LOCATING SMALL UAS RISK AND IDENTIFYING AREAS FOR INCREASED EDUCATION EFFORTS IN PHOENIX ARIZONA

by

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ABSTRACT

Development of unmanned aerial systems (UAS) in recent years has intensified the concern for risk to commercial aviation in the United States. Federal Aviation Administration (FAA) integration plans are continually underway and seek to address the incorporation of UAS into the national airspace structure. The initial phase establishes regulations for small UAS, however, a perceived increase in incidents with aircraft has heightened concerns for hazards associated with small UAS. Using reporting of encounters with small UAS from 2014-2016, a workflow focusing education efforts to spatial locations and using areas of interest for UAS users can improve safe integration of UAS technology into the national airspace system.

Keywords: Unmanned Aerial Systems (UAS), commercial aviation, safety, Geographic Information Systems

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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CHAPTER 1: INTRODUCTION

OBJECTIVE

The purpose of this project is to identify locations of potentially high UAS usage that would pose high safety risk to traditional aviation. The intent is to develop a workflow to find places where education strategies could be implemented to reduce the risk at these locations.

BACKGROUND

Unmanned Aerial Systems (UAS) technology (also called unmanned aerial vehicles (UAVs), drones, or remote controlled aircraft) has historically been limited to hobbyists with short range radio controlled aircraft operating in established parks and areas well clear of airports and federal airways. Recent years have shown a rapid development of technology, reducing the training required to operate UAS and increasing the market for personal and limited commercial use. The ease of operation creates a new generation of operators who have largely been unfamiliar with aviation regulations and have extended the use of UAS beyond the previously established areas. This has encroached upon airspace used by private and commercial aviation and posed a risk to safety.

Figure 1: UAS smartphone controller and UAS

The danger associated with small airborne hazards is not new. Since the early days of aviation, hazards to aviation have come from many directions. Environmental concerns like weather and wildlife have always been problematic. Logistical concerns like congestion and airspace are newer but still provide a challenge to aviators. Often technology has been used as a tool to mitigate the risks associated with these hazards. Radar technology still provides much of the real-time measurement of weather, congestion, and even birds. GPS systems have helped improve navigation techniques allowing more aircraft to operate safely without increasing airspace.

Understanding the nature of the UAS hazard is an important part in reducing the risk. The low cost and ease of operating small UAS opens a small part of the world of aviation to users who may lack the procedural knowledge of safe airspace operations that have been long established to reduce the risk of environmental and logistical factors.

Study Area

After completing an initial analysis of nationwide UAS incident reports spanning 2014-1015 (see Appendix A) to identify clusters of high incident rates Phoenix, AZ was selected due to its proximity to Northern Arizona University and its cluster of airports with a high incident reports. Additionally, the number or airports with high traffic in a close proximity allows for a complex environment to test the hypothesis.

Scope

This project will be based on mishap data collected by the Federal Aviation Administration in the United States from 2014-2016. The scope of this project is to identify and evaluate small UAS risk. UAS interest areas will be identified based on operation capabilities of commercially available small UAS and landmarks and features that would attract UAS usage near airfields and transportation corridors used by manned aircraft. Airspace around the major airports of Phoenix International Airport (PHX), Phoenix Deer Valley (DVT), Phoenix Goodyear (GYR), Phoenix Mesa Gateway (IWA), Glendale (GEU), Scottsdale (SDL), and Chandler (CHD) as well as smaller private and uncontrolled airfields were assessed. The intent is to create a model that can be used in other areas around the country with minor modifications. Identification of usage areas will allow for targeted regulation and mitigation strategies to be implemented. However, UAS regulation and mitigation effectiveness is not the primary focus of this research and all recommendations will be preliminary and need additional evaluation.

Research Questions

Can UAS interest areas be identified based on geospatial features?

Can UAS risk areas be based on geospatial features without incident reports?

Are there areas in a city where UAS interest areas are concentrated?

Can areas of higher concentrations be identified with reported UAS incidents?

Can technology provide a method to reduce hazardous UAS activity?

CHAPTER 2: LITERATURE REVIEW

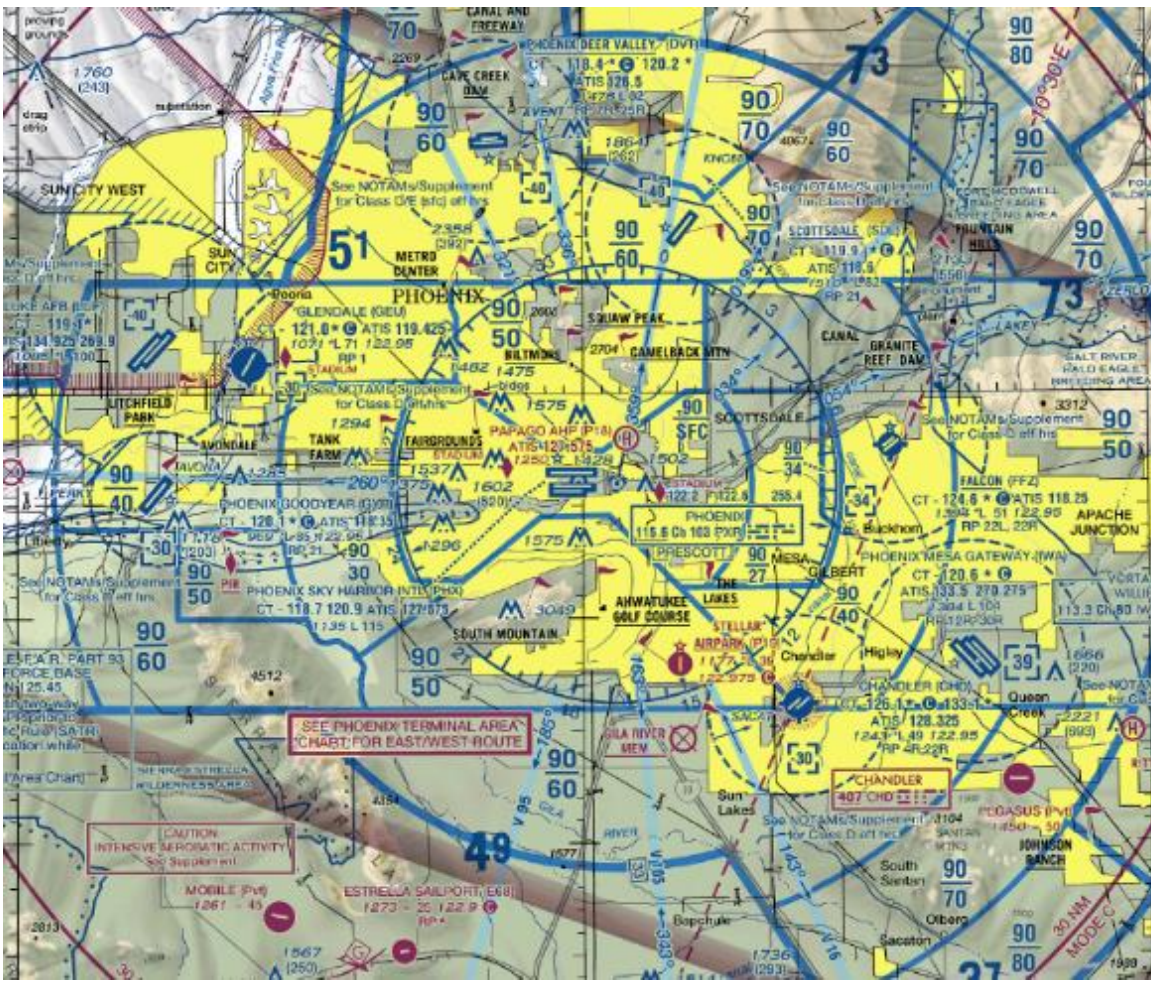
The following review addresses UAS technology to identify the capabilities and limitations of UAS control. Additionally it addresses the regulation efforts by the FAA to regulate that control, and areas where precise control is important (i.e. how FAA airspace works and where UAS fly).

UAS TECHNOLOGY DEVELOPMENT

The basic idea of unmanned aviation is not a new concept nor is it unique to last decade. While the popularity and usage demands have recently increased, the principles of unmanned aviation go back to the early 1940s. Unmanned aviation systems were developed by several countries during WWII. Early developments went largely unnoticed by the FAA due to the limited nature of their use. The basics of UAS operations are important to understand in order to study how UAS can be hazardous to manned aviation.

Unmanned Aerial Systems are somewhat misnamed as they are controlled by a living person every bit as much as so called manned aircraft. While current developments in automation may change the nature of the control, most UAS are still directly controlled by a pilot on the ground. The systems in UAS are composed of an air vehicle, a control apparatus, and a link between them. The air vehicle can be as small as a few ounces to a large as commercial airliners and designed with a variety of sensors that are carried and used for purposes ranging from law enforcement to agriculture and natural resource management. The ground control apparatus can also vary widely from a smart phone or tablet to a control station apparatus with multiple screens used for navigation and payload control. In early UAS, the link was a radio signal; this is still common in many hobby aircraft, known as radio controlled (or RC) planes. Radio control is limited to visual line of sight where an uninterrupted signal would travel in a straight line through the air to the flying vehicle. The controller would have to have visual contact with the air vehicle in order to give appropriate controls. Current technology now uses technology from cellular phones and satellite communications to control the air vehicle. These new technologies allow for beyond line of sight as the signal can be relayed more robustly through cellular towers or satellites and allow for two way communication between the air vehicles to the control apparatus. These new developments, in conjunction with cheaper systems, increased both the capability and popularity for commercial and recreational use. The FAA initially allowed UAS to operate on a limited basis under waivers and ignored smaller recreational UAS which were not initially expected to interfere with manned aviation.

FAA AIRSPACE



Airports having control towers (CT) are shown in blue, all others are shown in magenta.

Figure 2: Phoenix, AZ Airspace excerpt from FAA VFR Chart

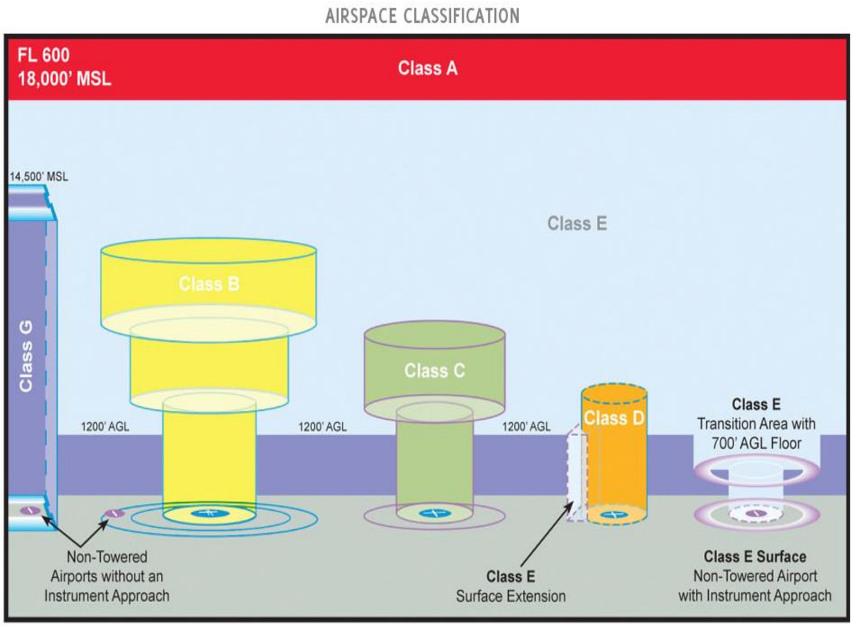


Figure 3: Airspace Diagram from https://www.faa.gov/air_traffic/flight_info/aeronav/digital_products/aero_guide/

The FAA classifies airspace into six main classes. Each class has different control procedures that provide safe operation. All but class G also require the ability to communicate with air traffic control and require a license to operate in. Areas near busy airspace or areas with airfields in close proximity the airspace can be complex, as seen in Figure 1. An excerpt of the legend is shown to the right with some of the pertinent information. The full legend published with this type of aviation chart would fill nearly 40 pages (FAA 2016). The complexity of these charts is an obstacle to untrained UAS operators. As a result the FAA has created a much simpler interface for locating hazards as shown in Figure 2 in a mobile phone application called B4UFLY. While this interface is clearer is oversimplifies busy airspace (Federal Aviation Administration 2016).

Class A airspace is medium to high altitude airspace from 18,000 feet above mean sea level (FL 180) to 60,000 feet above sea level (FL 600). This is generally used by large commercial aircraft and high performance military aircraft and it is beyond the altitude range of small UAS systems currently in use.

Class B airspace surrounds very busy airspace in the vicinity of large airports and can incorporate airspace in varying distances from a busy airport. It is under strict air traffic control. Under normal circumstances small UAS are not allowed in these areas.

Class C airspace surrounds smaller commercial or military airfields and usually has a tiered range of control from two-way radio communication to identification equipment.

Class D airspace surrounds small airfields that contain a control tower to moderate traffic.

Class E airspace is the largest amount of airspace generally above 1,200 feet above the ground to 18,000 above sea level. Most civilian and general aviation aircraft fly in class E airspace. It can also incorporate areas around airfields used for departure and approach corridors as well as around some small airfields that do not have a tower.

Class G airspace is often referred to as uncontrolled from the ground to 1,200 feet above the ground. This is the realm where small UAS will generally operate. (FAA 2016) Airspace below 1,200 feet will be the focus of this analysis and only the airspace components from surface to 1,200 feet will be used in this research.

HISTORY OF REGULATION IMPLEMENTATION

UAS have been operating on a limited basis for decades with varying levels of sophistication of systems from small hobby aircraft to larger military aircraft developed as aerial targets to operate in restricted areas. Recent developments in technology and commercial applications in UAS has increased the desire to expand operations outside the regimes of low altitude (radio controlled hobby aircraft) and restricted airspace (military aircraft), necessitating regulatory guidance that would protect commercial and private aviation. With manned aviation also expanding, the need to integrate UAS into the National Airspace System (NAS) in a manner that ensured safety for people both in the air and on the ground while promoting innovation and technology development became a high priority for the Federal Aviation Administration (FAA).

In February of 2012 Congress passed the FAA Modernization and Reform Act of 2012 which appropriated funding for future reforms requested to modernize the NAS infrastructure. Additionally, the bill mandated the FAA to have a plan to integrate UAS into the NAS beginning no later than September 2015. The Joint Planning and Development Office, a conglomeration on federal agencies including the FAA, National Aeronautics and Space Administration, and the Department of Defense, published a report to Congress outlining recommendations for the way forward (JOINT PLANNING AND DEVELOPMENT OFFICE (JPDO) 2015). In 2013 the FAA published the first edition of the *Integration of Civil Unmanned Systems (UAS) in the National Airspace System (NAS) Roadmap* **(U.S. Department of Transportation Federal Aviation Administration 2013)** that outlined the way forward. These documents constituted the initial motivation, methods, and policies expanding UAS usage outside of limited areas. This plan included a phased approach to allow for expanding usage while limiting growth in order to educate and implement safety measures. Initial measures created areas established for research and development of UAS by non-governmental agencies. Areas were defined by the FAA designating UAS testing airspace that was clear of current manned air traffic to be used for research and development.

Additionally, policies regarding “small UAS” had already become popular. By early 2015, the Notice of Proposed Rulemaking (NPRM) (Federal Aviation Administration 2015) for the Operation and Certification of Small Unmanned Aircraft Systems was published and enacted for UAS weighing less than 55 pounds. These regulations allowed for visual line of sight, daylight operation clear of people on the ground, and a maximum altitude of 400 feet above the ground. Operation in presently defined NAS classes were established for operators passing an FAA exam. Additionally, a classification of Micro UAS up to 4.4 pounds (which encompasses the majority of hobby aircraft) was defined which allowed for operation by unlicensed operators up to 400 feet above the ground in uncontrolled airspace. By December of 2015 further regulations (Federal Aviation Administration 2015) were created requiring registration of all UAS, regardless of size, by 19 February 2016. Future actions plan to incorporate regulations for larger aircraft operating at altitudes in conjunction with manned aviation as well as a plan for airfield designations, training and maintenance certifications, and minimum requirements for operations (U.S. Department of Transportation Federal Aviation Administration 2013).

Risk Analysis

To understand the risk posed by UAS, this practicum investigates risk based on the FAA Safety Analysis Process applied to small UAS. Identifying, evaluating, and resolving issues will provide a pathway to reducing risk. Identifying risk at a precise location requires data collection beyond the current system. This imprecise location for reports is a significant limitation of that data we have. Current reporting is collected by the FAA from pilot sightings reported over air traffic control radios real time or after landing by pilots or traffic control towers. The location assigned to the report or incident is based on the direction from the nearest airfield rather than exact position. Because of the imprecise location reports the exact location of UAS incidents is unknown. The compiled FAA reports have initially been consolidated to provide a single data file containing reports at a given airfield (Federal Aviation Administration 2017). The first step in evaluation is to identify how frequently the risk occurs. We will use reported incidents to assess frequency based on two things. First spatial statistics to find clusters of airports with high occurrences and second, a frequency based on airport usage. Another factor is to evaluate severity of the risk or the worst case scenario. The scope of this project is not to assess the severity of the risk but focus on the spatial frequency of the occurrences. Lastly, a resolution analysis will be conducted to provide suggested mitigation specifically to the spatially located areas where risk may be elevated due to increased frequency of occurrences.

Mid-Air Collision Avoidance (MACA)

Risk mitigation strategies have been previously used in manned aircraft. One example is Mid-Air Collision Avoidance (MACA) programs were developed by the United States Air Force (USAF) to educate civilian pilots flying at airfields near USAF operating areas about the local operations that might be encountered. MACA programs include images of aircraft at different scale and specific locations of operations including training routes as well as Air Force recovery landmarks. The purpose was to help civilians realize the areas where aircraft were likely to be encountered and what to look for. Airports near operating areas were a straightforward place to distribute information in these MACA programs since most aircraft must operate from an established runway. Within 50 miles of an Air Force airfield flying units are legally required to create and manage a MACA program (US AIR FORCE Safety Center 2016). Due to the flexibility of UAS systems the locations to implement a MACA program would not be as simple as locating airports within a certain range but locating specific high use and high risk areas.

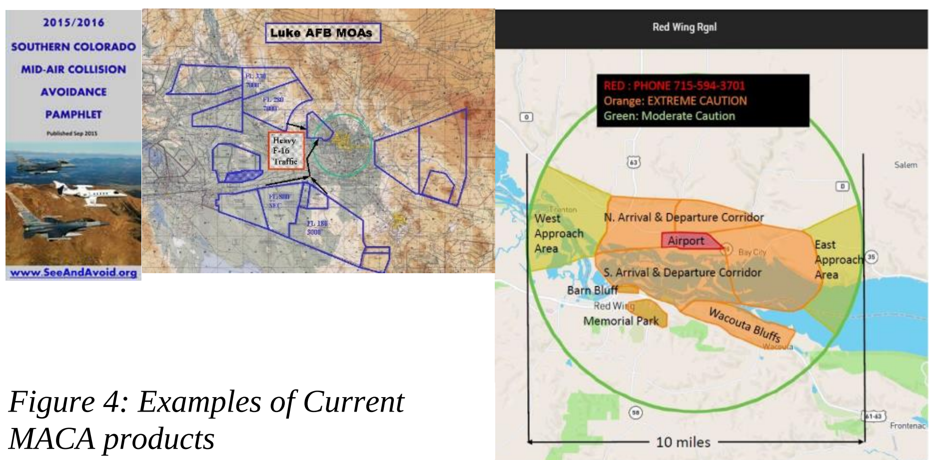


Figure 4: Examples of Current MACA products

UAS INTEREST AREAS

While MACA programs utilized distance from flying units to implement their risk mitigation strategies, small UAS are not limited to formal airfields. Therefore, in order to identify regions in which to implement small UAS risk mitigation, UAS interest areas need to be identified.

Little academic research has been focused on the nature of areas where UAS operators choose to fly, however, there are many recommendations from enthusiast and UAS groups who make recommendations to new UAS operators. Much of the focus of the articles is to inform readers where to avoid (ESRI and Geiling 2015) while others provide recommendations for specific areas in which to fly. Hivemapper is a startup company using aerial video as a tool to visualize the earth (Hivemapper 2016). They suggest flying locations as do several electronics retailers such as Tom's Guide (Baguley 2016).

A qualitative review categorizing the main attraction of the 100 Best Places to Fly in the United States (Baguley 2016) identifies common features that may increase the interest of flying from that location (see Appendix C for a full list of attractions).

First, a local point of interest, whether on public land or a private property with permission of the landowner, is the primary recommendation as many recreational UAS carry small cameras and a subject to film carries a significant draw for UAS operators. Second, proximity to a body of water. This could be due to a lack of obstructions as well as a subject to film. The third category is areas with significant elevation or topography compared to the surrounding areas. This enhances the ability to maintain line of

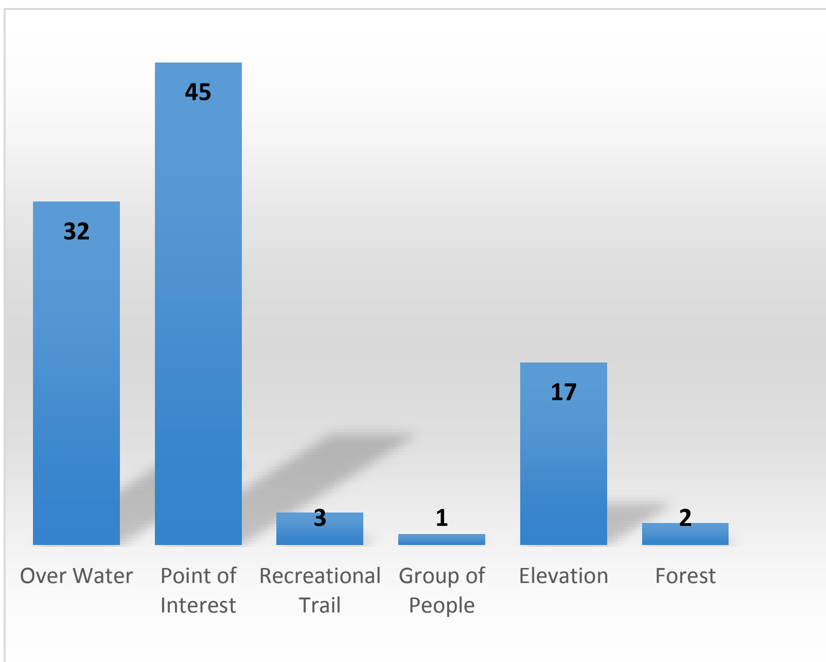


Figure 5: Qualitative Analysis and Categorization of UAS Recommendations

sight control as well as provides scenic views to film. Recreational trails, forest, and a group of people with a shared interest were also observed, although at much lower frequencies. While further academic research is needed to better understand the characteristics of UAS interest areas, most recommendations fit into at least one these three factors.

Anecdotal recommendations from Phoenix-area retailers and operators from a review of social media postings from the Phoenix Drone User Group also suggest that space to fly, or open land, is significant. In a similar manner to water, areas where a lack of vertical vegetation has appeal to users (Phoenix Area Drone User Group 2013). In a desert environment the vertical obstruction may be more from man-made obstacles than trees. Spaces that were often suggested were open sports fields, undeveloped lots, and agricultural areas. This fourth attribute will also be considered.

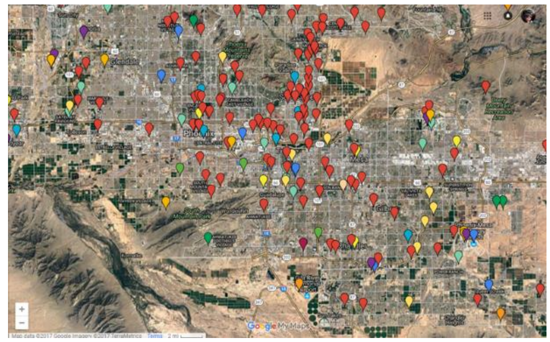


Figure 6: Phoenix Drone User Group recommended operation areas

SOLUTIONS

There are many possible solutions to reduce the safety risk while also allowing for small UAS use. One significant challenge is educating UAS operators about the risk they pose when they fly in airspace with other aircraft. FAA regulations requiring registration and licensing have

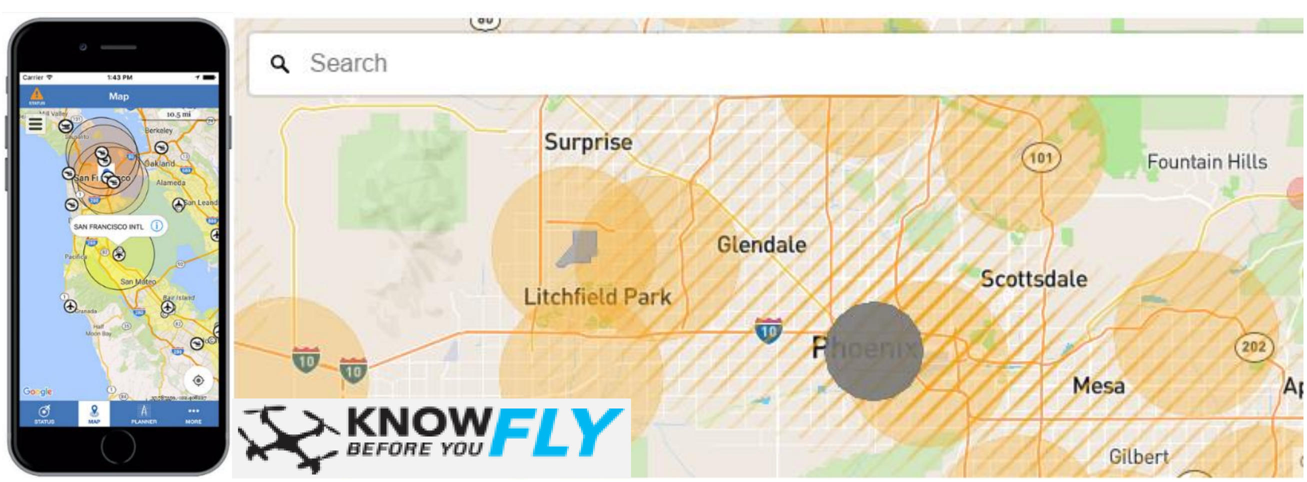


Figure 7: B4UFly and Know before you Fly website

provided an avenue to identify and reach out to hobbyists and other untrained users interested in low cost UAS technology. By educating the public about general hazards and specific local areas where UAS operation is especially dangerous (i.e. near airfields), the number of UAS operating in locations where the untrained operators are not permitted to fly can be reduced.

Another avenue to reducing hazards associated with UAS is to implement technology that can override the operators control ability in order to prevent accidents. One example of this is to install “see and avoid” technology used in other aircraft systems to react to an impending collision by either warning the operator or initiating an avoidance maneuver to prevent an accident (Insinna 2014). These systems primarily operate on transponder signals which UAS are currently not required to carry. This technology, however, could be expanded to include other sensors (RADAR, LIDAR, etc) that could detect a UAS at a limited range and provide input to maneuver to avoid a collision. This enables aircraft to identify and avoid other aircraft that are not required to carry transponder equipment.

Another technology that could reduce risk is geofencing. One method of geofencing uses software onboard the UAS to limit the locations where it is allowed to fly (DJI 2015), thus creating a virtual fence. This could be used to limit the altitude of a UAS or prevent a UAS from unknowingly entering controlled airspace. This would help prevent untrained individuals from operating in airspace that requires training, specific equipment, and/or communication with the airspace controllers. Additionally signal jammers in an array could be used to actively prevent UAS from flying in a certain areas creating area denial with a physical fence of signals.

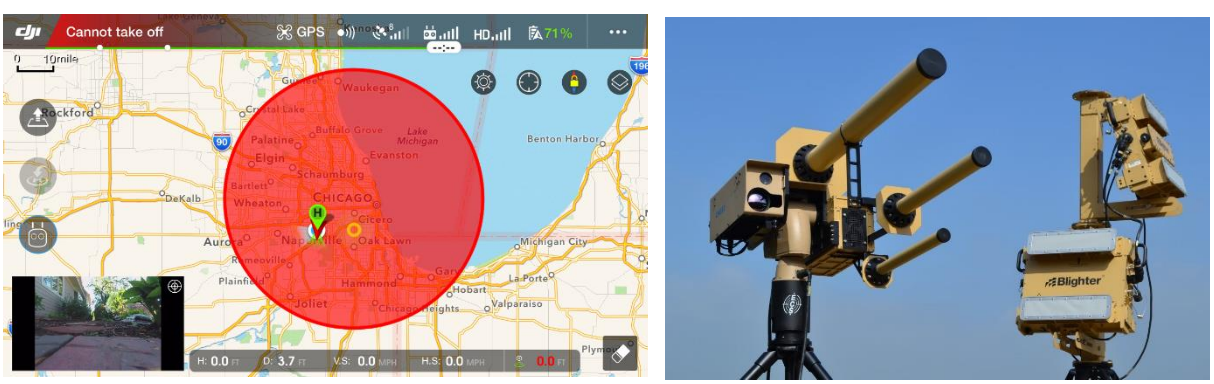


Figure 8: DJI Geofencing Screenshot and Area Denial tools

CHAPTER 3: METHODOLOGY

By evaluating the overlapping areas of FAA airspace and likely UAS usage we can assess high risk areas that would benefit from a UAS mid-air collision awareness education efforts. In order to assess these areas we need to compile data, create usage area maps, and assess overlap. From these overlapping areas we can rate as high, medium, and low risk. Additionally, UAS interest areas can be identified within these regions to determine locations to which solutions could be localized. This is based on a property boundary approach. For this study we selected public parks. Each park is assigned a score for risk and a score for interest. This process enables comparison between parks on common scale. The risk score is calculated independent of reported incidents in order to test how well the risk assessment is against reported incidents.

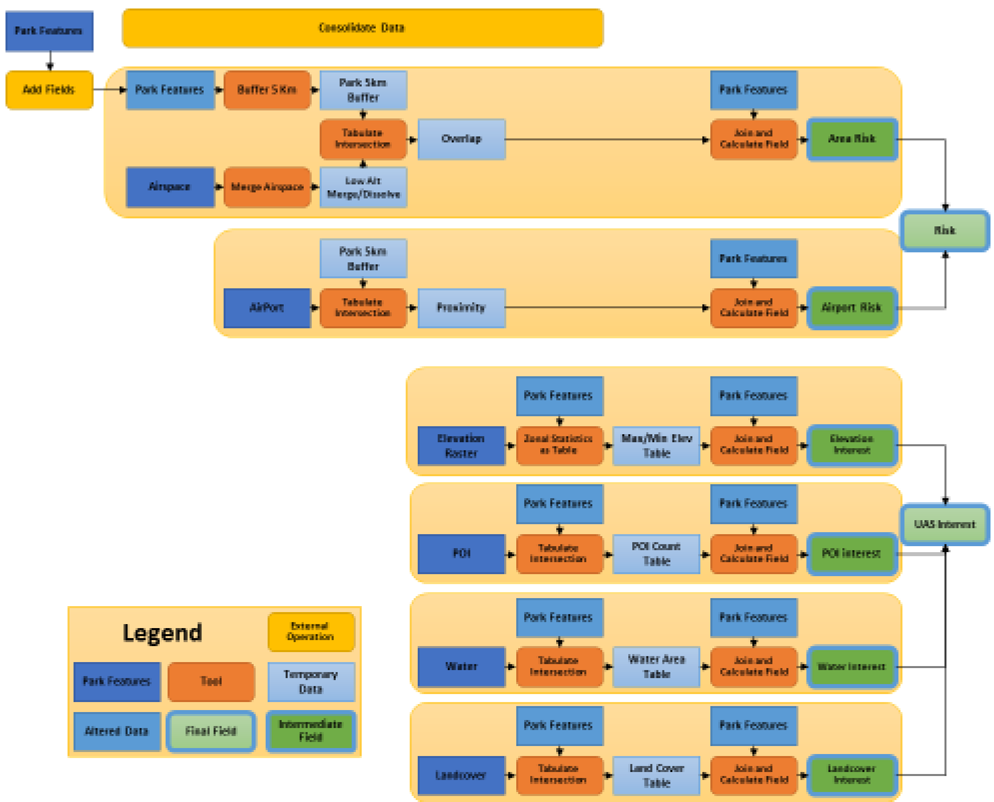


Figure 9: Methodology Flow for Interest and Risk Score

Methodology Flow

1. Identify FAA airspace structure. In order to understand the impacts of UAS on commercial aviation we will clearly delineate airspace structure with:

a. Airfields (Points)– from FAA Airport database
b. FAA Airspace (Polygon Feature Set) –from FAA Airport database

2. Identify UAS Potential Sites: Using criteria based on points of interest, proximity to water, and elevation variation we will points with a 0-3 score (1 point maximum for each criteria found at site)
    a. Parks (Polygons)- delineating public land areas available for recreation
    b. Points of interest (Points) – downloaded from municipal GIS database with areas of interest or built from another source
    c. Bodies of Water (Polygons) – downloaded from USGS identifying water
    d. Elevation (Raster) – buffer analysis based on high elevation points and maximum flight range and set in ft with a projection to the local coordinate system
    e. Landcover (Raster) – Overlap analysis of open space or undeveloped space. Using overlap with open areas and parks.

3. Overlap FAA Airspace and Potential recreational sites
    a. Identify areas to increase education efforts (Point Shapefile)
4. Data Validation
    a. Identify known areas of high incidents using 2014-2016 UAS incident reporting at each airport
    b. Airports (Point Shapefile) and UAS incidents (Table) statistical analysis
    c. Park polygon with Risk and interest score statistical analysis.

DATA COLLECTION

In order to understand risk associated with commercial aviation the first step is to collect and prepare data for analysis.

Primary to our analysis is the property boundary that will be used. Our selection for the scope of this research is public park boundaries but could be another political or geospatial boundary.

FAA Airspace and Airports: Class B, Class C, Class D, Class E Airspace is available with regular updates from the FAA geospatial library (National Flight Data Center (NFDC) 2016). This data will include airports, FAA operating airspace, and terminal departure and arrival corridors. The data also includes a field for minimum and maximum elevation for each Airspace class. Airport Fields required will be the three letter Airport Identifier (i.e. PHX = Phoenix International).

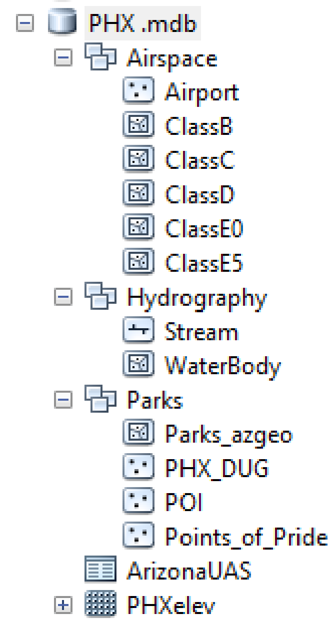


Figure 10: Sample Initial Data

Table 1: FAA Incident Reports

Arizona Statewide UAS Incident Summary	2014	2015	2016
Chandler	0	1	1
Deer Valley	0	2	3
Falcon Field	0	7	3
Glendale	0	4	0
Goodyear	0	0	1
Phoenix-Mesa Gateway	0	5	5
Phoenix International	0	7	14
Scottsdale	1	4	7

A basic hydrography dataset including permanent streams and bodies of water will enable location proximity to water. This data is available to download from the USGS National Map Viewer (USGS 2016).

Points of interest will are required to establish proximity to areas that could attract UAS operators. There is a variety of places. A web search for the area may have areas of interest or this could be manually created.

Elevation data will also be necessary for the area of interest available from the USGS National Map Viewer (USGS 2016).

The final initial data collection includes the UAS incident reports consolidated for the area of interest. This is a national database maintained by the FAA and will require some consolidation to get the complete data since 2014 when collection began. This data will have to be adjusted to include an Airport Identifier column to allow a join with the airport dataset. Each incident includes a description of where the incident occurred that usually includes the airport identifier, however some cases require more reading to assess the location. A sample for the State of Arizona is included in the attachments. Data is available from the FAA at https://www.faa.gov/uas/resources/uas_sightings_report/ (Federal Aviation Administration 2017).

EVALUATION

Data Preparation

After data was compiled it was prepared for analysis by selecting common projection systems and spatial reference. Airspace polygons were combined into a feature set with polygons organized by airspace class. Multiple park shapefiles were combined into a single feature set. Points of interest were also combined into a single point feature. To aid in processing elevation raster was limited to extent of airspace features.

Elevation Categorization of Parks

Table 2: Elevation Score

Elevation Differential	Score
0-10 ft Change	0
10-50 ft Change	0.4
50-200 ft Change	0.7
200 ft + Change	1.0

Elevation interest was categorized based on maximum elevation change within each park. Increased scores identify parks with greater interest due to large elevation differential. Once data was compiled, zonal statistics tool was used to identify maximum and minimum elevation within the park polygons. The Zonal Statistics or Zonal Statistics as Table tools uses an input zone and raster data to calculate spatial characteristics within a defined zone (Environmental Systems Research Institute, Inc. 2016). Using the elevation raster and the park polygons we located the highest and lowest elevation in the park boundaries to identify the point where the longest view may be possible. This elevation profile was used to assign a score to different parks since a varied topography is one factor identified to locate UAS interest.

Delineating UAS Effective Range

Establishing the possible range of small UAS based on maximum legal operating range allows this project to assess the surrounding airfields and areas that are effected by small UAS. Buffer analysis creates a set range in every direction to create a polygon where overlapping risk and interest are assessed. This extends range of UAS systems that are not bound to property lines on the surface. Buffer analysis extended the typical maximum range of UAS systems to address how they overlap with other areas. While view shed analysis could approximate the line of sight control more appropriately, the maximum effective range is often much less due to power requirements and battery capacity. Several popular systems have demonstrated range in excess of 4 miles. Table 3 illustrates the maximum range of several popular drones on the market. We used five kilometers as the maximum range of the drones for this analysis. It is important to note that this generally exceeds the legal distance to maintain visual contact with the drone based on the maximum threshold range according to Watson (Watson A 2009). Using his formula for alpha:

Table 3: Popular Small UAS Models

UAS Brand Name and Model	Reported Max Range (FCC Compliant)
DJI Phantom 3 Advanced	5 km
DJI Phantom 2 Professional	5 km
DJI Phantom 4	5 km
DJI Inspire2	7 km
DJI Inspire 1	5 km
DJI Mavic	7 km
Parrot AR 2.0	50 m
Yuneec Typhoon	1.6 km
Yuneec Typhoon 4K	1.6 km
Yuneec Tornado	700 m
GoPro Karma	3 km

$$\alpha = 2 * \tan^{-1}\left(\frac{W}{2R}\right)$$

Where W= 0.5 meters a conservative average wingspan (most are smaller) and R is the threshold range, α is the angle that our eyes can distinguish. Watson adjusted his formula due to research methods with an image of an aircraft on a screen. For our purposes we can use the 20/20 vision average person α=0.016 degrees (NDT Education Resource Center 2014). The resulting threshold range limits the theoretical acquisition range to R ≅ 1720 meters. While this could be an effective range to use as a buffer, we observed that risk is better calculated assuming that people are not following the regulation.

Using the Buffer Analysis tool we calculated a temporary feature set including both the area of the park as well as the buffer beyond the boundary (Environmental Systems Research Institute, Inc. 2016).

Identifying Intersecting Interest and Risk Areas

Since small UAS are not tied to property lines we can assess the overlapping areas of the maximum effective range with both areas of risk and areas of interest. By quantifying the amount of overlapping area we can score the effective risk or interest. For example, a park may not lay underneath high risk airspace, but the effective range of a small UAS could increase risk if the maximum effective range intersected airspace nearby.

The overlap of the 5000 meter buffer areas and the airspace boundaries was calculated from the amount of overlap a given buffer has with any surrounding airspace from surface to 700 feet. The total area of overlap was then added to the park feature as a field for each airspace type. Using the Tabulate Intersection tool we created a temporary feature set with a total area of overlap for each park will any airspace area. The resulting area was then divided by the whole area of the buffer to get a fraction of the possible flying airspace with FAA airspace. This number was then assigned to the area score for risk.

The overlap of the buffers with adjacent airfields is also an important risk factor. This was calculated using the Tabulate Intersection tool with the Airport point feature resulting in a count for each buffer area. This count is then adjusted to be on a 0.0-1.0 scale for a maximum score of 1.0 and is assigned to the airport risk field.

The overlap of water, points of interest, and land cover was also calculated in a similar manner using the park boundary and the POI, water, and land cover datasets. The Tabulate Intersection tool output with the bodies of water feature results in an area of overlap. Any park with water inside the boundary received a score of 1.0 or 0 for no water. Points of interest were calculated the same with 1.0 meaning there was at least one point of interest in the boundary, and 0 of there were none. Additionally land cover was a 1.0 for open land and 0 for developed.

To calculate the final score for risk we used a multiplier of 2.0 for airspace overlap and 1.0 for airport proximity. This means that the risk of flying FAA airspace is more significant than the risk posed by a private or lesser used airfield. These scores are then added together for a maximum score of 3.0. This would theoretically happen if 100 percent of the buffer area were inside FAA airspace and there were the maximum number of airfields were also inside this buffer. Realistically speaking this would essentially mean to be flying very close to an airport. Airports with FAA airspace generally have 4 nautical miles (7.4 kilometers) surrounding the airport. This is a very high risk area to fly.

The interest score is calculated by adding the sum of the resulting elevation, POI, and water fields. Each of these are have 1.0 multipliers which give a theoretical maximum of 3.0. This allows a high/low scale to be similar when viewed next to the risk high/low scale.

Table 4: All Fields of the parks feature class

FID
Shape
NAME
JURIS
TYPE
Shape_Length
Shape_Area
Water_Area*
Near_Water_Score*
Elevation_Score*
InterestPoint_Score*
Open_Space*
AirspaceOverlap_sqMeter*
Area_Score*
Airfield_Count*
Airfield_Count_Norm*
Risk_Score*
UAS_Interest_Score*

Validation

The final assessment after selecting the regions where proposed education efforts are necessary was to compare education sites with reported incidents. In order to assess how well the methodology worked we compared the high risk/high interest sites to the known. My hypotheses was that where there have previously been incidents, there will be sights in close proximity to those areas.

Chapter 4: Results

Preliminary results using Phoenix, Arizona and the surrounding regional airports identifies several locations where increased education efforts are in close proximity to areas reporting several incidents in the UAS encounter dataset. Initial data preparation included downloading available data and projecting all datasets into a common spatial reference. All data saved in the primary dataset uses an NAD 1983 UTM 12N. Preliminary research used park boundaries from the City of Phoenix. Attempts to create a complete set of parks from all the municipalities in the area was fruitless due to data sharing rules by several of the cities. The final features used were downloaded from the AZGEO Clearinghouse (AZGEO Clearinghouse - Central Arizona Project 2013) encompassing the entire state of Arizona, but were reduced 553 parks in the Phoenix area. This change in datasets resulted in different parks and may not contain all of the parks in the valley, however it is a more complete set than was readily available. Initially the park boundary database was updated to include several fields necessary to link UAS interest and risk for each park boundary in the dataset. Added fields included are shown in Table 4. Many of these fields are intermediate steps to define the overall interest and risk.

ASSESSING INTEREST

The first step in identifying the UAS interest and FAA Airspace risk was to characterize the elevation profile in each park. Using the Zonal Statistics as Table tool a minimum and maximum elevation was assigned to each park by extracting the elevation from the elevation raster. This table was used to characterize the elevation profile in the park to assign a score to the Elevation score field according to Table 1. The results of this analysis are represented below in Figure 7. Figure 7 shows the elevation values with park boundaries and FAA airspace overlays. Due to the largely flat area the majority of the parks received a score of 0. The parks around the isolated peaks will result in pockets of higher interest.

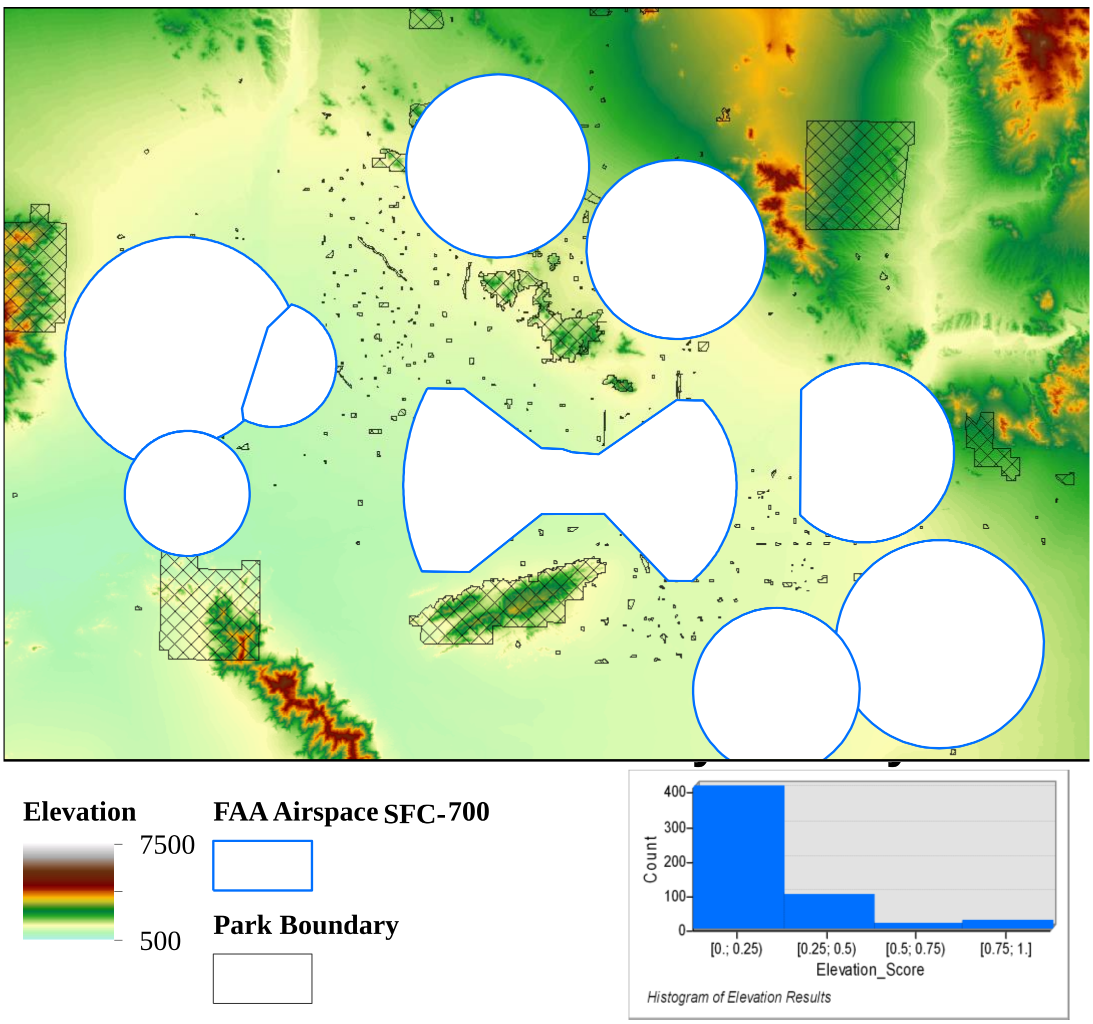
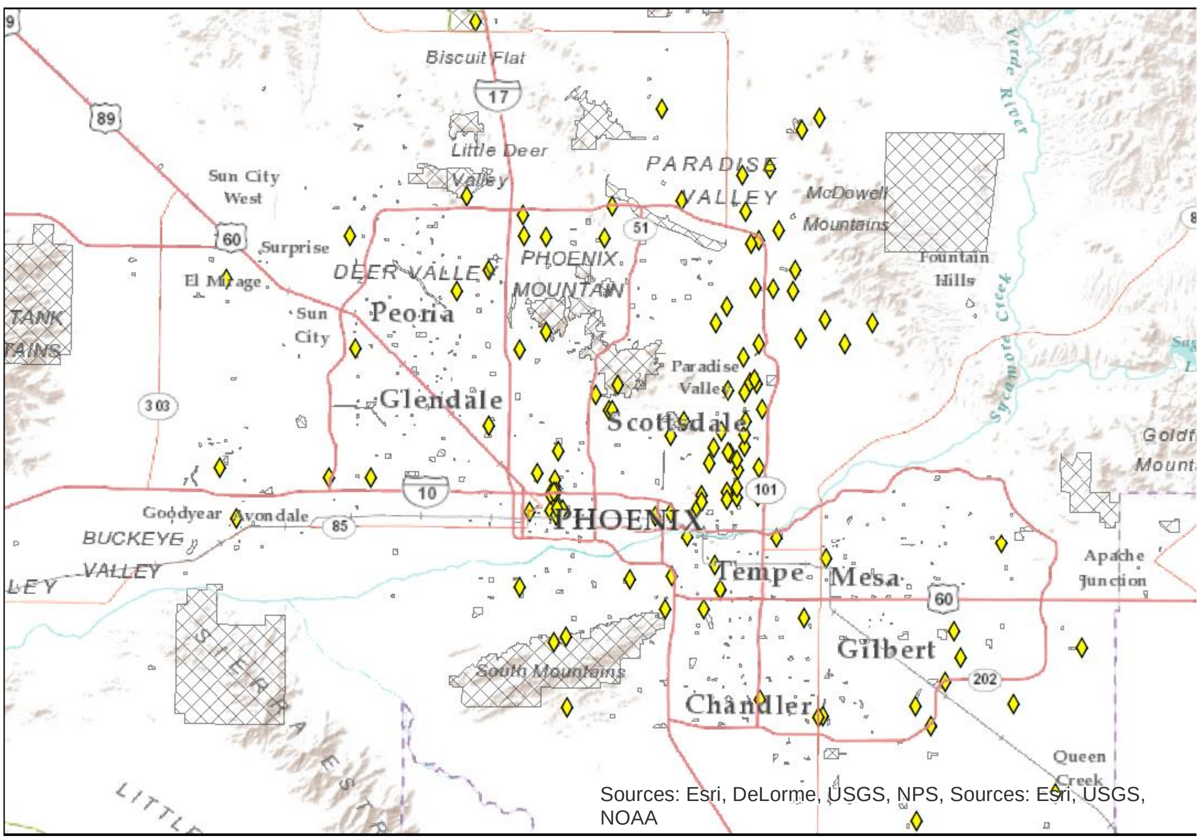


Figure 11 : Elevation with Park Boundary Overlay

The second attribute in the interest category was assessing points of interest. These data were compiled from groups of points of interest from the City of Phoenix, AZ and the Arizona Drone Users Group. They encompass a list of sites that are possibly of interest to operators of UAS. They are shown below on Figure 8. There are 119 points varying from museums, zoos, sports fields, and landmarks. These are also not all encompassing as there may be other landmarks that merit consideration, however, they do encompass the entire area. There are clusters of points that result in higher areas of interest that tend to be centered near higher population density. The scores assigned to parks based on proximity to parks are binary. Initially each point of interest was counted as one point causing the few parks with more than one point to stand out.



Park Boundary ◊ **Points of Interest**

Figure 12: Points of Interest

Additionally, we assessed that the difference between no points of interest and one point of interest was more substantial that if there were more than one point of interest.

The third attribute in consideration was the proximity to water. Phoenix has a desert landscape with mostly artificial bodies of water. Many of these are small, however, they still provide limited interest. Few of the parks had water nearby and only 43 of 553 were given a score due to proximity to water. Consideration was given to expanding the distance to water where a score was merited, however, the primary focus of this research is to identify which parks are most suited to education efforts so only parks containing water were considered.

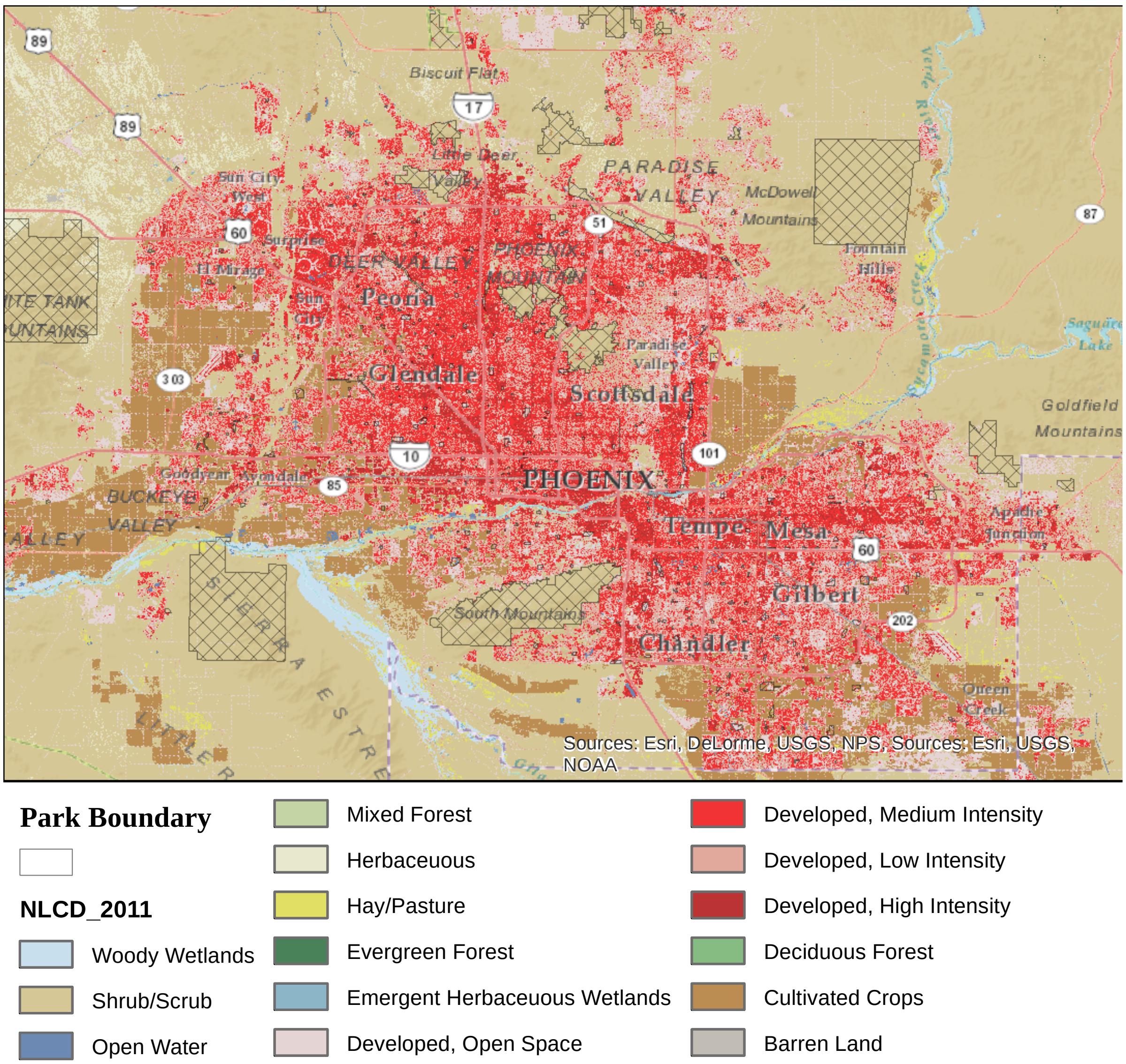


Figure 13: Land Cover

The fourth attribute was space. Using a land cover dataset available from the USGS National Map Viewer we used the 2011 National Land cover database and identified shrub/scrub, hay/pasture, developed (open space), cultivated crops, and barren land as attractive to UAS operators. The raster dataset was reclassified with these cover types as 1 with all others as 0, then created a polygon from this resulting raster and used tabulate intersection to identify the areas of interest. While most of the parks assessed were already open space we included using the land cover to identify regions that are attractive to drone operators that were not in public parks. Analysis of the parks was changed very little due to parks already being in open space, however an expanded approach outside parks was considerably affected by this attribute. This is shown above in Figure 9.

The total interest score is the sum of each sub-score with each attribute counting equally. Several trials were conducted with changes in the weight for each of the attributes. The overall

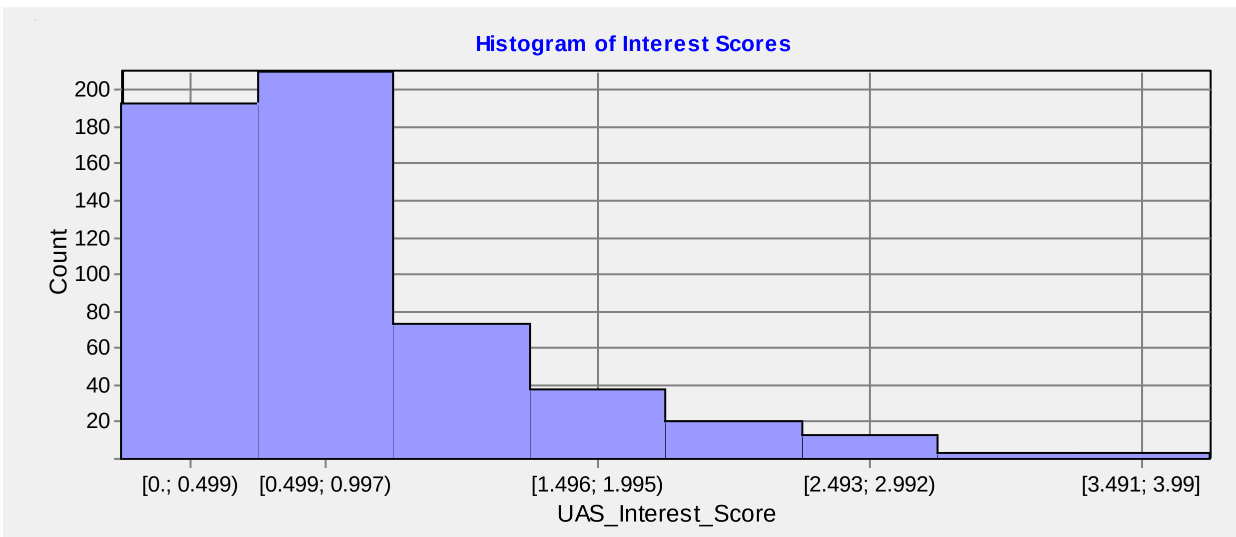


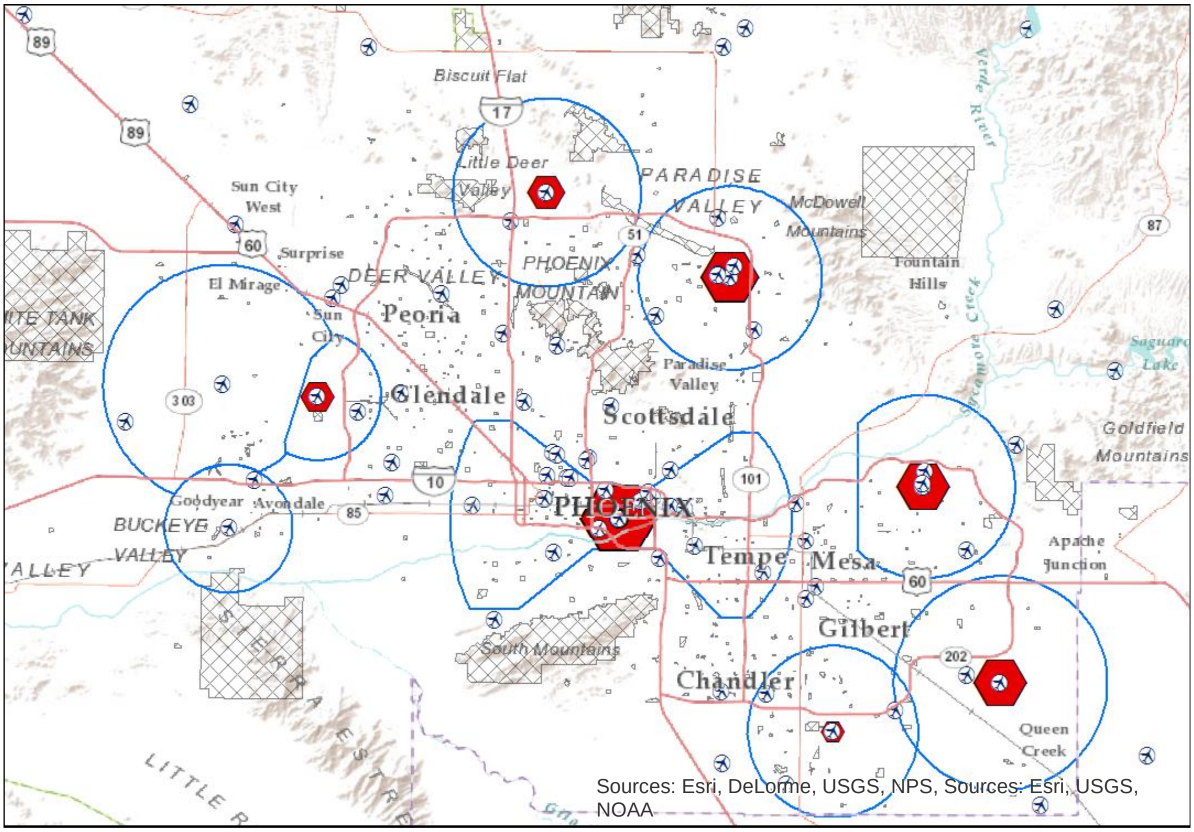
Figure 14: Interest Score Histogram

interest was appropriately affected but without additional background research these changes seemed too arbitrary. The ranking of attributes in terms on importance were Space, Points of Interest, Elevation, and then Water.

Assessing Risk

This range established how far away from the park we calculate potential risk caused by a small UAS flying from that park. There are two parts to this analysis. First, counting how many total airports, airfields, glider fields, and helicopter pads are within this range. Though usually less busy than the larger airfields the flying from these smaller areas is less controlled. This was completed by creating a buffer around the park polygon and counting how many airports lay within the buffer. This count was then scaled from 0 (no airports) to 1 (maximum airport count).

The highest score was 13 airfields. Most of the high scoring parks were near the center of Phoenix. In all, 397 of 553 parks had at least 1 airfield in close proximity. Figure 11 below shows airspace, airports, parks, and reported incidents at larger airfields.



Park Boundary **FAA Airspace SCF-700** **UAS Reports**

FREQUENCY

Airport 1

10

Figure 15: Airspace and Airports with Incident Reports

Second, determining how much overlap within the 5 km circle exists with the FAA airspace. In order to assess this correctly only the airspace at the surface will be addressed assuming the 400 foot restriction is met. To allow for a margin of error for the UAS operators all FAA airspace below 700 feet above ground level was used. For processing simplicity a single airspace feature was created, and each park was assessed an overlap area. This was completed using the Tabulate Intersection tool where each park was assigned an overlap.

The total risk score was calculated by assessing the percentage of area within the 5 km buffer that overlapped with FAA airspace. If 100% of the area was within the FAA airspace, a score of 10 was assigned. 90% received 9 points and so on.

The count of airfields within the 5 km buffer was then added to this score, 1 point for every airfield. For reference, then highest risk score was 2.61.

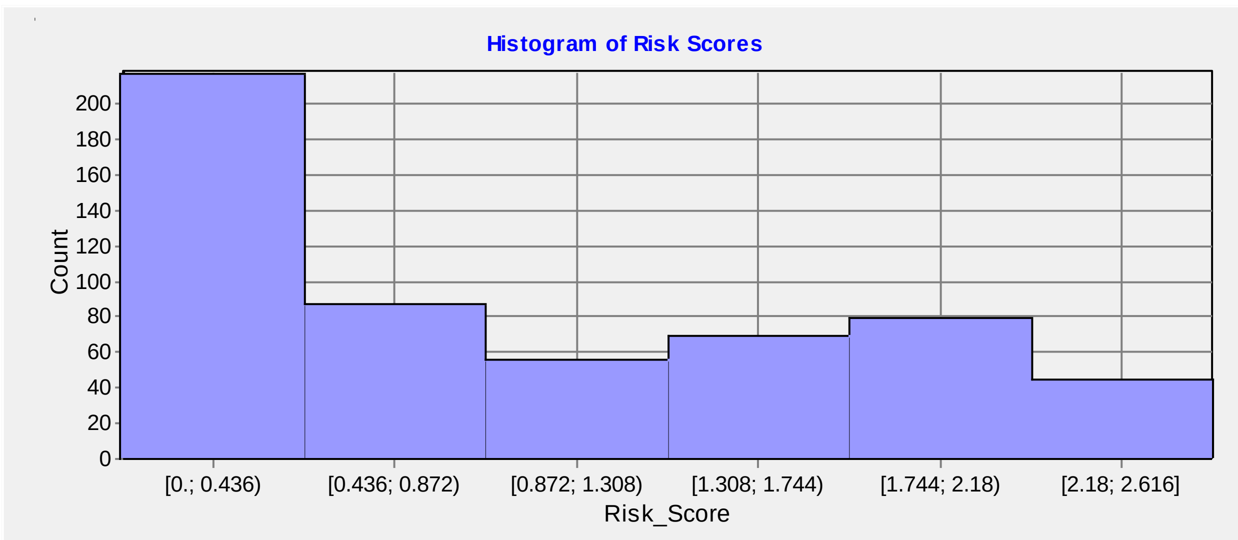


Figure 16: Risk Score Histogram

The combination of both high risk and high interest are the primary concern for this project. At those parks education efforts are poised to be the most worthwhile. In order to categorize these scores as high medium and low we will look to the data. For Interest, the score range is 0-4. By looking at the histogram for interest in Figure 10 there is sharp drop near a score of 1 driving a score >1 as low interest. Medium and high interest indicate more than 1 attraction to that park. Medium interest will then be established for scores ≥ 1 and <2 as medium and parks with a score ≥ 2 as high interest. The result is 36 high interest parks, 114 medium interest parks, and 403 low interest parks

Risk can be categorized by from low risk; 0 < Risk_Score < 1, med risk; 1≤ Risk_Score < 2, and high risk; Risk_Score ≥ 2 with a maximum score of 3 possible. The histogram for risk in Figure 12 shows a sharp drop, then a level plateau with little slope. These scores are predictable more even since the distribution of airports across the valley is dispersed. Most of the score is driven by parks near the FAA airspace. The result is 73 parks with high risk, 163 with medium risk, and 317 with low risk. Of note 135 parks had a risk score of 0.

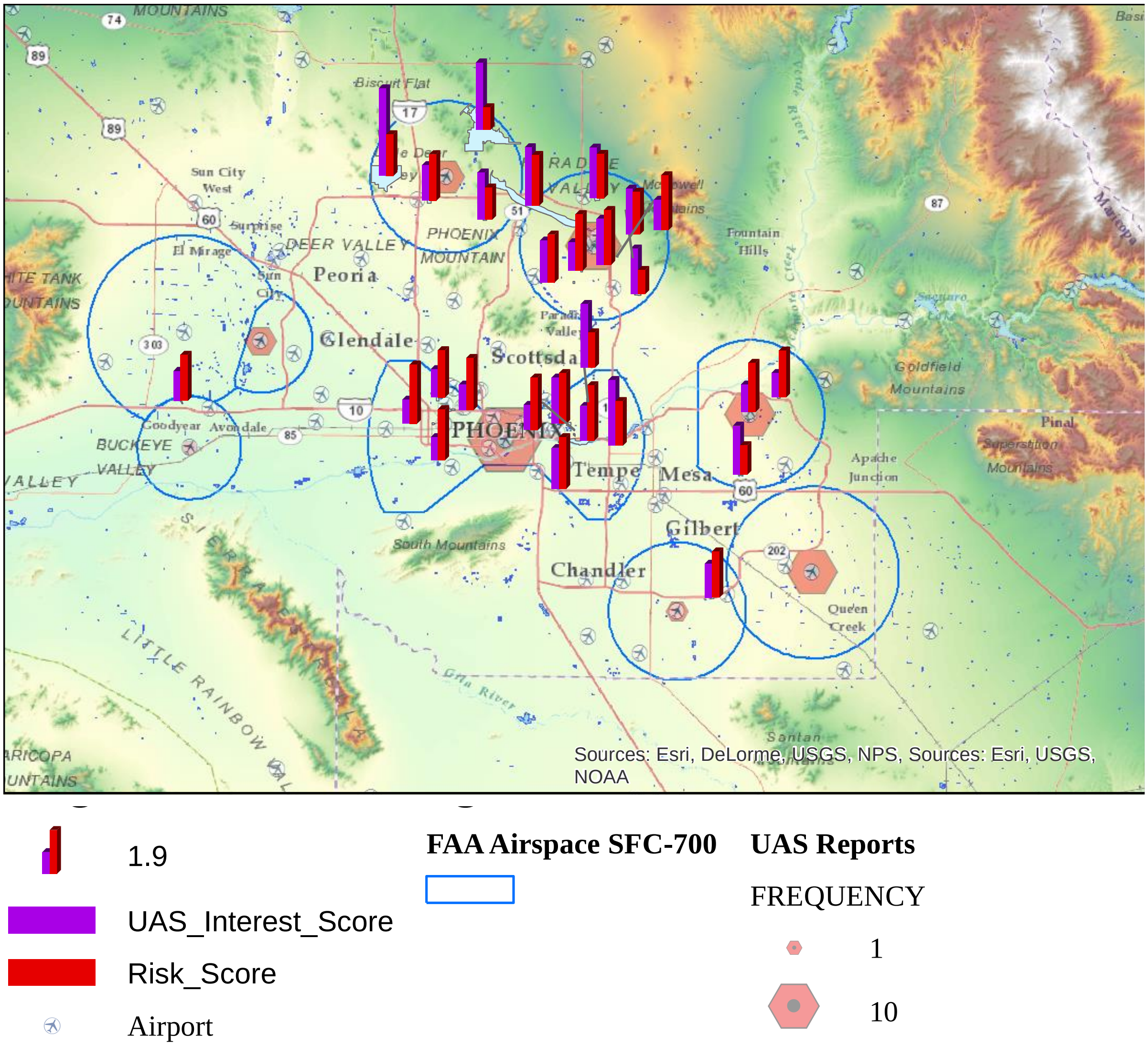


Figure 17: High Risk and High Interest Parks

By combining both of these we can get groups of parks that are appropriate for focused education efforts. The parks that have both high interest and high risk; as well as medium interest and high risk or high interest and medium risk. The list of these parks is reasonably short. As seen in Figure 12 there are 27 parks that merit education efforts. These parks lay in close proximity to several of the airports with high incident reports. There are some interesting areas where there are several incident reports with no parks in the vicinity. Of the approximately 143 parks in the Mesa and Chandler areas there are a representative amount of high risk areas, the high interest areas is lower than much of the region. This is largely due to limited data available to identify points of interest. There are some points of interest in this area, but fewer than the rest of the valley. Table 5 lists parks with the associated interest and risk score that are identified.

Table 5: Notable Parks

Park Name and City	Interest Score	Risk Score
WESLEY BOLIN MEMORIAL PLAZA, PHOENIX	1.07	2.61
CACTUS PARK, SCOTTSDALE	1.25	2.48
RIO SALADO PARK, TEMPE	1.52	2.44
NORTHSIGHT PARK, SCOTTSDALE	2.03	2.42
THUNDERBIRD PARK, SCOTTSDALE	1.34	2.42
TEMPE WOMENS CLUB, TEMPE	1.11	2.31
MARGARET T. HANCE PARK, PHOENIX	1.12	2.30
PAPAGO PARK, PHOENIX	1.80	2.28
MARGARET T. HANCE PARK, PHOENIX	1.02	2.25
REACH RECREATION AREA, PHOENIX	2.57	2.24
EVELYN HALLMAN PARK, TEMPE	2.04	2.24
FALCON FIELD PARK, MESA	1.22	2.17
MESCAL PARK, SCOTTSDALE	1.85	2.11
ENCANTO PARK, PHOENIX	1.25	2.09
SUMMIT PARK, MESA	1.08	2.07
ZANJERO PARK, GILBERT	1.51	2.05
DEER VALLEY PARK, PHOENIX	1.58	2.05
BULLARD WASH LINEAR PARK, GOODYEAR	1.31	2.03
VISTA DEL CAMINO PARK, SCOTTSDALE	2.90	1.97
THOMPSON PEAK PARK, PHOENIX	2.23	1.96
AZTEC PARK, SCOTTSDALE	2.03	1.89
ADOBE DAM RECREATION AREA, PHOENIX	3.86	1.83
EL DORADO PARK, SCOTTSDALE	2.80	1.55
GROVERS PARK, PHOENIX	2.08	1.42
GREENFIELD PARK, MESA	2.16	1.30
SCOTTSDALE RANCH PARK, SCOTTSDALE	2.01	1.06
CAVE BUTTES RECREATION AREA, PHOENIX	2.97	1.00

Chapter 5: Conclusion and Discussion

Conclusions

Through the workflow defined by out methodology we successfully identified 18 parks that we think are well suited for signs, posters, and awareness-building education efforts to help people understand the hazards in their local area. These parks account for around 3% of all the parks examined in this study. Though this number is small, it illuminates areas where cities in the Phoenix area could be more restrictive or, conversely, less restrictive by allowing operations in the parks with high interest and low risk. Many of these parks may already ban small UAS operations. However, without significantly more information about the precise location where UAS incidents are reported by pilots it is difficult to assess risk with more precision. Any measurable increase in safety, i.e. a reduction in incidents, as a result of identifying these locations is also many years in the future.

Discussion Points

One factor that bears mentioning is the choice of maximum capable range versus legal range in selecting the buffer analysis. After a review of the incident reports it is apparent that the legal restrictions are not necessarily met, therefore, to assess risk a maximum capable range is more appropriate to evaluate risk.

Another consideration is that by using park polygons to evaluate areas of interest and risk that a significant amount of area is ignored. Many UAS operators likely look for anywhere that will allow them to fly, and these places may not be on in public property. To account for this, we created a 2x2 kilometer square grid covering the research area to evaluate interest and risk independent of a park, then recommend parks within that grid as areas to focus education efforts. While the risk and interest may not be centered at the park, citizens in the area may still respond positively from the locally targeted advertising. Additionally education efforts could be tied to point sites in some cases, to the same effect as a park. Using this alternative method the results are indicated in Figure 14. The resulting intersection with parks yields 100 parks that are within this region, however this area also includes areas outside the park. Of note, Luke Air Force Base has no incidents reported since the Air Force reporting procedure is separate from the FAA. All other areas seem to fit correlate the area of high interest and high risk with the number of incidents reported.

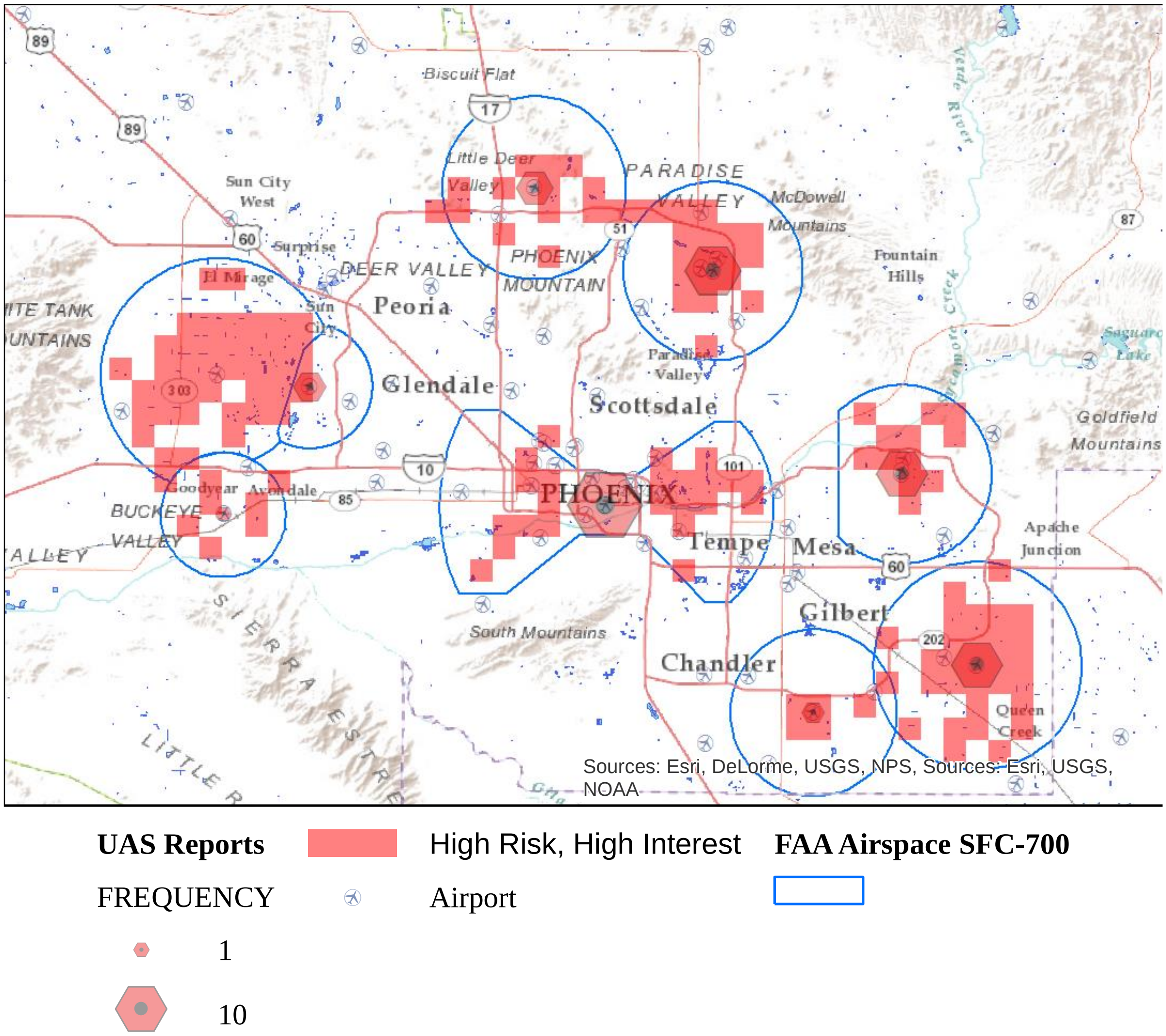


Figure 18: High Interest and High Risk using the Grid Method

Recommendations for Future Research

One significant point identified during this research is that there has been little done to understand who uses small UAS and how they use small UAS.

While results using the methodology outlined in our research offer positive results, many of the assumptions could be validated through several means. First, a survey of operators could help identify the attributes of the areas they choose to fly in order to better understand and characterize an ideal location. Additionally, a look at what different groups use drones and how they use them will likely create different flows to assess interest. For example, is the primary use as a recreational hobby or is the use the means to an end, like amateur photography. This research could be at a local scale, like the Phoenix, AZ area, or on a more national scale to identify universal trends.

Another more difficult area of research would be a study regulation violations and where and why these violations occur. This could help assess whether there other methods to educate these operators or are they choosing to violate the law.

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APPENDICES

APPENDIX A: TIMELINE

August 2016-January 2017: Idea development and preliminary data collection

January 2017: Proposal draft and preliminary methodology development

February 2017: Committee formation and Proposal Approval

February 2017- April 2017: Final data collection and

April 2017: Practicum Presentation

May 2017: Final Practicum Report submission

APPENDIX B: UAS INCIDENTS SUMMARY (ARIZONA)

Source	Date and Time	City	State	Description	Airport	Notes
UAS_Sightings_r	9/3/16 11:24	PHOENIX	Arizona	[illegible] QUADCOPTER UAS AT SAME ACFT ALTITUDE OF 3,500 FEET 8 W PHOENIX. NO EVASIVE ACTION TAKEN. PHOENIX ARPT PD WAS NOTIFIED. MOR Alert for P50 Type: Other	PHX	Manual
UAS_Sightings_r	8/29/16 12:00	PHOENIX	Arizona	[illegible] PASS 300 FEET BELOW ACFT AT 2,300 FEET 2 W OF MESA GATEWAY ARPT, PHOENIX, AZ. NO EVASIVE ACTION TAKEN. MESA PD NOTIFIED. UAS MOR Alert for IWA Type: Hazardous and/or Unauthorized UAS Activity	IWA	
UAS_Sightings_r	8/25/16 15:16	PHOENIX	Arizona	[illegible] Type: Hazardous and/or Unauthorized UAS Activity Date/Time: Aug 25, 2016 - 1916Z A/C: (HELO) Summary: HELICOPTER CONDUCTING PHOTO MISSION 3 SW OF KPHX REPORTED A DELTA WING DRONE NEAR HIS LOCATION. TOOK PICTURES OF THE DRONE AND REPORTED THE DRONE AT 1400 MSL. CITY OF TEMPE POLICE INFORMED.	PHX	
UAS_Sightings_r	8/25/16 11:38	DEER VALLEY	Arizona	[illegible] AND LOOP101, 3 SE DEER VALLEY ARPT. NO EVASIVE ACTION TAKEN. NO DESCRIPTION OF UAS GIVEN. LEOS NOTIFICATION UNKN. UAS MOR Alert for DVT Type: Hazardous and/or Unauthorized UAS Activity Date/Time: Aug 25, 2016 - 1538Z	DVT	
UAS_Sightings_r	8/24/16 21:09	PHOENIX	Arizona	[illegible] AND BLUE UAS 3 W PHOENIX. NO EVASIVE ACTION TAKEN. PHOENIX PD WAS NOTIFIED. UAS MOR Alert for PHX Type: Hazardous and/or Unauthorized UAS Activity Date/Time: Aug 24, 2016 - 0209Z	PHX	
UAS_Sightings_r	8/12/16 13:53	BRENDA	Arizona	[illegible] SCOTTSDALE, AZ, AT 7,000 FEET REPORTED DESCENDING TO 6,200 FEET IN AN EVASIVE MANEUVER TO AVOID COLLISION WITH UAS, TYPE UNKN. CONTROLLER ISSUED TRAFFIC THAT INDICATED 7,600 FEET. NO EVASIVE ACTION REPORTED. LEOS NOT NOTIFIED. UAS MOR Alert for ZAB Type: Hazardous and/or Unauthorized UAS Activity	ZAB	No Airport
UAS_Sightings_r	8/12/16 9:45	SCOTTSDALE	Arizona	[illegible] HELICOPTER REPORTED A UAS OPERATING .5 MILE FROM THE ARPT. UAS WAS NOT VISIBLE FROM THE ATCT. PILOT THAT REPORTED THE UAS WAS DRIVING IN THE AREA NOT IN AN ACFT. LEO NOTIFICATION NOT REPORTED. UAS MOR Alert for SDL Type: Hazardous and/or Unauthorized UAS Activity	SDL	
UAS_Sightings_r	7/6/16 15:45	PHOENIX	Arizona	[illegible] OBSERVED A BLACK, 4 ROTOR, UAS THE SIZE OF 3-4 BASKETBALLS FLY OVER ACFT BY APPROXIMATELY 100 FEET WHILE ON 1.5 MILE FINAL FOR RUNWAY 25L AT 1,500 FEET. NO EVASIVE ACTION TAKEN. PHX ARPT POLICE NOTIFIED. UAS MOR Alert for PHX Type: Hazardous and/or Unauthorized UAS Activity	PHX	
UAS_Sightings_r	6/30/16 18:08	PHOENIX	Arizona	[illegible] QUADCOPTER UAS OFF ACFT RIGHT SIDE 1.5 E PHOENIX. NO EVASIVE ACTION TAKEN. PHOENIX PD WAS NOTIFIED AT. WOC UAS MOR Alert for P50 Hazardous and/or Unauthorized UAS Activity Date/Time: Jun 30, 2016 - 2250Z	PHX	Manual
UAS_Sightings_r	6/28/16 14:44	PHOENIX	Arizona	[illegible] PHOENIX DEER VALLEY ARPT AT 4,300 FEET REPORTED A UAS, 100 FEET ABOVE. NO EVASIVE ACTION REPORTED. PHX ARPT AIR SUPPORT NOTIFIED. WOC UAS MOR Alert for DVT Hazardous and/or Unauthorized UAS Activity	DVT	
UAS_Sightings_r	6/27/16 13:19	Mesa	Arizona	UAS MOR Alert for FFZ Hazardous and/or Unauthorized UAS Activity Date/Time: Jun 27, 2016 - 2019Z A/C: (P28A) Summary: ADVISED A UAS AS HE WAS TURNING DOWNWIND.	FFZ	
UAS_Sightings_r	6/3/16 17:47	Phoenix	Arizona	[illegible] UAS JUST OFF OF RIGHT SIDE .5 MILE FINAL RWY 30L WITHIN 100-200 FEET. NO EVASIVE ACTION WAS TAKEN. UNKN IF LEO NOTIFIED. UPDATE : INFO FROM FAA OPS: PHOENIX, AZ/UAS INCIDENT/1504M/CESSNA C510, REPORTED SEEING A PURPLE AND WHITE QUAD COPTER UAS DIRECTLY AHEAD 100-200 FEET ABOVE ACFT ALTITUDE OF 1,800 FEET. NO EVASIVE ACTION TAKEN. MESA PD WAS	IWA	Manual
UAS_Sightings_r	5/19/16 18:22	Phoenix	Arizona	[illegible] LIGHTS 100 YARDS OFF AIRCRAFT RIGHT SIDE AT SAME ALTITUDE OF 1,100 FEET. NO EVASIVE ACTION TAKEN. PHX AIRPORT OPS WAS NOTIFIED. MOR Alert for PHX Hazardous and/or Unauthorized UAS Activity	PHX	
UAS_Sightings_r	5/15/16 11:55	Sedona	Arizona	[illegible] DIAMETER UAS WHILE HEADING SOUTHWEST BOUND AT 1,000 FEET 1 S SEDONA ARPT. NO EVASIVE ACTION TAKEN. SEDONA PD NOTIFIED . MOR Alert for P50 Hazardous and/or Unauthorized UAS Activity	P50	No Airport
UAS_Sightings_r	5/14/16 11:37	Chandler	Arizona	[illegible] COPTER WITH ATTACHED CAMERA OPERATING BETWEEN 6 AND 40 FEET ABOVE GROUND LEVEL. NO EVASIVE ACTION TAKEN. CHANDLER PD NOTIFIED. MOR Alert for CHD Public inquiry or concern (including all pilot reported NMACs)	CHD	

UAS_Sightings_r	5/2/16 18:23	Tulsa	Arizona	[illegible] UAS APRX 2-3 FEET IN DIAMETER ON THE LEFT SIDE AND 200 FEET BELOW THE AIRCRAFT. PIC BELIEVED THE UAS TO BE A PHANTOM SERIES. AIRCRAFT WAS NORTHBOUND AT 1,800 FEET 10 WSW TULSA. NO EVASIVE ACTION TAKEN. TULSA AIRPORT PD NOTIFIED. MOR Alert for TUL	TUL	wrong State
UAS_Sightings_r	4/30/16 15:39	Phoenix	Arizona	PRELIM INFO FROM FAA OPS: PHX/UAS INCIDENT/1155P/PHX TRACON ADVISED , AS350, OBSERVED AN ORANGE BASKETBALL SIZED UAS WITH 4 ROTORS FLY WITHIN 50 FEET OF AIRCRAFT AT 500 FEET 2 NW OF PHX. NO EVASIVE ACTION TAKEN. CITY OF PHOENIX PD NOTIFIED.	PHX	
UAS_Sightings_r	4/23/16 14:57	PHOENIX	Arizona	PRELIM INFO FROM FAA OPS: PHOENIX, AZ/UAS INCIDENT/1135P/PHOENIX TRACON REPORTED CESSNA C172, OBSERVED A QUADCOPTER TYPE UAS AT 200 FEET VCNTY PHOENIX. NO EVASIVE ACTION REPORTED. LEOS NOTIFIED.	PHX	
UAS_Sightings_r	4/19/16 19:48	SCOTTSDALE	Arizona	[illegible] UNIDENTIFIED UAS BELOW ACFT AT THE 5 O'CLOCK POSITION WHILE WESTBOUND AT 4,500 FEET 10 SE SCOTTSDALE. NO EVASIVE ACTION REPORTED. MARICOPA COUNTY SHERIFF NOTIFIED. MOR Alert for SDL Hazardous and/or Unauthorized UAS Activity	SDL	
UAS_Sightings_r	4/17/16 10:10	PHOENIX	Arizona	[illegible] ACFT ALTITUDE OF 1,800 FEET .5 SE PHOENIX-MESA GATEWAY ARPT. NO EVASIVE ACTION TAKEN. MESA PD NOTIFIED. MOR Alert for IWA Hazardous and/or Unauthorized UAS Activity Date/Time: Apr 17, 2016 - 0WSAZ	IWA	
UAS_Sightings_r	4/15/16 13:56	SHOW LOW	Arizona	[illegible] METALLIC ROTOR UAS APPROX 35-55 LBS BELOW THE ACFT WHILE SOUTHWEST BOUND AT 10,500 FEET 8 S SHOW LOW. NO EVASIVE ACTION TAKEN. SHOW LOW PD NOTIFIED. MOR Alert for ZAB Hazardous and/or Unauthorized UAS Activity	SOW	Manual
UAS_Sightings_r	4/12/16 20:33	SCOTTSDALE	Arizona	[illegible] VCNTY SCOTTSDALE ARPT. NO EVASIVE ACTION TAKEN. NO REPORT OF LEOS. MOR Alert for P50 Hazardous and/or Unauthorized UAS Activity Date/Time: Apr 12, 2016 - 0WSAZ	SDL	Manual
UAS_Sightings_r	4/1/16 19:34	Phoenix	Arizona	[illegible] UAS AT 2,200 FEET WHILE ON 4 MILE FINAL FOR RUNWAY 8. UAS PASSED UNDERNEATH ACFT. NO DESCRIPTION PROVIDED. PHOENIX ARPT PD NOTIFIED. MOR Alert for P50 Date/Time: Apr 1, 2016 - 1943Z	PHX	Manual
UAS_Sightings_r	4/1/16 13:28	Phoenix	Arizona	[illegible] REPORTED A UAS AT 1,000 FEET WHILE ON 1 MILE FINAL FOR RUNWAY 7. UAS PASSED UNDERNEATH ACFT. NO DESCRIPTION PROVIDED. PHOENIX ARPT PD NOTIFIED. MOR Alert for PHX Other	PHX	
UAS_Sightings_r	3/31/16 11:08	Phoenix	Arizona	[illegible] PHX, WAS EASTBOUND AT 1,800 FEET WHEN UNIDENTIFIED UAS WAS SPOTTED 3 W OF APPROACH END OF RUNWAY 7R. MILITARY, C130, ALSO REPORTED A UAS IN THE SAME LOCATION. NO EVASIVE ACTION TAKEN BY EITHER ACFT. PHOENIX PD NOTIFIED. MOR Alert for PHX Type: Other	PHX	
UAS_Sightings_r	3/25/16 17:15	Pheonix	Arizona	[illegible] HEADING NORTHBOUND, OBSERVED A WHITE UAS HEADING SOUTHBOUND, 300-400 FEET BELOW ACFT, 1.5 - 2 MILES W OF PHOENIX-MESA GATEWAY ARPT. NO EVASIVE ACTION TAKEN. MESA PD NOTIFIED. MOR Alert for IWA Type: Public inquiry or concern (including all pilot reported NMACs)	IWA	
UAS_Sightings_r	3/21/16 22:08	Phoenix	Arizona	[illegible] OBSERVED A UAS OFF LEFT WING AT 3,200 FEET 7 SE IWA. NO EVASIVE ACTION REPORTED. MESA POLICE DISPATCH NOTIFIED. MOR Alert for IWA Type: Public inquiry or concern (including all pilot reported NMACs) Date/Time: Mar 21, 2016 - 0138Z	IWA	
UAS_Sightings_r	3/20/16 16:48	Phoenix	Arizona	[illegible] PHX, OBSERVED A WHITE UAS .5 S WHILE ON 1 MILE FINAL RUNWAY 26 AT 1,800 FEET. NO EVASIVE ACTION TAKEN. PHX ARPT POLICE NOTIFIED. MOR Alert for PHX Type: Public inquiry or concern (including all pilot reported NMACs)	PHX	
UAS_Sightings_r	3/20/16 0:37	Scottsdale	Arizona	[illegible] REPORTED A UAS OPERATING BELOW 200 FEET ON THE 2 MILE FINAL FOR RWY 21 NEAR THOMPSON PEAK RD AND HAYDEN RD. SCOTTSDALE PD NOTIFIED. MOR Alert for SDL Type: Public inquiry or concern (including all pilot reported NMACs)	SDL	
UAS_Sightings_r	3/18/16 17:40	Tuscon	Arizona	[illegible] FEET REPORTED A DARK UAS, FIXED WING, PASSED BEHIND THE ACFT. NO EVASIVE ACTION TAKEN. PIMA COUNTY SHERIFF NOTIFIED. MOR Alert for U90 Type:	U90	Tucson - No Airport
UAS_Sightings_r	3/12/16 1:00	Scottsdale	Arizona	[illegible] SOUTHBOUND REPORTED A QUADCOPTER UAS AT 5,500 FEET 3 NW SCOTTSDALE. UAS PASSED 500 FEET BELOW ACFT. NO EVASIVE ACTION TAKEN. SCOTTSDALE PD NOTIFIED. MOR Alert for P50 Type:	SDL	Manual

UAS_Sightings_r	3/5/16 14:13	Scottsdale	Arizona	[illegible] UAS AT 250 FEET 1 E SDL. NO EVASIVE ACTION REPORTED. SCOTTSDALE PD NOTIFIED. MOR Alert for SDL Type: A/C operated at Altitude/Route/Speed other than expected/intended (includes TCAS RA - No Loss/spillout) Date/Time: Mar 5, 2016 - 2113Z	SDL	
UAS_Sightings_r	3/1/16 10:45	Phoenix	Arizona	[illegible] ENCOUNTERED A UAS AT 9,000 FEET 6 SE PHOENIX. NO EVASIVE ACTION REPORTED. UNKN IF LEOS NOTIFIED. MOR Alert for P50 Type: Other Date/Time: Mar 1, 2016 - 1845Z	PHX	Manual
UAS_Sightings_r	2/26/16 0:15	Mesa	Arizona	[illegible] OBSERVED A DARK RED UAS AT 2,600 FEET 4 S OF FALCON FIELD. NO EVASIVE ACTION REPORTED. MESA PD NOTIFIED MOR Alert for FFZ Type: A/C operated at Altitude/Route/Speed other than expected/intended (includes TCAS RA - No Loss/spillout)	FFZ	
UAS_Sightings_r	2/21/16 1:05	Mesa	Arizona	[illegible] Type: Date/Time: Feb 21, 2016 - 0105Z A/C: (C172) Summary: Aircraft reported a drone, basket ball in size with numerous lights at approximately 500ft AGL while on a left downwind	FFZ	
UAS_Sightings_r	2/20/16 13:38	Phoenix	Arizona	[illegible] PHOENIX ARPT. NO DESCRIPTION WAS GIVEN. NO EVASIVE ACTION TAKEN. UNKN IF LEOS WERE NOTIFIED. MOR Alert for P50 Type: Public inquiry or concern (including all pilot reported NMACs) Date/Time: Feb 20, 2016 - 1825Z	P50	No Airport
UAS_Sightings_r	2/19/16 15:40	Tusayan	Arizona	[illegible] Type: Public inquiry or concern (including all pilot reported NMACs) Date/Time: Feb 19, 2016 - 2023Z A/C: (DHC6) Summary: PILOT REPORTED NMAC WITH A DRONE NORTH OF ZUNI ALPHA A (36N 06' 111W 51') @ 8700 MSL, DRONE APPEARED	GCN	
UAS_Sightings_r	2/17/16 5:44	Phoenix	Arizona	[illegible] Type: Other Date/Time: Feb 17, 2016 - 1030Z A/C: (HELO) Summary: HELICOPTER WEST BOUND AT I10 AND I17 REPORTED A DRONE AT 2,000FT. NO KNOW EVASIVE ACTION TAKEN, NO	PHX	
UAS_Sightings_r	2/13/16 19:49	Mesa	Arizona	[illegible] Type: Other Date/Time: Feb 13, 2016 - 0016Z A/C: HELO Summary: A/C REQUESTED A NORTHEAST DEPARTURE. THE TOWER CONTROLLER DEPARTED A/C VIA TAXIWAY YANKEE	IWA	
UAS_Sightings_r	1/30/16 16:22	Phoenix	Arizona	[illegible] Type: Date/Time: Jan 30, 2016 - 1622Z A/C: MSQT726 (PA28) Summary: MSQT726 WAS ON LEFT FOR RUNWAY 7L AT 2300FT AND REPORTED A UAV BELOW THEM AT 1700FT. MSQT726 WAS	DVT	
UAS_Sightings_r	1/23/16 15:14	Scottsdale	Arizona	PRELIM INFO FROM FAA OPS: SCOTTSDALE, AZ/UAS INCIDENT/1514M/ CESSNA C172, REPORTED SEEING A WHITE UAS AT 500 FEET VCNTY SCOTTSDALE ARPT. NO EVASIVE ACTION TAKEN. SCOTTSDALE PD WAS NOTIFIED.	SDL	Manual
UAS_Sightings_r	1/18/16 14:34	Tucson	Arizona	[illegible] SOUTHEAST BOUND AT 3,700 FEET ON FINAL FOR RUNWAY 11L WHEN A LARGE ORANGE UAS PASSED 100 YARDS TO THE RIGHT OF THE ACFT. NO EVASIVE ACTION TAKEN. UAS WAS LARGE ENOUGH TO BE SEEN BY ATC PERSONNEL IN THE TOWER FROM 3 MILES AWAY. TUCSON PD NOTIFIED. MOR Alert for TUS	TUS	
UAS_Sightings_r	1/16/16 7:04	Goodyear	Arizona	[illegible] LIGHTED UAS AT 2,300 FEET .5 MILE E AND 1 MILE N OF THE APCH END RUNWAY 21. NO EVASIVE ACTION TAKEN. GOODYEAR PD NOTIFIED. MOR Alert for GYR Type:	GYR	
UAS_Sightings_r	1/1/16 11:19	Phoenix	Arizona	[illegible] 1,800 FEET 6 W PHOENIX. NO EVASIVE ACTION TAKEN. UNKN IF LEO WAS NOTIFIED. MOR Alert for PHX Type: VFR A/C in proximity to terrain/obstructions affecting safety of flight Date/Time: Jan 1, 2016 - 0819Z	PHX	
UAS_Sightings_r	12/8/15 19:31	Phoenix	Arizona	[illegible] REPORTED AN UNIDENTIFIED UAS WHILE SOUTHWEST BOUND AT 2,000 4 NE PHOENIX-MESA. NO EVASIVE ACTION TAKEN. MESA PD NOTIFIED. MOR Alert for IWA Type: Public inquiry or concern (including all pilot reported NMACs)	IWA	
UAS_Sightings_r	11/26/15 23:38	Phoenix	Arizona	[illegible] HOUSE LOCATED NEAR STATE ROUTE 51 AND GLENDALE IN PHOENIX. HE STATED THAT AROUND 2101 LOCAL, HE OBSERVED A SMALL OBJECT BECOME AIRBORNE OVER HIS HOUSE WITH GREEN AND RED LIGHTS. SHORTLY AFTER, HE OBSERVED ANOTHER SIMILAR LOOKING OBJECT BECOME AIRBORNE IN THE SAME AREA. AT 2116 LOCAL, BOTH OBJECTS DISAPPEARED FROM VIEW. OFFICER WAS CONCERNED THAT THE OBJECTS WERE POSSIBLY DRONES OPERATING INSIDE THE CLASS BRAVO AIRSPACE. DRONE ACTIVITY WAS NOT REPORTED BY ANY AIRCRAFT DURING THAT TIME FRAME.	PHX	
UAS_Sightings_r	11/24/15 0:43	Chandler	Arizona	[illegible] ARPT. NO EVASIVE ACTION TAKEN. UNKN IF LEOS WERE NOTIFIED. MOR Alert for CHD Type: Other Date/Time: Nov 24, 2015 - 1943Z	CHD	

UAS_Sightings_r	11/12/15 16:35	Phoenix	Arizona	[illegible] Type: Public inquiry or concern (including all pilot reported NMACs) Date/Time: Nov 12, 2015 - 1635Z A/C: HELO Summary: HELO FLEW PAST GOOD SAMARITAN HOSPITAL (1.5 MILES NW OF PHX) AND REPORTED A DRONE AT 1300'. HE	PHX	
UAS_Sightings_r	11/8/15 19:00	Phoenix	Arizona	[illegible] UAS HOVERING OVER RUNWAY 8 AT 1,500 FEET 6 NE PHX ARPT. NO EVASIVE ACTION TAKEN. PHOENIX PD NOTIFIED. MOR Alert for PHX Type: A/C entered airspace on other than expected/intended altitude/route/speed or without a point-out or handoff. Date/Time: Nov 8, 2015 - 1900Z	PHX	
UAS_Sightings_r	11/2/15 0:00	Phoenix	Arizona	[illegible] OPERATING S OF PHX HEADING E. NO CONFLICT WITH ACFT REPORTED. MOR Alert for PHX Type: Date/Time: Nov 2, 2015 - 1825Z	PHX	
UAS_Sightings_r	10/23/15 19:45	Phoenix	Arizona	[illegible] Type: A/C entered airspace on other than expected/intended altitude/route/speed or without a point-out or handoff. Date/Time: Oct 23, 2015 - 1945Z A/C: N/A (UAS) Summary: PHOENIX AIRPORT OPERATIONS NOTIFIED PHX TOWER VIA CITY HANDHELD RADIOS THAT THEY WERE INFORMED OF	PHX	
UAS_Sightings_r	10/13/15 15:40	Phoenix	Arizona	[illegible] HELO, OBSERVED A REMOTE CONTROLLED ACFT AT 800 FEET, 3-4 NE OF DVT. NO EVASIVE ACTION REPORTED. UNKN LEOS NOTIFIED AND GROUND UNITS RESPONDED TO POSSIBLE REMOTE OPERATOR. MOR Alert for DVT Type:	DVT	
UAS_Sightings_r	10/3/15 15:18	Scottsdale	Arizona	[illegible] UAS (NO DESCRIPTION PROVIDED) ON HIS RIGHT SIDE ABOUT 50 FEET BELOW ACFT WHILE NORTHBOUND AT 1,850 FEET 1.5 SW SCOTTSDALE NEAR A MALL. NO EVASIVE ACTION TAKEN. SCOTTSDALE PD NOTIFIED. MOR Alert: At 2218Z the Local controller was informed by helicopter that a drone, approximately 1850 MSL, was in the vacinity of Paridise Valley mall.	SDL	Manual
UAS_Sightings_r	9/23/15 15:57	Phoenix	Arizona	PRELIM INFO FROM FAA OPS: PHOENIX, AZ/UAS INCIDENT/1557P/PHOENIX-DEER VALLEY REPORTED CESSNA C172, ON DOWNWIND FOR RUNWAY 25R, OVER 7TH STREET, OBSERVED A UAS AT 700 FEET. NO DESCRIPTION OF UAS. NO EVASIVE ACTION WAS TAKEN. LEO NOT NOTIFIED.	DVT	Manual
UAS_Sightings_r	9/10/15 20:12	Mesa	Arizona	[illegible] Date/Time: Sep 10, 2015 - 2012Z A/C: UNKNOWN (DRONE), OXF205 (PA28) Summary: OXF205 REPORTED A DRONE AS ROUND ABOUT 2 FT IN DIAMETER 1 ML ENE OF FFZ AT 2400MSL.	FFZ	
UAS_Sightings_r	9/9/15 15:56	Mesa	Arizona	[illegible] OPERATING AT 100 FEET BELOW ACFT 4.5 MILES ENE FALCON FLD ARPT, AZ. NO EVASIVE ACTION WAS REPORTED. NO LEO NOTIFIED. MOR Alert for FFZ Type: A/C operated at Altitude/Route/Speed other than expected/intended (includes TCAS RA - No Loss/spillout)	FFZ	
UAS_Sightings_r	8/28/15 0:00	Prescott	Arizona	[illegible] PASSED 100 FEET BELOW THEM OVER THE EMBRY RIDDLE CAMPUS AT 5,900 FEET, 1.5 SW PRESCOTT. NO EVASIVE ACTION REPORTED. UNKN IF LEO NOTIFIED. MOR Alert: RDDL38 1.5 MILES SW OF PRC AT 5900'MSL OVER THE EMBRY RIDDLE CAMPUS REPORTED A REMOTE CONTROL AIRPLANE IN CLOSE PROXIMITY APPROXIMATELY 100 FEET BELOW THEM.	PRC	Manual
UASEventsNov2(	8/9/15 21:35	Glendale	Arizona	[illegible] ALTITUDE 100 FEET OFF LEFT WING VCNTY MIDFIELD GLENDALE ARPT. GLENDALE PD WAS NOTIFIED. MOR Alert for GEU Number: GEU-M-2015/08/09-0001	GEU	
UASEventsNov2(	8/2/15 1:45	Phoenix	Arizona	[illegible] A BLACK AND YELLOW QUADCOPTER TYPE UAS BELOW THE NOSE OF THE ACFT AT 7,000 FEET TRAVELING NORTH BOUND 6 NNE PHX. NO EVASIVE ACTION TAKEN. PHOENIX PD NOTIFIED MOR Alert for P50	PHX	Manual
UASEventsNov2(	7/24/15 8:41	Yuma	Arizona	PRELIM INFO FROM FAA OPS: YUMA, AZ/UAS INCIDENT/0841P/USN CD61, T45, REPORTED SEEING A UAS 100 FEET BELOW AND LEFT OF ACFT ALTITUDE OF 2,500 FEET 5 WSW YUMA. YUMA SHERIFF DEPT NOTIFIED AT 928-783-4427. NO EVASIVE ACTION TAKEN. NO DESCRIPTION GIVEN.	NYL	Manual
UASEventsNov2(	7/22/15 21:01	Phoenix	Arizona	[illegible] A QUAD COPTER AT 8,000 FEET HEADING N 13 NW PHX. EVASIVE ACTION UNKN. UNKN IF LEO NOTIFIED. MOR Alert for P50 Number: P50-M-2015/07/22-0003	P50	No Airport
UASEventsNov2(	6/30/15 17:40	Mesa	Arizona	PRELIM INFO FROM FAA OPS: MESA, AZ/UAS INCIDENT/1012M/FALCON FIELD ATCT ADVISED OXFORD 880, PIPER PA44, REPORTED A RED AND BLACK UAS APPROXIMATELY 1 FOOT LONG AT 1,300 FEET 3.5 S FFZ. NO EVASIVE ACTION TAKEN. NOT REPORTED IF LEO NOTIFIED.	FFZ	Manual
UASEventsNov2(	6/22/15 18:05	Mesa	Arizona	[illegible] APPROXIMATELY 1.5 FEET WIDE ON THE RIGHT CROSSWIND FOR RUNWAY 22R AT PATTERN ALTITUDE. NO EVASIVE ACTION TAKEN. LOCAL POLICE HELICOPTER WAS IN LOCAL AREA AND WENT TO LOOK FOR UAS BUT DID NOT SEE ANYTHING. MOR Alert for FFZ	FFZ	

UASEventsNov2(	6/21/15 23:15	Mesa	Arizona	PRELIM INFO FROM FAA OPS: MESA, AZ/UAS INCIDENT/0815P/OXFORD FLIGHT SCHOOL OXF213, PIPER P28A, REPORTED A ROUND UAS AT 3,500 FEET 8 E FALCON FIELD, OPERATING CLOSE TO A REMOTE ACFT AIRPARK. NO EVASIVE ACTION TAKEN. LEOS NOTIFICATION UNKNOWN.	FFZ	
UASEventsNov2(	6/20/15 14:12	Mesa	Arizona	AMBULANCE 5, HELO, ENCOUNTERED A UAS AT 2,800 FEET OPERATING ABOVE ACFT 10 NE PHOENIX - MESA GATEWAY ARPT. ACFT MANEUVERED AROUND UAS. MESA PD NOTIFIED. MOR Alert for IWA Number: IWA-M-2015/06/20-0001	IWA	
UASEventsNov2(	6/10/15 17:29	Mesa	Arizona	PA44, REPORTED A RED AND YELLOW, CIRCULAR SHAPED UAS PASSED DIRECTLY BELOW ACFT AT 3,300 FEET 4 S FFZ. EVASIVE ACTION UNKN. UNKN IF LEO NOTIFIED MOR Alert for FFZ	FFZ	
UASEventsNov2(	5/21/15 10:32	Yuma	Arizona	PRELIM INFO FROM FAA OPS: YUMA, AZ/UAS INCIDENT/1332P/YUMA MCAS ATCT REPORTED BLKSP51, HARRIER, WHILE DOING A LOW APPROACH SOUTHWEST BOUND AT 500 FEET DIRECTLY OVER THE AIRPORT REPORTED A BLUE HELICOPTER TYPE UAS 100 FEET ABOVE AND OFF HIS RIGHT SIDE. NO EVASIVE ACTION TAKEN. YUMA PD NOTIFIED	NYL	
UASEventsNov2(	5/19/15 0:00	Glendale	Arizona	GLENDALE, AZ (GEU): F282, REPORTED A WHITE DRONE AT 400 FEET IN THE VICINITY OF A LOCAL HIGH SCHOOL. HIGH SCHOOL IS LOCATED 2.5 NE OF GEU AIRPORT. N52PD REPORTED THE DRONE WAS APPROXIMATELY 1/2 NM EAST OF HIS POSITION. THE DRONE REMAINED IN THE AREA OF THE HIGH SCHOOL FOOTBALL STADIUM. GLENDALE POLICE DEPARTMENT NOTIFIED	GEU	
UASEventsNov2(	5/17/15 15:09	Scottsdale	Arizona	PRELIM FROM FAA OPS: SCOTTSDALE, AZ/UAS INCIDENT/1509M/SCOTTSDALE ATCT ADVISED ROBINSON R44, OBSERVED A UAS 3 SW SDL OVER PARADISE MALL AT 400-500 FEET. NO EVASIVE ACTION TAKEN. PHOENIX PD NOTIFIED.	SDL	
UASEventsNov2(	5/17/15 13:10	Phoenix	Arizona	19 N PHOENIX. NO EVASIVE ACTION TAKEN. PHOENIX ARPT PD NOTIFIED. MOR Alert for P50 Number: P50-M-2015/05/17-0002	P50	No Airport
UASEventsNov2(	5/9/15 17:56	Glendale	Arizona	GLENDALE PD NOTIFIED AT 623-930-3000. MOR Alert for GEU Number: GEU-M-2015/05/09-0001 Type: Other	GEU	
UASEventsNov2(	4/18/15 17:04	Phoenix	Arizona	PRELIM INFO FROM FAA OPS: PHOENIX, AZ/UAS INCIDENT/1704P/UNIVERSITY OF NORTH DAKOTA 540, CESSNA C172, REPORTED A BLUE UAS PASSED 100 FEET BELOW THEM 7 SE PHOENIX-MESA GATEWAY ARPT AT 3,300 FEET. NO EVASIVE ACTION REPORTED. UNKN IF LAW ENFORCEMENT NOTIFIED.	IWA	Manual
UASEventsNov2(	4/16/15 23:15	Scottsdale	Arizona	Number: P50-M-2015/04/16-0005 Type: Public inquiry or concern (including all pilot reported NMACs) Date/Time: Apr 16, 2015 - 2315Z A/C: C25B Summary: The pilot of C25B was inbound to SDL for VA to Ry21 from the South. The Biltmore controller vectored the aircraft from	SDL	Manual
UASEventsNov2(	4/14/15 21:17	Phoenix	Arizona	PHX ESTABLISHED ON A 15 MILE STRAIGHT IN FINAL, INDICATED THEY HAD PASSED A UAS AT THEIR SAME ALTITUDE OF 5,000 FEET. NO CONFLICTS REPORTED. MOR Alert for P50 Number: P50-M-2015/04/14-0003	PHX	Manual
UASEventsNov2(	4/14/15 2:30	Glendale	Arizona	Number: GEU-M-2015/04/14-0001 Type: Other Date/Time: Apr 14, 2015 - 0230Z A/C: EVAC12 (ASTAR) Summary: EVAC12 WAS TRANSITIONING FROM NORTH TO SOUTH ENROUTE TO BANNER ESTRELLA HOSPITAL. WHEN	GEU	
UASEventsNov2(	4/9/15 12:55	Scottsdale	Arizona	PRELIM INFO FROM FAA OPS: SCOTTSDALE, AZ/UAS INCIDENTS/1255P/SCOTTSDALE ATCT REPORTED A HELO (REGISTRATION/TYPE UNKN) OBSERVED A SMALL UAS AT 2,400 FEET 5 NW SCOTTSDALE HEADING SOUTHEAST. SCOTTSDALE PD NOTIFIED.	SDL	Manual
UASEventsNov2(	3/24/15 16:39	Mesa	Arizona	PRELIM INFO FROM FAA OPS: MESA, AZ/UAS INCIDENT/1639P/NATIVE AMERICAN AIR AMBULENCE 5, HELICOPTER, TRANSITIONING IWA'S AIRSPACE TO THE EAST REPORTED A UAS AT 2,000-2,400 FEET 5 ENE IWA.	IWA	Manual
UASEventsNov2(	3/21/15 4:20	Mesa	Arizona	UAS, 50 FEET AWAY FROM HELICOPTER AT SAME ALTITUDE OF 600 FEET 4.5 E FALCON FIELD ARPT. GROUND UNITS UNABLE TO LOCATE UAS. MOR Alert for FFZ Number: FFZ-M-2015/03/23-0002	FFZ	
UASEventsNov2(	2/15/15 14:03	Phoenix	Arizona	PRELIM INFO FROM FAA OPS: PHOENIX, AZ/UAS INCIDENT/1403M/PHOENIX-MESA GATEWAY ATCT ADVISED LANCAIR LNC4, REPORTED A UAS AT 2,200 FEET 5 E PHOENIX-MESA GATEWAY ARPT. NO EVASIVE ACTION TAKEN. MESA PD NOTIFIED.	IWA	Manual

UASEventsNov2(	11/14/14 18:58	Scottsdale	Arizona	PRELIM INFO FROM FAA OPS: SCOTTSDALE, AZ/UAS INCIDENT/1858P/PHOENIX TRACON ADVISED THAT A CITIZEN REPORTED A UAS WITH MULTIPLE LIGHTS WAS FLYING ABOUT 100 FEET ABOVE HIS HOME , SCOTTSDALE. PHOENIX PD NOTIFIED .	SDL	Manual

APPENDIX C: PYTHON SCRIPT


```
# Name:Practicum.v2

# Import system modules
import arcpy
from arcpy import env
from arcpy.sa import *
import tools

# Set environment settings
workspace = r"C:\Users\Baxter\Documents\MSWork\Practicum\PrelimPHX.mdb"
env.workspace = workspace
scratch = r"C:\Users\Baxter\Documents\MSWork\Practicum\scratch.gdb"
env.scratchWorkspace = scratch
env.overwriteOutput = "TRUE"
env.rasterStatistics = "STATISTICS 1 1 {}"
arcpy.env.cellSize = "MINOF"

#Step 1 Complile data: Airspace (FeatureSet), Elevation (Raster), Parks(polygon), Points of Interest(added later)


#Step 2 Prep Data: Limit Airspace to applicable area and altitude
                #  Ensure Projection and Spatial Reference are Set
                #  Clip Elevation to extent of Airspace
                #  Combine Parks into single feature class
#Step 3 Analysis #run Script to locate elevation points within parks, establish viewshed, and convert viewshed to polygon
                 #overlap viewshed with airspace polygon for overlap area statistic
                 #order overlap to identify priorities

# SET Extent (based on max airspace concern i.e. PHX Class E

# Clip Elevation Raster to Extent of working airspace

# Set local variables
in_poly = "grid"
polyField = "OBJECTID"
polyField_1 = "OBJECTID_1"

in_Raster = "PHXelev_prj_ft" ## LIMIT RASTER SIZE to MAX AIRSPACE LIMIT +5 nm. UAS have long range, speed up processing for viewshed.
points_interest = "POI"
waterbody = str(workspace)+'\Hydrography\waterbody'
landcover = 'lc_Merge' #polygon from landcover raster, undeveloped polygons merged

#Add Fields for Analysis Results
arcpy.AddField_management(in_poly,"Water_Area","DOUBLE")
arcpy.AddField_management(in_poly,"Near_Water_Score","DOUBLE") #Result 1 or 0

arcpy.AddField_management(in_poly,"Elevation_Score","DOUBLE")   #Result 0, 0.4, 0.7, 1.0

arcpy.AddField_management(in_poly,"InterestPoint_Score","DOUBLE")   #Result 1 or 0

arcpy.AddField_management(in_poly,"AirspaceOverlap_sqMeter","FLOAT")
arcpy.AddField_management(in_poly,"Area_score","DOUBLE")        #Result 0-1 (Percent/100)

arcpy.AddField_management(in_poly,"Airfield_Count","SHORT")
arcpy.AddField_management(in_poly,"Airfield_Count_Norm","DOUBLE")   #Result 0-1

```

```python
arcpy.AddField_management(in_poly,"Open_Space","DOUBLE")
arcpy.AddField_management(in_poly,"Risk_Score","DOUBLE")     #Result 0-2
arcpy.AddField_management(in_poly,"UAS_Interest_Score","DOUBLE") #Result 0-3
# Check out the ArcGIS Spatial Analyst extension license
arcpy.CheckOutExtension("Spatial")
poly_max_table = arcpy.sa.ZonalStatisticsAsTable(in_poly, polyField, in_Raster, 'poly_max_table',"NODATA", "MIN_MAX")
#make Layer
arcpy.MakeFeatureLayer_management(in_poly,'in_poly_lyr')
#Buffer 5km
Park_Buffer5km = arcpy.Buffer_analysis(in_poly,'Park_Buffer5km',"5000 meter")
#Buffer 300m
arcpy.Buffer_analysis(in_poly,'Park_Buffer300m',"300 meter")
def NormField(inLayer,inField,outField):
    statsX = arcpy.Statistics_analysis(inLayer,str(inLayer)+'_stats',[[inField,"MIN"],[inField,"MAX"]])
    search = arcpy.da.SearchCursor(statsX,"*")
    for row in search:
        break
    minX = row[2]
    maxX= row[3]
    del search
    arcpy.CalculateField_management(inLayer,outField, "Norm(!"+inField+"!,{0}, {1})".format(minX, maxX),"PYTHON",\
                                    "def Norm(score,min,max):\n  norm = (score-min)/(max-min)\n  return norm")
#Intersection with Airspace
#Merge Airspace
Airspace_Merge = arcpy.Merge_management(["Airspace/ClassB","Airspace/ClassC","Airspace/ClassD","Airspace/ClassE0","Airspace/ClassE5"],'Airspace_Merge')
Airspace_Merge_Low = arcpy.MakeFeatureLayer_management('Airspace_Merge', 'Airspace_Merge_Low', "[LOWALT]='SFC'")
Airspace_Merge_Dissolve = arcpy.Dissolve_management('Airspace_Merge_Low', 'Airspace_Merge_Dissolve')
arcpy.TabulateIntersection_analysis(Park_Buffer5km, "ORIG_FID", 'Airspace_Merge_Dissolve','Airspace_5kmBuffer_ovrlp')
arcpy.TabulateIntersection_analysis(Park_Buffer5km, "ORIG_FID", "Airspace/Airport", 'Airport_5kmBuffer_ovrlp')
#Risk_airport
arcpy.AddJoin_management('in_poly_lyr', polyField,'Airport_5kmBuffer_ovrlp', "ORIG_FID")
```

```
arcpy.CalculateField_management('in_poly_lyr',str(in_poly)+".Airfield_Count", "!Airport_5kmBuffer_ovrlp.PNT_COUNT!", "PYTHON")
arcpy.RemoveJoin_management('in_poly_lyr')

NormField('in_poly_lyr',"Airfield_Count","Airfield_Count_Norm")

#Risk_airspace
arcpy.AddJoin_management('in_poly_lyr', polyField,'Airspace_5kmBuffer_ovrlp', "ORIG_FID")
arcpy.CalculateField_management('in_poly_lyr', str(in_poly)+ ".AirspaceOverlap_sqMeter", "!Airspace_5kmBuffer_ovrlp.AREA!", "PYTHON")
arcpy.RemoveJoin_management('in_poly_lyr')


arcpy.AddJoin_management('in_poly_lyr', polyField,'Park_Buffer5km',"ORIG_FID")
#Risk_Area Score
arcpy.CalculateField_management('in_poly_lyr',str(in_poly)+".Area_score", "!"+str( in_poly)+".AirspaceOverlap_sqMeter! /!Park_Buffer5km.Shape_Area!","PYTHON")
arcpy.RemoveJoin_management('in_poly_lyr')

#Total Risk Score with multiplier option
arcpy.CalculateField_management('in_poly_lyr',"Risk_Score", "WtScore(!Area_score!,!Airfield_Count_Norm!,{0},{1})".format(2.0,1.0),"PYTHON",\
                                "def WtScore(field1,field2,mult1,mult2):\n wtscore=0+mult1*field1+mult2*field2\n  return wtscore")
arcpy.CalculateField_management('in_poly_lyr',"Risk_Score", "Rescore( !Risk_Score! )" ,"PYTHON",\
                                "def Rescore(inField):\n  if inField>0:\n newscore= inField\n  else:\n    newscore = 0\n  return newscore\n")


#Interest
#Interest Elevation Score
arcpy.AddJoin_management('in_poly_lyr',polyField,'poly_max_table',polyField_1)
arcpy.CalculateField_management('in_poly_lyr',str(in_poly)+".Elevation_Score", "ElevScore( !poly_max_table.MAX_! , !poly_max_table.MIN_! ) ","PYTHON", \
                                "def ElevScore(max,min):\n  if max-min<10:\n score= 0.0\n  elif  10<= max-min<50:\n    score = 0.4\n  elif 50 <=max-min<200:\n score= 0.7\n  else:\n    score = 1.0\n  return score\n")
arcpy.RemoveJoin_management('in_poly_lyr')

#Interest Water Score (area intersection, then score)
arcpy.TabulateIntersection_analysis(in_poly, polyField, waterbody ,str(scratch)+ '/water_overlap')
arcpy.AddJoin_management('in_poly_lyr',polyField,scratch+'\water_overlap',polyField_1)
arcpy.CalculateField_management('in_poly_lyr',str(in_poly)+".Water_Area", '!water_overlap.AREA!', 'PYTHON')
arcpy.RemoveJoin_management('in_poly_lyr')

arcpy.CalculateField_management('in_poly_lyr',"Near_Water_Score", "WaterScore( !Water_Area!)", 'PYTHON', \
                                "def WaterScore(waterarea):\n  if waterarea <0:\n score=0\n  else:\n    score = 1\n  return score\n")

#point of interest
arcpy.TabulateIntersection_analysis(in_poly, polyField, points_interest,str(scratch)+ "/"+'POI_count')
arcpy.AddJoin_management('in_poly_lyr',polyField,scratch+'\POI_count',polyField_1)
arcpy.CalculateField_management('in_poly_lyr',str(in_poly)+".InterestPoint_Score", "CountScore(!POI_count.PNT_COUNT!)", 'PYTHON', \
                                "def CountScore(countarea):\n  if countarea <0:\n
```

```
score=0\n  else:\n    score = 1\n  return score\n")

arcpy.RemoveJoin_management('in_poly_lyr')

arcpy.CalculateField_management('in_poly_lyr',"Near_Water_Score", "WaterScore(!Water_Area!)", 'PYTHON', \
                                "def WaterScore(waterarea):\n  if waterarea <0:\n    score=0\n  else:\n    score = 1\n  return score\n")
#Land Cover

arcpy.TabulateIntersection_analysis(in_poly, polyField, landcover, str(scratch)+"/"+'lc_overlap')
arcpy.AddJoin_management('in_poly_lyr',polyField,scratch+'\lc_overlap',polyField_1)
arcpy.CalculateField_management('in_poly_lyr',str(in_poly)+".Open_Space", "PercentDec(!lc_overlap.PERCENTAGE!)","PYTHON",\
                                "def PercentDec(inField):\n  decimal=inField/100\n  return decimal")
arcpy.RemoveJoin_management('in_poly_lyr')

#Total UAS interest score
arcpy.CalculateField_management('in_poly_lyr',"UAS_Interest_Score", "Weight(!InterestPoint_Score!,!Elevation_Score!,!Near_Water_Score!,!Open_Space!,{0},{1},{2},{3})".format(1.0,1.0,1.0,1.0),"PYTHON",\
                                "def Weight(field1,field2,field3, field4,mult1,mult2,mult3, mult4):\n  wtscore=0+(mult1*field1)+(mult2*field2)+(mult3*field3)+(mult4*field4)\n  return wtscore\n")

arcpy.CalculateField_management('in_poly_lyr',"UAS_Interest_Score", "Rescore(!UAS_Interest_Score! )",'PYTHON',\
                                "def Rescore(inField):\n  if inField>0:\n    newscore= inField\n  else:\n    newscore = 0\n  return newscore\n")
```

APPENDIX D: LIST OF INTEREST SITES USED TO CATEGORIZE INTEREST

http://www.tomsguide.com/us/places-to-fly-drones-america,news-23199.html

Northeast 15 http://www.tomsguide.com/us/pictures-story/833-places-to-fly-drones-northeast.html#s1

Wreck of the SS Atlantus

Picture 2 of 18

Located just off Cape May Point, the remains of the the SS Atlantus, a World War I experimental concrete ship, make a great target for the adventurous drone flier.

Lucy The Elephant

Picture 3 of 18

Built in 1882, this 65-foot tall wood and tin structure in Margate City, NJ was built to look like Jumbo, P.T. Barnum's largest elephant. Lucy, at 90 tons, is considerably larger.

Arthur Kill Boat Graveyard

Picture 4 of 18

Where do ships go to die? The Arthur Kill Boat Graveyard, just off Staten Island. You'll need to check in with the air traffic control at Linden airport, though, as it is just inside the 5-mile limit around them.

Lock 12

Picture 5 of 18

The Farmington Canal originally ran 80 miles, from New Haven to Northampton, MA. Lock 12 is one of the few remaining locks along this canal, which is now an 84-mile recreational trail.

East Rock

Picture 6 of 18

Panoramic views of the Long Island Sound, and picturesque New Haven: what's not to like for the drone flier? Fly carefully, though: the south part of the park is less than 5 miles from New Haven Airport, so you'll need to notify the ATC that you are flying in the area.

Bailey Island

Picture 7 of 18

Bailey island is a small island off the Maine coast that has a picturesque harbour and more rugged, rocky shores than you can shake a gimbal at. It's a perfect spot for flying and videoing the gorgeous Maine coast.

Maine Hacker Club

Picture 8 of 18

The MHC is a group of Maine hackers who get together every couple of weeks to discuss making things. Drones are one of their main areas of interest, so it is a great spot to drop into if you are flying in the area.

Walden Pond

Picture 9 of 18

Thoreau praised the quiet and tranquility of Walden Pond, but things have moved on since then: it's now a popular spot for fishing and boating. Drones are also allowed, but you do need to contact the ATC at Hanscom Field, which is less than 3 miles away.

Mount Auburn Cemetery

Picture 10 of 18

Mount Auburn is a beautiful cemetery filled with statuary and historic gravestones. You need to get permission in advance to use anything more than a tripod for photography, though, so make sure you fill out this form before your visit.

Purgatory Falls

Picture 11 of 18

Legend has it that the Devil invited churchmen to dinner here, then burned a hole in the rock by accident. Overcooked satanic meals notwithstanding, Purgatory falls is a beautiful spot to fly over.

Mount Monadnock

Picture 12 of 18

Mount Monadnock was denuded of trees by a fire that was meant to scare wolves away. That fire burned up all of the trees on the peak, and they have never grown back. This makes for clear flying from this balding 3800-foot peak.

Point Judith

Picture 13 of 18

Want to watch the sun rise with your drone? Point Judith in Rhode Island is a good spot, with a sheltered bay and east-facing shoreline that makes for a dramatic sunrise.

South East Lighthouse

Picture 14 of 18

This unusual lighthouse was moved a few years ago to stop it falling off the surrounding cliffs, but it is still in a wonderfully atmospheric spot, right on the south eastern tip of Block Island, off the Rhode Island coast. It is close to the Block Island airport, though, so a call to notify them that you are flying nearby is in order.

Emily's Bridge

Picture 15 of 18

Local legend has it that a jilted lover hanged herself on this bridge, and has been haunting it ever since. Reports tell of scratched cars, unearthly screeches and all sorts of spooky happenings. Will she haunt your drone or possess your propellers? There’s only one way to find out...

World's Tallest Filing Cabinet

Picture 16 of 18

Erected as a protest over the delays in building a new freeway connector on the site, the self-styled world's tallest filing cabinet is 38 drawers high. The road is still in a bureaucratic limbo, so the sculpture remains standing.

Mid-Atlantic 14 http://www.tomsguide.com/us/places-to-fly-drones-america,news-23199.html

Rehoboth Beach

Picture 2 of 17

Rehoboth Beach in Delaware is the archetypal east coast beach, with fancy houses on the shoreline and a gorgeous sandy beach facing into the sunrise. It’s a perfect spot for flying a drone early in the morning.

Kentucky Hills

Picture 3 of 17

The Kentucky hills outside of Burnaugh are perfect drone flying country, with rolling hills that seem to go on for ever.

Old Sublimity Bridge

Picture 4 of 17

The old Sublimity Bridge is one of many drone-worthy sites in the Bee Rock Recreation area in the Daniel Boone National Forest. The bridge dates from the 1930s, and is open to foot traffic only.

Ship Graveyard, Mallows Bay

Picture 5 of 17

Maryland is a tough place to fly drones, as its small size and number of airports make it hard to find a clear space to fly. However, parts of the Potomac are clear to fly on if you call the local airport and let them know, such as Mallows Bay, which is the home to lots of abandoned and wrecked ships that make great drone targets.

Point of Rocks, MD

Picture 6 of 17

Transport fans will love Point of Rocks, as it has railways, roads and canals, all within a stone's throw of each other.

Deep River Park

Picture 7 of 17

The remains of an old dam stand imposingly over the Deep River, creating an impressive urban ruin that is perfect for drone flying.

Pilot Mountain, NC

Picture 8 of 17

Pilot mountain is the core of a prehistoric volcano that looms over the skyline, dominating the area. Drones aren't allowed in the State Park area itself, but there are plenty of nearby spots to fly from and get a dramatic view of the mountain.

Statue of Liberty

Picture 9 of 17

No, not that one. This replica of the Statue of Liberty sits on the pedestal of a demolished railway bridge halfway across the Susquehanna river. This one is for the advanced flier, as it requires flying a long way over a river to reach it.

Reading Pagoda

Picture 10 of 17

The Reading Pagoda was originally intended to be a luxury hotel, but the business failed and the pagoda and land was donated to the city. Now, it is run by a non-profit group and holds a cafe with beautiful panoramic views of the city. It is within 5 miles of the Reading regional airport, though, so you should notify them before flying.

Pinson Mounds State Archaeological Park

Picture 11 of 17

Pinson Mounds is a series of prehistoric mounds, some dating back over 2500 years and aligned with the four cardinal directions. It isn’t clear how the mounds were used, but it was obviously an important ceremonial site for the locals.

Cherokee Reservoir

Picture 12 of 17

With over 400 miles of shoreline, there is plenty to fly over on the Cherokee Lake or Cherokee Reservoir. Whatever you call it, it is formed by the Cherokee Dam, a hydroelectric dam that was built in 1941.

Foamhenge

Picture 13 of 17

“Foamhenge/Where the foam does dwell/shaped to look like rocks/from Stonehenge as well” - with apologies to Spinal Tap. The future of this replica is uncertain, as the land is becoming part of a state park, and the state has asked the artist to remove it.

Monongahela National Forest

Picture 14 of 17

The awesomely named Monongahela National Forest is a great spot to fly, but as pilot Jonathan Oakes found out, forests can be tricky. Especially if you don’t see those overhanging branches….

Yellow Spring

Picture 15 of 17

Yellow Spring is a small town right in the heart of the Blue Ridge mountains. It’s not just blue, though: this video from J&J Productions shows how the mountains are a riot of green trees and dramatic rock formations.

Southeast 12 http://www.tomsguide.com/us/pictures-story/836-places-to-fly-drones-southeast.html#s2

USS Alabama Memorial Park

Picture 2 of 15

A World War II battleship makes a dramatic subject to video from a drone. Kevin Henderson took this gorgeous video of the USS Alabama, and the many airplanes that surround it at the Battleship Memorial Park in Mobile, AL. One thing to note: the park is on the edge of the controlled airspace for Mobile Airport (KBFM), so you need to call the air traffic control at 251-607-0469 and let them know you are flying a drone.

Bamahenge

Picture 3 of 15

Want to fly a drone over Stonehenge? Elberta, Alabama is the place to go. Well, sort of. Bamahenge is a fiberglass replica of the original, located in this small town in the southeast corner of Alabama. The replica was built by the owner of the nearby Baldwin Marina to celebrate the opening of the marina, and since then he has added a number of fiberglass dinosaurs nearby to add to the prehistoric feel.

Key Largo

Picture 4 of 15

Much of Florida is a no-go area for drones because of the number of small airports and national parks. Key Largo is a fine spot to fly, though, and Youtube user Megawattharry flew his fancy DJI Inspire drone there to capture this wonderful video of the sun setting over the Gulf of Mexico.

Airstream Ranch

Picture 5 of 15

As a tribute to the 75th aniiversary of the iconic trailer brand, a local RV dealer built this work of art by partly burying seven trailers. It's right by the interstate highway, though, so fly carefully.

Stone Mountain Park

Picture 6 of 15

The most famous feature of Stone Mountain Park just outside Atlanta is the gigantic Confederate Memorial Carving on the side of the pluton, a massive dome of volcanic rock. While the surrounding ground was worn away over millions of years, the dome remains, and it is a wonderful place to fly a drone.

Blood Mountain

Picture 7 of 15

The wonderfully named Blood Mountain is one of the highest peaks in Georgia, and sits close to the Appalachian trail. Craig Levine took this video there, capturing the colors of autumn in the forests.

Lake Martin, LA

Picture 8 of 15

Lake Martin is the archetypal Louisiana swamp, with moss hanging from the trees and the quiet, still air that makes even the gators sleepy. It’s a perfect spot for flying a drone, as long as you stick on the eastern end: the north is within the 5-mile limit around the Lafayette airport.

Sunflower Field, Gilliam

Picture 9 of 15

Youtube user myiphonerocks captured a rather awesome sight with his Phantom 4: a field of sunflowers, ready to be harvested.

Windsor Ruins

Picture 10 of 15

The Windsor house was completed in 1861, but a fire in 1890 completely gutted the house, leaving only the ornamental pillars that framed the house. You can even pretend to be Montgomery Clift or Elizabeth Taylor: parts of the 1957 movie Raintree County were filmed there.

Lake Peigneur

Picture 11 of 15

Lake Pegineur went from fresh to salt water overnight when a drilling team accidentally hit a salt mine under the lake, flooding it and contaminating the water. This makes it an oddity: an inland salt water lake.

Busted Plug Plaza

Picture 12 of 15

I don’t pretend to be an art critic, but I like Busted Plug, a giant artwork of a sidewalk hydrant that’s been knocked over by some cosmic accident. It’s located in a car park in downtown Columbia, South Carolina.

UFO Welcome Center

Picture 13 of 15

One resident of Bowman, South Carolina has decided to welcome our new alien overlords and provide them a place to stay. He built the UFO Welcome Center to welcome aliens, complete with a flying saucer. He offers tours for a dollar, and don't forget to ask and tip him when flying a drone. We don't want the planet to get a bad reputation for being rude, after all.

Great Lakes 12 http://www.tomsguide.com/us/pictures-story/827-places-fly-drones-great-lakes.html

Starved Rock State Park

Picture 2 of 15

The attractively named Starved Rock State Park is a large park that includes lots of gulleys, waterfalls and interesting things to fly over, as the TAPP Channel found out when they took the family and a Phantom 3 out for a days walk.

Silver Spray Shipwreck

Picture 3 of 15

Just off the lake shore in Chicago is the wreck of the Silver Spray, a liner that ran aground and sank in 1914. Only the top of the boiler is visible above the water, but on a clear day, a drone can see the rest of the ship through the water.

Empire Quarry

Picture 4 of 15

It is called the Empire Quarry because the limestone used to clad the Empire State Building was mined here. Now abandoned, it is a perfect spot to fly a drone.

Buzzards Roost Trail

Picture 5 of 15

The Buzzards Roost Trail is a hiking path that runs through the Hoosier National Forest, with several scenic spots to fly by the shoreline of Patoka Lake.

Sleeping Bear Dunes

Picture 6 of 15

Named after a local legend about a mother bear waiting for her cubs, Sleeping Bear Dunes is a gorgeous spot on the shore of Lake Michigan that is ideal for drone flying. While the National Shoreline area is off-limits for drones, the shoreline around Glen Arbor is clear for flying.

Thunder Bay Marine Sanctuary

Picture 7 of 15

Thunder Bay Marine Sanctuary is a favorite with divers who explore the numerous shipwrecks in the area. It’s a great spot for flying drones as well, though, as the clear water means that you can see many of the shipwrecks below the water.

Franconia Sculpture Park

Picture 8 of 15

The Franconia Sculpture Park in St. Croix River Valley doesn’t allow drones most of the time, but they do have a regular event where a local drone club meets in the park and flies around the myriad pieces of modern sculpture on display. Check their calendar for details.

The Worlds Largest Crow

Picture 9 of 15

Erected to celebrate the centenary of the state of Minnesota, this fiberglass crow is bigger than most. Over 18 feet tall in total, sitting on a 30-foot long twig, it nests in the small town of Belgrade.

Lake Ladue

Picture 10 of 15

Formerly known as the Akron City Reservoir, Lake Ladue is a picturesque spot to shoot sunrises and sunsets over the trees.

Chagrin Falls

Picture 11 of 15

The town of Chagrin Falls, Ohio gets its name from the waterfall that is right in the middle of the town. It’s not the biggest waterfall out there, but it’s conveniently placed to inspect with even a small drone.

Lake Geneva

Picture 12 of 15

Lake Geneva is a favorite spot for boating in Wisconsin, and what goes better with a boat than a drone? Justin filmed this video from his boat with a Phantom 3, taking you on a tour of the lake.

Louis' Bluff

Picture 13 of 15

The town of Wisconsin Dells is known as the waterpark capital of the world. There is no shortage of natural beauty around there as well, though. This bluff is a rock outcrop near Wisconsin Dells that overlooks the Wisconsin River. It's a great spot to fly and get some nice shots of the rock and water.

Plains 16 http://www.tomsguide.com/us/pictures-story/835-places-to-fly-drones-plains.html#s2

The Ozark Mountains

Picture 2 of 19

The Ozark Mountains are beautiful to fly over any time of the year, according to Ozark Drones, an Arkansas drone video company who put together this video of the mountains in spring, summer, fall and winter. We would be inclined to agree, especially in the fall with the beautiful colors of the leaves.

Greers Ferry Lake

Picture 3 of 19

About 60 miles north of Little Rock, Greers Ferry lake is a reservoir that has become a hotspot for boating on a warm day. As such, it's a wonderful spot to fly a drone, with plenty of interesting shoreline, boats and other things to fly over.

Albert the Bull

Picture 4 of 19

Albert is a bull. A 30-foot tall bull with 15 feet between the horns. He's made of concrete and lives in a park in downtown Audubon, Iowa.

High Trestle Trail Bridge

Picture 5 of 19

Built on the remains of an old railway bridge, the High Trestle Trail is a bike path with a difference. It spans the Des Moines river with remarkable views over the river and surrounding towns, and is illuminated at night.

The Keeper of the Plains

Picture 6 of 19

The Keeper is a huge statue on the grounds of the Mid-American All-Indian Center, which works to preserve American Indian culture and art. It's a remarkable piece of work that dominates the skyline. It is close to a few airports in Withchita, though, so check before you fly over this remarkable sculpture.

Big Brutus

Picture 7 of 19

Big Brutus is big. Damn big. At 160 feet tall and with a 150 feet boom, this massive dip digger dominates the skyline. It's located in a mining museum that also has plenty of other interesting exhibits on the history of mining.

Elephant Rocks State Park

Picture 8 of 19

This park got its name from a geological oddity, a series of granite rocks that look like a family of elephants walking in a line. It makes for a great backdrop for videos.

Worlds second largest rocking chair

Picture 9 of 19

Keep on rockin in the free world with the world's second largest rocking chair, located in Fanning, just off historic route 66. It was the biggest until a larger one was built in Illinois.

Carhenge

Picture 10 of 19

Replicas of Stonehenge were all the fashion once, it seems. This one, near Alliance in Nebraska, is made out of vintage american automobiles, painted to match the dull grey rocks of the original.

Chimney Rock

Picture 11 of 19

Chimney rock is a rock pillar that stands nearly 300 feet high. Located in western Nebraska, the rock was a familiar navigation point for wagon trains heading further west.

Salem Sue

Picture 12 of 19

North Dakota is mostly flat, but standing proud near one of the lumpier bits is Salem Sue, a giant cow. She's the world's largest Holstein sculpture, a 38-foot high tribute to the dairy heritage of the state.

Enchanted Highway

Picture 13 of 19

This 32-mile stretch of highway in the western part of the state is home to some of the largest scrap metal sculptures in the world. There are seven sculptures in total, including "geese in flight" shown in this video.

The Blue Whale of Catoosa

Picture 14 of 19

This charming roadside playground was built when a local businessman wanted to make an unusual birthday gift for his wife. He succeeded by building a large water slide and playground in the shape of a blue whale.

Pops

Picture 15 of 19

No trip down Route 66 would be complete without a visit to Pops, a soda pop store that looks like it just landed outside Arcadia. Come for the 66-foot high LED illuminated soda bottle, stay for the signature collection of over 700 types of soda pop.

Giant Prairie Dog

Picture 16 of 19

If you get sick of the Badlands National Park and their ban on drones, the Badlands Ranch has the antidote: a giant Prairie Dog. This landmark stands proudly along the main road into the park next to the ranch store, where you can also feed live prairie dogs.

Porter Sculpture Park

Picture 17 of 19

The Porter Sculpture park is the home to over fifty sculptures by Wayne Porter which are more frightening than folksy. Visitors are encouraged to climb and take photos with the sculptures of subjects from pink dragons and giant bull heads, and the park welcomes drone users and pets.

Mountains 12 http://www.tomsguide.com/us/pictures-story/832-places-to-fly-drones-mountains.html#s2

Mount Evans

Picture 2 of 15

It's a scary drive to the top of Mount Evans, but it is the highest paved road in the USA, and the highest point in the Colorado Rockies, at 14,240 feet. Be sure to check if the road is open before you start, though: it is closed in winter and for bad weather.

Royal Gorge Bridge

Picture 3 of 15

The highest bridge in the United States, the Royal Gorge Bridge is suspended 965 feet above the Arkansas River, and spans more than 1,200 feet.

Hanging Lake

Picture 4 of 15

It’s a bit of a hike, but if you don’t mind carrying your drone the 1.7 miles along the trail to Hanging Lake, it is worth it. Part of the White River National Forest, this idyllic mountain lake is crystal clear and has some gorgeous waterfalls flowing into it: perfect for exploring with a drone.

Shoshone Falls

Picture 5 of 15

At Shoshone falls, the Snake River plunges more than 200 feet over two waterfalls, complete with a gorgeous overlook that makes for a perfect spot to fly a drone from. Just watch out for the spray from the waterfall.

Perrine Bridge

Picture 6 of 15

Just down the river from the Shoshone falls is the Perrine Bridge, a favorite spot with base jumpers. It’s also a favorite of drone pilots, as it provides some beautiful vistas of the Snake River Canyon.

Thistle Ghost Town

Picture 7 of 15

Thistle was once a thriving town that serviced trains for the railway. After the railway industry collapsed, the town was left abandoned, and is now partly submerged by the shifting course of the Thistle Cree

Wahweap Hoodoos

Picture 8 of 15

A Hoodoo is a weathered pillar, made when soft rock is eroded by weather to leave behind a pillar of harder rock. It’s a serious hike to reach the Wahweap Hoodoos, but they are stunning when you finally reach them.

Bighorn Medicine Wheel

Picture 9 of 15

The origins of this historic monument are uncertain, but it’s a striking site to look at from the air.

Devils Tower

Picture 10 of 15

The Devils Tower National Park is, unfortunately, off-limits to drones, as the National Park Service doesn’t allow them. It is possible, however, to get a great view by flying outside the park, or, if you like to live dangerously, take off from outside and fly over the park...

Shoshone National Forest

Picture 11 of 15

With 2.4 million acres of ground to cover, you could spend your entire life flying over the Shoshone National Forest and still not see it all.

Garnet Ghost Town

Picture 12 of 15

In 1898, a thousand people called Garnet, Montana home. Now there are none: it's a perfectly preserved ghost town. As well as the town itself, the area has lots of trails through the Garnet mountains.

Earthquake Lake

Picture 13 of 15

As the name suggests, Earthquake Lake was formed after a 1959 earthquake that measured a ground-moving 7.3 on the Richter scale. The quake blocked the flow of the Madison River, forming this 6-mile long lake. Just make sure you aren't flying above it when the next quake comes.

Pacific 11 http://www.tomsguide.com/us/pictures-story/834-places-to-fly-drones-pacific.html

Prince William Sound

Picture 2 of 14

Wildlife and drones don't usually mix well, but whales are an exception. They aren't bothered by things flying in the air, and you can sometimes get incredible shots of them. AkxPro managed to shoot this remarkable video of Humpback whales feeding in Prince William Sound, Alaska by flying his drone off a whaling boat. The whales are co-operating to confuse the fish with bubbles, then lunging up to swallow them by the huge mouthful.

Flattop Mountain

Picture 3 of 14

Flattop mountain is a 3,350-foot high mountain just outside Anchorage, which makes it one of the most climbed mountains in Alaska. Ian Borowski decided to drag a drone to the top of this and the neighboring Peak 2, and was lucky enough to get calm weather at the top: perfect for flying his Phantom 3 and taking some gorgeous video of the sun setting.

The Blythe Intaglios

Picture 4 of 14

The Blythe Intaglios are a series of huge petraglyphs, rock carvings that are 171 feet tall. They are, according to the Bureau of Land Management, "best viewed from the air", which seems like a perfect excuse for a drone flyover.

Salvation Mountain

Picture 5 of 14

Created by eccentric loner Leonard Knight, Salvation Mountain is a, well, painted mountain. Living out of a truck, Knight created this monument out of donated house paint over many years. He died in 2014, but the work has been preserved and extended by fans since then.

Port San Luis

Picture 6 of 14

North of Los Angeles is a quiet town called Port San Luis. With a gorgeous beach and a point that juts out into the pacific, it's a perfect spot to capture atmospheric sunsets.

Morro Bay

Picture 7 of 14

With gorgeous beaches and a rock outcrop just begging to be flown over, Morro Bay is a perfect spot for flying a drone.

Haiku Stairs

Picture 8 of 14

The Haiku Stairs (AKA Stairway to Heaven) is a set of stairs that was originally built to reach a radio station on a local mountain. The stairs have been closed to hikers since 1987 as they aren't safe. You can reach parts of them by drone, though, and local resident Doctor Rennie has done just that to film the stairs from top to bottom. Watch out if you want to try this, though: parts of the stairs are within the restricted airspace of the local Marine Corps airbase, and they don't appreciate rogue drones flying nearby.

Sandy Beach Park

Picture 9 of 14

The government of Hawaii doesn't allow drones in many of its parks, which makes many of the most beautiful places there no-fly zones. They do allow flying in the Sandy Beach Park, though, which is also one of the best body surfing spots on the islands.

Fort Rock

Picture 10 of 14

High in the Oregon desert, Fort Rock is the imposing remains of a magma eruption into a lake bed millions of years ago. The magma pushing against the lake bed created this unusual formation, which resembles a prehistoric fort. Hence the name, and a great spot for flying drones.

Proxy Falls

Picture 11 of 14

The Willamette National Forest in Oregon is full of waterfalls, with one of the most picturesque being Proxy Falls. It’s a tight spot to fly, though: overhanging trees and the steep wall that the falls come off requires some careful flying.

Abandoned Tillamook Railroad

Picture 12 of 14

John Gustin found an awesome spot to fly his drone: an abandoned railway line, complete with overgrown bridges, abandoned railway cars and its own waterfall. It looks like something of a hike to get there, but worth it...

Southwest 8 http://www.tomsguide.com/us/pictures-story/837-places-to-fly-drones-southwest.html

Winslow Meteor Crater

Picture 2 of 11

Fifty thousand years ago, a small meteor hit Arizona, leaving a crater a mile wide. It’s a wonderful spot to fly a drone and ponder on your own insignificance in the face of cosmic forces, then enjoy the air conditioning in the visitors center. John Coggi took this great video of the crater, flying his Phantom 3 over the rim to show the immense size of this crater.

Red Mountain

Picture 3 of 11

Drones aren’t allowed in national parks, which means no flying in the Grand Canyon. Just south of this, though, is Red Mountain, part of the Kaibab National Forest north of Flagstaff, which does allow drones on much of the land it manages. Red Mountain is a dramatic spot that rises out of the barren landscape, and a great place to fly, as YouTube user Cvedeler found out.

Zephyr Cove

Picture 4 of 11

Just up the shoreline from Tahoe City, Zephyr Cove is a great place to fly a drone away from airports and other problems. You can also get some great views of the paddle steamers that take tourists out onto the lake.

The International Car Forest of the Last Church

Picture 5 of 11

Part art project, part religious statement, the International Car Forest of the Last Church is certainly striking. It’s a forest of old cars and buses, buried in the Nevada desert and painted.

Pistachioland

Picture 6 of 11

Just off US-54 is the nuttiest place in the USA, the Pistachio Tree Ranch & Arena Blanca Winery. To help people find this location, the owners built the world's largest pistachio. Once you are sick of flying around this 30-foot tall pistachio nut, you can stop into the gift shop and buy some... Pistachios.

Lake Las Vegas

Picture 7 of 11

Although it is overshadowed by its bigger downstream brother Lake Meade (which is a national park, and is off-limits for drones), Lake Las Vegas has its charms. This small lake is surrounded by high-end resorts and golf courses for the elite of Las Vegas, so fly carefully.

Stonehenge II

Picture 8 of 11

This fiberglass replica lacks some of the grandeur of the original, but it is an impressive replica of what it might have looked like in its heyday. The replica was built by a local farmer, but was moved to land owned by a local arts foundation when the builder sold his land. The foundation has plans to add a dance floor, which was not part of the original Stonehenge.

SS Selma

Picture 9 of 11

Just off the Seawolf Park on Pelican Island, Galveston is the remains of the SS Selma, a prototype concrete ship that was scuttled here in 1920 after it was damaged. Now, it serves as a great target for local drone users looking for an interesting subject.

Top 10 Places to Fly a Drone in LA

https://blog.hivemapper.com/top-10-places-to-fly-a-drone-in-la-c6b63540864e#.3xtklmyju

Fly with Hivemapper across Los Angeles

Rose Bowl Lot H Field, Pasadena, CA

This field in front of the Rose Bowl doesn’t even have a proper name, but is well known by drone flyers near Pasadena. As the field is usually pretty empty, this is a perfect place to practice low flying, or, of course, to capture great shots of one of the most iconic American sports stadiums of all time.

Elysian Park, Los Angeles, CA

Up in the hills overlooking Dodger Stadium is Elysian Park. Here, there’s plenty of space and open terrain to fly over, including a great, safe vantage of Downtown LA without flying over any freeways or congested areas. If you’re flying a DJI drone with recent firmware, you’ll be unable to get too close to Dodger Stadium as DJI has designated MLB and NFL stadiums as no-fly zones, but you can still get good shots while staying safe.

Griffith Park, Los Angeles, CA

For unrestricted flights and a dash of solitude, check out Griffith Park. With attractions like the Griffith Observatory and the Greek Theatre, there's plenty of destination flying to be had— or you can just cruise aimlessly, enjoying the wide open expanses of this urban oasis.

Lake Hollywood Park, Los Angeles, CA

Looking for a great launch point to capture the Hollywood Sign? This is it. It's just a nondescript patch of grass, but this one is all about location, location, location. Besides being just a short flight from the Hollywood Sign, you can also capture greats shots of the Hollywood Reservoir with Downtown LA off in the distance.

Echo Park Lake, Los Angeles, CA

Gorgeous lake that sits in front of the Los Angeles skyline. There's plenty of space around the perimeter to launch and operate from. Great for revealing shots of the city as your drone starts low and just barely clears the spouting fountain.

Hermosa Beach Pier, Hermosa Beach, CA

Hermosa Beach Pier is one of the few major beach areas in all of Los Angeles County that isn't within a five-mile radius of an airport. In fact, it lies concurrently just outside the five mile-radius of three different airports. Get all your gorgeous shots of crashing waves, surfing displays and picturesque LA sunsets here without worry of violating FAA dictates.

Agua Amarga Canyon, Palos Verdes Estates, CA

Agua Amarga Canyon is the perfect perch from which to explore the elevated coastline and palatial estates of Palos Verdes. No need to hike down to the bottom—just pull over and launch from the cliff's edge.

Exposition Park, Los Angeles, CA

Perhaps the highest concentration of interesting places to explore in LA resides here. Flying from Exposition Park not only provides revealing views of its fascinatingly symmetrical rose gardens, but also easy access to the Natural History Museum, California Science Center and Los Angeles Memorial Coliseum, among other attractions. Get here early to avoid crowds.

Topanga State Park, Topanga, CA

A bit of a trek from the city, but worth it if you're looking to get away from civilization for a while. Sprawling grasslands framed by unique rock formations make this essential territory to explore by drone.

Santa Monica Pier, Santa Monica, CA

Caution on this one. The Santa Monica Pier no doubt provides some of the coolest visuals in the LA area, but it's also potentially a trouble spot. There doesn't seem to be many officials aware of the rules, however. This past weekend, I asked a couple Santa Monica police officers next to the Pier if I was ok to fly my Phantom and they said they weren't aware of any reason why I couldn't. If you do choose to fly here, you are required to let the Santa Monica Airport control tower know by giving them a call at 310–458–8591, as the Pier is within five miles.