

# HD And SD Lenses And Cameras

**PRODUCTION** | *Optimizing Your Camera's Performance In The Era Of HD*

by Larry Thorpe

In these days of the transition to DTV a question surfacing with some regularity centers on the wisdom of mixing HD and SD lenses with professional HD and SD cameras. The emergence of a global interface standard for 2/3-inch lenses certainly does facilitate a freedom to mount SD lenses on HD cameras and HD lenses on SD cameras. The various combinations do work operationally. Upon an initial subjective assessment they might even seem to make credible video. The question then becomes whether that video is the best that can be created.

It can be said at the outset that investing in an HD lens for an SD camera is a *very* sound decision, both from the viewpoint of technical performance and long-term investment. It immediately ensures a higher performing object image presentation to the camera than is possible with even the best SD lens. That in turn produces a better SD picture from the camera because the HD lens will have a higher MTF, or *modulation transfer function* (horizontal and vertical) across the SD spatial frequency band.

To the extent that contemporary HD lenses also exhibit superior control over lens aberrations, this too directly benefits the SD imagery. This lens-camera

combination also supports a superior upconversion from SD to HD as a consequence of the inherently sharper image. This allows the degree of SD camera digital detail enhancement to be lowered, which reduces noise, contouring on luminance transitions and aliasing (especially vertical aliasing in interlaced video signals)—all of which favors the digital upconversion process. Finally, that same HD lens can readily transfer to some future HD camera. Thus, an HD lens on an SD camera is—overall—a sound investment for today and for tomorrow.



Canon's HJ17ex7.6B IRSE, its newest HD lens for ENG applications, offers an unprecedented combination of features and affordability.

**HIDDEN DANGERS** The converse—deploying an SD lens on an HD camera—is not at all a sound decision. Clearly, the attraction for this consideration is the possible cost savings afforded by redeployment of an existing SD lens, or the purchase of an SD lens lower in cost than its HD counterpart. Such a decision is often technically defended on the simplistic assumption that it merely adds a degree of optical low pass filtering that will somewhat soften the HD image and possibly further aid curtailment of HD aliasing. This is true in one sense, but it ignores some other more real and insidious technical perils.

The performance of any camera—SD or HD—is only as good as the two-dimensional object image presented by the lens to the camera image sensors. The optical passband required to fulfill the 1080-line HD system bandwidth is 2.7 times that of the best SD 16:9 5.5 MHz 480-line system. For the 720-line HD system, the requisite optical passband is

## ► THE BOTTOM LINE

Although the global interface standard for 2/3-inch lenses makes it possible to mount an SD lens on an HD camera, it's not a good idea. In addition to softening the video image, an SD lens on an HD camera produces further impairments to picture sharpness as the lens operational controls are exercised, and it also exacerbates chromatic aberrations. Mounting an HD lens on an SD camera is, however, a good idea, both from the viewpoint of technical performance and as a long-term investment.

## Long term, it is in everybody's interest to reach a point where all lenses intended for either SD or HD cameras are designed to the exacting imaging disciplines of HD.

approximately twice that of SD. These are tremendous extensions in spatial frequency and they impact both horizontal and vertical resolution. Indeed, that extension is the very essence of the visual enhancement to picture sharpness that constitutes *high definition*.

SD lenses roll off rapidly and unpredictably over that higher spatial frequency region—quite understandable since the design criteria for SD lenses was sensibly directed for optimization of the SD pass-band, with little consideration beyond those spatial frequencies. But when an SD lens is on an HD camera, any attempt to compensate for the limitations of that SD lens, such as resorting to HD camera digital image enhancement to restore sharp-

ness, serves only to exacerbate camera noise and possibly to introduce the associated traditional edge effects that have always marred SD imagery. Quite apart from impairing the originating HD image itself, both can possibly bode trouble for downstream digital processes within the complex digital compression environment of the contemporary DTV broadcast system (usually entailing multiple codecs).

Even worse, is that the real hidden devil lies in the details of the erratic optical behavior of the SD lens across those higher “out of band” spatial frequencies. Camera MTF is, happily, a relatively fixed characteristic—largely defined by the fixed sampling lattice of the sensor array, a fixed optical low-pass pre-filter and

fixed electronic filtering. MTF of both HD and SD lenses, on the other hand, is highly dynamic. That is because the MTF of *all* lenses varies with:

- Distance from the center of the image plane.
- Object distance (relating to focus control).
- Focal length (relating to zoom control).
- Aperture (relating to iris control).

Accordingly, as the lens operational controls of iris, zoom and focus are manipulated during an HD production, the out-of-band MTF behavior of the SD lens is especially unruly and unpredictable. The central design imperative of the HD lens, on the other hand, has been to both elevate MTF over the requisite higher spatial frequencies while simultaneously tightly controlling all of these variations. That design combination exercises a far greater impact on perceived picture sharpness in the “higher definition” realm of HDTV. The behavior of the SD lens beyond the normal SD pass-band is particularly erratic—a consequence of pragmatic lens designs that simply never concerned themselves with those higher

spatial frequencies. HD lens designs, on the other hand, successfully curtail these dynamic alterations in MTF at the higher spatial frequencies.

**CHROMATIC ABERRATIONS** Another hidden peril of an SD lens on an HD camera relates to chromatic aberrations—the real nemesis in HD lens-camera systems. This relates to the very fundamental optical phenomenon of each separate color wavelength having a unique focus and magnification as it passes through even a single glass element. This is greatly compounded with multi-element lenses (contemporary broadcast lenses can have anywhere from 20 to 35 elements). Highly sophisticated compensating strategies are mobilized in HD lens design to reduce these to an acceptable level (although it's virtually impossible to reduce them to zero).

An industry standardization group—composed of representatives from all of the major camera and optical manufacturers—closely examined the 2/3-inch HDTV lens-camera interface in the early 1990s. They ultimately produced the

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interface standard, BTA S-1005-A, that precisely defines the mechanical, optical and electrical interfaces between the lens and the camera. Central within this standard is an agreed-to precision offset in the path length of the red and blue camera image sensors relative to the green sensor. This was a compromise wrung from the

contending expertise of the optical manufacturers—all of whom were concerned with chromatic aberrations in the very small 2/3-inch image format HD lens (and each having proprietary strategies for dealing with this aberration).

HD lenses are meticulously designed with these offsets in mind. SD lenses, how-



MARK FORMAN

Larry Thorpe explains the benefits of proper lens testing at a recent SMPTE New York Chapter meeting.

ever, are designed to *quite different offset specifications*. Thus, mounting an SD lens on an HD camera will introduce unpredictable chromatic aberrations. They will become even more unpredictable as the lens zoom control is exercised. It is universally acknowledged that visible chromatic aberrations constitute one of the most unacceptable impairments to high quality HD imagery.

**THE AGE OF THE HD LENS** The marketplace is now seeing a broadening hierarchy of HD acquisition systems to address both different production applications and a wide diversity of HD production budgets. This product hierarchy comprises a range of image-format sizes, a variety of image-sensor sampling lattices and diverse bit rate reduction recording strategies. They range from the emerging large-format 35mm digital HD cameras, to new tapeless HD camcorders (embodying 2/3-inch, 1/2-inch and 1/3-inch image formats), to the presently popular lower-cost HDV camcorders (mostly using 1/3-inch image formats). The optical manufacturers are presently grappling with the implications of all this in terms of a commensurate hierarchy in HD lenses (with careful attention to a matching range of costs and performances). Suggestions of SD lenses being part of this mix will introduce technical confusion and will ultimately manifest itself in widespread disappointment when the picture performance of such systems are ranked with those utilizing true HD lens-camera systems.

Separately, the suggested use of any 2/3-inch SD lens on the emerging 1/2-inch and 1/3-inch HD camcorders via the presently available lens adapters should not ignore the further aberrations introduced by these additional glass elements which are universally of SD design.

Long term, it is in everybody's interest to reach a point where all lenses intended for either SD or HD cameras are designed to the exacting imaging disciplines of HD. Over the past decade optical manufacturers have made tremendous strides in driving down the costs of HD lenses. Larger production quantities (with attendant economies of scale) will hopefully soon render it unnecessary to continue designing SD lenses. That will be a win-win all round.

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