STEREOSCOPY

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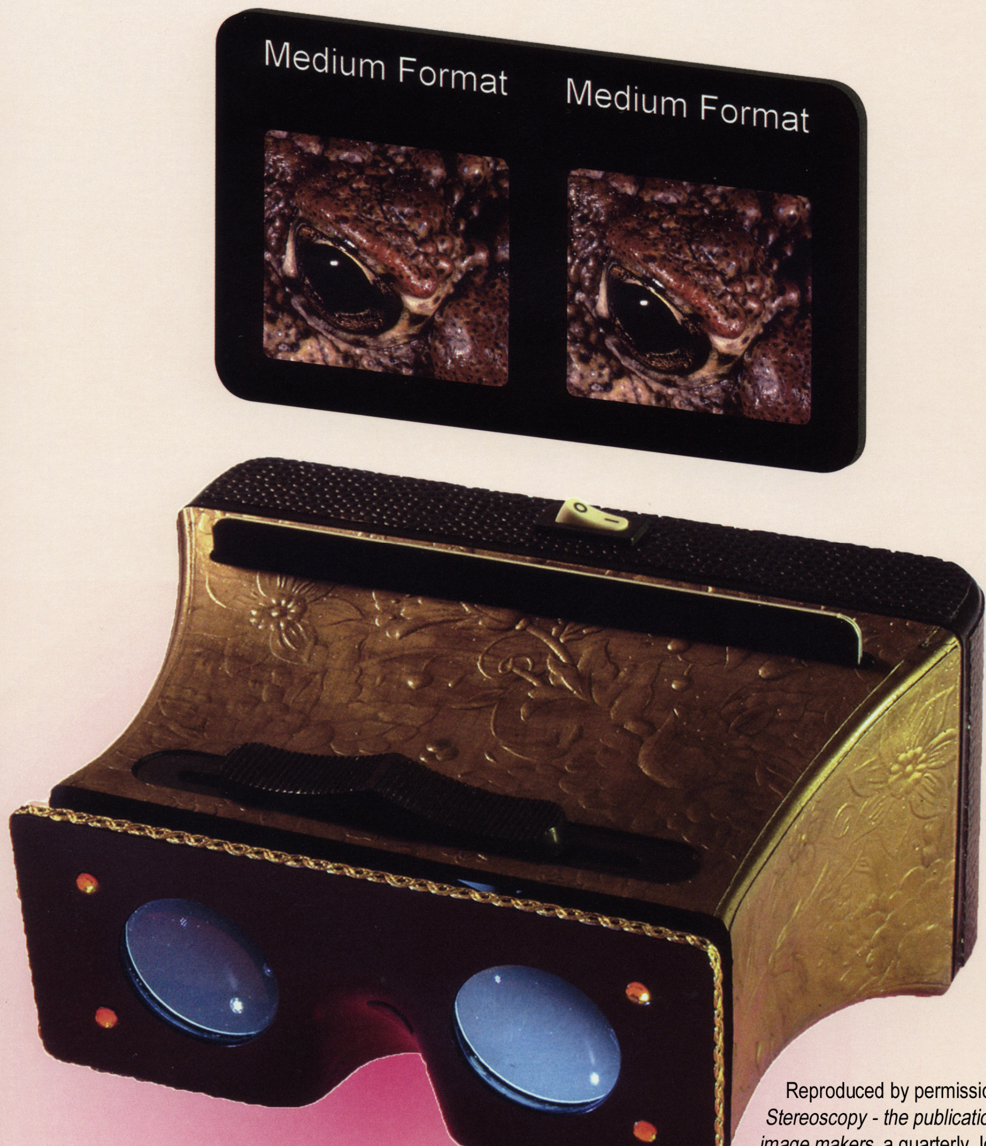

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STEREOSCOPY

Issue 4 2007 Series 2 - Number 72

From the Treasurer

Alexander Klein

Jan asked me to write a few short paragraphs: *Tempus fugit* – and when you hold this issue in your hands, time has already fled well into 2008. Which means that we are late. Very late actually! But you received two issues at once — so we are very seriously catching up.

David Kesner should be given credit for being the co-editor of this issue — he was instrumental in gathering together many of the articles. And since this is a team effort, I would also like to mention Joe Pedoto, who has spent numerous hours making layouts at odd hours of the day (and night).

By now, I am sure you want to show your gratitude — and there are three ways of doing that: FIRST by making sure that you already paid your 2008 membership dues (because you don't want to miss the next issue). SECOND by contributing an article, photos, notes, thoughts to our Editor, Jan Burandt — and THIRD by showing the last four issues around to your 3D friends, telling and showing them how pretty and informative our four-colour journal has become, compared to the "old days" of mostly black & white. Find us new members — we are just a few members away from signing up our 1,000th member!

ISU Online

ISU Discussion Group:
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Front cover: Regal Medium Format Stereo Slide Viewer, made by Sam Smith, stereoscopia.com
Notes about Back Cover: Robert Bloomberg

Top images: MacroMIYA Macro Stereo Camera uses a Mamiya body for vertical pictures on 120 roll film, made by Tom Pennings based on Jac Ferwerda's famous NilMelior camera (Fig 10.9B in his book *The World of 3-D*). Tom used surface mirrors instead of prisms. The stereo base is variable from 10 mm down to 2 mm. Five interchangeable lenses with distance rods. Focal lengths: 100 mm, 75 mm, 50 mm, 40 mm, & 32 mm. Separation of apertures (stereo-base): 10 mm, 6.8 mm, 4.5 mm, 3 mm, & 2 mm

Bottom: Jackson's chameleon (*Chamaeloeo jacksonii*)

STEREOSCOPY
(ISSN 0254-4482) is published quarterly by the International Stereoscopic Union, and is circulated to members.

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The Ideal Medium

by Michael K. Davis, Flower Mound, Texas USA

In the rush to digital, film has been all but forgotten by the majority of 2D photographers, professional and amateur alike. Even among stereographers the majority of us have at least daydreamed of ways to adapt the advantages of digital shooting to our passion for 3D, while others have taken the plunge by using digital projectors or viewers like John Hart's spectacular single-mirror MirScope Viewer™ to display large inkjet (or analog) prints produced from digital (or analog) cameras.[1] But no one has yet found a way to digitally replicate that which, in my opinion, is the ideal medium for stereographers: the unrivaled phenomenon of well-crafted pairs of backlit medium format transparencies displayed in a portable, handheld stereo viewer.

To fully appreciate the analog experience already available to stereographers producing medium format stereo transparencies for display in handheld viewers, we can start by imagining the tools required to accomplish the same thing digitally. Doing so should give you a newfound enthusiasm for the very capable technology that's available to us right now, today, shooting state-of-the-art medium format transparency films for use in stereo viewers that embody a technology dating back to the mid-19th century: The Brewster-design viewers[2] just can't be beat, in my opinion. They suffer none of the ghosting associated with polarized projection and anaglyph[3] views, nor the bulk, weight, and alignment problems associated with double-mirror Wheatstone[4] stereoscopes.

Imagine an electronic head-mounted display (HMD) capable of delivering the equivalent of 21.8 Megapixels[5] to each eye, in stereo. HMDs operating at resolutions equivalent to what we can enjoy in a $39.95 medium format stereo viewer[6] simply do not exist, except in our imaginations, and it's reasonable to argue that they may not exist for many years. "Based on the human eye's minimum resolution of 1 arcminute [1/60th of a degree],[7] an HMD with a field of view of 40° should not have less than 2400 pixels in either dimension."[8] That's 60 pixels/degree of angle of view, but the market is already content with HMDs having resolutions as low as 1280x1024, 800x600, or even 640x480, not just for entertainment, but also for medical and military applications.[9] HMDs costing $20,000 or more can deliver no more than 20 pixels/degree of angle of view.[10] If we assume a conservative equivalent of 4094x4094 pixels in each 52x52mm transparency (from a 2000 dpi scan), a medium format stereo viewer, when focused at Infinity, can deliver detail equivalent to 107 pixels/degree of angle of view – more than 5 times the detail available in a $20,000 HMD,[11] and right at the limits of what our eyes can appreciate.[12]

How can we have any expectation of future HMDs delivering 4094x4094 pixels across a 38-degree angle of view[13] when the highest resolution LCD monitors available today include the likes of the 22-inch IBM T221,[14] delivering only 9.2 Megapixels at 3840x2400? Even if we spent the $25,000 necessary to set two of these side by side (including a PC equipped with the required graphics adapters), we'd still have less than half the resolution enjoyed in a handheld medium format stereo viewer. Digital can't compete!

We're not likely to see a digital display device capable of replicating what we can see in a medium format transparency because the market that throttles many such innovations just isn't likely to demand it. The native resolutions of today's best HDTV flat-panel televisions go no higher than 1920x1080 pixels,[15] yet the average consumer raves about the detail these displays offer. Double that of the standard definition CRT's they've replaced when operating at 1080i or 1080p, these devices offer an improvement in resolution, to be sure, but the average person has never experienced the "high resolution" their eyes are actually capable of appreciating.

2x Mamiya 7ii with 43 mm f4.5 on 28" Jasper Engineering slide bar and Arca Swiss B-1 ball head

Sadly, the general public is like the proverbial "tiger that has never left his cage" and thus, a market demand for digital display systems with resolutions approaching the limits of human acuity may never come to pass. Manufacturers otherwise interested in developing such devices could find themselves waiting a long time for any economic incentive to proceed.

Imagine working with a dual-21.8 Megapixel digital stereo camera, or at least a digital twin-camera rig comprised of two 21.8 Megapixel cameras, that offers a color depth far exceeding the 14-bit depth available in today's best digital cameras. Again, it doesn't exist today, but there's a good chance that color depths will improve in future cameras. Some film scanners operate at color depths as high as 16-bits (per color channel) for a reason – analog films have a virtually endless palate of color, well in excess of what can be captured in a 14-bit raw file.

Imagine using digital cameras equipped with sensors large enough to have lenses offering the perfect balance between available Depth of Field and vulnerability to diffraction – sensors much larger than "full frame" 24x36mm sensors. An easily overlooked advantage of medium format stereography for handheld viewers is the fact that the 3.4x enlargement imposed by a 75mm viewer lens focused at Infinity allows the medium format stereographer to use the very same f-stops that a 35mm-based stereo viewer would require for sufficient depth of field at the 7x magnification imposed by the shorter focal length lenses used in such viewers.[16] In other words, if we're comparing smaller format viewers to medium format handheld viewers, there is *no actual loss* of Depth of Field in moving from shorter focal length camera lenses to equivalent focal length Medium Format camera lenses because there is a simultaneous reduction in enlargement factor that offsets what would otherwise be a requirement for smaller Circles of Confusion.

Enlargement factor and viewing distance are critical factors in selecting the Circle of Confusion diameter one should use for Depth of Field calculations.[17] The

52 pounds of gear with Bogen3021 tripod on folding hand truck

real beauty of this is that the medium format stereographer enjoys an additional benefit inherent to shooting with larger physical apertures for any given f/number: reduced vulnerability to diffraction. Thanks to the larger CoC diameters permissible at half the enlargement factor, a medium format stereographer producing transparencies for a handheld viewer enjoys the very same Depth of Field a smaller format stereographer would obtain at apertures as small as f/22, without suffering the image degradation caused by diffraction at such small apertures in the smaller formats.

No digital camera equipped with a "full frame" (24x36mm) sensor can enjoy this benefit, even if we could find a way to get the necessary number of pixels recorded to film for use in a backlit handheld viewer. Only a medium format digital camera or back comes close to having a sensor large enough to enjoy the freedom from diffraction enjoyed by medium format film cameras, but most such sensors, though larger than 24x36mm, are actually much smaller than the 56x56mm frame produced by a 6x6cm film camera. Still, they do offer less vulnerability to diffraction at any given f-Number, but we're still faced with the task of using digital files to produce transparencies of the quality we're currently enjoying with a purely analog workflow.

Film recorders are all but extinct, but the best can record no more than 2000 lines, whether to 35mm, 6x6cm, or 4x5-inch films. Specifications for the Lasergraphics' LFR Mark VI™ DPM Film Recording System[18] indicate an ability to record as many as 16,000 lines, but just try and find a service bureau possessing one of these units that will encourage you to attempt more than a 2000 line recording. It seems these recorders just don't have enough precision to actually realize any benefits at resolutions higher than 2000 lines. I'm eager to hear any news to the contrary because with a 120/220 back attached to the Lasergraphics film recorder, that works out to only 907 dpi on a 56x56mm chrome. That's *less than half* the 2000 dpi required to match the resolution that can be achieved by camera lens and film. Those who have ventured down this path can testify that film recorders can't match the quality of a "real" medium format transparency.

Imagine being able to shoot at ISO settings as high as 200 without suffering intolerable grain or noise in the final stereo view. One of the great advantages of digital captures is just how "clean" they are compared to film scans. This advantage begins to vanish as ISO settings are increased, but the good news for medium format stereographers producing transparencies for use in handheld viewers is that once again, the low enlargement factor (3.4x for a 75mm viewer focused at Infinity) is of great benefit. Stereographers working with smaller formats are well aware of how 7x magnification can make film grain quite visible even in RMS 7 films, like Fujichrome Astia 100F.[19]

The grain of popular RMS 8 films like Fujichrome Velvia 100F, the newer Velvia 100,[20] and Provia 100F,[21] is so diminutive it's practically invisible at 3.4x magnification. I've found that I can even push process Provia 100F one stop (asking the lab to extend the development time to compensate intentional underexposure), to enjoy the benefits inherent with ISO 200, with grain becoming visible only in large, untextured subjects such as featureless, uniformly overcast skies. I find it so unobjectionable that I routinely shoot Provia 100F at 200. Push processing has the added benefit of enhancing the color saturation and contrast of Provia 100F which, compared to the Velvia family of films, is somewhat lacking, though with more accurate color.

Lastly, the medium format stereographer's ability to push a film like Provia 100F to ISO 200 further negates the intrinsic DoF advantage enjoyed by smaller formats. The increased grain would be intolerable at the 7x magnification found in smaller format stereo viewers, but at 3.4x magnification, it's not a problem. The medium format shooter can stop down one additional stop for additional depth of field (or use the next fastest shutter speed) in any given lighting situation, relative to the small format stereographer who is stuck with shooting at ISO 100.

Another factor that earns Medium Format the right to be called the ideal medium for stereography is the simple fact that unless we use a viewer equipped with mirrors or prisms, suffering the inconveniences associated with such designs, our eyes are too closely set to view prints or transparencies wider than about 62mm (and finding viewer lenses having a Field of View sufficient to cover a chip that wide is next to impossible, anyway). For a species with an average interpupillary distance (IPD) of 65mm, medium format fits our IPDs very nicely. 4x5 sheet film is just too large and the smaller formats are compromised by grain, diffraction, and a subtle, but indisputable reduction in tonality.

If you're ready to take the medium format plunge, be warned that achieving the resolutions I've touted above isn't as easy as ordering a 3DWorld TL-120 Stereo Camera[22] and using it with a point-and-shoot mentality. The TL-120 is so capable it deserves to be handled with a discipline that can extract all that it has to offer, despite its willingness to be exploited as a P&S camera. Image quality begins with excellent lenses and a film transport mechanism that will maintain film flatness. The 3DWorld TL-120 isn't lacking in either regard, but a "weakest-link-in-the-chain" discipline must be followed to achieve resolutions that approach the limit of what the human eye can appreciate in a 3.4x magnification stereo viewer.

Here's a summary of the factors I control in an effort to maximize image quality:

For landscape stereography, I recommend the use of Don Fleming's DoFMaster freeware[23] to create spinning disk Depth of Field calculators (one for each focal length you possess) to determine both the focus distance and the working aperture. I print them on heavy paper and then laminate both disks before attaching them together with an "OIC Brass Fastener". The trick is to select the right Circle of Confusion diameter when customizing the DoF calculators. For a 75mm stereo viewer focused at Infinity, where the magnification would be 3.4x, I recommend the DoF calculator of your choice be customized to limit Circles of Confusion to a diameter of 0.059mm. If you'll be using a medium format viewer with adjustable focus (down to an virtual image distance of 25cm, where the magnification would be 4.4x), I recommend the DoF calculator be customized to limit CoC's to a more aggressive diameter of 0.046mm. In either case, the chosen CoC diameter's I've suggested will support a post-magnification resolution of 5 lp/mm in the virtual image – enough detail to satisfy a majority of people.

If, instead, you would prefer to limit defocus to what many would consider the very edge of what can be appreciated by healthy human eyes (supporting a virtual image resolution of 8 lp/mm), I recommend customizing the DoF calculator to limit CoC's to a diameter of 0.037mm for a 75mm medium format viewer focused at Infinity, or 0.028mm if the viewer can be focused as closely as 25cm (10 inches). Having selected your Maximum Circle of Confusion Diameter for the anticipated viewer magnification and desired image resolution, specify this value on the DOFMaster "Properties" screen. This one Circle of Confusion value will be appropriate for all focal lengths. (If you've chosen to use some other form of DoF calculator in the field, supply the suggested CoC diameter where appropriate.) Keep in mind that these smaller CoC diameters can only be had at the expense of smaller apertures (longer exposures) and greater working distances to your nearest subjects, but if you diligently adhere to the DoF calculator's recommendations, both to select your shooting aperture and the distance at which to focus, defocus will not be the limiting factor in achieving eye-popping resolution.


Saturn slide medium-format stereo viewer with lightbox

There's one last thing to worry about with aperture selection. You can't use the aperture indicated by the DoF calculator if doing so will cause diffraction to inhibit your desired print resolution. In other words, there's no point in stopping down further to make the Circles of Confusion caused by defocus smaller at your chosen Near and Far sharp distances if doing so is going to make diffraction's Airy disks (across the entire image) larger than your maximum permissible CoC diameter. Fortunately, this isn't an issue for medium format stereographers because diffraction would not inhibit a goal of 8 lp/mm at 3.4x magnification until the lens is stopped down all the way to f/27.[24]

When using any Depth of Field calculator, table, or lens barrel engraving, occasions will arise where the DoF calculator is advising you to use an aperture that's implausible due to insufficient light and/or contentious shutter speed requirements (when subject motion demands a faster shutter speed). When this happens, you need to increase the camera's distance to the nearest subject without changing the focal length —or— reduce the focal length without changing the camera to subject distance (until a viable aperture will provide sufficient DoF) —or— reload the camera with a faster (grainer) film. The only alternatives are to compromise your desired image resolution by ignoring your DoF calculations, or a better option by far — put the camera away without taking the shot.

Use your lens hoods to prevent glare; the improvement in contrast can be substantial. (I recommend flocking the inside surfaces of the TL-120 lens hoods.) Use a heavy, stable tripod equipped with a capable ball-head and quick-release. Use Mirror-Lock-Up (MLU) if shooting with an SLR that offers it. Use a long, flexible cable release, a wireless remote control, or the camera's self-timer. This goes without saying, but I'll say it anyway - use a shutter speed that's fast enough to arrest subject motion. If the DoF calculator says you can shoot wide open or nearly wide open, don't do it - stop down a couple of stops to avoid the aberrations suffered at a lens' widest apertures. (This assumes you're not purposely trying to achieve "selective focus" – an aesthetic choice that I personally find unacceptable in stereo views.)

If, over time, diligent adherence to focusing at the distances indicated by your choice of DoF calculator does not provide sufficient DoF at the Near and Far sharps, it will most likely be due to focusing errors (or errors in estimating the Near/Sharp distances). You don't have to use a laser rangefinder unless you want to get every last bit of available shutter speed out of a system - which is a nice thing to have when shooting landscapes that aren't holding absolutely still (which is most of the time). If you can afford to make longer exposures, you can compensate any slop caused by errors in reading Near and Far distances from your lens barrel and that caused by errors in setting a calculated focus distance - by just stopping down a bit further.

If you have the patience to use a laser rangefinder, both for measuring your Near and Far Sharp distances and for finding a target on which to focus that resides at a calculated focus distance, you won't have to "stop down a bit further" to compensate distance-related errors. I recommend the Stanley TLM-100[25] (made by a division of Leica). It will give you 1/4-inch accuracy from 2 feet out to about 60 feet in bright sunlight (or about 90 feet in dim light on light-colored targets). It sells for about U.S. $99.00 and will do a great job with determining the distance to your Near Sharp and helping you find a subject that resides at a calculated focus distance. Far Sharps that reside beyond 60 feet can be "guesstimated" by looking at the distance scale

Bio

Michael K. Davis has been shooting the natural landscape with medium format cameras for 45 years. A Mamiya 7 twin-camera MF stereo rig was his first venture into stereography. Having never attempted to sell any of his 2D fine art prints, it was at the 2001 NSA Convention, in Buffalo, New York, just six months after he had started shooting 3D, that Mart McCann, of Portland, Oregon, an exceedingly gracious patron of stereography, inspired Mike with his first sale of a medium format stereo view. He has since sold over 150 medium format views in private sales.

http://www.AccessZ.com

e-mail address: zilch0@primenet.com

King Inn medium-format stereo viewer

on your lens barrel without much impact on the final results.

If you really want to know the exact distance to Far Sharps that reside beyond the range of distances covered by the Stanley TLM-100 (out to 400 yards), I recommend the Opti-Logic 400XL Laser Rangefinder[26] — forget about Bushnell's laser rangefinders — but keep in mind that the Opti-Logic 400XL has a minimum working distance of about 12 feet, not close enough to handle your Nears. (The minimum working distance is limited by the speed of a rangefinder's processor — the shorter the distance to be measured, the less time it takes for the modulated laser light to travel to the target and back.) I started by recommending you get only the 2-to-60-foot Stanley TLM100. This will satisfy most landscape photographer's needs, because the Far Sharp distances aren't as critical as the Near Sharp and Focus distances, when they lie at 200 feet or more. It's when the Fars lie at relatively close distances beyond 60 feet, but less than 200 feet, that you might wish you had a "long-distance" rangefinder.

If you want to be totally on top of this and don't like the idea of carrying two rangefinders, you can go for an instrument like the Stanley TLM-300.[27] It will give you 3/32-inch accuracy from 2 inches all the way out to 650 feet, according to the manufacturer's specifications (probably more like 2 inches to 500 feet in bright sunlight on less than ideal targets, but that's more than sufficient for our purposes).

So how does one use all of this when shooting landscapes in the field? Here it is, step-by-step, for use with true stereo cameras or twin camera rigs. (These steps assume you have already downloaded the

DoFMaster software and created a spinning disk DoF Calculator, customizing it with the appropriate focal length and CoC diameter, as discussed above – or – you have equipped yourself with some other DoF calculator that can be used in the field, customizing it appropriately):

1. Choose your focal length and point-of-view as you normally would, then erect your tripod underneath the camera.

2. Measure the distance from the camera back to the nearest subject in the frame. That's your Near Sharp distance.

3. Measure the distance from the camera back to the farthest subject in the frame. This is your Far Sharp distance. (Assume 10,000 feet for subjects that reside at Infinity.)

4. Input the Near and Far Sharp distances into your choice of Depth of Field calculator that has been optimized to deliver a circle of confusion that will support your desired image resolution at the anticipated magnification.

5. The DoF calculator will provide a Focus Distance and the smallest f-Number necessary to support the desired print resolution.

6. Ask yourself if the calculated f-Number is both available on your lens —AND—equal to or smaller than the f-Number at which diffraction would inhibit the desired image resolution. Then ask yourself if the corresponding shutter speed required for correct exposure (given the available light and the current ISO setting) is sufficient to arrest all subject motion. If you can't use the DoF calculator's recommended f-Number (because your lens doesn't offer it, or it would induce visible diffraction (at f/32 in the case of a medium format camera), or the corresponding shutter speed would be too slow to arrest subject motion), you'll have to back away from the nearest subject (to increase your Near Sharp distance) and start over at Step 1, or leave the camera where it is, but use a shorter focal length (go wider) and start over at Step 4.)

7. With your f-Number set as indicated by your DoF calculator, use your rangefinder to locate a good target on which to focus that resides at the calculated Focus Distance. That target does not have to be within the intended image frame. You can swing your camera around on the tripod, 180-degrees if necessary, to focus the lens on anything that's at the calculated distance — use the rangefinder to find any target anywhere that's at the right distance, then re-establish your intended composition to make the exposure, leaving the focus setting alone.

That's it. If you want to bracket exposures, do so by changing your shutter speed, not your aperture (think "aperture-priority mode").

Obviously, there are factors other than defocus, diffraction, and camera or subject motion that can prevent us from achieving a "desired" resolution at an anticipated magnification – not the least of which is the total resolving power of the camera lens and film in combination. I've examined Fujichrome Provia 100F transparencies produced by the 3DWorld TL-120 and can say that the performance of its 80mm f/2.8 lenses is nothing short of spectacular. To my eye, at 8x magnification, contrast and resolution appear to be every bit as good as the transparencies I've produced with Mamiya 7 ii lenses[28]. That's saying a lot, but I have no doubt that the TL-120 can achieve on-film resolutions as high as 39 lp/mm with Provia 100F and similar films – more than sufficient to achieve the 27 lp/mm needed on-film to support a desired virtual image resolution of 8 lp/mm in a 3.4x magnification viewer, or the 35 lp/mm needed on-film to support the same desired resolution of 8 lp/mm in a 4.4x magnification viewer.

When showing your work, make a point of telling people that no post-exposure manipulation is used in the making of your 3D images – that everything they're seeing was achieved in-camera. This greatly distinguishes our work from that of digital photographers who can fix just about anything with Photoshop. If the view is comprised of original transparencies (not dupes), you might want to make a fuss over the fact that they're looking at film that was actually at the location seen in the viewer, that it's a first-generation image – another aspect of analog stereography that deserves attention.

Lastly, please join me in writing the folks at 3DWorld to request they develop and market an illuminated, handheld medium format viewer with adjustable focus. Their mounting jig[29] is a great start in that direction, but currently, their only handheld viewer is a fixed-focus, STL (steal-the-light) design.

Spreadsheets for CoC calculation, Depth of Field, Stereo Base, Pre-exposure, and other topics can be found on the Tools page at my web site: http://www.AccessZ.com

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[2]Del Phillips, *Brewster Viewers*, http://home.centurytel.net/s3dcor/Brewster/Brewster.htm, (2007)

[3]Wikipedia, *Anaglyph Images*, http://en.wikipedia.org/wiki/Anaglyph_image

[4]Peter Wheatstone, *Stereography – 3D Pictures*, http://www.geocities.com/CapeCanaveral/8341/stereogr.htm, (19th April 1998)

[5]Assumes: A) The use of 52x52mm transparencies in a 75mm viewer focused at Infinity; B) that the best color transparency films can deliver at least enough detail to satisfy a 2000 dpi scan; C) that the camera lens and film together can achieve an on-film resolution of at least 39 lp/mm; and D) that digital camera sensors (other than the Foveon) suffer a 30% loss of resolution from that indicated by pixel count alone, due to their use of the Bayer Algorithm and anti-aliasing filters. See the author's *Stereo Viewer Virtual Image Area Comparison Calculator*, http://home.globalcrossing.net/~zilch0/tools/SVCalc.xls

[6]3Dstereo.com, Inc., 2Q Stereo Slide Viewer, http://www.3dstereo.com/viewmaster/svn-2qb.html

[7]John B. Williams, *Image Clarity – High Resolution Photography* (Boston/London: Focal Press, 1990): p. 40.

[8]Clarence E. Rash , Melissa H. Ledford, and John C. Mora (of the U.S. Army Aeromedical Research Laboratory), *Helmet Mounted Displays: Design Issues for Rotary-Wing Aircraft*, http://www.usaarl.army.mil/hmdbook/cp_002.htm

[9]———, *Helmet Mounted Displays: Design Issues for Rotary-Wing Aircraft*, http://www.usaarl.army.mil/hmdbook/cp_002.htm

[10]Sensics, Inc., *piSight*™ *Specifications*, http://

www.sensics.com/products/pisight_specifications.php

[11]Assumes 52x52mm transparencies in a viewer equipped with 75mm lenses, scanned at 2000 dpi. See the author's *Stereo Viewer Virtual Image Area Comparison Calculator,* http://home.globalcrossing.net/~zilch0/tools/SVCalc.xls

[12]Assumes the use of 52x52mm transparencies having a minimum on-film resolution of 39 lp/mm, viewed in a 75mm viewer focused at 10 inches, having a magnification of 4.39x – thus having a post-magnification resolution of 8.9 lp/mm – which exceeds the 8 lp/mm practical limit of human resolving power at a viewing distance of 10 inches. See: John B. Williams, *Image Clarity – High Resolution Photography* (Boston/London: Focal Press, 1990): p. 56, Table 8.1.

[13]Horizontal Angle of View = 2 * ArcTan (Image Width / (2 · FL)). The horizontal angle of view for a 75mm viewer using 52x52mm chips is 38.2 degrees when focused at Infinity.

[14]Wikipedia, IBM T220/T221 LCD Monitors, http://en.wikipedia.org/wiki/T221

[15]David Katzmaier, HDTV Resolution Explained, http://www.cnet.com/4520-7874_1-5137915-1.html, (September 12, 2006)

[16]See the author's MS-Excel spreadsheet, *Not Just Another Depth of Field Calculator!* at http://home.globalcrossing.net/~zilch0/tools/MDoF997s.xls, which includes an *Apparent Image Size Calculator for Stereo Viewers* that will aid in the selection of an appropriate Circle of Confusion diameter for use with any Depth of Field calculator.

[17]Wikipedia, Circle of Confusion, http://en.wikipedia.org/wiki/Circle_of_confusion

[18]Lasergraphics, Inc., LFR Mark VI ™ DPM Specifications, http://computergraphicsgroup.com/filmrecs/dpm56.htm

[19]Fujifilm USA, Astia 100F Features, http://www.fujifilmusa.com/JSP/fuji/epartners/proPhotoProductAstia.jsp

[20]FujiFilm USA, Velvia Features, http://www.fujifilmusa.com/JSP/fuji/epartners/proPhotoProductVelvia.jsp

[21]FujiFilm USA, Provia Features, http://www.fujifilmusa.com/JSP/fuji/epartners/proPhotoProductProvia.jsp

[22]Hang Zhou 3D World Photographic Equipment Co., Ltd, 3DWorld TL-120 Stereo Camera, http://www.3dworld.cn/show_product_detail_en.asp?id=65

[23]Don Fleming, *DOFMaster Depth of Field Calculator,* http://www.dofmaster.com/custom.html, (2006)

[24]This formula can be used to determine the f-Number (N), at which diffraction's Airy disks will begin to inhibit a desired resolution at the anticipated enlargement (magnification) factor: N = 1 / enlargement factor / desired resolution / 0.00135383

[25]The STANLEY® FatMax® TruLaser™ TLM 100 Distance Measurer is available at http://laserstreet.com/stanley-tlm100.htm and other retailers.

[26]The Opti-Logic 400XL Laser Rangefinder is available at http://www.cspoutdoors.com/op40lasran.html and other retailers.

[27]The STANLEY® FatMax® TruLaser™ TLM 300 Distance Measurer is available at http://laserstreet.com/stanley-tlm300.htm and other retailers.

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