package deliveries will be permitted, but it is expected that individuals who sign up for quick shipping services which require sUAS will sign an electronic waiver to grant airspace rights to delivery drones directly above their properties, as mentioned before.

3.6 Proximity sUAS and Area of Operation

A trending usage of sUAS currently is for real estate agents to collect aerial pictures of properties on the market. With the aforementioned plan in place, the process for taking such photographs would be slightly different as to uphold safety and privacy. Say a real estate agent is attempting to sell a large two acre property in the suburbs. Assume that the current owner of the property has waived his or her right to the airspace for the real estate agent to operate freely on the property (this paper will not address the legal issues which stem from this). If the agent wants to obtain aerial photographs of the property for posting on the Internet, she can use her sUAS to photograph the property from above without any flight authorization so long as the elevation of the sUAS does not exceed 83 feet, and so long as she does not disobey local ordinances which dictate how close a private sUAS can approach an adjacent property and its private airspace. She will most likely have already acquired a license to operate sUAS.

Upon operating within the appropriate thresholds, the real estate agent discovers that she cannot capture photographs of the entire property without exceeding 83 feet. She then has three options to operate outside of the property's private airspace. She can seek permission from adjacent property owners to operate in their private airspace for a brief period of time to get a wider view of the property. The adjacent owners would notify the sUAS airspace manager (or some other overseer of sUAS operations) of their intentions to waive their private airspace to another operator, the real estate agent, if they were so inclined. The airspace manager would then inform the operator of the new boundaries to her flight and a time window for when she can operate. Another option would be to contact the sUAS airspace manager to reserve the free airspace directly above the 83 foot private airspace boundary. She could estimate that her sUAS would need to hover at 120 feet to obtain the photographs she needs. The airspace manager could then geo-fence a new volume of airspace above the property which extends to 140 feet to prevent other operators from interfering. Note that the real estate agent could operate in free airspace without making a reservation, but her sUAS would be required to have sense-and-avoid technology, and she would run the risk of coming into contact with package delivery and other sUAS in free airspace.

The third option would be to reserve extended free airspace. If the local ordinances proclaim that free airspace begins at 40 feet above public property, she could reserve the airspace (through the airspace manager) above the street from 40 to 100 feet, for example, or operate there without making a reservation if her sUAS is equipped with sense-and-avoid. Regardless of which option she chooses, she must launch her sUAS from the property she has permission to operate in, unless she has special permission from the municipality to launch from public land, such as the street, sidewalk, or a parking lot. Any of the three options for leaving private airspace might require one or more days of preparation. However, if she continues to operate her sUAS within the private airspace of the property she has been approved to sell, then she can launch and operate her sUAS as she pleases.

Conclusion

The task of organizing the low-altitude physical airspace for sUAS is somewhat complicated. In addition to preventing sUAS from crashing with one another, the privacy and safety of those on the ground must also be an important consideration. While Amazon and NASA have made early progress in this subject area, there was still a large gap in the combined vision of the two entities. The first step in establishing a proposal for the sUAS physical airspace design required the separation of sUAS into two distinct categories: destination sUAS and proximity sUAS. In order to design the airspace, one needs to know what to design for. Destination sUAS are those which seek to reach one or more destinations and return to base as quickly as possible. This allowed for the formulation of corridors, which permit destination sUAS, such as package delivery vehicles, to travel quickly and safely in file through the upper reaches of free airspace. Proximity sUAS are those which do not have a definite flight path but require a certain volume of airspace to achieve their goals, such as photography sUAS. Reserved airspace and private airspace are meant for proximity sUAS to operate safely without interference from other sUAS.

Private airspace is expected to extend to 83 feet above the property elevation, unless the structure on the property requires adjusting the top-end boundaries. The lateral boundaries will not be virtual lines immediately above the property lines, but rather a smaller outline of the property, shrunken by a distance determined by local ordinances as to protect the privacy of adjacent property owners. Property owners can waive their exclusive airspace rights to allow for package deliveries or other sUAS services. Above the 83 foot mark is free airspace, in which all sUAS must have sense-and-avoid technology and operate at a relatively low speed limit. Proximity sUAS users may reserve free airspace for some purpose so long as they do not prevent other operators from performing their duties. Destination sUAS users may reserve free airspace for extended periods of time in areas they frequently travel through. The expectation is that some airspace manager will oversee airspace reservations. Above public land, local ordinances will determine how low free airspace extends.

Finally, corridors for destination sUAS will be established in high traffic airspace to safely funnel vehicles between two well-traveled points. Destination sUAS will use the outer radius of the corridor to merge and reach the set speed required by traffic in the corridor. Once in the corridor, the sUAS must follow the speed limit, if there is one, or cruise at a safe distance from the preceding sUAS. Some corridors might have passing lanes for faster sUAS, complete with acceleration/deceleration zones to safely reach and return from them. The passing lanes will only be accessible from the main corridor, much like how highways do not let traffic enter in the left lane. When a Destination sUAS wants to leave a corridor and reenter free airspace, it must use the outer radius of the corridor to exit and slow to the speed required by vehicles in free airspace.

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