Meeting Optical Needs for Drones

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Recent UAV system developments have drawn attention to the optical needs of the UAV industry. As detectors become larger in size and smaller in pixel size, UAV optics with higher MTF values and lower F# are the key to maximizing imaging performance.

The unmanned aerial vehicle (UAV) industry is growing rapidly, with Teal Group analysts estimating that worldwide UAV production will total $135 billion in the next ten years[1]. When equipped with high performance EO/IR camera payloads, UAVs, also known as drones, lend themselves to a wide range of imaging applications.

The drone market consists of defense, government, and commercial applications. In the area of defense and government, drones are used for military and police surveillance, border control, security, and search and rescue operations. Between 2009 and early 2017, at least 347 law enforcement and emergency responder agencies in the U.S. acquired drones[2].

In the commercial drone market, demands have been growing. Commercial drones with thermal imaging capabilities are playing a prominent role in inspecting electrical power lines, oil pipelines, and other infrastructures. Thermal imaging drones are also used to assist in firefighting operations, locating and assessing fires, even when visibility is poor.

As UAV technology is implemented for increasingly varied and sophisticated tasks, there has been a call to maximize imaging performance. In particular, detectors are increasing in both resolution (number of pixels) and format (size), while decreasing in pixel size. Also, smaller drones are being manufactured for commercial use. These trends present specific optical needs.

While advances in detector resolution should improve imaging performance, this is impossible without an accompanying improvement in lens quality. In optics-limited systems, lens quality is essential - an inferior lens will produce an inferior image, even with the best detector. In order to match these high performance detectors, lower F# and tighter tolerances are required, forming lenses with minimal aberrations. Lenses must also have a long focal length, for use when UAVs capture images from large distances.

[1] Teal Group (2017)
[2] Gettinger, D. (2017). *Public Safety Drones.* Retrieved from Center for the Study of the Drone.

The UAV industry presents its own unique set of limitations. When it comes to developing optical components and optical systems for UAV payloads, three factors must be measured. These factors can be summarized by the acronym SWaP – size, weight, and power consumption. UAV payloads, especially for smaller commercial UAVs, impose strict size and weight restrictions. Power consumption must be reduced to minimize fuel usage, thus maximizing flight time. As UAV detectors grow in size, it's more difficult to meet SWaP goals.

The challenge falls on lens manufacturers to design and produce compact, lightweight lenses – minimal is critical. Concurrently, image performance must not be compromised. Various technologies are being used to meet these optical needs. These technological solutions include innovative optical and mechanical designs, exotic materials, free-form optics, and unique lens coatings.

Diamond turning technology can be used to produce aspheric and diffractive surfaces with exceptional levels of accuracy and quality. Aspheric lens surfaces are desirable, particularly when it comes to infrared optics, showing significant increases in optical performance over their spherical counterparts. Aspheric-Diffractive lens surfaces allow for the integration of multiple functions, such as chromatic and spherical aberration corrections. Lenses produced by diamond turning can therefore combine multiple elements, reducing overall size and weight.

Continuous zoom lenses, with maintained focus, are another way to reduce lens size and weight, while keeping performance high. These lenses are smaller and lighter than using multiple single FOV-lenses. In addition, a continuous zoom lens enables better mission flexibility by allowing changes in magnification during a UAV operation.

The use of durable, anti-reflective lens coatings also improves optical performance, without any impact on the size or weight of the lens. Lens coatings minimize transmission losses by reducing reflection. Advanced coating techniques can be used to produce tailor-made coatings. These coatings can be designed to meet the needs of the UAV industry, where drones may be deployed in a variety of environments, each presenting its own optical challenges.

For example, Ophir Optics designs and manufactures in the field of UAV optics, developing high performance LWIR and MWIR lenses to suit the requirements of the UAV industry. Working in collaboration with defense and commercial customers has led to the creation of infrared lenses with unparalleled optical performance. These lenses also take the SWaP constraints of the UAV payload platform into consideration. Ophir uses lens types such as continuous zoom lenses, athermal lenses, as well as technologies such as diamond turning, free-form optics, and advanced lens coatings, to reach the highest levels of IR thermal imaging performance quality. Ophir's most recent lens, the LightIR, is a high-performance IR thermal imaging zoom lens designed specifically for use in UV payloads. The LightIR is the smallest, lightest, and most compact lens of its type, available on the market today.

Optical solutions are the key to UAV performance, maximizing imaging quality, without a heavy toll on the UAV payload. As UAV technology continues to develop, and the demand for UAVs increases, optics will continue to play a vital role in the industry.