

# Engineering Solutions for Military and Aerospace

# DEFENSE

## TECH BRIEFS

## Designing COTS Optics Into Defense Projects

**W**hen settling in to design a new optical device for a defense application, it is often desirable to use Commercial Off The Shelf (COTS) optical components wherever possible. COTS optics offer many advantages over their custom-design counterparts. Lower prices and quicker lead times are two distinct advantages with COTS optics over custom components, which immediately lead to lower sample cost and quicker prototype iteration. In moving to production, these advantages lead to higher profit margin and quicker delivery cycles.

Another distinct advantage in using COTS optics versus custom components is the absence of control through International Traffic and Arms Regulations (ITAR). Using unregulated optical components greatly expands the available vendor network for the specifier of components in an ITAR-controlled assembly. Many companies exist that sell commercially available optics, most of which use catalogs and searchable websites as marketing and organizational mediums to enable the specifier to locate COTS optics of interest.

But how do these companies add new products to their offering that are relevant to military and defense applications? How do commercial components remain outside of International Traffic and Arms Regulations (ITAR) but still meet stringent defense specification requirements? The answer lies within the source of information used in specification development. Presented here are a specification methodology and two examples of commercially designed optics that have distinct relevance to a range of defense applications.

Commercial optics product lines are designed to serve varied application

spaces whose needs are often speculative. While that may sound cavalier, the speculation is based on concrete data points in industry and academia that coagulate into a specification and customer profile. In other words, COTS optics product lines are often produced without a specific customer waiting for delivery. Rather, they are designed to meet an anticipated need based on adjacent technologies. Concrete data points may include the next generation of CCD or CMOS imaging sensors, the next family in commercial laser diode wavelengths, or fundamental advances in optical manufacturing equipment.

Conveniently enough, the defense industry tirelessly seeks to employ the latest and greatest technologies in its newest devices so as to gain a tactical advantage. That said, one of the many new product goals of a COTS optics company is to identify new commercially available technologies that are relevant to the defense industry and release products that enhance the use of such technologies. A current example is within the field of Short Wave InfraRed (SWIR) imaging, which is generally taken to be the wavelength band ranging from 0.9 — 1.7 $\mu$ m.

SWIR imaging has many interesting applications in the fields of food & beverage inspection, silicon wafer process monitoring, and surveillance for the defense industry. SWIR imaging can reveal bruises on apples not readily apparent to human visual inspection (Figure 1).

Opaque bottles such as laundry detergent or baby powder become partially transparent in the SWIR band (Figure 2). Partial transparency in the bottle allows the inspector to see liquid or other material levels not immediately observable in the visible band.

With regard to silicon wafer inspection, wafers are transparent in the SWIR band. Various illumination techniques in the SWIR band reveal manufacturing and material variances in silicon wafers. Variances in illumination can then be used for quality evaluation of the finished silicon wafer.

These examples all fall within the classical machine vision inspection arena where linear array cameras have been employed. A continuous ribbon image forms the raw data set, on which pass/fail criteria is employed for quality control. As a result, linear array SWIR

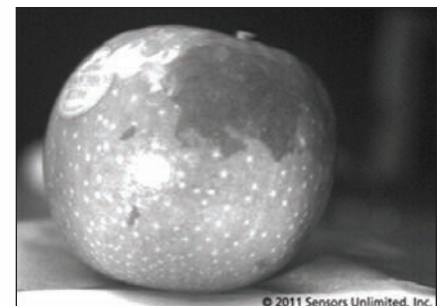


Figure 1. An apple as viewed in the visible band (left) and the SWIR band (right), which reveals a subsurface bruise.

cameras are deregulated and available outside ITAR oversight. The deregulated linear array SWIR sensor can then form the basis for specifications of a product line of non-ITAR controlled SWIR lenses. A full line of various focal lengths will be released based on specifications of the linear array SWIR cameras and previous data from successful visible machine vision lenses.

As a matter of coincidence, new SWIR imaging lenses have applicability to area array SWIR sensors. The area SWIR sensors are currently controlled by ITAR due to the wide range of surveillance and other defense-specific applications related to real-time imaging. SWIR lenses designed for the non-ITAR controlled linear arrays are immediately applicable to the ITAR controlled SWIR area array cameras. The dual applicability arises from the fact that imaging lenses are designed to meet performance across an entire image circle. The image circle diameter is a one-dimensional value meaning a design for the height of a single line of pixels is equivalent to a design for the diagonal of an area array of equal height. This, of course, assumes that the pixel sizes and the overall image height are also equivalent. Thus the SWIR imaging lens performs well on both the ITAR-controlled SWIR area array as well as the uncontrolled linear array SWIR sensor.

Imaging lenses such as that described above have many performance specifications that require a fairly complex optical design. Elsewhere, there is a wealth of applications where the overlap between commercial specification and military requirement is much simpler. For example, in defense-based laser ranging applications, a lens serves as a simple collimator for a single infrared laser wavelength. To meet the needs of the application, a commercial off the shelf infinite conjugate asphere can



Figure 2. Example of a visibly opaque bottle in the visible band (left) and the SWIR band (right) which facilitates observation of the material level inside the bottle.

be used to collimate the infrared laser and collect the reflected beam back onto the photo-sensor. The back-end time-of-flight algorithm is then used to yield the range value. All that is asked of the lens is to collimate a light source and refocus the reflected light onto the detector. Off the shelf infinite conjugate aspheres and, in some cases, achromats or singlets may suit the need depending on signal to noise requirements. In this case, a COTS lens can be used in the assembly and the surrounding mechanics designed to meet the optical specifications — primarily focal length — of the COTS lens. While the surrounding mechanics may be ITAR-controlled since they are custom designed for the ITAR controlled assembly, the lens is not and can therefore be shopped around for the best price-to-performance ratio.

On the other hand, if the entire assembly is designed from scratch including the lens, all constituent components are ITAR controlled and subject to limited vendor networks. A vendor network limited to those authorized to produce ITAR components generally leads to higher price and longer delivery times.

The SWIR lens example is one of convenient overlap, where an imaging lens is specified for a non ITAR controlled device and has applicability to a similar ITAR controlled piece of equipment. Both cameras are on the cutting edge of technology, which reinforces the notion that within optics, what is commercially available often mirrors that which is required for military applications. In the laser range finding example, the optical task at hand in the defense application is easily met by an off the shelf component.

In both examples it is in the best interest of the specifier of optics for an ITAR controlled device to seek out components that are commercially available. In most cases within the optical component realm, that which is commercially available will meet the needs of the military application and will have advantages both in price and delivery schedule.

*This article was written by Joel Bagwell, R&D Manager, Edmund Optics (Barrington, NJ). For more information, visit <http://info.hotims.com/34455-521>.*



Figure 3. Edmund Optics' commercially available 25mm SWIR imaging lens.

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