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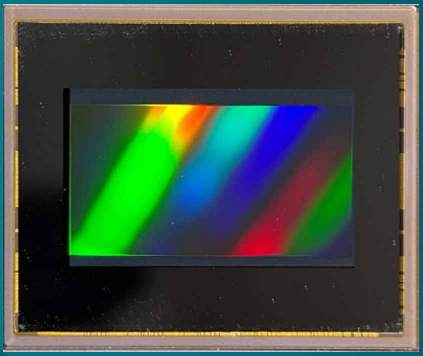

Imaging System Architectures:
Technical Comparison of 1 vs. 3-Imager Designs and 2/3" vs. Super 35 Image Sensor Formats

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For many years, high-end live production cameras have predominantly utilized three 2/3" CMOS image sensors in combination with a prism beam splitter and B4-mount lenses. This configuration has been widely regarded as the optimal balance of image quality, depth of field, lens compatibility, and operational flexibility across a broad range of production scenarios.

In recent years, however, the landscape of live production cameras has evolved. New configurations have emerged — differing in both the number of image sensors and the size of the image sensor — each influencing the choice of lens mount and the design of the optical system.

But what are the trade-offs between single-sensor and three-sensor camera systems, and how do different sensor formats, such as 2/3" and Super 35, influence those choices? This paper explores these considerations to help guide the selection of the most appropriate imaging architecture for today's diverse live production needs.

Single vs. Three-Imager Systems

When using identical image sensors, a three-imager optical block consistently delivers superior image quality compared to a single-sensor design. But does this mean single-sensor systems are inherently inferior or without valid use cases? Not at all. The optimal choice depends entirely on the specific requirements of the application.

Full-resolution Capture in All Three Color Channels

The superior image resolution of three-imager systems is a result of their use of a prism beam splitter. This optical component separates incoming full-spectrum light into its red, green, and blue components, directing each onto a dedicated image sensor (see Fig. 1). As a result, each sensor captures the full native resolution of its respective color channel.

For example, in a three-sensor HD system, each channel captures 2.1 megapixels, resulting in full-resolution RGB data. Likewise, a three-sensor UHD system delivers 8.3 megapixels per channel, providing full-color resolution directly at the sensor level.

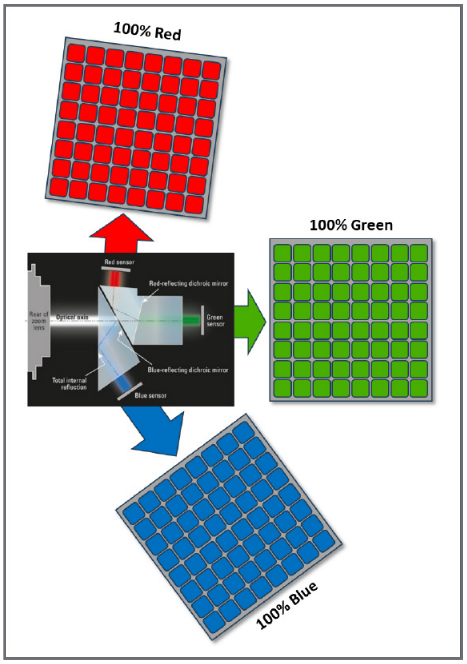


Figure 1 – Prism beam splitter at a three imager camera.

However, there are many scenarios in which a single-sensor solution is not only viable but may offer distinct advantages — particularly when comparing different sensor generations or formats. For instance, a modern single-sensor UHD camera with an 8.3-megapixel sensor can outperform an older three-sensor HD system (3 × 2.1 MP) in terms of overall resolution and image sharpness.

Smaller Pixel Sensors Narrow the Performance Gap

Still, pixel count alone is not the sole determinant of image quality. Several other key factors influence the performance, including pixel size, light sensitivity, dynamic range, signal-to-noise ratio (SNR), and shutter type (rolling versus global). In general, sensors with larger pixels collect more photons per pixel, which enhances low-light performance and extends dynamic range.

Historically, this gave larger-pixel sensors a clear advantage, particularly in challenging lighting conditions. However, advances in CMOS fabrication — most notably the use of finer lithographic processes — have enabled remarkable improvements in small-pixel performance. Modern UHD sensors with pixel pitches as small as 2.5 µm can now deliver image quality comparable to HD sensors from a decade ago with 5.0 µm pixels.

These technological advances have steadily narrowed the gap between single-sensor and three-sensor architectures, allowing both approaches to deliver broadcast-quality results across a wide range of live production environments.

Advantages of a Single State-of-the-Art 2/3" Global Shutter UHD CMOS Sensor Compared to Legacy Three-Sensor HD Systems

One of the primary advantages of a modern camera equipped with a single, state-of-the-art 2/3" global shutter UHD CMOS sensor lies in its higher overall pixel count: 8.3 megapixels (1 × UHD sensor) compared to 6.3 megapixels (3 × 2.1 MP HD sensors).

Because a single UHD sensor uses a Bayer color filter array (see Fig. 2), approximately 4.2 megapixels are allocated to the green channel, with 2.1 megapixels each dedicated to red and blue. This results in oversampling of the green channel — which significantly enhances luminance resolution. Luminance is a key contributor to perceived image sharpness, as the green channel plays the most prominent role in standard color processing.

Additionally, a native UHD signal can be generated from a single sensor through a de-Bayering process. This is not possible with a three-sensor HD system, which lacks the necessary pixel density to produce a true UHD output.

However, for a fair and comprehensive comparison, it's essential to consider all relevant parameters — not just resolution. For example, a modern single-sensor UHD camera may outperform an older three-sensor HD system in terms of spatial resolution, but other factors such as shutter type significantly affect real-world performance.

Consider this: a single-sensor UHD camera with a rolling shutter may produce sharper images than a three-sensor HD camera with global shutters. However, rolling shutters are typically unsuitable for demanding live production environments, where fast motion, LED lighting, or flash photography can introduce artifacts such as skew, partial exposures, or banding. In contrast, global shutter HD cameras are preferred in these scenarios due to their superior motion handling and immunity to such artifacts, even if they offer lower absolute image sharpness.

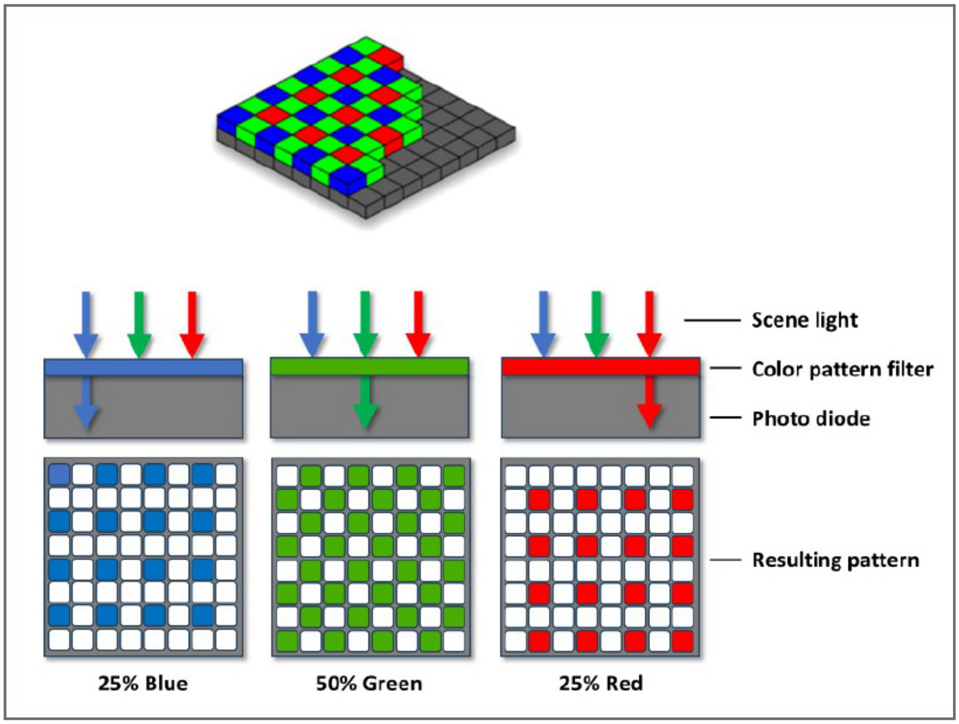


Figure 2 – Bayer patter color separation filter at a single imager camera.

But what if both systems use global shutters and have comparable sensitivity and dynamic range?

In that case, a single UHD sensor can deliver significantly better overall image performance than a three-sensor HD system. This highlights the importance of evaluating not just individual specifications like pixel count or shutter type in isolation, but the total system performance in the context of the intended application.

Single-Sensor Performance in the LDX 110 Series

The LDX 110 Series cameras utilize the same advanced 2/3" Xenios UHD CMOS sensor found in the higher-end LDX 135 and LDX 150 models. The key distinction lies in the sensor configuration: the LDX 110 features a single-sensor architecture, whereas the LDX 135 and LDX 150 employ a three-sensor optical system. This makes the LDX 110 a cost-effective, entry-level solution that still leverages the full performance potential of the latest 2.5 µm UHD pixel design, manufactured using state-of-the-art 65nm CMOS image sensor (CIS) technology.

When compared to earlier-generation three-sensor HD systems — such as the LDX 92 Series — the LDX 110 delivers a significantly improved modulation transfer function (MTF), enabling superior reproduction of fine image details. Notably, these image quality gains are achieved without compromising light sensitivity or dynamic range.

In addition, the LDX 110 Series offers native UHD output and integrates many advanced features from the newer LDX 100 platform, including:

- In-camera LUT processing for optimized HDR/SDR workflows
- A feature-rich compact camera version for space-constrained environments
- Upgradability and modular options for enhanced operational flexibility

Are There Trade-Offs?

Yes, but it depends on the application. While the single-sensor design offers several advantages, it also introduces one notable limitation. The use of a Bayer color filter array results in green, red, and blue signals being sampled at different spatial frequencies (see Fig. 2). This asymmetry complicates the design of the optical low-pass filter (OLPF) and increases the potential for color moiré artifacts.

Unlike in three-sensor systems — where interference patterns are typically achromatic — any aliasing artifacts in a single-sensor system are inherently chromatic, and thus often perceived as more distracting. This is particularly relevant in scenes with fine patterns or high-frequency content, such as LED walls.

To address this, LDX 110 cameras are equipped with a second-stage optical low-pass filter specifically optimized for these challenging scenarios. This additional filter significantly improves moiré suppression and overall image quality in environments where aliasing would otherwise be more pronounced.

While the optimized second OLPF provides a noticeable improvement in aliasing performance for the LDX 110 Series, it does have limitations. In demanding applications such as LED wall environments — where minimizing aliasing is the highest priority — three-sensor HD cameras are also not the ideal solution. In these scenarios, the LDX 135 and LDX 150 Series cameras offer superior aliasing suppression and represent the best choice.

LDX 110 vs. LDX 92 Series

How does the LDX 110 series compare to a similarly positioned three-sensor LDX 92 series camera?

In nearly all key performance metrics, the LDX 110 series delivers significantly improved results. The advantages of the newer platform are evident not only in image quality — including resolution, detail reproduction, and dynamic range — but also in enhanced feature sets and broader workflow support, such as integrated HDR/SDR processing and native UHD output.

Although single-sensor systems typically present greater challenges with moiré suppression, the LDX 110 addresses this effectively through the inclusion of a second-stage optical low-pass filter, optimized for scenes with high-frequency content such as LED displays.

Conclusion: Single vs. Three-Imager Systems

When using matched — ***identical*** — image sensors, a three-imager camera delivers superior image quality compared to a single-sensor system, due to full-resolution capture in all three color channels.

Yet, when compared to a substandard (older) image sensor, a single-sensor camera leveraging the latest CMOS imaging technology can offer a high-performance, cost-effective solution that meets the demands of many contemporary live production workflows — especially when compared to older three-sensor HD systems.

Considerations for Comparing Image Sensor Sizes

A common question that arises in camera system design is: why choose a particular image sensor size (Fig. 3), and why does it matter?

The primary image-related effect influenced by sensor size is depth of field, which is indirectly dependent on the sensor's physical dimensions. Larger sensors require longer focal lengths for the same field of view, which in turn results in a shallower depth of field.

While the desired visual look can often be achieved through a combination of lens selection, aperture adjustment, and camera positioning, these options are often limited by real-world constraints, such as available space, lighting conditions, and production workflow. In practical terms, this means depth of field control is often not as flexible as it may appear in theory.

Additionally, when comparing cameras with different sensor sizes, several other critical factors must be considered — particularly in terms of lens compatibility, mount standards, and overall system integration. Sensor size affects not only the visual characteristics of the image but also the types of lenses available, their optical performance, and how well they support the needs of specific production environments.

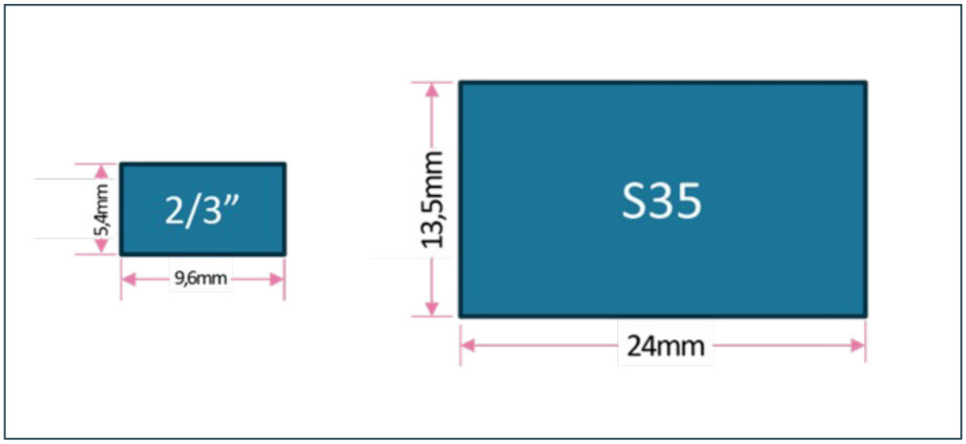


Figure 3 – Comparing 2/3" and S35 image size.

Object conditions, 2.1m height, 100m distance		
Image Size	2/3" (d = 11 mm)	S35 (d = 27.5 mm)
Focal Length	260 mm	650 mm
Lens Aperture	Dof	
F.no		
2.8	5.8m	2.5m
4.0	8.3m	3.6m
5.6	11.6m	5.0m
8.0	16.6m	7.2m

Figure 4 – Depth of field comparison.

Sensor Size and Lens Mount

Sensor size directly influences the lens mount, which determines the range of compatible lenses — a critical consideration in both the development and practical deployment of camera systems. In live television production, B4-mount lenses designed for 2/3-inch sensors remain the industry standard, as they uniquely satisfy the diverse operational and optical requirements of live broadcast workflows. These include compact size, low weight, wide zoom ranges, and predictable depth of field characteristics suited to multi-camera environments.

In contrast, larger Super 35 (S35) sensors, typically paired with PL-mount lenses, introduce specific limitations. While they are well-suited for certain controlled or cinematic applications, these systems often produce a depth of field that is too shallow for many standard camera positions used in live production. Furthermore, the limited availability of high zoom-ratio lenses for the S35 format reduces operational versatility, making such systems less practical for the dynamic, multi-angle demands of live multi-camera productions.

Sensor Size and Depth of Field

Sensor size affects both the field of view and the depth of field. For a given framing or scene coverage, larger sensors require lenses with longer focal lengths. Since depth of field is inversely related to focal length, this results in a shallower depth of field when using larger sensors. While this can enhance cinematic aesthetics, even in live applications, it may present challenges for many typical camera positions in live production, where maintaining consistent focus across multiple — and sometimes fast-moving — subjects is essential (Fig. 4).

Sensor Size and Lens Aperture, F-Number

The f-number of a lens is calculated by dividing the focal length by the effective aperture diameter. A smaller f-number indicates a faster lens, meaning a wider aperture and greater light-gathering capability.

For cameras with Super 35 (S35) sensors, longer focal lengths are required to achieve the same field of view as cameras with 2/3" sensors. To maintain the same f-number (i.e., the same aperture opening in terms of light transmission), the lens diameter must increase proportionally with the focal length. As a result, achieving a fast lens on an S35 sensor requires substantially larger lens elements.

In the context of live production, there are practical limitations regarding the size, weight, and handling of lenses. These constraints make it difficult to deploy large, fast lenses for S35 cameras in low-light environments, where wider apertures are critical.

Additionally, the larger diameter of the lens elements significantly increases manufacturing complexity and cost, imposing further limitations on the practical use of S35 systems in certain live production scenarios.

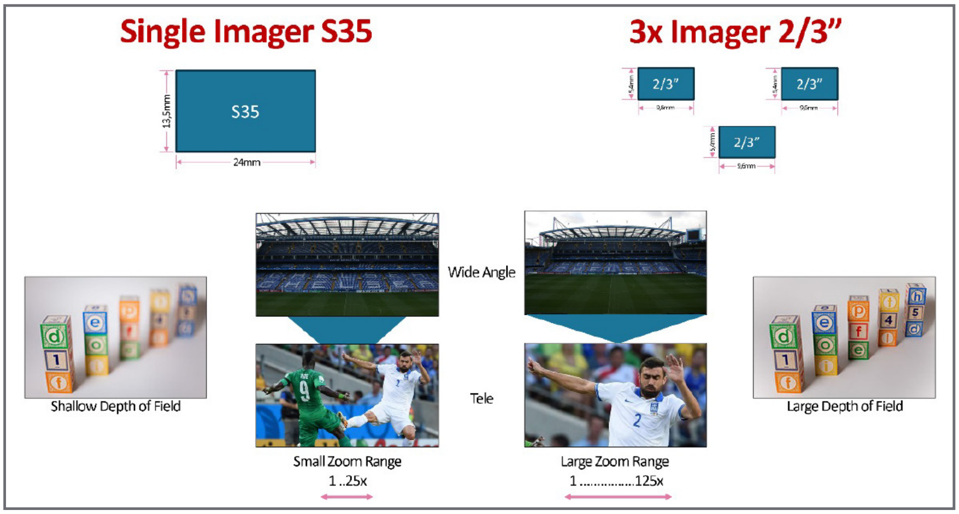
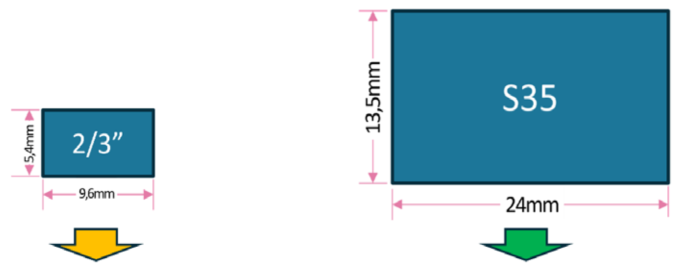


Figure 5 – Comparing depth of field at S35 and 2/3" imagers.



H-pixel	3840	x 2.5	9600
V-pixel	2160	x 2.5	5400
Total pixel	8.294.400	x 6.25	51.840.000

Figure 6 – Comparing pixel count of the active image area.

Sensor Size and Zoom Range

For B4-mount lenses, zoom factors of 20x or more, maximum apertures around f/1.8, and a weight of approximately 2 kg are standard for compact, portable broadcast applications. Large box-style B4 lenses can achieve zoom ranges of up to 125x, while still maintaining similarly fast apertures — making them ideal for versatile live production scenarios.

In contrast, PL-mount lenses offer significantly more limited performance in this context. A portable PL-mount lens with a 20x zoom typically weighs between 6 and 7 kg and has a maximum aperture of only T/7.5. Even among large-format box-style PL lenses, the maximum zoom range tops out around 40x, with a maximum aperture of only f/2.8, despite having dimensions and weight comparable to a 125x B4 lens. As a result, using large-format image sensors often involves compromises in operational flexibility — particularly in terms of zoom range and the ability to quickly reframe shots, both of which are critical in dynamic, multi-camera live production environments (Fig. 5).

Sensor Size and Pixel Count

When using the same pixel structure from 2/3" UHD imagers on a Super 35 (S35) imager, the result is a 6.25-times higher total pixel count. This increase is due to the S35 sensor having 2.5 times the width and height of the active image area, resulting in a 2.5^2 (i.e., 6.25) times larger imaging surface. (Fig. 6).

The substantial 6.25× oversampling of the Super 35 (S35) sensors results in an exceptionally high modulation transfer function (MTF), allowing for minimal reliance on electronic image enhancements such as detail correction. This leads to remarkably smooth yet highly detailed images — a level of image quality that standard 2/3" cameras cannot deliver in live production environments.

This advantage, particularly when combined with global shutter operation, makes these cameras an ideal choice for main camera positions in many sports productions, where wide-angle shots with fine detail are common and virtual ad replacement solutions may be deployed.

Conclusion: 2/3" vs. Super 35 Image Sensor Formats

Both 2/3" B4-mount cameras and Super 35 (S35) PL-mount cameras have their own strengths and limitations. It's not a matter of which is better, but rather understanding which is best suited for a given application.

2/3" B4-mount cameras offer a highly flexible solution for many standard camera positions in live sports and entertainment productions. In contrast, S35 PL-mount cameras deliver the shallow depth-of-field aesthetic that is characteristic of cinematic storytelling, which can also enhance certain live productions.

Integrating both imaging systems within a single camera family — sharing the same feature set and controls — offers the most versatile and powerful solution for live broadcast applications (Fig.7).

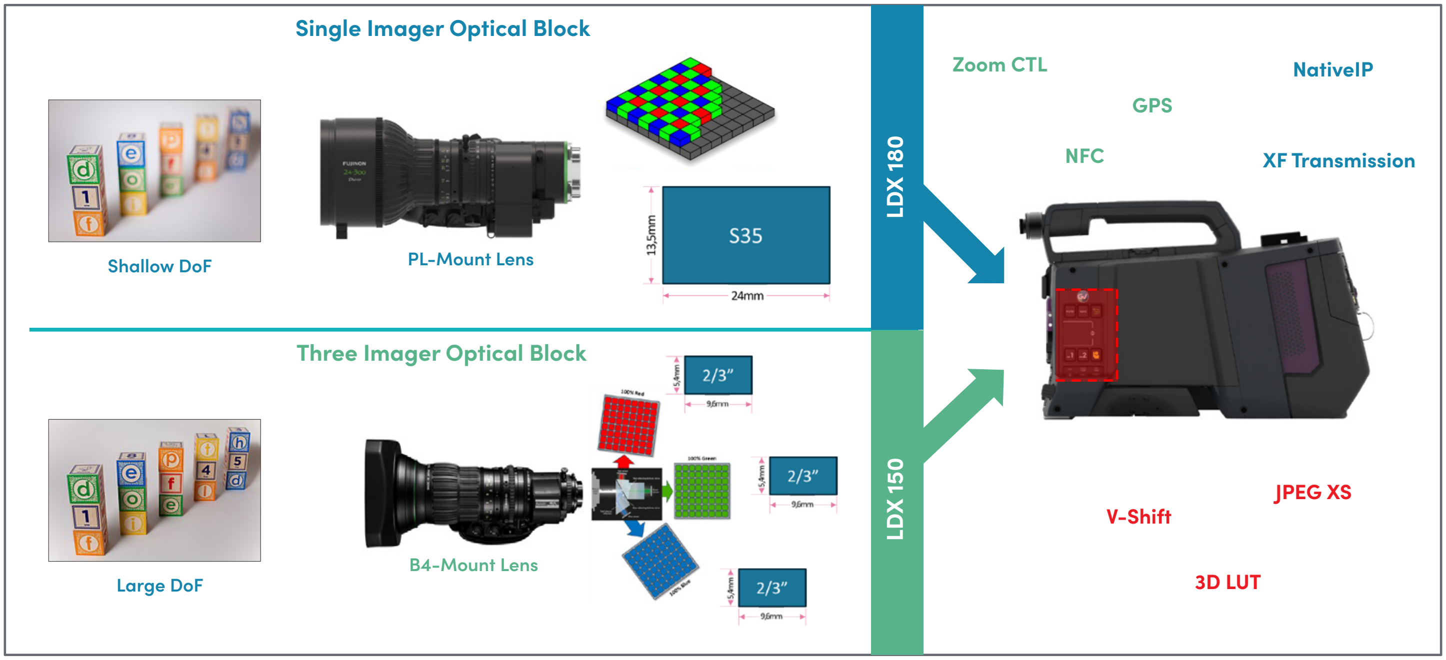


Figure 7 – Integrating single S35 and three 2/3" imaging systems in the same camera family.