

# Lens companies keep pace with increasing image sensor sizes

Sensors ranging from 10 to 150 MPixels require appropriate optics for optimal performance.

## James Carroll

When selecting appropriate lenses to pair with image sensors, systems integrators must first consider sensor size and resolution. Not doing so sets developers up for failure instead of success from the get-go.

Today's machine vision market offers industrial cameras with increasingly large image sensors, which necessitates the need for lens and optics developers to meet expanding machine vision needs.

With more high-resolution image sensors available today than ever before, lenses must be correctly paired. If a low-resolution lens pairs with a high-resolution image sensor (defined here as 10 MPixels and up) the performance of the optical delivery system—and in turn, the overall machine vision system—becomes limited by the lens.

Opto Engineering (Mantova, Italy; [www.opto-e.com](http://www.opto-e.com)) recently released a new series of telecentric lenses for up to APS-H sensors in its TC12M series (Figure 1). These telecentric, F-Mount lenses feature a compact design ideal for various industrial inspection applications, according to the company.

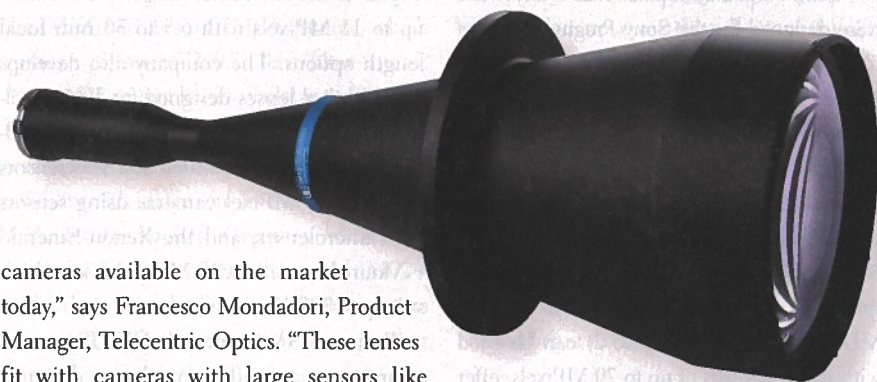
"The TC12M series for detectors with image circle up to 33.5 mm were developed to meet the growing trend of higher-resolution

cameras available on the market today," says Francesco Mondadori, Product Manager, Telecentric Optics. "These lenses fit with cameras with large sensors like APS-C (Sony IMX342) and APS-H formats (Python 25K)."

The company also offers the TC16M telecentric lens series, which fits 45 mm format detectors with high resolutions up to 29 MPixels, or 8k pixel line detectors.

Computar (Cary, NC, USA; [www.computar.com](http://www.computar.com)) makes several lenses designed for high-resolution image sensors used in various machine vision applications. The MPZ series offers models with focal lengths from 8 to 75 mm for 1" sensor types. Some customers, according to the company, use these C-Mount lenses with the Sony IMX183 sensor, a 20.48 MPixel sensor with 2.4  $\mu\text{m}$  pixel size. In its MPY series of 12 MPixel lenses, the company offers lenses in focal lengths from 8 to 50 mm. Designed for 1.1" sensors, the C-Mount lenses target machine vision and intelligent transportation applications.

In addition, Computar offers three 4K, 1/1.8" format, S-Mount board lenses (3.8, 5.2, and 1.65 mm fisheye) with IR correction, and the TEC-V0345165MPY-WI telecentric lens, which is



**Figure 1:** Designed for APS-H sensors, TCM12 series telecentric lenses offer a compact design for various industrial imaging applications. *Photo credit: Opto Engineering*

compatible with 12 MPixel sensors on 1.1" cameras. Specifically, the C-Mount lens was specially designed for the Sony IMX253 sensor, a 12.37 MPixel sensor with 3.45  $\mu\text{m}$  pixel size.

While Sill Optics (Wendelstein, Germany; [www.silloptics.de/en](http://www.silloptics.de/en)) offers telecentric lenses designed for sensors like the 12.37 MPixel Sony IMX253 CMOS sensor—which has a 17.6 mm diagonal size—the company offers lenses suitable for much higher resolutions as well. This includes the S5LPJ1555 bi-telecentric lens with M60x1 thread, which can be used with a 56 mm diagonal image sensor and 3.45  $\mu\text{m}$  pixel size (125 MPixels for a 44 x 33 mm sensor) and the S5LPJ3005/M72 with M72 thread (same image sensor size compatibility).

Additionally, the company offers lenses for image sensors of 50 MPixels and up, including the S5LPJ7255/M72 lens, which can be



used with a 50 mm diagonal image sensor and 4.6  $\mu\text{m}$  pixel size—which equals 56.7 MPixels or a 40 x 30 image sensor. These sensors primarily target line scan sensors but can be used with area scan as well, according to the company.

Moritex Corporation (Saitama, Japan; [www.moritex.com](http://www.moritex.com)) also offers several C-Mount lenses designed for high-resolution image sensors, including the ML-M-UR

series of lenses with focal lengths ranging from 6 to 50 mm. The lenses have a resolving power of 200 lp/mm and 2.2  $\mu\text{m}/\text{pixel}$ . ML-U-SR lenses were designed for the Sony Pregius family of CMOS image sensors up to 12 MPixels and provide full-field compatibility with 3.45  $\mu\text{m}$  pixels (150 lp/mm), according to Baechler.

ML-MC-G macro, ruggedized lenses, which Moritex designed for robotics applications, can be used with sensors up to 12 MPixels and offer a resolving power of 150 lp/mm in focal lengths from 12 to 75 mm. ML-MC-XR lenses (Figure 2) can be used with image sensors of up to 20 MPixels, offer a resolving power of 200 lp/mm, and are available in 25, 35, 50, and 90 mm focal lengths. ML-T lenses also target 1.1" sensors up to 12 MPixels and offer focal lengths of 20, 25, 35, 50, and 75 mm. Additional high-resolution lenses offered by the company include the MML-SR series and several bi-telecentric lenses in the MTL series.

Fujinon CF-ZA-1S lenses (Figure 3) from Fujifilm (Tokyo, Japan; <http://mvlens.fujifilm.com/en>) support high-resolution, 1.1" image sensors with 2.5  $\mu\text{m}$  pixel size up to 23 MPixels. The relative illumination (which represents the combined effect of vignetting and roll-off in a lens), reaches above 90%, with clear images obtained from the image center to the peripheral area, according to the company. Available focal lengths range from 8 to 50 mm.

Goyo Optical (Saitama, Japan; [www.goyooptical.com](http://www.goyooptical.com)) recently released a line of 1.1" format, 12 MPixel lenses. Available in focal lengths of

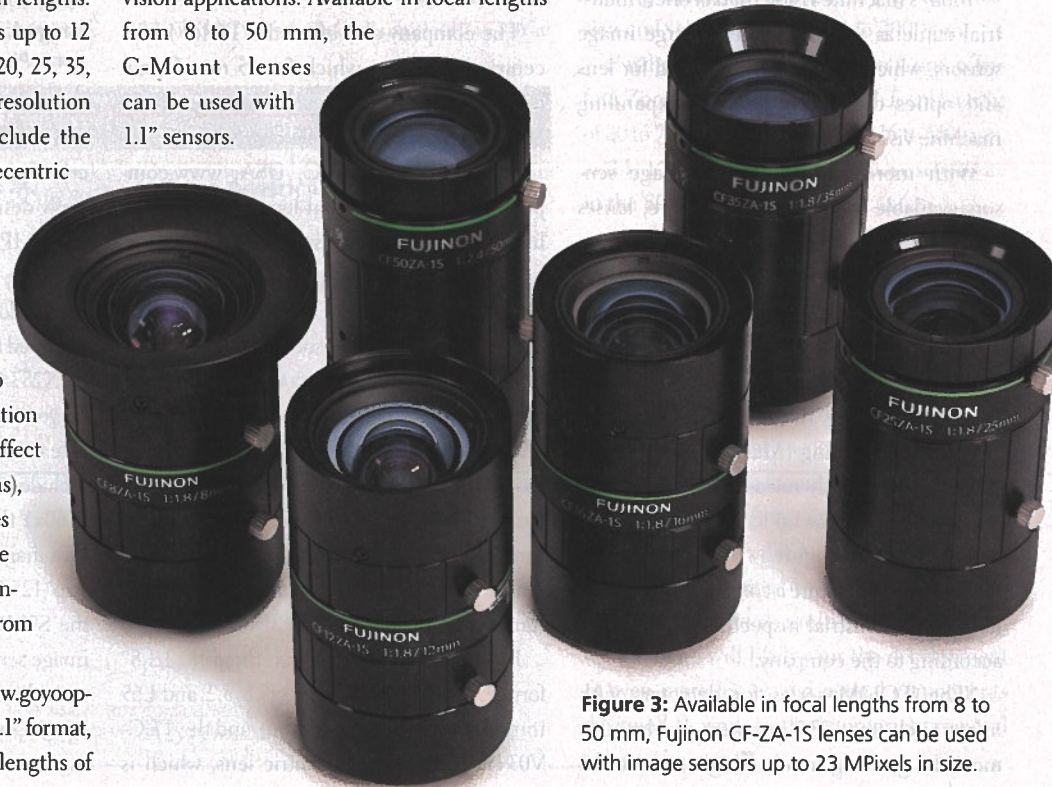


**Figure 2:** ML-MC-XR lenses can be used with image sensors of up to 20 MPixels at a resolving power of 200 lp/mm.

16, 25, 35, 50, and 75 mm, the C-Mount lenses feature a 260 line pair per mm (lp/mm) resolution. In addition to these sensors, the company offers 12 MPixel lenses in 4/3", 1", and 2/3" formats.

With its Xenon-Opal series (Figure 4) Schneider-Kreuznach (Bad Kreuznach, Germany; [www.schneiderkreuznach.com](http://www.schneiderkreuznach.com)) offers 12 mm focal length C-Mount lenses for 1.1" sensors up to 12 MPixel using sensors with microlenses, while the Xenon-Topaz C-Mount lenses target 1.1" sensors up to 12 MPixels with 6.5 to 30 mm focal length options. The company also develops several other lenses designed for 10 MPixel-plus image sensors, including its anti-shading C-Mount lenses, which suit 1.3" sensors for up to 12 MPixel cameras using sensors with microlenses, and the Xenon-Emerald F-Mount bayonet or V48-Mount lenses, which suit up to 29 MPixel sensors.

Tamron USA (Commack, NY, USA; [www.tamron-usa.com](http://www.tamron-usa.com)) offers four lenses designed for 12 MPixel image sensors used in machine vision applications. Available in focal lengths from 8 to 50 mm, the C-Mount lenses can be used with 1.1" sensors.



**Figure 3:** Available in focal lengths from 8 to 50 mm, Fujinon CF-ZA-1S lenses can be used with image sensors up to 23 MPixels in size.

Kowa American Corp. (Torrance, CA, USA; [www.kowa-usa.com](http://www.kowa-usa.com)) also makes the JC10M 2/3" lens series designed for 10 MPixel image sensors offered in focal lengths of 5 to 50 mm, and a series of 1.1" 12 MPixel C-Mount lenses in focal lengths ranging from 6.5 to 50 mm. Both lens series target machine vision and factory automation applications.

When asked if any of its electrically-tunable lenses can work with 12 MPixel image sensors, Optotune (Dietikon, Switzerland; [www.optotune.com](http://www.optotune.com)) confirmed that the EL-16-40-TC in fact, does. Tests performed with the EL-16-40-TC, along with a 12 mm Edmund Optics (Barrington, NJ, USA; [www.edmundoptics.com](http://www.edmundoptics.com)) lens and a 12 MPixel USB 3.1 camera from IDS Imaging Development Systems (Obersulm, Germany; [www.ids-imaging.com](http://www.ids-imaging.com)) resulted in Nyquist limited resolution with 140 lp/mm at a working distance of 966 mm and 131 lp/mm at 500 mm respectively.

VS-H-IRC/11 series lenses from VS Technology Corporation (Tokyo, Japan; [www.vst.co.jp/en](http://www.vst.co.jp/en)) also support up to 12 MPixel sensors. These C-Mount lenses feature sensitivity in the visible to NIR range and focal lengths of 12, 16, and 25 mm.

Likewise, Theia Technologies' (Wilsonville, OR, USA; [www.theiatech.com](http://www.theiatech.com)) ML610M 2/3" is a 12 MPixel varifocal C-Mount lens with 6 to 10 mm focal range. The company also offers several other high-resolution lenses, including the 12 MPixel SL410 (CS-Mount) and ML410 (C-Mount) lenses, which offer varifocal range from 4 to 10 mm that can be used with image sensors up to 1/1.7" and target machine vision and security applications. The TL410 and TL1250 motorized lenses target ITS/ANPR/LPR, robotics, and video surveillance applications. These 12 MPixel or 4K resolution lenses are designed to resolve 1.55  $\mu\text{m}$  size pixel pairs with 300 lp/mm MTF and maintain the resolution performance in the NIR range of the spectrum.

Designed for integration into 360° cameras used for small room surveillance, the 12 MPixel TY180IR IR-corrected fisheye lens allows viewing of an entire hemisphere on a single 1/2.3" 4K sensor. Lastly, the 12 MPixel SL1250 telephoto lens targets long distance security and surveillance and license plate recognition applications using sensors ranging from 1/2.3" up to 1/1.7".

"Not taking care to match the sensor's pixel size with the resolving power of the lens runs the risk of wasting your investment in a higher-resolution camera or over-specifying a high-resolution lens that is overkill for the sensor," says Jeff Gohman, President and Chief Optical Designer, Theia Technologies.

Available with C-Mount, F-Mount, M42, or custom mount options, Navitar's (Rochester, NY, USA; [www.navitar.com](http://www.navitar.com)) Resolv4K fixed and zoom lenses can be used with 10 MPixel image sensors and up. The company also offers 1.1" format, C-Mount lenses with focal lengths from 6.5 to 16 mm that can be used with 12 MPixel cameras, and 2/3" format, C-Mount lenses in focal lengths ranging from 5 to 50 mm suitable for use with 10 MPixel sensors.

Designed for APS-C high-resolution, large format image sensors, Edmund Optics' CA series of fixed focal length lenses target machine vision applications and feature TFL Mount (M35 x 0.75, 17.5mm flange). The lenses are available in 50, 75, and 100 mm focal lengths.

"In matching optics with larger image sensors, you have the same effect as with the

special requirements for non-visible imaging," says Greg Hollows, Vice President, Imaging, Edmund Optics. "For image sensors with higher resolution and smaller pixels, lenses must be designed specifically to hit these high-performance performance ranges."

While defined as 10 MPixel-plus here, high-resolution extends much further. With its 20MXSM, Canon USA (Melville, NY, USA; [www.canon-cmos-sensors.com](http://www.canon-cmos-sensors.com)) offers a 120 MPixel CMOS sensor with 2.2  $\mu\text{m}$  pixel size. Sony (Tokyo, Japan; [www.sony.com](http://www.sony.com)) also has the 100 MPixel IMX461 and the 150 MPixel IMX411 area scan CMOS image sensors, which offer 3.76  $\mu\text{m}$  pixel sizes. SVS-Vistek (Seefeld, Germany; [www.svs-vistek.com](http://www.svs-vistek.com)) uses the IMX411 in its shr411MCX camera, which comes with an M72x0.75 lens filter thread. Many M72-mount lenses available today target line scan sensors, and those suitable for use with area scan sensors do not yet approach full compatibility with image sensors this size.

Zeiss (Oberkochen, Germany; [www.zeiss.com](http://www.zeiss.com)), for instance, offers a lens with M72 x 0.75 filter thread (F-Mount, M42 camera mount). This lens works with image sensor



**Figure 4:** Available with a 12 mm focal length, Xenon-Opal lenses target 1.1" sensors up to 12 MPixels using sensors with microlenses.

sizes of 24 x 36 mm, but the Sony IMX411 measures 60.3 x 47.90 mm. Which is to say that, while the lens may provide adequate coverage, it does not cover the full image size. Sill Optics also offers M72 x 0.75 lenses, including the S5LPJ3005/M72, which suits image sensors with a maximum diagonal of 56 mm (125 MPixel equivalent for a 44 x 33 mm sensor). While large, such lenses do not fully support large image sensors like the IMX411. As these sensors deploy into real-world applications, lenses designed specifically to work with them should begin to emerge. ■

**Companies mentioned:**

<b>Canon USA</b> Melville, NY, USA <a href="http://www.canon-cmos-sensors.com">www.canon-cmos-sensors.com</a>	<b>Kowa American Corp.</b> Torrance, CA, USA <a href="http://www.kowa-usa.com">www.kowa-usa.com</a>	<b>Sony</b> Tokyo, Japan <a href="http://www.sony.com">www.sony.com</a>
<b>Computer</b> Cary, NC, USA <a href="http://www.computar.com">www.computar.com</a>	<b>Moritex Corporation</b> Saitama, Japan <a href="http://www.moritex.com">www.moritex.com</a>	<b>SVS-Vistek</b> Seefeld, Germany <a href="http://www.svs-vistek.com">www.svs-vistek.com</a>
<b>Edmund Optics</b> Barrington, NJ, USA <a href="http://www.edmundoptics.com">www.edmundoptics.com</a>	<b>Navitar</b> Rochester, NY, USA <a href="http://www.navitar.com">www.navitar.com</a>	<b>Tamron USA</b> Commack, NY, USA <a href="http://www.tamron-usa.com">www.tamron-usa.com</a>
<b>Fujifilm</b> Tokyo, Japan <a href="http://mvlens.fujifilm.com/en">http://mvlens.fujifilm.com/en</a>	<b>Opto Engineering</b> Mantova, Italy <a href="http://www.opto-e.com">www.opto-e.com</a>	<b>Theia Technologies</b> Wilsonville, OR, USA <a href="http://www.theiatech.com">www.theiatech.com</a>
<b>Goyo Optical</b> Saitama, Japan <a href="http://www.goyooptical.com">www.goyooptical.com</a>	<b>Optotune</b> Dietikon, Switzerland <a href="http://www.optotune.com">www.optotune.com</a>	<b>VS Technology Corporation</b> Tokyo, Japan <a href="http://www.vst.co.jp/en">www.vst.co.jp/en</a>
<b>IDS Imaging Development Systems</b> Obersulm, Germany <a href="http://www.ids-imaging.com">www.ids-imaging.com</a>	<b>Schneider-Kreuznach</b> Bad Kreuznach, Germany <a href="http://www.schneiderkreuznach.com">www.schneiderkreuznach.com</a>	<b>Zeiss</b> Oberkochen, Germany <a href="http://www.zeiss.com">www.zeiss.com</a>
	<b>Sill Optics</b> Wendelstein, Germany <a href="http://www.silloptics.de/en">www.silloptics.de/en</a>	

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