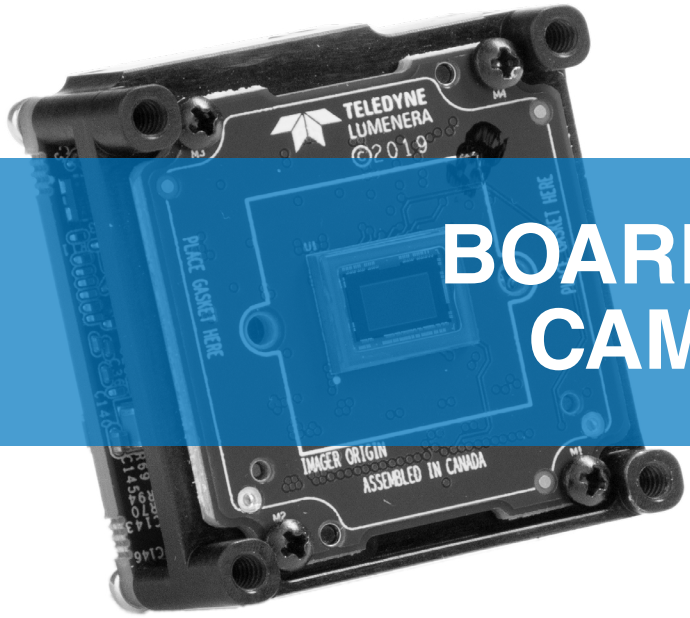
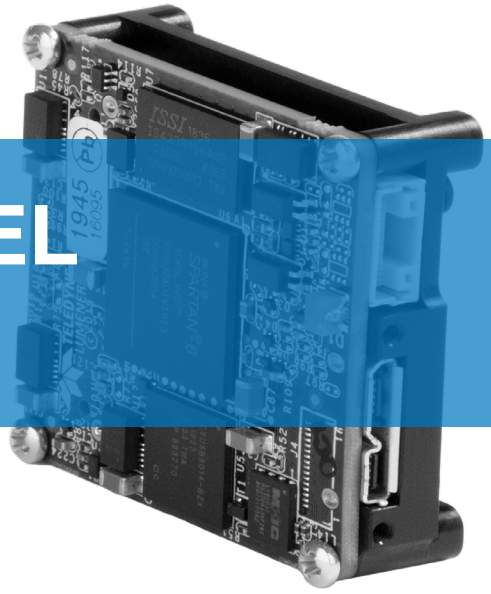
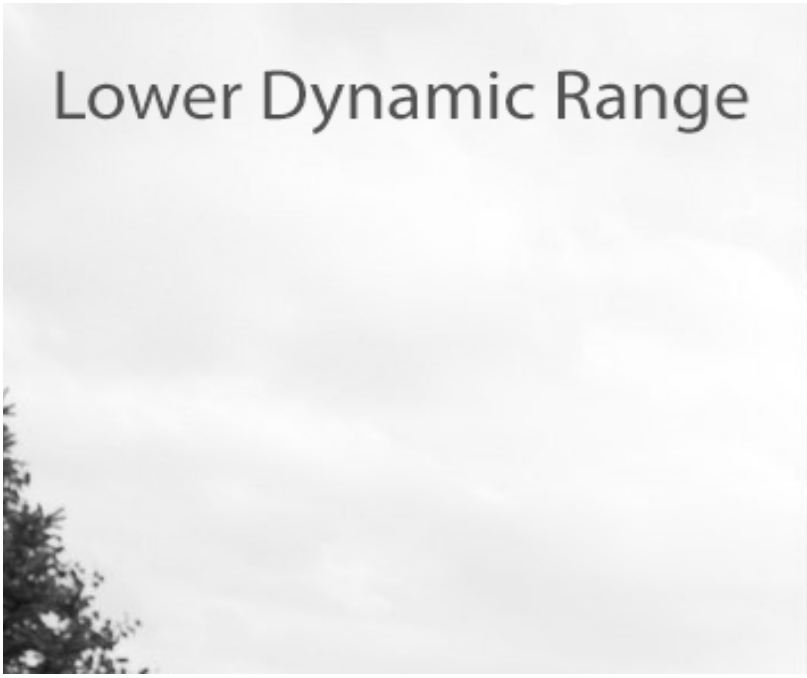




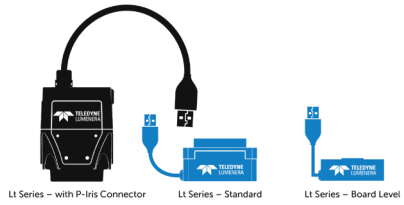
BOARD LEVEL CAMERAS

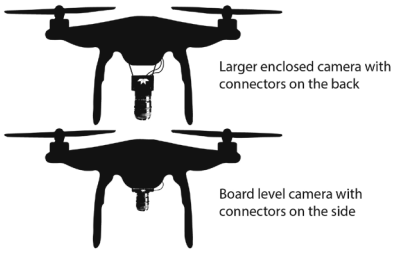
Solving Big Vision Challenges With a Small Vision Solution

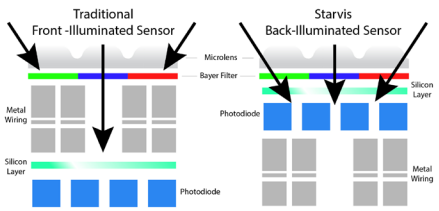


TELEDYNE LUMENERA **WHITE PAPER**

BOARD LEVEL CAMERAS







WHAT'S INSIDE

INTRODUCTION

Embedded systems require a compact and light weight imaging solution. Due to the potentially limiting size an embedded system can occupy on its own, it can be difficult to incrementally fit in a camera system. However, there are camera options that have a lighter and minimalistic design.

Industrial cameras normally have protective enclosures that can be problematic when adding a camera to a vision system where space is tight. For many devices it can be difficult to integrate an enclosed camera if there are already predetermined dimensions that a camera will need to fit based on existing designs. Additionally, for many applications that use embedded systems, weight is a key factor due to limitations on mechanical and electrical equipment.

Although in some of these cases, it could be useful to explore OEM options for custom enclosures or find ways to remove parts of the surrounding material on the camera to reduce the size, board level cameras are a simpler and more cost-effective way to overcome these challenges. Without the added weight of an enclosure and the reduced size of just having a sensor exposed on the PCB, a camera can be adapted to many applications where it might not typically fit. This document will cover various reasons why board level cameras can make a difference in a vision system, applications for board level cameras, and explore some board level camera options available on the market.

BOARD LEVEL CAMERA DESIGN

Light Weight

By minimizing the amount of material used to construct a camera, a vision system can reduce the amount of work needed to move a camera or other attached components. Board level cameras are ideally suited for applications where there are weight restrictions or for applications that use an internal power source to move the camera. A battery powered device is a great example of how reducing weight can improve an application by increasing battery life and, therefore, increasing imaging time.

Compact

Similarly to how removing an enclosure can reduce weight, it also frees up a lot of space. Many applications can have pre-existing designs that can only fit vision systems of a certain size. Therefore, a thinner design without extra material can fit a camera into much tighter spaces. Choosing a board level camera can allow more applications to keep adding the latest imaging technology, without compromising on the overall size.

Light Weight

To fully understand the advantages that a board level camera can bring to the table, look no further than OEM manufacturers. The ability to integrate a camera without the need to make alterations to the enclosure or body was one of Teledyne Lumenera's main goals of producing a new series as board level cameras. Many OEM vision systems already have an enclosure for the overall product and do not require another layer of protection for the camera itself. By reducing the amount of material needed, the weight and size of the entire vision system can be reduced as well. Figure 1 illustrates that the board level camera clearly has the most compact and thinnest design.

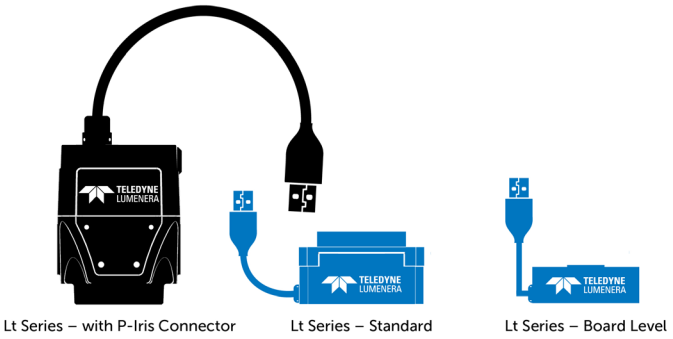


Figure 1 – A comparison between the size of Teledyne Lumenera's cameras with a Board Level Camera on the right

APPLICATIONS

Aerial Imaging

Size, weight, and power restrictions (SWaP) are often the reason why a certain camera cannot be used by a UAV. As a result of these restrictions, larger format cameras have been a hurdle for bringing better imaging performance to aerial imaging applications. Therefore, board level cameras should be designed to provide high performance imaging in a smaller form factor with the use of UAVs in mind.

There are useful design considerations for board level cameras being used with UAVs. For example, board level cameras equipped with connectors located on the sides of the cameras allow for less vertical real estate to be occupied by the camera. Unlike conventional connectors that are located on the rear, this placement allows for easy stacking of components within a device. By placing a board level camera right under another component instead of having wires create a gap, aerial imaging systems can utilize a more compact design. A comparison between vision system size can be seen in Figure 2, where a full-sized enclosed camera with connectors on the back is shown on the top, and a board level camera with side connectors can be seen on the bottom.

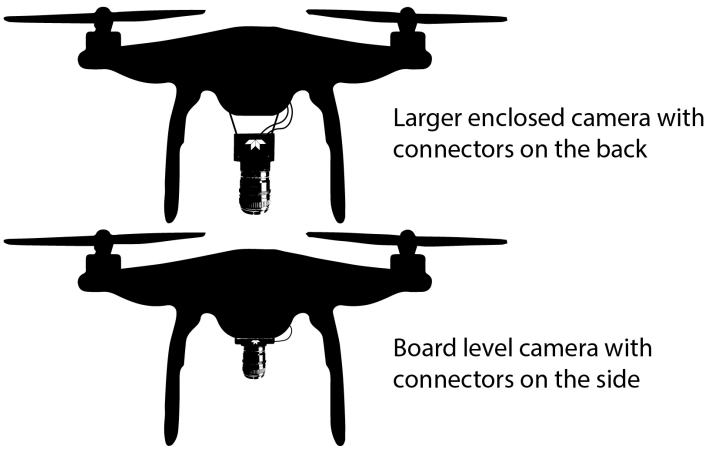


Figure 2 – A visual comparison for UAV imaging between a large enclosed camera and a board level camera

Size usually affects weight as well. The small design of a board level camera helps reduce the load on imaging systems such as UAVs. Battery powered UAVs strongly rely on design choices that reduce weight to increase flight time. The heavier a UAV will be the more the motors have to work to generate enough thrust to fly. Therefore, the UAV will have to use more power and drain its battery quicker, reducing the overall flight time and number of images the system can capture.

When it comes to aerial imaging, less is more. When imaging large areas from above, it is easier to get a steady image of the ground. This means there is not a lot of motion that needs to be imaged, allowing the vision system work well with lower frame rates. The Lt Series Board Level Cameras from Teledyne Lumenera are capable of frame rates ranging from 22 – 162 fps to provide flexibility for a wide variety of aerial imaging applications.

With such a small form factor, board level cameras can be used for multi-camera synchronization. For imaging larger areas from a bird's eye view, using multiple smaller cameras can result in improving the horizontal resolution at a better price to resolution value than using a single large camera. For more information on how to optimize aerial imaging performance, read the whitepaper, "Using A Single Versus Multiple Cameras In Aerial Imaging."

Portable / Handheld Devices

When a vision system is required to be transported, having the most compact system can be what makes or breaks a design. Without sufficiently small enough vision components, a device might not be suitable for mobile use. For Teledyne Lumenera, fitting compact designs has been a primary reason for developing a series with board level support from the very beginning. Handheld vision systems that need to be used in all types of environments will drastically benefit from such a minimal camera design since it will directly impact the ease of use and how comfortable the vision system is to use with a reduced weight and size.

The biggest hurdle for developing a vision system to be portable or handheld will often be the optics. Even with board level cameras having such a thin form factor, a large lens, such as a telephoto lens can add lots of weight and bulk to a product. Therefore, minimizing the overall footprint of the vision system is critical for allowing more options for camera lenses to be a potential fit. Since a lens cannot be made smaller, having a smaller camera option such as a board level camera can make a difference. Additionally, by using a board level camera, a variety of lens mounting options are also available. This added flexibility can help ensure that the vision system can adopt the right lens choice.

For reliable high-speed data transfer over short distances, USB3 cameras are a great choice. With very light supporting hardware unlike more bulky camera interfaces, USB3 cameras offer a many space saving options. To minimize the space taken up by the cabling it can be beneficial to invest in a USB3 cable with 90-degree USB connector, shown in Figure 1 with the Lt Series Board Level Camera.

Outdoor Imaging

When imaging outdoors the lighting from the sun is constantly changing. The problem with variable lighting is that no one filter solution can account for all the different types of conditions that can come from outdoor imaging. Therefore, one of the most important things to consider is how a camera will accurately capture the details with lighting constantly coming from different directions and casting unique shadows.

Dynamic range refers to a camera's ability to discern details over highlights and shadows. High dynamic range is the ability to retain lots of detail from those bright and dark areas. The value of dynamic range is measured in decibels show with the units, dB. Since dynamic range is a measurement of the lowest to highest value of brightness a camera can capture, a higher value is desirable because this represents a large range of environments where a camera can capture images. A contrast between a lower and higher dynamic range can be seen in Figure 3, where detail and color are more clearly visible in the higher dynamic range. Additionally, to learn more about how dynamic range is calculated, along with its relation to the signal-to-noise ratio and full well capacity, read the blog, "Understanding Dynamic Range And Signal-To-Noise Ratio When Comparing Cameras."

Figure 3 – A comparison of dynamic range

Life Sciences

With clinics having limited space due to high demand from patients and various specialized devices, the option to install something compact goes a long way. Additionally, medical imaging equipment is usually designed for desktop use.

With size in mind, board level cameras are designed to be compatible with many form factors and enclosures to ensure easy integration within medical equipment. Dimensions for a medical device are usually determined in the planning phase which results in a lack of flexibility when it comes to imaging equipment. This means that larger camera solutions will not make it past the first round of discussions since performance is irrelevant if the camera cannot be installed within the device.

Competing with similar sized camera modules, board level cameras are a drop-in replacement for many imaging solutions looking for an upgrade in image quality. Often a board level camera module is just a stripped-down camera, however a proper board level camera ensures that additional design choices are added to help the camera integrate into a vision system. This can include a thinner design, side mounted connectors, and multiple lens type options.

THE TELEDYNE LUMENERA LT SERIES BOARD LEVEL CAMERAS

Some vision systems need a more compact and light weight solution that standard industrial cameras cannot provide. Luckily, the Teledyne Lumenera Lt Series Board Level Cameras, as shown in Figure 4, are equipped with powerful sensor technology, featuring both, Sony ® global shutter Pregius™ and rolling shutter Starvis™ CMOS sensor. With a wide range of models that include 2 – 12 megapixel cameras, the Board Level Cameras can meet a variety of imaging application needs. These cameras have been designed with embedded systems in mind, with a flush back and connectors for cables on the side to minimize the space required for vision systems.

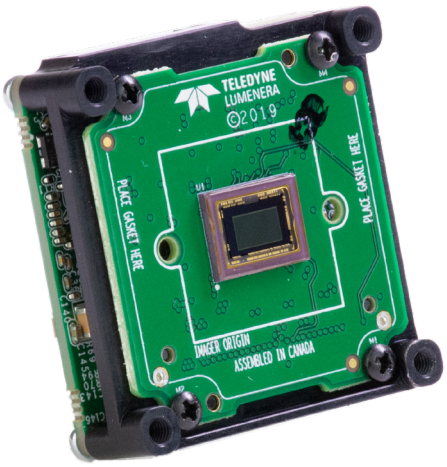


Figure 4 – Teledyne Lumenera Lt Series Board Level Camera

Lens Options for Compact Imaging

Lenses are no longer bound to a single mounting type. Due to the Lt Series Board Level Camera design, there is no lens mount included with the camera. Therefore, several types of lenses can be used based on the type of mount a user ends up adding to the vision system. C, CS, and S (M12) lens mounts are all potential choices for an embedded system that wants to take advantage of a small form factor. An example of a C-mount and CS-mount lens can be seen in Figure 5. S-mount lenses are a great choice when savings are important since they tend to be much cheaper due to their physically smaller construction.

Figure 5 – C-mount (left) and CS-mount lens (right)

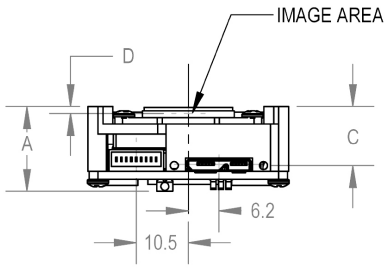
Thin Form Factor with Ruggedized Design

Unlike a traditional industrial camera, the Lt Series Board Level Cameras do not come with a robust enclosure. Instead, these thin cameras offer a thin form factor that maximizes the overall length of the vision system. This is done without sacrificing the rugged design elements expected from an industrial camera. To protect the PCB and electronics on the Lt Series Board Level Cameras, Teledyne Lumenera uses industrial grade connectors that hold the two boards together to connect the sensor board with the USB3 interface. This offers an industrial grade solution for a lightweight design.

The addition of these rugged connectors adds to the value for industrial applications such as aerial imaging. Knowing that the camera is protected against strong vibrations means the camera is cable of ascending to high elevations without the need to worry about environmental conditions affecting the integrity of image acquisition. To improve aerial imaging even further, Teledyne Lumenera also offers an ordering option to apply a conformal coating onto the PCB of the camera which protects against humidity. Conformal coating is expanded upon in the blog, "Protecting Aerial Imaging Equipment With Conformal Coating."

Side Mounted Connectors for Easy Installation

For many applications the size of a camera is the selling point. Instead of a typical industrial camera design that has connectors on the back, board level cameras have side mounted connectors that allow the back of the camera to lie flat against other components. In imaging systems that require an overall shorter size, implementing the Board Level Cameras allows for a 17.1mm thin camera (as thin as 14.1mm) to reduce the physical foot print a vision system will take up, as shown in Figure 6.



MODELS	DIMENSION		
	A	C	D
LT-1950B LT-2020B LT-2420B LT-4020B LT-4030B	17.1	11.9	1.3
LT-1900B LT-3840B	14.1	8.9	1.4

Figure 6 – The compact dimensions of the Lt Series Board Level Cameras

The Lt Series Board Level Cameras also feature optional placements for the side mounted connectors. The connectors can be placed on any side, including left, right, top, or bottom. For applications such as aerial imaging where a vision system may use stereo imaging, with two cameras side by side, or even more than two cameras, the cables can be positioned on any side to minimize any interference they might cause. This flexibility with lenses and cable positioning are the basis for the overall design choices that make the Lt Series Board Level Cameras a powerful imaging solution for so many different use cases.

New Sensors for Better Sensitivity

Sony's Starvis sensors have been added to the Teledyne Lumenera product line with the Lt Series Board Level Cameras. Alongside the new low cost, Sony Pregius sensors, the Board Level Cameras combines the best sensitivity in the market with a small form factor. The sensitivity of the Starvis sensors has continued to increase over each iteration and in comparison to sensors of a similar size.

Global shutter cameras are available with the Board Level Cameras but for applications where fast moving subjects are not an obstacle, the Lt Series Board Level Cameras also have more affordable rolling shutter options with very high sensitivity that can prove to be more useful for low light environments. Back-illuminated sensors flip the traditional design philosophy. The Starvis sensor series from Sony moves the photodiode layer of an imagining sensor above the metal wiring on the sensor. By having the photodiode on an upper layer, a wider range of incident light can excite the sensor and create a brighter image. In a traditional front-illuminated sensor, the metal wiring is above the photodiode and blocks some of the incoming light to the sensor, as seen in Figure 7, where a diagram of a back-illuminated sensor can be seen allowing more light to reach the photodiode and increase camera sensitivity.

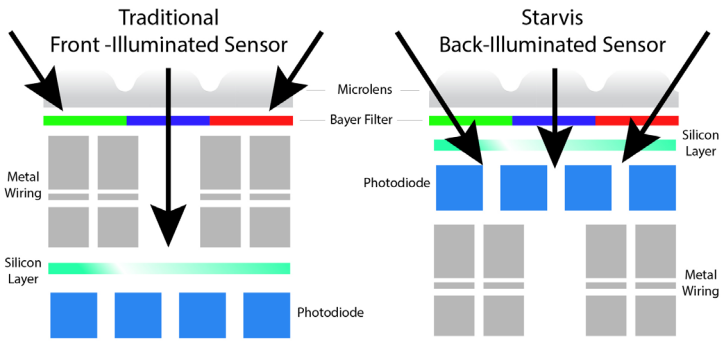


Figure 7 – A traditional sensor on the left with a back-illuminated sensor on the right

Models of Lt Series Board Level Cameras

The models within the Teledyne Lumenera Lt Series Board Level Cameras are featured in the table below. These cameras range from 2 – 12 megapixels and with an upcoming future release of a 20 megapixel Board Level Camera. Each of these cameras comes in either a color or monochrome sensor version, except for the Lt-C1900B which is only available in color.

Models	Resolution	Frame Rate	Sensor
Lt-C1900B	2.1 MP	60 fps	IMX327 color
Lt-C1950B / Lt-M1950B	2.3 MP	162 fps	IMX392 color/ mono
Lt-C2020B / Lt-M2020B	3.2 MP	55 fps	IMX265 color/ mono
Lt-C2420B / Lt-M2420B	5.1 MP	35 fps	IMX264 color/ mono
Lt-C3840B / Lt-M3840B	8.3 MP	44 fps	IMX334 color/ mono
Lt-C4030B / Lt-M4030B	8.9 MP	31 fps	IMX267 color/ mono
Lt-C4020B / Lt-M4020B	12 MP	22 fps	IMX304 color/ mono

For more information on board level cameras and how to chose the right camera for your vision system, contact Teledyne Lumenera's imaging experts at sales.lumenera@teledyne.com and visit our website at teledynelumenera.com.