An Open Letter to The 4K Industry – We Need to Get This Right

by Mobile TV Group's CEO, Philip Garvin

After six months of production on our 4K/UHD/HDR mobile unit, 39 Flex, at events as varied as the Masters, PGA Championship, a Garth Brooks concert, Beach Volleyball, MLB games, and Notre Dame football, we have found inconsistencies in the quality of the video. The apparent sharpness or resolution of the 4K images can appear to be no better than 1080i or even 720p. After in-house testing and numerous inquiries with camera and lens manufacturers **we have learned that delivering high quality 4K produced with cameras with 2/3" imagers requires some untraditional camera setting procedures.**

The main advantage of 4K over 2K (regular HD) is the extra resolution. So if that better resolution is impaired, you have all the challenges of 4K production without any of the advantages. Many people who think they have seen 4K pictures (and been disappointed), have not seen 4K/UHD at its best. When you get maximum performance from 4K cameras you get an absolutely amazing picture that is well worth the trouble and expense.

The sharpness problem with 4K did not develop until Sony (and now Grass Valley) produced a true 4K camera with 2/3" imagers. Previously 4K cameras had larger imagers, but these were not truly compatible with the large telephoto lenses used in sports. Those big lenses are designed to work with 2/3" imagers. To cram 4K pixels into 2/3" imagers, Sony and GV had to reduce the size of each pixel from approximately 5um to 2.5um (Sony) or 2.6um (GV).

Unfortunately, at 2.5um pixel size, something called "lens diffraction" affects sharpness if the iris is closed beyond F4 (instead of at F8 or F11 with 5.0um pixels as on regular HD cameras)**.**

"Lens diffraction" is something that happens when you adjust the aperture or iris of a lens. When the iris is fully opened (e.g. 1.8 or 2.8) the light passes through the lens in straight lines. As you close the iris (e.g. F4 to F16) light has to reduce in size to pass through the smaller iris and then expand again to reproduce the full image. That cone effect reduces sharpness with any imager/pixel size, but does so much sooner when the pixels are smaller. Lens diffraction is a grim reality of optics. The only way to avoid its impact on sharpness is to be mindful of the iris setting in relationship to the pixel size. (In bright lighting, shaders will have to use ND filters and/or negative gain instead of closing the iris beyond F5.6.) A more technical presentation is offered below.

A good primer on lens diffraction is available from the digital cinema world at: http://www.cambridgeincolour.com/tutorials/diffraction-photography.htm. One can also get details on this from lens manufacturers like Larry Thorpe at Canon and Josh Ewing at Fujinon. (A qualifier: 4K cameras do make great looking pictures at any F-stop because they are newer and employ up-to-date imagers and processing.)

Camera ops and video shaders will legitimately complain that at F4, there is limited depth of field. That is why **Mobile TV Group recommends that the F4 setting should primarily be used for high position cameras that shoot the wide shots and "game cameras" where depth of field is less critical**. For field or

court level cameras, some resolution will have to be sacrificed in favor of better focus. The good news is that we have found that if these lower position cameras are super slow motion cameras shooting in 1080i or 1080p with replays up-converted to 4K, the results are outstanding. Apparently the high frame rate greatly benefits the quality of the up conversions. Since lower position cameras are used in replay more frequently than live, one might conclude that 4K production is best done with a mix of 4K and 1080i/1080p SSMO cameras.

There are other camera settings on the Sony 4300, besides iris, which affect picture quality. Besides resolution, noise levels are more critical in 4K because the 4K encoders are more sensitive to noise than HD encoders. So edge settings, detail, etc. have to be optimized. But iris-related settings are most impactful. Mobile TV Group's recommended settings for the Sony 4300 cameras in 4K are noted below.

Mobile TV Group Camera Settings for Sony 4300:

Start with a reset to factory settings. Check to make sure the "Absolute Numbers on the MSU are "O". Adjust 4K settings per below, then adjust HD settings as desired (e.g. HD Detail).

Iris: F4 to F5.6 (adjust ND filter and use negative gain accordingly)
Detail: Leave Level, threshold, etc. at Factory setting.
Adjust DTL boost frequency to (-)50. (This affects edges and reduces noise. Then you turn on HD Adjust and dial Frequency back to 0, so that only the 4K output is affected.)
Detail Threshold and other: This needs to stay with Factory setting.
Crispness: This is also needs to stay with Factory adjustment

Use the following additional settings when using HDR in 4K:
-Select S-Log3 or HLG and use factory settings for 4K HDR (Preliminary Settings)

Use the following additional settings when using SDR for HD:
- SDR GAIN off-set adjustment: set to -8 to -10db
- SDR black off-set adjustment: set to -3 to -5

Lens Diffraction Technical Specs:

The essential difference between the HDTV lens-camera and the UHDTV lens-camera is as follows:

1) In an HDTV camera F-4.0 delivers a high MTF of about 85% at 50 LP/mm (an established yardstick for perceived sharpness).
2) In an HDTV camera the lens can be stopped down to F-16.0 and will produce close to a 50% MTF at 50 LP/mm --- and this is still perceived as quite sharp. So in an HDTV camera anything from wide open to F16 is acceptable.
3) In a 4K/UHD 2/3" camera the lens setting of F-4.0 produces a still very good MTF of more than 70% at 100 LP/mm.
4) In a 4K/UHD 2/3" camera a lens setting of F-5.6 will produce an acceptable 62% MTF at 100 LP/mm. Anything less than 60% MTF will result in perceivable loss of sharpness in wide shots in 4K/UHD. So anything from wide open to F5.6 will result in sharp 4K/UHD images.

MTF=Modulation Transfer Function--plotted curves that show the behavior of picture sharpness
LP/mm=Line Pairs per Millimeter ---- the standard way of referring to optical resolution.