UAV Detection and Mitigation

Available Technologies and Solutions to Defend from UAV-Based Threats.

Technical Brief

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1 The Proliferation of UAV's

Unmanned Aerial Vehicles (UAVs), also known as Drones have become the latest technology to see rapid growth in capabilities over the past few years. Outside of military usage, commercial UAV's continue to proliferate, from "hobbyist toys" to recognized contributors of organizations. Today, UAVs can be used for search-and-rescue, media access, first responder assistance and surveying/mapping applications. However, they can be used for nefarious purposes as well, requiring the many security and law enforcement organizations to become diligent of what is flying in their airspace. There are documented cases where UAV's have assisted prisoners escape with tools and cell phones, videos of UAV's equipped with spy cameras, guns, and even explosives. In fact, in February 2016 the FAA senior advisor on UAV Integration was quoted "The explosive growth of the unmanned aircraft industry makes evaluating detection technologies an urgent priority".

We hope this paper will provide the reader with some analysis of the systems and technologies that are being enlisted to aid in the discovery of both the UAV and the operator. We are focused on Commercially off the Shelf (COTS) solutions available today, understanding that there are solutions from large military contractors, that becoming more mature and more cost effective, and may eventually reach the commercial availability.

2 The Detection Technologies

We begin with the discussion of the sensor technologies utilized by the majority of systems, as each sensor type has finite limits in their accuracy, effective range, and robustness.

Our research has shown there are primarily 7 types of sensors that are being used in the detection of UAVs. They include acoustic, visual, radio frequency (RF), RADAR, LADAR, LiDAR and thermal imaging. Most, if not all of these technologies, "locate" the UAV and, in some case the operator as well. The following will provide overview of each type as they relate to their capabilities and efficiency.

Acoustic Detection

Acoustic sensors operate on the ability to hear and recognize sounds that emanate from UAVs. It does this by comparing the received sound waves of the UAV to a database of UAV known sounds. While acoustic sensors have the ability to not only detect, but to also identify, they have their limitations. Their detection range is limited (typically no more than 40M) and certain environmental conditions and ambient noise will make detection difficult. These include noisy locations such as airports, heavily populated areas, and in cases where multiple drones are present it may be impossible to differentiate between multiple UAVs. The current acoustic sensors cannot be used to locate a detected UAV, however there are some efforts to use similar technology that is used to locate gun fire in cities, to aid in the locationing of UAVs.

Visual Sensors

Visual sensors (cameras) provide the most user-friendly input and output to detection of UAVs. There is always an advantage in seeing the threat, as opposed to just knowing it is there. As camera technology continues to evolve In resolution, distance, and mobility, these advances will result in better effective range and drone recognition when combined with an associated object tracking and image comparison software. COTS visual sensors typically have an effective range of 100M to 300M depending on the quality of the camera and lens. While weather will have an effect on this range, typically cameras will provide that important visual confirmation of the threat, thus enabling mitigation efforts to focus on the area of discovery versus a general alert found with acoustic methods. One limitation related to visual sensors includes the need for precise calibrations of the field of view. Without establishing predetermined visual landmarks as a basis of distance, visually locating a drone will be difficult. As the UAV market diversifies and more drones come available, new images will be required to insure an up-to-date detection database for identification, so

it is important that any systems selected have the ability to update their databases, or develop a machine learning ability. This would apply to all technologies where there is a comparison between the detected UAV and stored files, whether visual, audio or other types.

Radio Frequency

Radio Frequency (RF) sensors can provide early threat awareness to a complete x, y locationing of a UAV and, in some cases the operator of the UAV. There are industry standards and FCC compliance requirements of all commercial UAVs. When a UAV is compliant to the standards, it can be easily identified and tracked using RF sensors. There are different RF sensors, some will only provide the warning, while others will provide both warning and locationing. Locationing typically will require more than one sensor, to be accurate. Most COTS RF Sensors have shown ranges from 500 to 1500M, with some military sensors having a range of up to 6KM, but their costs may restrict organization within government and industry from their use. As with the other technologies, there are limitations, if you encounter a highly modified UAV, it may not be identified. But in general, the radio frequency space is limited and can be monitored effectively.

RADAR

RADAR is a proven technology to detect and track a target, providing x, y and z components for precise location. This technology is starting to become a more affordable option to detect, locate, track UAVs. RADAR, with a detection range of up to 5KM, is the most mature and robust technology, but it does have its own limitations. UAVs are small, with the potential to be undetected or misidentified by the radar. RADAR also requires optimum weather conditions, special licensing, and learned skills of an RADAR operator; additionally, it would not be able to locate the operator of the UAV.

LADAR

LADAR functions by transmitting and receiving laser beams to scan and process the signal echoed from targets. Like RADAR, LADAR may be used to detect, locate, track and in some cases, identify the UAV. This technology is relatively new to this task. Only a hand full of companies has started to investigate migrating their systems for potential use in this space. Limitations are the same as RADAR above, except that no special licensing is required.

LIDAR

LIDAR is a method that measures distance to a target by illuminating that target with a pulsed light, and measuring the reflected pulses with a sensor. Differences in light return times and wavelengths can then be used to make digital 3D-representations of the target, which can be subsequently compared to a database. Similar to RADAR and LADAR may be used to detect, locate, track and, in some cases, identify the UAV. A newer technology, its use is in its infancy for UAV detection. It has limited use in less than optimal environmental conditions (rain, fog, mist), requires extensive data storage and processing power, and the other limitations of RADAR and LADAR.

Technology	Advantages	Limitations
Acoustic	Identification	Range No Locationing Environmental Impacted
Visual	Locationing Identification Tracking	Calibration Data Processing
Radio Frequency (RF)	Locationing (UAV and Operator) Identification Range Tracking	Database Management Impact from other RF Emitting Devices
RADAR	Locationing Identification Range Tracking	Special Licensing Skilled Operator Cost
LADAR	Locationing Identification Range Tracking	Special Licensing Skilled Operator New Technology Cost
LiDAR	Locationing Identification Range Tracking	Special Licensing Skilled Operator New Technology Environmental Impacted Cost
Thermal Imaging	Nocturnal Operation Environmental condition resistant	No Locationing Database Management

Figure 1 Sensor Technology Comparison

Thermal Imaging

Thermal imaging is a method of improving visibility of objects in a dark environment by detecting the objects' infrared radiation and creating an image based on that information. In comparison to the other discussed technologies, thermal imaging is very close to visual sensors, although the costs are higher, and the integration is more challenging. Benefits it has over visual is its ability to be used for “night vision” in UAV detection without the need for ambient light required for Infrared. Other benefits include its ability to penetrate obscurants such as smoke, fog and haze, and less susceptible to weather conditions. Thermal Imaging has comparable range to visual of 100M to 300M. Thermal Imaging doesn’t produce direct location information, and cannot aid in locating UAV operator.

3 The Systems

While there are seven different technologies being used in the detection, there are even more suppliers using each of the technologies. Most of these suppliers are single sensor based systems and provide minimal integration to each other.

	Drone Detector	Drone Shield	Orelia	Dedrone	Domestic Drone Counter Measures	AARONIA	Sensofusion	Kelvin Hughes	Thales SQUIRE	APS SkySafe
Audio Detection	YES	YES	YES	YES	NO	NO	NO	NO	NO	YES
Radio Frequency	YES	NO	NO	YES	YES	YES	YES	NO	NO	YES
GPS Detection	YES	NO	NO	NO	NO	NO	YES	NO	NO	NO
Video Detection	NO	NO	NO	YES	NO	NO	NO	YES	NO	YES
Thermal Dectection	NO	NO	NO	Agnostic	NO	NO	NO	YES	NO	NO
Radar Detection	NO	NO	NO	Agnostic	NO	NO	NO	YES	YES	YES
Detect Flying Drones	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Detect Autonomous Drones	YES	YES	YES	YES	NO	YES	YES	YES	YES	YES
Detect Drone Operator	NO	NO	NO	YES	NO	NO	YES	NO	NO	NO
Estimated Best Distance	1000M (RF)	40M (Audio)	40M (Audio)	100M (Video), 1000M (RF)	15m (RF)	1000M	10KM	5000M	5000M	1000M (Radar)
Database Updates and	YES	YES	NO	YES	NO	NO	YES	NO	NO	YES
Connectivity for Remote Locations	YES	NO	NO	Agnostic	NO	NO	NO	YES	NO	YES
Power for Remote locations	YES	NO	NO	Agnostic	NO	YES	NO	YES	YES	YES
Available Technology as of 8/01/17	Audio/RF	Audio/Video	Audio	RF, Video, Audio, Radar	Video, RF	RF	RF	Radar, Video, Thermal	Radar	Radar, Video, Audio
Open Interface	NO	NO	NO	YES	NO	NO	NO	NO	NO	NO

Figure 2 Commercially available products with capabilities

4 The Solution

We consider the UAV detection landscape fairly crowded. We see some definite advantages with some of the technology over other technology, and we believe it is important to find solutions that allow a comprehensive detection capability without an overly complex systems approach.

Sengex’s approach to all of these DDS offerings and services is simple: **identify** the customer’s objective, **understand** the environment(s), and **work** with the **vendor** and technologies that give **customer**s the best chance for success. Sengex has concluded that there is no single technology that will provide the detection with the needed effectiveness and operate in all environments. To that end, we have developed a series of best practices and partnered with a proven vendor to address our diverse customers' needs.

Dedrone, a company that recognized early on that no single technology can deliver the required results and pioneered the use of multi-sensor technologies. They continue their philosophy in the further development of

their DroneTracker platform, it allowing integration with the best sensor technologies. Whether deployed onsite or in the cloud, the Dedrone platform will allow disparate sensors to be integrated into a single system through standards based interfaces, and deliver customers one system that presents everything on a single pane of glass.

Dedrone's machine learning platform empowers customers to regain the control of their airspace and best fits Sengex's model for integration. Dedrone has developed or partnered with existing sensor vendors to offer a comprehensive "complete solution" that combines sensor technologies to produce a multifaceted platform that can be modified to meet specific customer's needs, their environments and budgets. DroneTracker can integrate with any ONVIF camera, which includes cameras from major manufacturers like Bosch, Pelco, and Axis. Furthermore, they have integrated Robin Radar and Airbus Spexer radars, Rhode and Schwartz RF sensors and jammers, Squarehead acoustic sensors, IACIT (Brazil) jammers, and HP Wust (Germany) jammers (in locations where interdiction is allowed)

Sengex integration services combined with the variety of DroneTracker FCC/FAA compliant off-the-shelf ready options will enable customers to prepare and deploy before the fear of a threat becomes a reality.

Dedrone has secured over 200+ installations worldwide, many through their reseller network, and continues to be the leader in the market. Dedrone has secured $28M in funding from a who's who of the investment community. Investors like Menlo Ventures, Felicis Ventures, and John Chambers, Executive Chairman of Cisco, further substantiates the Dedrone technology, their approach and the trust in their team.

5 Conclusion

Sengex is a leading systems integrator, and has a proven track record of delivering integrated physical security to government and defense organizations for years to include Wireless Intrusion Detection (WIDS)and weapons detection. We recognize the challenges every environment presents, and we would like to help you develop the strategies your organization needs to be successful in the detection and locating UAVs, as detection is step one in the battle against all UAV attacks. Let us bring the power of the most successful Drone Tracking system on the market, to help you.