ANOMALOUS UAV ACTIVITY

in Houston Metropolitan Area

AUGUST 2021 THROUGH AUGUST 2022

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ANOMALOUS UAV ACTIVITY IN HOUSTON METROPOLITAN AREA

Revision History

VERSION	AUTHOR	DATE	RATIONALE
1.0	D. Kovar	08/07/22	First draft
1.1	D. Kovar	08/09/22	Second Draft

OVERVIEW

URSA conducted a one-year study of UAV activity in the Houston metropolitan area. Stating that the skies over Houston are busy is an understatement – over 14,000 unique drones performed over 75,000 flights from August 2021 through August 2022. (However, 14,830 of those flights never moved, so there are a total of 61,136 actual flights.) During the same period there were at least 750,000 manned aircraft operations at the various airports in the region.

The majority of drone operations appear to have complied with published regulations, laws, and guidelines.

81%

OF THE FLIGHTS STAYED BELOW 400 FEET AGL

84%

OF THE FLIGHTS TOOK PLACE DURING DAYLIGHT HOURS

HOWEVER, ONLY

28%

OF THE FLIGHTS STAYED WITHIN RELIABLE VISUAL LINE OF SIGHT FOR THE ENTIRE FLIGHT.

THE REPORTS

This is the first of three reports covering the anomalous UAV activities in the Houston area. This report covers UAVs and what they flew over and around, including prisons, heliports, and critical infrastructure. It also covers various types of non-compliant operations, such as the operator being beyond the visual line of sight of the drone, flying above 400 feet or above LAANC grid ceilings, or one-way flights.

The second report covers NMAC events, or near mid-air collision events. The FAA NMAC definition is:

> **"A NMAC is an incident associated with the operation of an aircraft in which a possibility of a collision occurs as a result of proximity of less than 500 feet to another aircraft, or a report is received from a pilot or flight crew member stating that a collision hazard existed between two or more aircraft."**

Unfortunately, we have only human observations available to document NMAC events, until now. This second report combines ADS-B, manned aircraft data, with UAV track data to identify when UAVs and manned aircraft were in close proximity to each other. The number of close approaches between UAVs and manned aircraft is, unfortunately, significant operation. We look forward to collaborating with officials or private sector investigators to run these incidents to ground and to perform similar research for other regions.

The third report looks at close approaches between UAVs and ships. We have investigated UAVs interacting with various types of ships on an individual basis in the past. This is our first opportunity to combine commercial maritime track data from AIS with UAV track data in volume.

All of the anomalies identified in these reports are just that – anomalies. They all require additional investigation in order to conclusively determining the nature of the UAV operation. We look forward to collaborating with officials or private sector investigators to run these incidents to ground and to perform similar research for other regions.

LEGAL CONSIDERATIONS:

BEFORE DIVING INTO THE DATA AND ANALYSIS, WE MUST INCLUDE THE FOLLOWING:

DISCLAIMER OF WARRANTY. THE SERVICES AND DATA MADE AVAILABLE ARE FURNISHED AS IS, WHERE IS, WITH ALL FAULTS AND WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE.

URSA'S AAP-NMAC PLATFORM

In plain English, before drawing any conclusions it is very important to understand the nature of the data, how it is generated, how it is analyzed, and the overall context. Then, and only then, may we start drawing conclusions.

URSA's Airspace Awareness Platform + NMAC (AAP-NMAC) was developed to support FAA research into unmanned UAV activity in the low altitude National Airspace. Led by Associate Professor Ryan Wallace of Embry-Riddle Aeronautical University, the ASSURE A50 project used AAP-NMAC to produce the first of three annual reports for the FAA on this topic.[1]

AAP-NMAC uses what is commonly known as counter UAS (CUAS) data as the primary source for UAV behavior and metadata. URSA's vendor and source agnostic ability to unlock valuable insights from often expensive CUAS data is unique in the industry and puts us on the leading edge of efforts to focus on broader airspace awareness issues.

ANOMALOUS UAV FLIGHTS IN HOUSTON AREA

This report focuses on the anomalous UAV activity in the Houston area. The FAA report cited above provides extensive documentation on the normal activity of UAVs in the national airspace, including Houston.

THE DATA

Our website covers all the types of data used by the platform. For these reports, all the data types were used. The graphic on the first page shows the areas covered by the three main types: UAV, manned aircraft, and commercial marine vessels. Please note that the UAV data covers a full year from August 2021 through August 2022 but the ADS-B data and AIS data only cover January 2022 through June 2022.

The time span for the UAV data covers unequal parts of 2021 and 2022 so comparisons between the two years do not represent equal time periods.

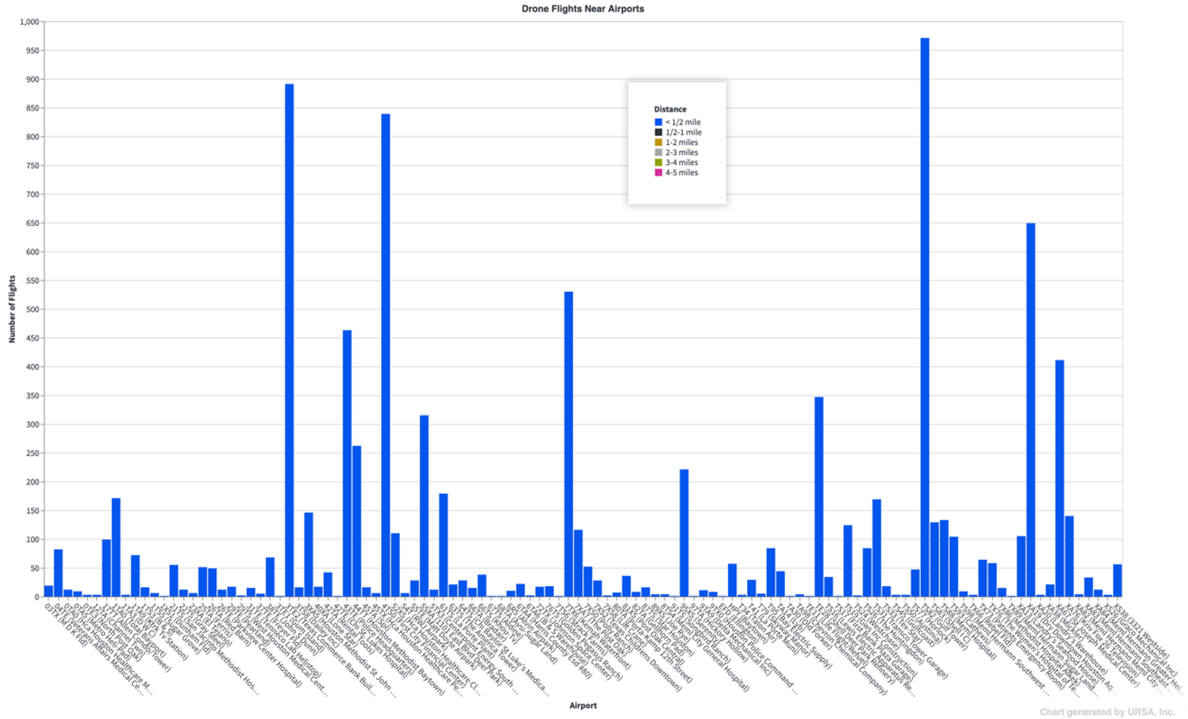
AIRSPACE

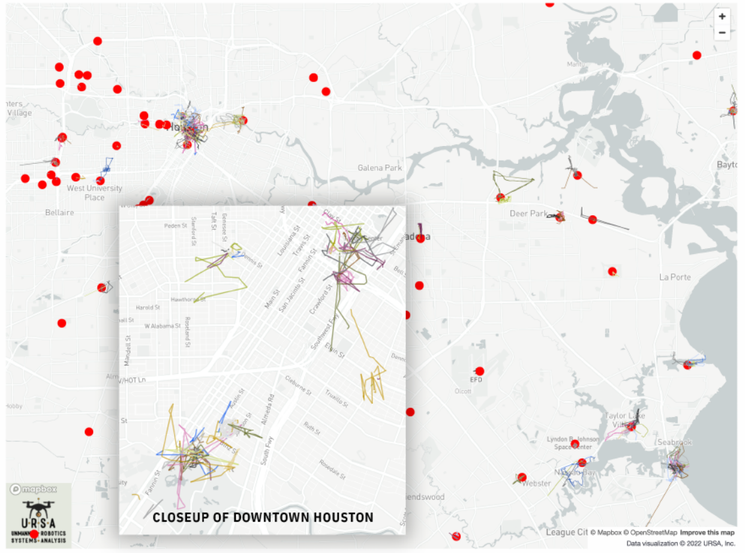
This first section covers airspace issues – high altitude flights, possible LAANC violations, anomalous high altitude flights, and flights near heliports and airports. (Flights near manned aircraft are covered in the second report.)

Wallace, R.J., Terwilliger, B.A., Winter, S.R., Rice, S., Kiernan, K.M., Burgess, S.S., Anderson, C.L., De Abreau, A., Arboleda, G., & Gomez, L. (2022). Small Unmanned Aircraft Systems (sUAS) Traffic Analysis: Initial Annual Report [Grant No. A11L.UAS.91]. Alliance for System Safety Through Research Excellence (ASSURE), Federal Aviation Administration.

CLOSE APPROACHES TO HELIPORTS AND AIRPORTS

Houston, like most major urban areas, has a significant number of heliports and any UAV flight downtown will fly near at least a few heliports. The heliport at the Gulf Tower had nearly 1,000 UAV flights within half a mile of it.





Many of these heliports are rarely used but others, such as ones located at major hospitals, support significant volumes of traffic.

The landing and takeoff phases of any flight involve the least margin for error or interference, and a UAV operating near a manned helicopter on approach to a medical center's helipad poses significant risk. Even if the pilot notices the UAV operating in the area that may be sufficient reason to go around or divert, delaying access to advanced medical care by precious minutes.

It is impossible to determine how many flights near heliports and airports are conducted by operators who are aware of their surroundings and are coordinating with the manned aircraft operations in the area. This is one of many areas requiring additional research.

POSSIBLE LAANC VIOLATIONS

LAANC is the Low Altitude Authorization and Notification Capability that provides UAV operators permission to fly in certain areas known as "LAANC grids". Each grid has a maximum altitude above which a LAANC waiver is required to fly. The grids closest to airports are often "zero grids", meaning that any flight more than 0 feet above the ground requires approval.

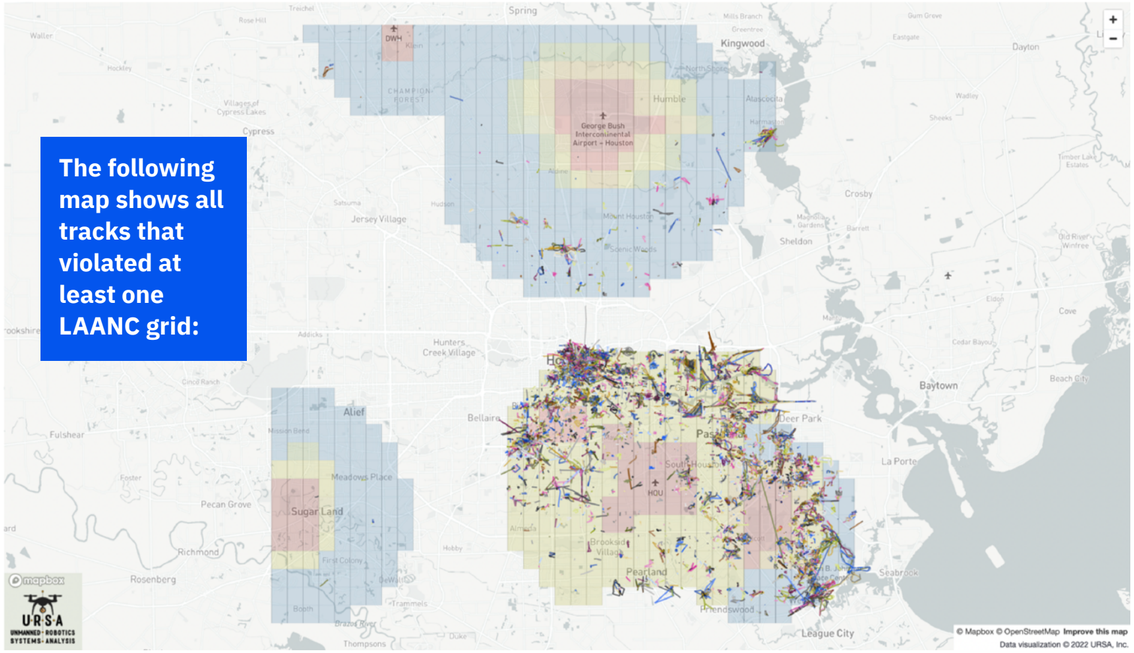
The following chart shows all of the flights that exceeded at least one LAANC grid. What we do not know is how many of these flights received approval to do so.

OUT OF 75,949 FLIGHT(S) FLOWN BY 11,886 DRONE(S) IN THE DATASET:

- **13,560 FLIGHT(S) (17.9%)** VIOLATED THE CEILING FOR A LAANC GRID 18,933 TIMES.
- **8,184 FLIGHT(S) (10.8%) FLOWN BY 2,248 DRONE(S)** FLEW SOLELY ABOVE THE GRID CEILING IN AT LEAST ONE LAANC GRID AREA.
- **11,509 FLIGHT(S) (15.2%) FLOWN BY 3,578 DRONE(S)** FLEW IN AT LEAST ONE LAANC GRID AREA, BUT REMAINED BELOW THE GRID CEILING.
- **5,376 FLIGHT(S) (7.1%) FLOWN BY 2,082 DRONE(S)** FLEW BOTH ABOVE AND BELOW THE GRID CEILING IN AT LEAST ONE LAANC GRID AREA.
- **50,880 FLIGHT(S) (67.0%)** DID NOT FLY THROUGH ANY LAANC GRID AREAS.

17.9%

OF ALL UAV FLIGHTS IN THE HOUSTON AREA WOULD HAVE REQUIRED LAANC APPROVAL TO LEGALLY CONDUCT THE FLIGHT OPERATION.



BEYOND (REASONABLE) VISUAL LINE OF SIGHT

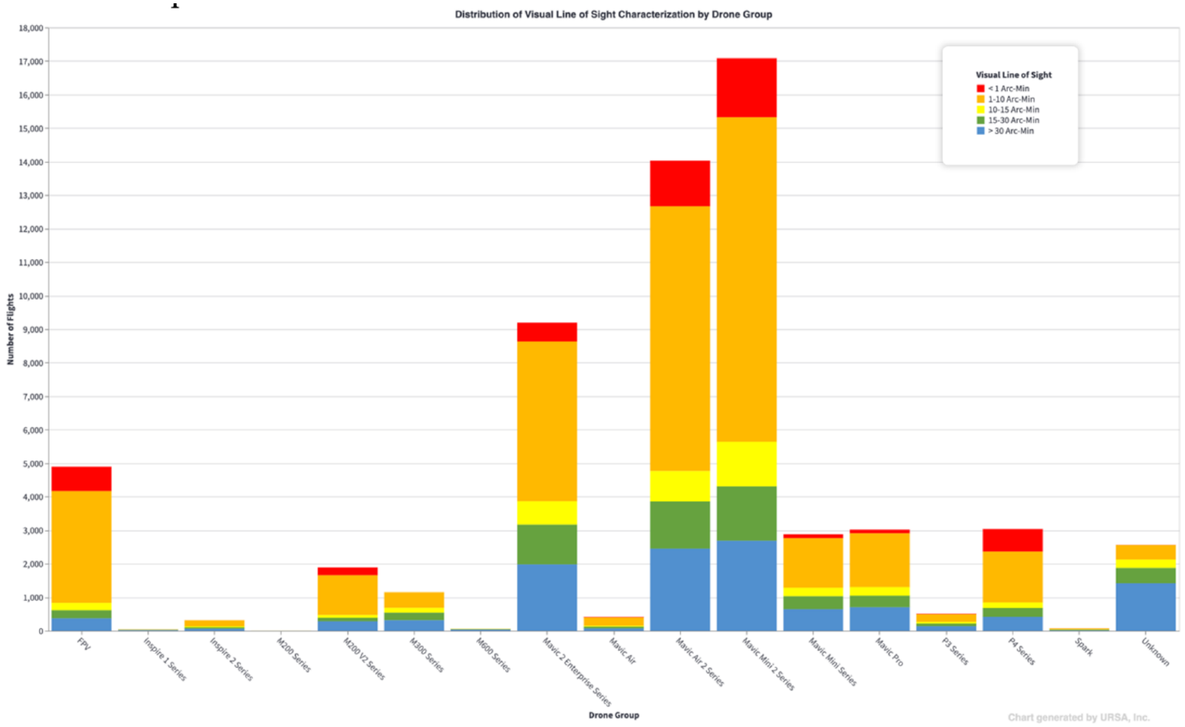
Ryan Wallace identified an approach to determine the maximum distance that each UAV model could be seen with unaided human vision. In cases where the data contained the pilot's location, the type of drone, and the furthest location of the drone from the pilot, we could use this approach to determine if the flight was operating beyond visual line of sight.

A significant number of flights did operate BVLOS. It is possible that they had a waiver, or were using a series of visual observers, in some cases.

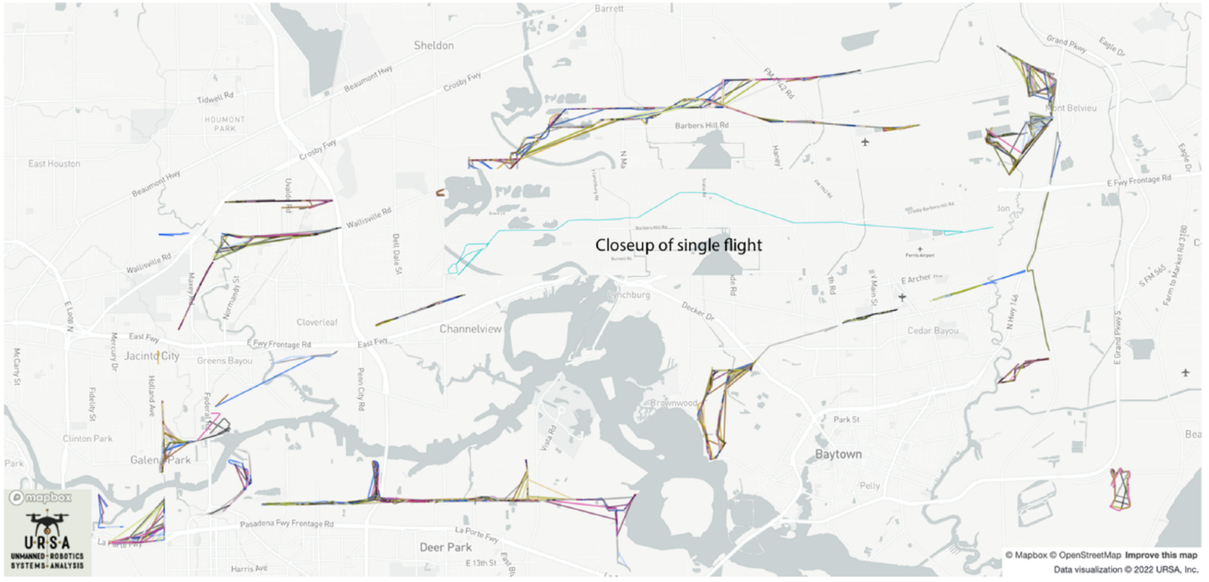
In the charts below, anything red, orange, or yellow would either be undetected or detected but not recognized. Red is less than 1 arc minute, orange is between 1 and 10 arc minutes, and yellow is between 10 and 15 arc minutes.

BEYOND (REASONABLE) VISUAL LINE OF SIGHT

The most common BVLOS drones were the Mavic Mini and Mavic Air, followed closely by the Mavic 2 Enterprise and the new FPV model.



One standout in the data is a M200 V2 which conducted 707 flights over the course of this study. 112 of those flights flew more than 10,000 feet from the operator, including near or over airports. Based on the UAV model and flight tracks, these were probably commercial inspection flights.

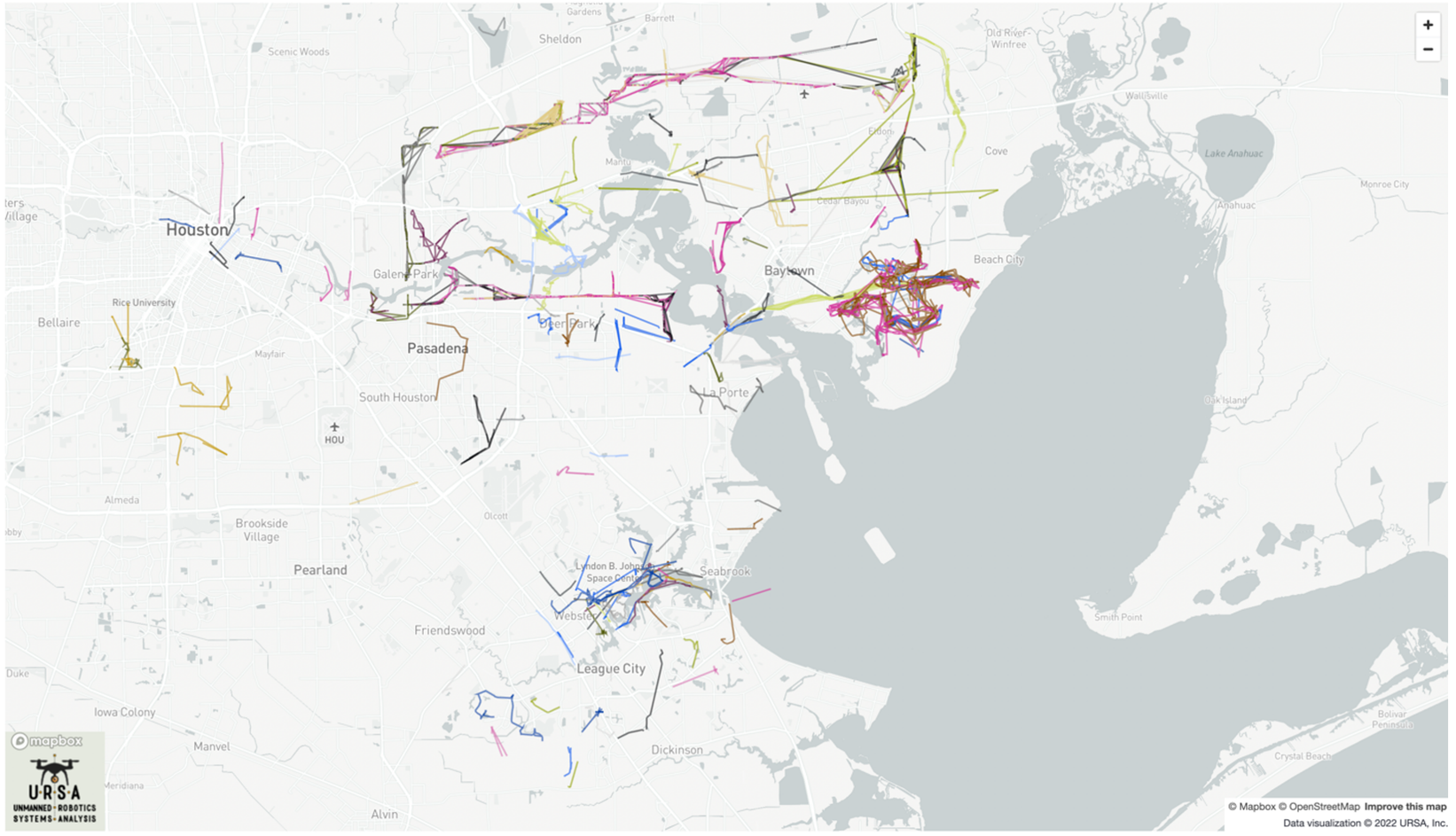


"ONE WAY" FLIGHTS

A "one way" flight is one that does not end in close proximity to where it began. We often see these on the ocean or rivers due to UAVs filming boats in motion. Others are due to data errors where the sensor "saw" one leg of the flight but not the other. Some are "fly aways" or flights where the operator ignored the low battery warning and had to land before the UAV could return to the launch site.

All of these examples are present in this subset of the activity in the Houston area but other flights do not fall into any of these categories and bear additional investigation. For example, the flights over the Space Center only have location data outside of the boundaries but the flight's duration is long enough to have flown over the facility – there appears to be a data gap in the middle of the flight. The same UAV conducted other flights on the edge of the facility.

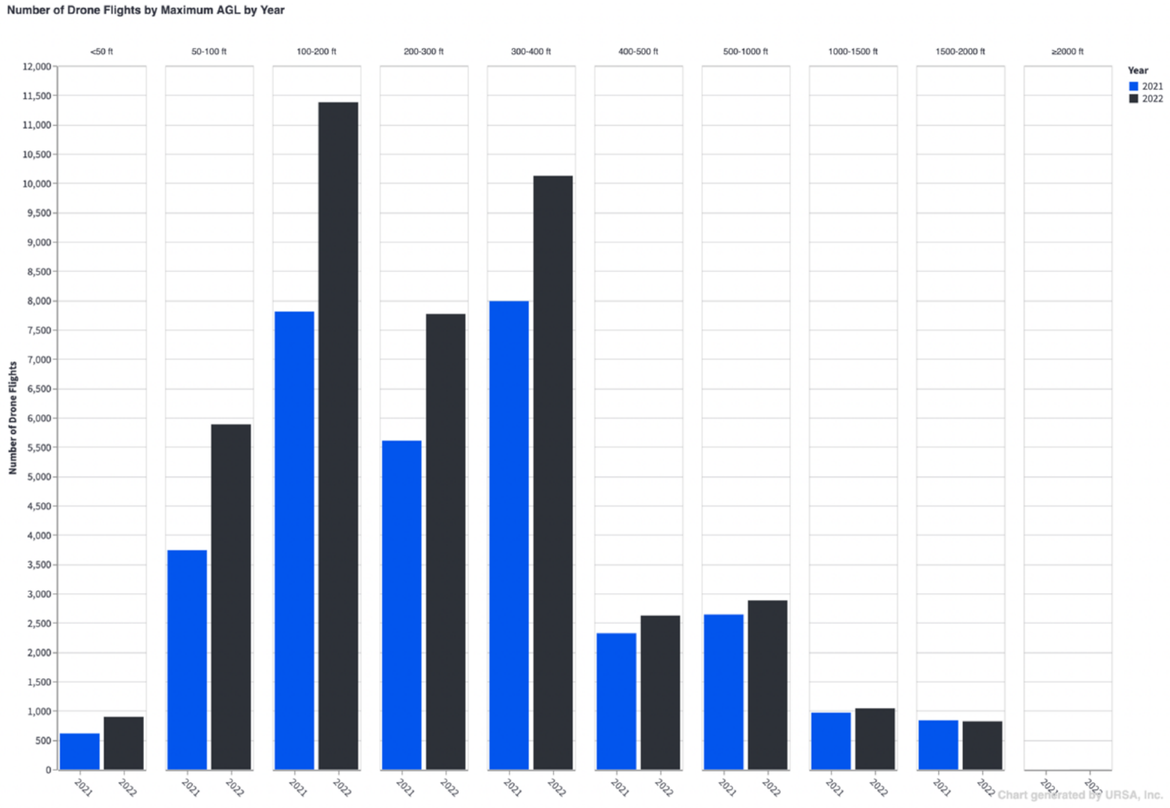
Many of the flights north and east of the downtown in pink appear to be legitimate flights though possibly at low altitude.



HIGH ALTITUDE FLIGHTS AND MOTIONLESS "FLIGHTS"

Overall, 81.4% of the flights were below the FAA-prescribed maximum height (AGL) of 400 feet. Remarkably few exceeded 1,500 feet AGL. (The anomalous flights discussed below were excluded from this chart.)

However, here is a group of anomalous "flights" that require discussion and investigation. "Flights" is in quotes because the UAVs involved appear at altitude, remain relatively stationary, and then disappear from the data. Did something mask their ascent and decent from altitude? Are the UAVs involved failing to transmit the identifying data for some reason, except at altitude? Is this data synthetic, or "spoofed"?



HERE ARE SOME EXAMPLES:

1. A Mavic Air 2S conducted nine flights over a six month period, most of which appeared to hold position and altitudes ranging from 300 feet above ground level to 8,000 feet AGL. Further, the only data points for each flight were for the position at altitude, there was no data for a climb to or descent from altitude.

   All the flights occurred in one of three locations.

2. A DJI FPV drone held position at an altitude of 4,251 feet and then appeared at 4,875 feet two seconds (one internal clock tick) later. It then descended to 4,096 feet AGL in a single clock tick.

   There was no data showing it climbing to altitude or descending.

3. Two more Mavic Air 2S and a second FPV demonstrated the same behavior along with a Mavic Mini 2.

4. A M300RTK appeared at 2,163 feet AGL, held altitude with some minor horizontal movement, and then vanished three minutes later.

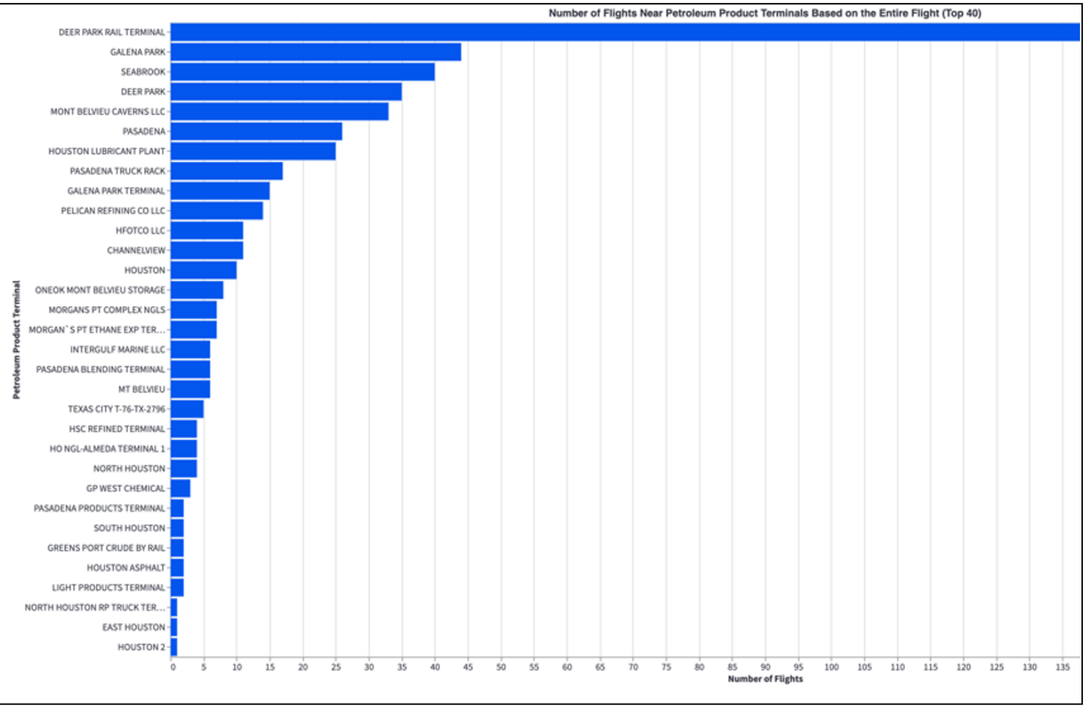
FLIGHTS NEAR CRITICAL INFRASTRUCTURE

There are an enormous number of critical infrastructure sites in the Houston area, many associated with petroleum or other energy production and storage functions. It may be hard to fly in the area without approaching critical infrastructure. The number of sites also creates challenges for visualizing the data in a meaningful way. We focus on a few types of facilities. If you are interested in analysis relating to other facilities in the Houston area, please get in touch.

FLIGHTS NEAR PETROLEUM PRODUCT TERMINALS

The map on the left shows all the drone flights that flew within 500 feet of a facility identified as a petroleum product terminal. The chart on the right shows how many flights occurred within 500 feet of a facility. Both suggest that there is reason for concern.

A small number of drones performed most of the flights on the map. Further, they only flew near critical infrastructure. This suggests, though does not prove, that they were operated by inspectors working with the facilities. The details behind the chart on the right are similar – a single drone performed 90% of the flights near Deer Park and three drones performed the vast majority of the flights near Deer Park Rail Terminal.



FLIGHTS NEAR PETROLEUM PRODUCT TERMINALS

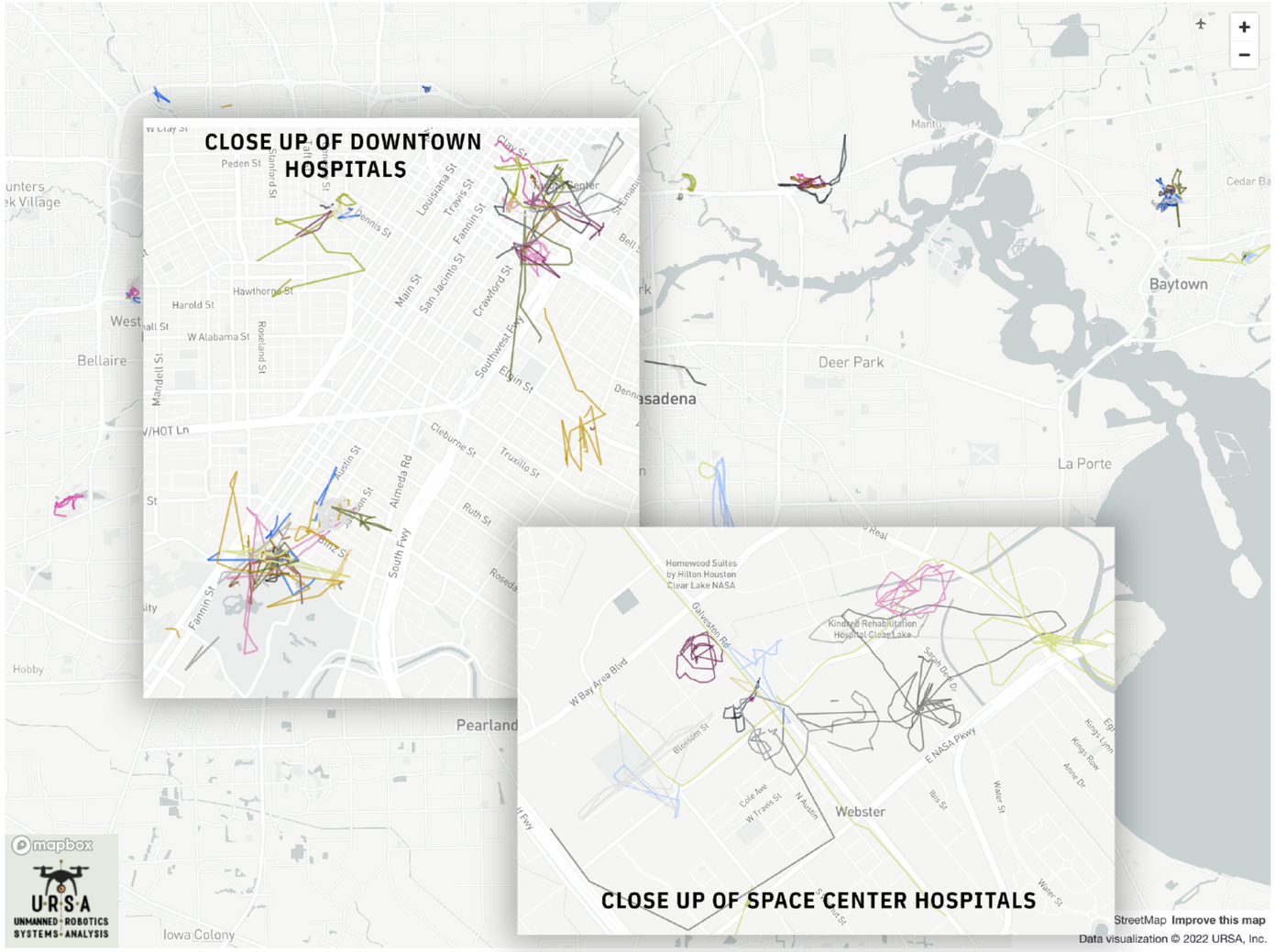
A problem is that the anomalous flights hide in the noise and investigators need to look on the edges and in the gaps. For example, this UAV appeared in the Houston data set only on a single day. It flew four flights in one hour and then never flew again in the area.

These are just a few examples that highlight the importance of combining UAV subject matter experts with investigators with extensive local knowledge of what is, and is not, normal.

FLIGHTS NEAR HOSPITALS

There were 279 UAV flights that passed within 500 feet of a hospital. The density of flights in the downtown area and the hospitals account for some of the identified traffic but clearly other flights were specifically over hospitals.

The two insets provide a closer view of the flights downtown and flights near the Space Center.



CONCLUSION

The material you just read offers a small window onto the activity of DJI UAVs during a single 12 month period in just one urban area. There is clearly a lot more work to do if we as a community truly want to understand the normal and the malicious UAV activity in the national airspace.

OUR DATA PROVIDERS

Much of the data used is open source – weather, land use, geospatial, etc. However the critical vehicle track data – UAVs, manned aircraft, and commercial shipping – comes from our excellent vendors who built incredible companies to collect and distribute this critical data.

PROVIDER OF UAV / DRONE DATA

Airguard is a leading airspace security software for drone detection. The AirGuard platform arms your team with real-time airspace security against rogue drones providing visibility and integration with existing security systems. AirGuard is a layered open platform software that integrates with electronic drone-detection technologies like radio Frequency (RF) sensors, Directional finding sensors, and 3rd party specialty drone Radars and cameras in order to provide your team with the most comprehensive and advanced airspace security.

To learn more, visit www.Airsight.com

PROVIDER OF ADS-B MANNED AIRCRAFT DATA

The OpenSky Network is a non-profit association based in Switzerland. It aims at improving the security, reliability and efficiency of the air space usage by providing open access of real-world air traffic control data to the public. The OpenSky Network consists of a multitude of sensors connected to the Internet by volunteers, industrial supporters, and academic/governmental organizations.

To learn more, visit https://opensky-network.org/

PROVIDER OF AIS COMMERCIAL SHIPPING DATA

Spire Global, Inc. (NYSE: SPIR) is a leading global provider of space-based data, analytics, and space services, offering access to unique datasets and powerful insights about Earth from Space so that organizations can make decisions with confidence, accuracy, and speed. Spire uses one of the world's largest multi-purpose satellite constellations to source hard to acquire data and enriches it for the maritime, aviation, and weather industries.

To learn more, visit http://spire.com.

APPENDIX 1: DATA VALIDATION AND CLEANING

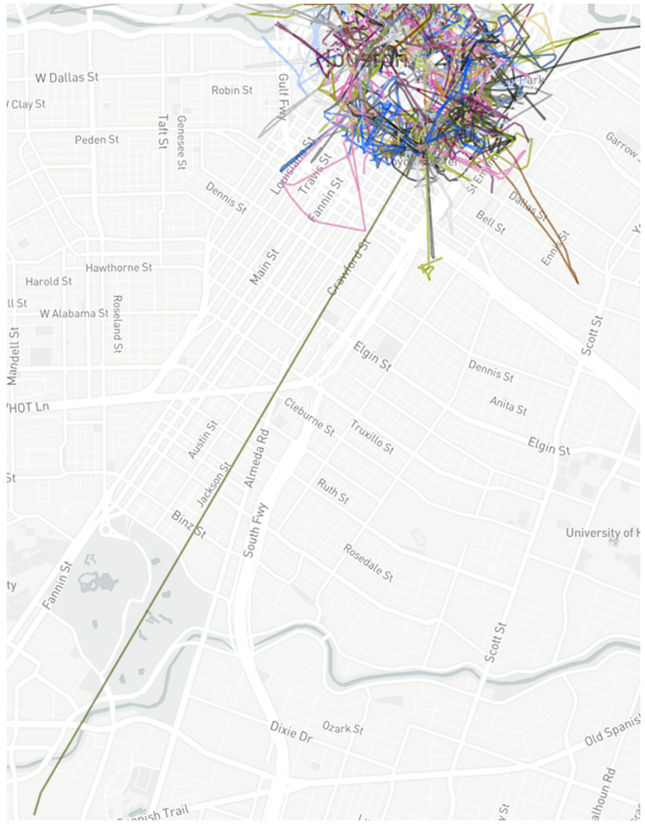
The data describing the drone operations is very noisy due to many factors. The drone may not always transmit data, data may not get to the receiver due to radio signal propagation issues, and sometimes either the drone or the receiver simply does odd things with the data.

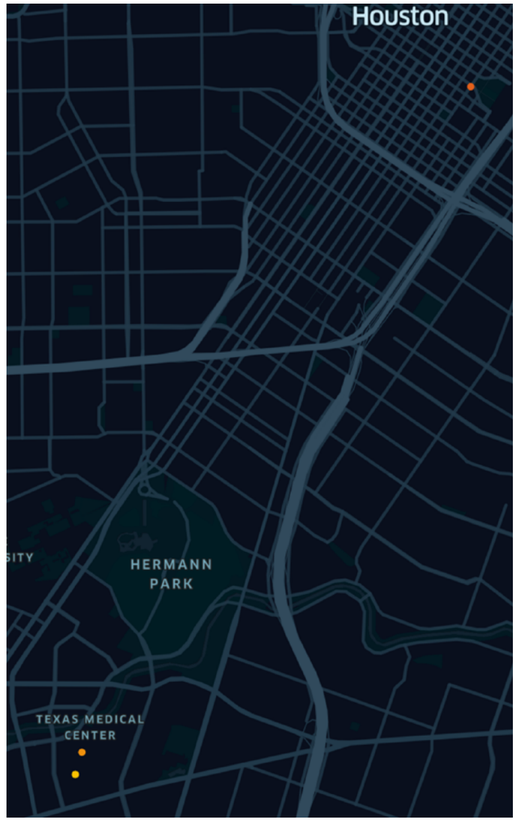
HERE IS AN EXAMPLE:

A human and a computer algorithm will interpret that flight as a likely one-way flight into or out of the urban core of Houston.

The computer will also determine that this was a very high-speed flight and might assign it a high threat classification based on the "fact" that the data shows a small drone traveling at high speed towards downtown Houston.

The computer, and the human looking at the computer's visualization of the flight, are arriving at a conclusion that is not supported by the data.





HERE IS A DIFFERENT REPRESENTATION OF THE DATA:

The two points in the lower left represent a total of 81 data points all at the same two locations and at the exact same altitude. The third point in the upper right represents 53 points all at that location and all at the same altitude.

There is a three minute and fifty-six second gap in the timestamps between the lower left and the upper right. The distance between those two points is 4.2 miles.

Somehow, that drone traveled at 64 mph in metro Houston but due to the gap in the data we cannot draw any sound conclusions on how, or why. Collaboration with local investigators is important for resolving this specific problem and identifying similar problems in the future.

Which brings us to the importance of tagging data for both investigative purposes and for cleaning purposes. Investigating anomalous UAV flights is important for the entities involved in the specific flight and is also important for our community's understanding of sUAS activity across the country.