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70-200mm Zooms

11 Lenses Tested

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Has autofocus ever annoyed you because it missed a moving target? Or when it pumps back and forth searching for the right setting? Things get even worse if a focus error exists that is too slight to see in the viewfinder but is glaringly obvious when you view your images on a computer. Glitches like these often spoil a whole sequence of photos and raise the question of what's wrong and how you can improve the situation.

The best solution is to get to grips with how the autofocus system built into your DSLR or mirrorless camera works. Our Author Ralph Altmann has dug deep into the technology behind today's autofocus systems and has come up with a great article that tells you all you need to know about how your camera keeps things sharp. He has also invented a simple computer-based method for testing your camera's AF system and even explains how to improve its accuracy. See page 68 and this issue's free online content for details.

Now you can head off to the racetrack or your child's birthday party safe in the knowledge that your photos will come out pin sharp. And, if you're looking for the right universal lens for the occasion, check out our 70-200mm zoom test on page 16 for details of the best name-brand and third-party glass on the market.

Have fun and see you next time ...

Peter Nonhoff-Arps

Peter Nonhoff-Arps



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Portfolio

Charlotte Steffan is a master of minimalistic compositions and a shoots using a minimum of gear too.

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Telephoto Zoom Test

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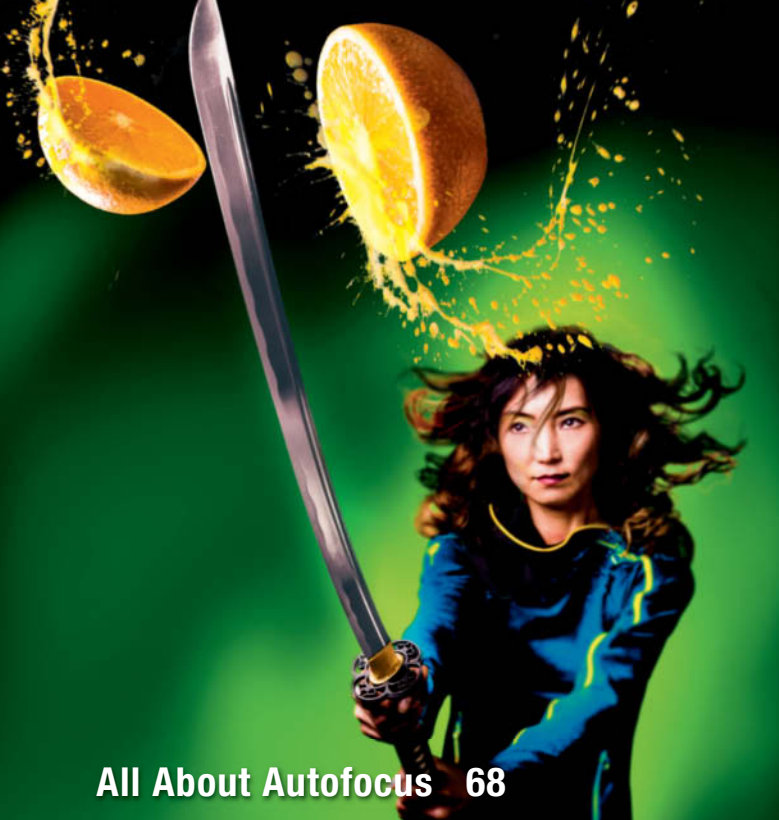
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Full Version Software

Movavi Photo Editor is a powerful photo editor that enables you to give your images extra polish with just a few simple clicks.

Special Edition Software

Franzis Color Projects Professional offers new and unique ways to transform your photos into digital works of art using smart tools and a crystal-clear workflow.

Videos

- Coached Shooting:
Advice from Bert Stephani
- Transparent Fruits:
Cool Effects with Little Effort
- One Light Shooting:
Portraits with the Softbox
- Tim Mantoani:
The Man with the Large-format Camera

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Visit www.ct-digiphoto.com/downloads212015 for free access to a full version of *Movavi Photo Editor*, a special *c't* edition of Franzis *COLOR projects professional* and a range of exciting videos and video tutorials.

Movavi Photo Editor

Full version software: Movavi Photo Editor lets you optimize your photos in just a few clicks.

Spontaneous snapshots often contain color errors, sloping horizons or unwanted details that spoil the look of the photo. Movavi Photo Editor provides the tools you need to remove these annoying side effects with just a few simple clicks and the 'Resize' tool enables you to scale your edited images as you wish. A single click on the 'Magic Enhance' button automatically optimizes contrast, saturation and color temperature, while the 'Cut Out' tool makes swapping out backgrounds a snap and the 'Delete' tool simply erases objects you don't like. You can also create custom text overlays



and save your results in a range of formats. *Photo Editor* has a clean, easy-to-use interface that makes advanced image processing tasks simple to perform.

c't Digital Photography readers can register via e-mail for a free copy of Movavi Photo Editor. Windows users qualify for a 40% discount on a purchase of Movavi Photo Studio, and Mac users receive a 60% discount on Movavi Video Converter. These offers are valid until January 15th 2016. (tho)

Coached Shooting

Video tutorial: Bert Stephani plays coach and lets us in on some of his secrets for great portrait sessions.



In this workshop, pro photographer Bert Stephani puts his camera down and lets his assistant Laurent photograph a model. Stephani has plenty of useful tips for his less experienced colleague and certainly proves his mettle as a photo coach, constantly optimizing his assistant's ideas. As well as helping Laurent concentrate on the details, he also discusses basics like composition, the choice of background and communication with the model. As a viewer, you can learn from Laurent's mistakes and use the results to improve your own portrait photography skills. (sea)

Image Processing Tools

Windows

Artweaver Free
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GIMP Portable
GREYCs Magic Image Converter (GMIC)
HeliosPaint
Hugin
Inkscape
Luminance HDR
Movavi Photo Editor 2.1.0 **Full Version**

Mac OS

COLOR projects professional **Special Edition**
GIMP
GREYCs Magic Image Converter (GMIC)
HeliosPaint
Hugin
Inkscape
Luminance HDR
Movavi Photo Editor 2.1.0 **Full Version**

Linux

GREYCs Magic Image Converter (GMIC)
HeliosPaint
Luminance HDR
Movavi Photo Editor 2.1.0 **Full Version**

Photo Tools

Windows

AmoK Exif Sorter
Enblend/Enfuse
EnfuseGUI
ExifTool
FastStone Image Viewer
Gallery
WordPress
XAMPP
XnView

Mac OS

AmoK Exif Sorter
EnfuseGUI
ExifTool
Gallery

MacPorts

WordPress
XAMPP

Linux

AmoK Exif Sorter
Enblend/Enfuse
ExifTool
Gallery
WordPress
XAMPP

Sample Images

Autofocus Test Image and Photoshop Actions
Lens Test Sample Images

Videos

Coached Shooting – Advice from Bert Stephani
One-light Shoot – Portraits with the Softbox
Tim Mantoani – Large-format Portraits
Transparent Fruits – Cool Effects with Little Effort

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Use of the Windows version requires a two-stage online registration during installation. Mac users need to install the trial version and send an email to the manufacturer containing the text *c't Digital Photography – Color projects for MAC*. You will then receive a free serial number via email. Registered readers also qualify for a 40% discount on upgrades to the full version of *PHOTO WORKS projects #3*. These offers apply until March 31st 2016. (tho)

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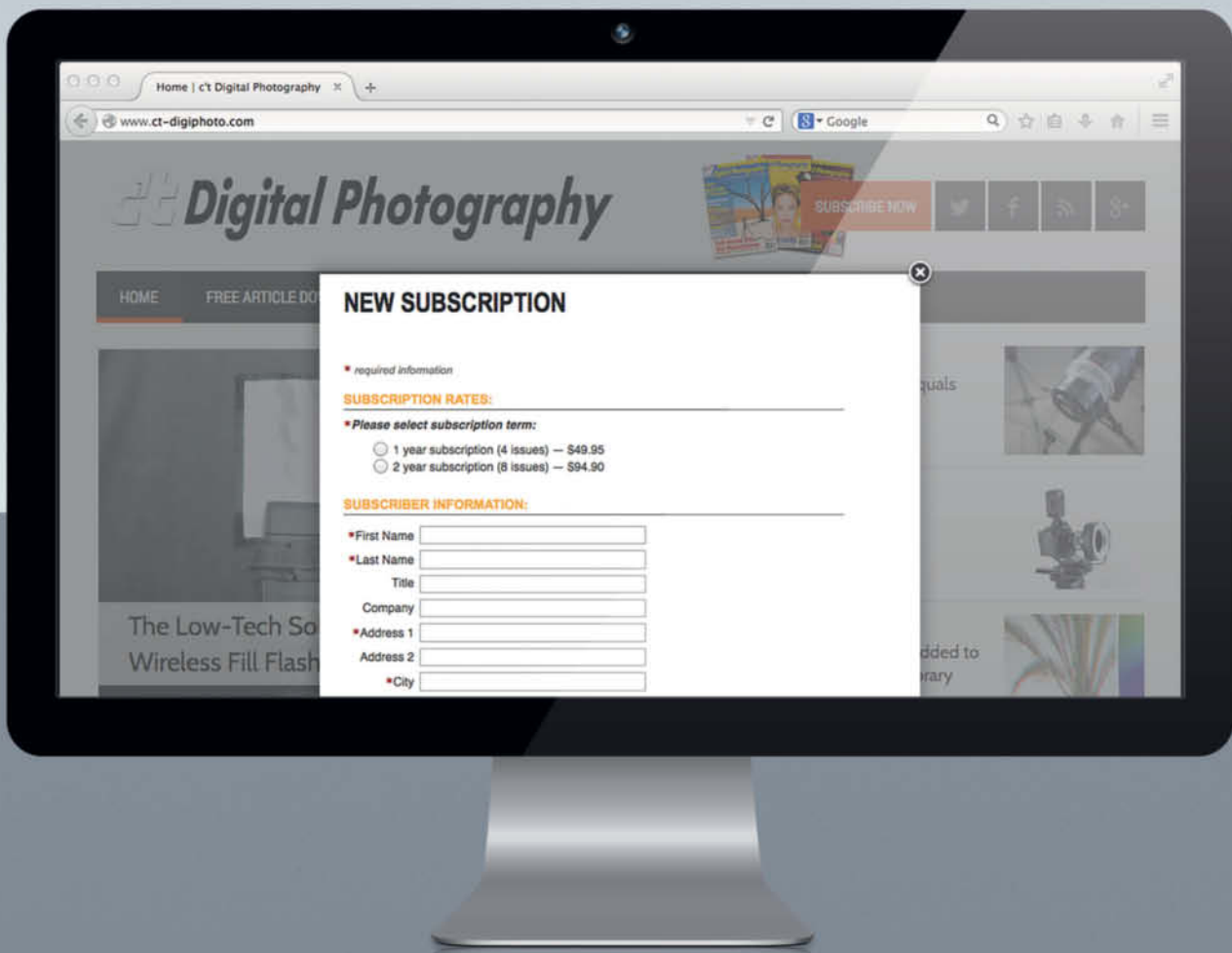
Keep on top of the latest trends and get your own regular dose of inside knowledge from our specialist authors. Every issue includes tips and tricks from experienced pro photographers as well as independent hardware and software tests.

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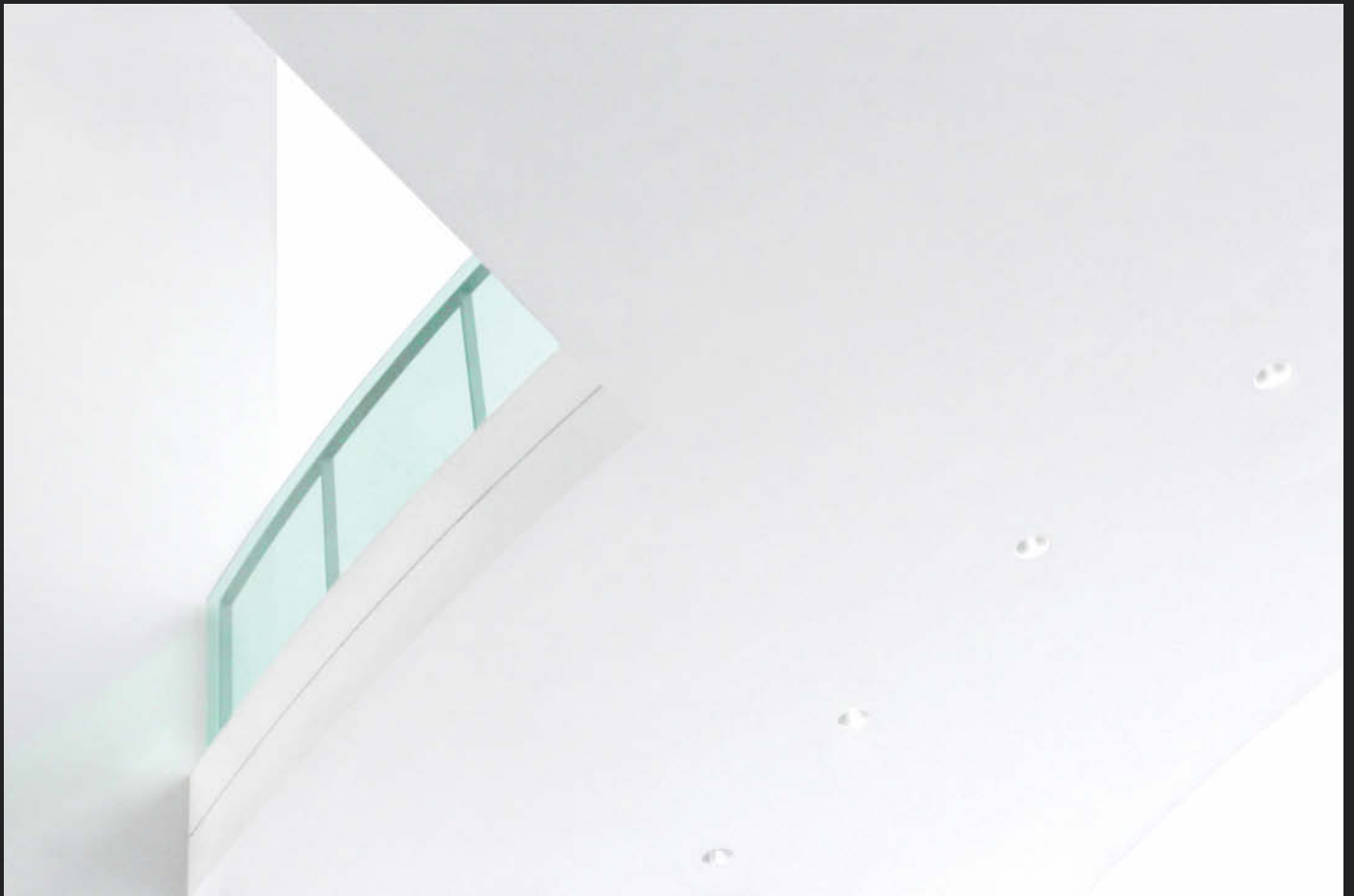
Portfolio

Charlotte Steffan

Lines, patterns, nuances of color... Charlotte Steffan likes things minimalist and tidy – and that's how she likes her photographs too, most of which she takes using her iPhone.



Church Windows, Mannheim, Germany (2004)



Green Glass, Munich, Germany (2005)

Photographing the patterns revealed in felled tree trunks and sawn-off branches, taking inspiration from road markings, looking for graphic elements in rows of houses or window frames – out and about with her camera, looking for subjects and allowing the world to make its impressions on her, Charlotte Steffan is not seeking the sensational and prefers instead to “show the everyday in a new light”.

The 60-year-old artist came late to photography after taking early retirement. She lives in Mannheim and spends a lot of time traveling the city and its environs, but not with a heavy camera and multiple lenses.

In the last few years she has used nothing more than an iPhone most of the time.

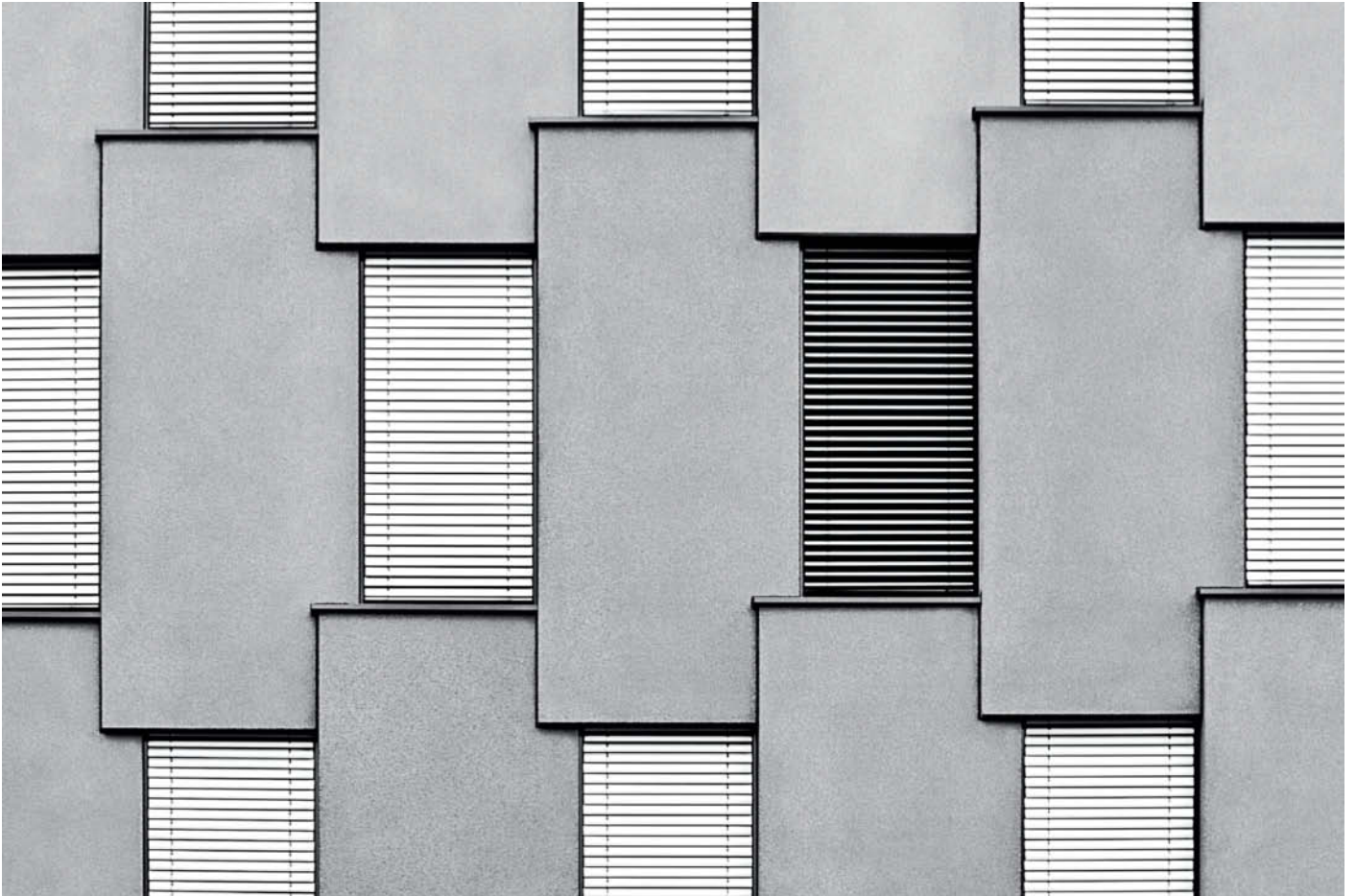
“I’m totally happy with the quality,” she says – and she knows what she’s talking about. “Early on, as I concentrated more and more on technical things like aperture, exposure, noise and sharpness, my eye for subjects became less keen and my photography was the poorer for it, despite using a reflex camera and high-quality lenses.” Acquaintances and critics constantly commented on this shift too, she remembers.

At some point, she pulled the plug on it all, having realized that the fun had gone out of

photography for her. Yet fun, rather than technology, which she now keeps to a bare minimum, was the essential ingredient for good photos. Now, her phone’s fixed focal length lens is perfectly sufficient, “and I don’t care whether there is more noise in my images than the ones I made with my super-duper DSLR.”

But what determines whether an image is successful or not? Her answer is impartial and personal: “My images are supposed to stir up the viewer’s emotions,” she says. “For me, a good image is one that I like.”

This is why Steffan also prefers to avoid ‘deep and meaningful’ discussion and



Office Building, Mannheim, Germany (2010)

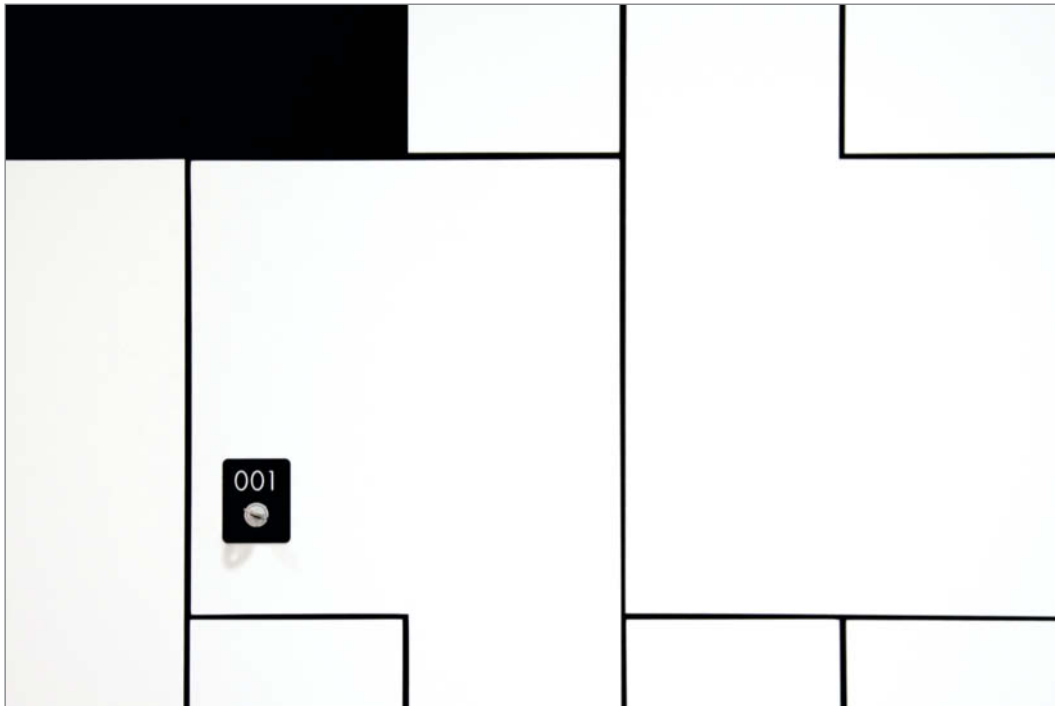
interpretation of her photographs. “For me, the subject is important, and the image has to make the right impact.” She names her images by describing them, rather than inventing a prosaic title – a method borrowed from Robert Haeusser, one of her favorite role models.

“I like line, I like black and white, and I like everything to be tidy,” is how she outlines her photographic preferences and favorite stylistic devices. “Technical processes and skills transform raw material into a form which, thanks to intense observation, evocative symbolization and visual effectiveness, far exceeds the result of

the present moment,” as the quote from well-known photographer and writer Andreas Feininger explains on her website. “If that can be achieved, then it is a good photo; reality has become art.” That is her goal.

Steffan is enjoying increasing success with this approach, having now displayed her work to a broad public at 17 exhibitions. Her most recent show comprised only iPhone photos, and she is now selling these images too. Even the city council in Mannheim is a customer, she says with a wink, although in this case, the buyer acquired some of her equally fascinating infrared images rather than her more graphic works. (keh)

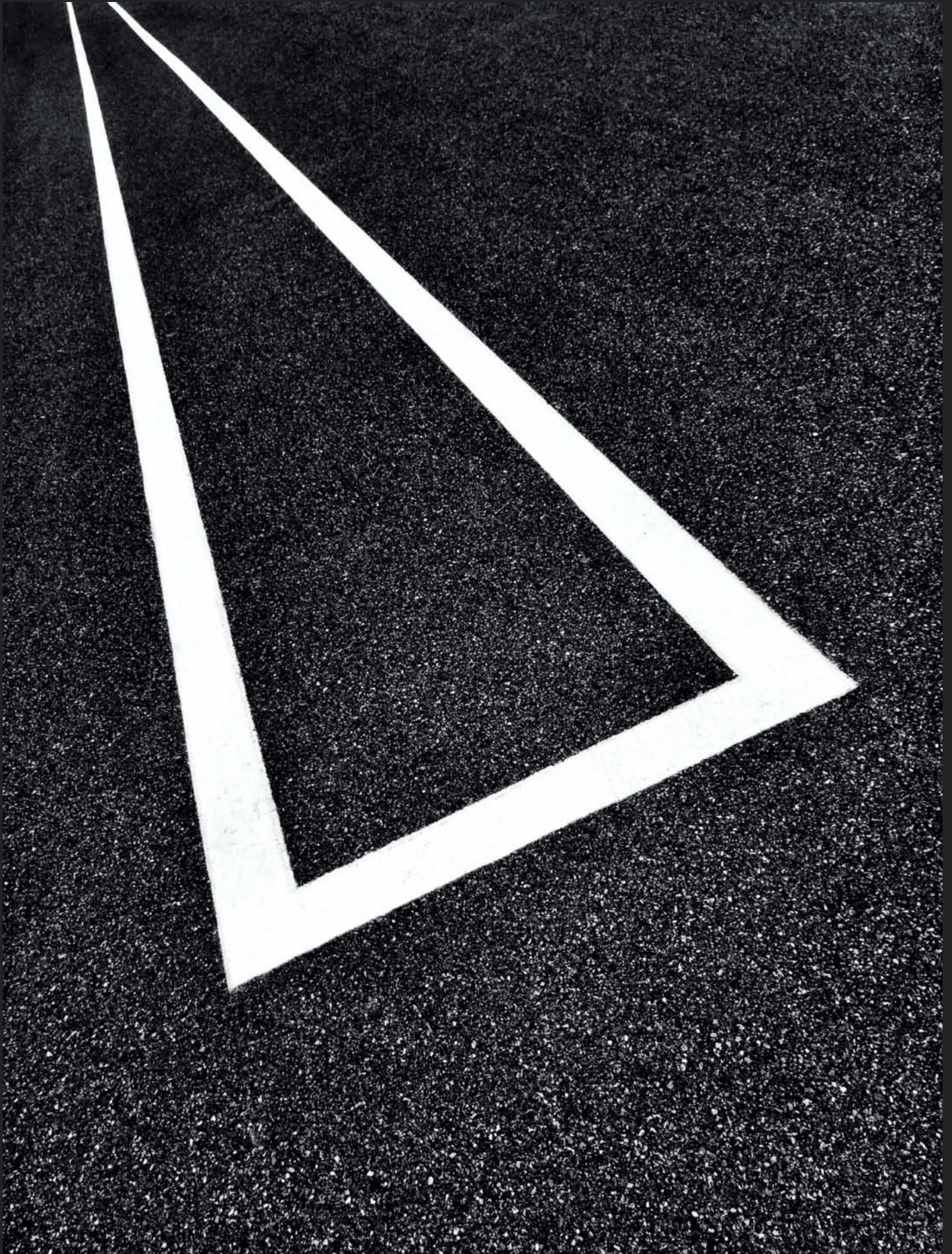
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Steffan](http://www.xing.com/profile/Charlotte_Steffan)



Locker, Stuttgart, Germany (2010)



Floor Lamp, Berlin, Germany (2006)



Road Markings, Nuremberg, Germany (2015)

Universal Lens Test

70-200mm Zooms

Telephoto zooms are great all-around lenses for a wide range of situations and enable you to bring distant subjects closer, create great-looking background blur and give your photos added impact. Understandably, they are especially popular with travel photographers. We test a selection of camera manufacturers' own-brand lenses for DSLRs and mirrorless systems and compare them with their cheaper third-party rivals.

A telephoto zoom with a focal length range from 70-200mm and a constant maximum aperture is an essential part of any serious photographer's gear. Ideally, such a lens is robust, provides high optical quality and offers pro-grade features into the bargain.

These specifications make this type of lens ideal for travel photography, enabling you to bring distant subjects closer and capture camera-shy wildlife subjects without scaring them. The comparatively small angle of view also helps to separate selected details from the background – an attribute that opens up new vistas for vacation snaps that go above and beyond garden-variety postcard-style compositions.

Heavy Duty

Telephoto focal lengths enable you to fill the frame with your subject without having to

move closer and to compress the field of view so that the background and foreground appear closer together. These characteristics make fast telephoto zooms great for capturing portrait subjects in front of subtly blurred backgrounds. 'Compressing' the field of view is an effective compositional tool that you can use to combine multiple subjects that don't usually belong together in a single frame.

The downside of all this photographic power is added bulk, especially in faster lenses (i.e., those with larger maximum apertures). For example, the Canon EF 70-200mm f/2.8L IS II USM weighs 3.3lb and is 7.8" long. Used with a full-frame DSLR such as the EOS 6D, you will have to lug nearly 5lb of gear around, which can be really tiring on a long hiking tour. Used with the Nikon D610, The AF-S NIKKOR 70-200mm f/2.8G ED VR II cracks the 5lb mark.







Sony makes no genuinely fast 70-200mm zoom for its Alpha a7-series cameras, and the best on offer has a maximum aperture of f/4.0 (on the right). This means less compositional flexibility and less bokeh but also less weight to carry around compared to the faster Nikon equivalent (above).



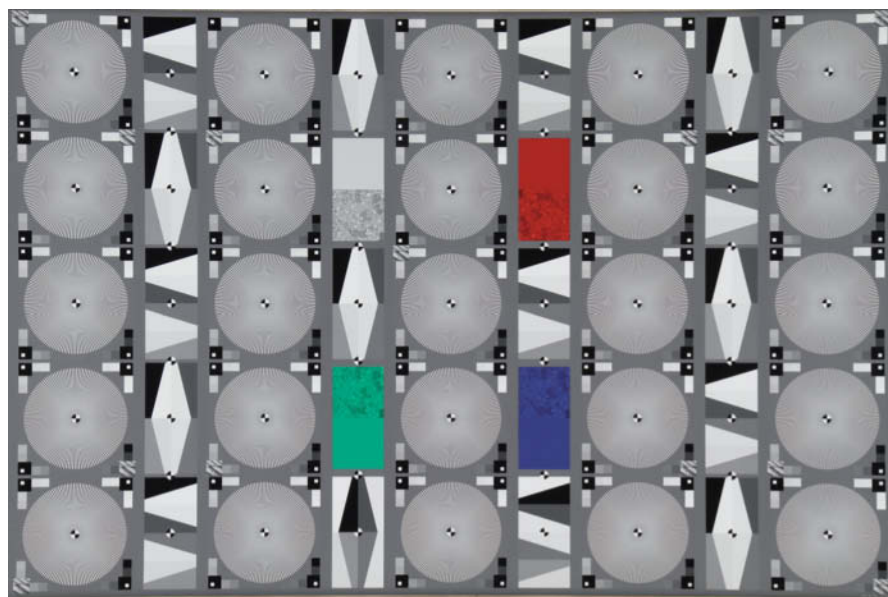
Third-party Alternatives and Slower Lenses

Weight alone is probably not the only factor that will scare off some hobby photographers. The RSP for the stabilized f/2.8 L-series Canon lens is \$2,099, and the AF-S 70-200mm NIKKOR is slated to sell for \$2,400.

But there are alternatives. The major camera manufacturers all offer 70-200mm zooms with a smaller maximum aperture of f/4.0. The Canon EF 70–200mm f/4L IS USM weighs less than 2lb and costs just over half the price of its faster sibling, while the AF-S NIKKOR 70-200mm f/4G ED VR weighs in at 1.9lb and costs \$1,000 less than the faster

version. These models are definitely easier to carry but sacrifice some capability for portability.

This is also where third-party lenses come into play. Sigma and Tamron both offer 70-200mm f/2.8 zooms for various mounts and, although its RSP lies at \$1,399, the Sigma 70-200mm f/2.8 EX DG APO OS HSM for Canon and Nikon is available on the open market for less than \$1,200. The Tamron 70-200mm f/2.8 Di VC USD has an RSP of \$1,499 but can be purchased online with various rebates. Both these lenses are stabilized, which is a real boon when shooting at long focal lengths.



This is the test chart we use to determine the number of line pairs each lens can resolve

70-200mm Lenses for APS-C DSLRs

The lenses mentioned so far are all full-frame models that can also be used with APS-C cameras from the same manufacturer, although you have to account for the crop factor if you do. Dedicated APS-C telephoto zooms are rare, and Canon only offers zooms for its crop format cameras with variable maximum apertures. Nikon, too, concentrates on offering the maximum possible zoom range and gives less emphasis to speed in its APS-C lenses.

To date, all Pentax DSLRs have APS-C sensors, so the K-Mount DA* 50-135mm f/2.8

ED (IF) SDM makes a great 70-200mm (equivalent) lens with a constant maximum aperture. Pentax has also recently introduced the full-frame K-Mount HD D FA* 70-200mm f/2.8 ED DC AW which was available for pre-order for around \$2,300 as we went to press. Used with an APS-C camera, its focal length range equates to 105-300mm.

Mirrorless Alternatives

Makers of mirrorless system cameras, too, have realized how popular this range of focal lengths is among photographers. Sony makes 70-200mm lenses for its A-Mount SLT cameras and its mirrorless E-Mount models. The FE 70-200mm f/4.0 G OSS has a geometry designed specifically for use with the Alpha a7-series cameras and, due to its modest maximum aperture of f/4.0, is relatively compact. Its RSP of around \$1,500 makes it slightly more expensive than the direct competition.

The Fujinon XF 50-140mm f/2.8 R LM OIS WR is designed for use with the Fujifilm X-series APS-C cameras, weighs 2.19lb and sells at \$1,600. Samsung's APS-C 50-150mm f/2.8 S ED OIS lens for its mirrorless NX-mount cameras covers virtually the same range, while the Panasonic 35-100mm f/2.8 Lumix G Vario (currently available for about \$1,500) does the same job in the Micro Four Thirds camp. The Lumix G Vario 35-100mm f/4.0-5.6 ASPH. isn't as fast but is much less bulky and costs just \$400.

The Test Field

We tested a Nikon D810 with the AF-S NIKKOR 70-200mm f/2.8G ED VR II, the AF-S NIKKOR 70-200mm f/4 G ED VR, the Sigma 70-200mm f/2.8 EX DG APO OS HSM, the Tamron SP 70-200mm f/2.8 Di VC USD and the Tokina AT-X 70-200mm f/4 PRO FX. The Nikon's high-resolution 36-megapixel sensor is a challenge to the best of lenses, so this wasn't an easy task. The Sony FE 70-200mm f/4 G OSS had a similarly tough job proving its mettle used with the mirrorless Sony a7R, which also has a 36-megapixel full-frame sensor. We tested the two full-frame Canon zooms using the pro-grade EOS 5D Mark III which, with its 22-megapixel sensor, is more forgiving than the Nikon or the Sony when it comes to less-than-perfect detail rendition. We weren't able to get our hands on an EOS 5DS in time for this test, but we promise to use one to re-test the Canon zooms as soon as possible.

In the APS-C camp, we tested the Pentax DA* 50-135mm f/2.8 ED (IF) SDM on an APS-C K-3 body as well as the Fujinon XF 50-140mm

f/2.8 R LM OIS WR and the Samsung 50-150mm f/2.8 S ED OIS.

How We Tested

To achieve objective, measurable results, we tested all the lenses listed above under rigorous lab conditions. This involved taking test shots of a chart comprising 25 Siemens stars with sine wave-shaped brightness gradients, and we photographed the chart to fill the frame for a range of apertures. Our testers always focus manually and capture four or five shots for each combination of focal length and aperture. They then use custom software to analyze all the captured frequencies and determine the degree of contrast between the brightest and darkest image areas. This value falls off with increasing frequency (i.e., in finer details) until details are no longer recognizable, which usually occurs at a contrast value of around 10%.

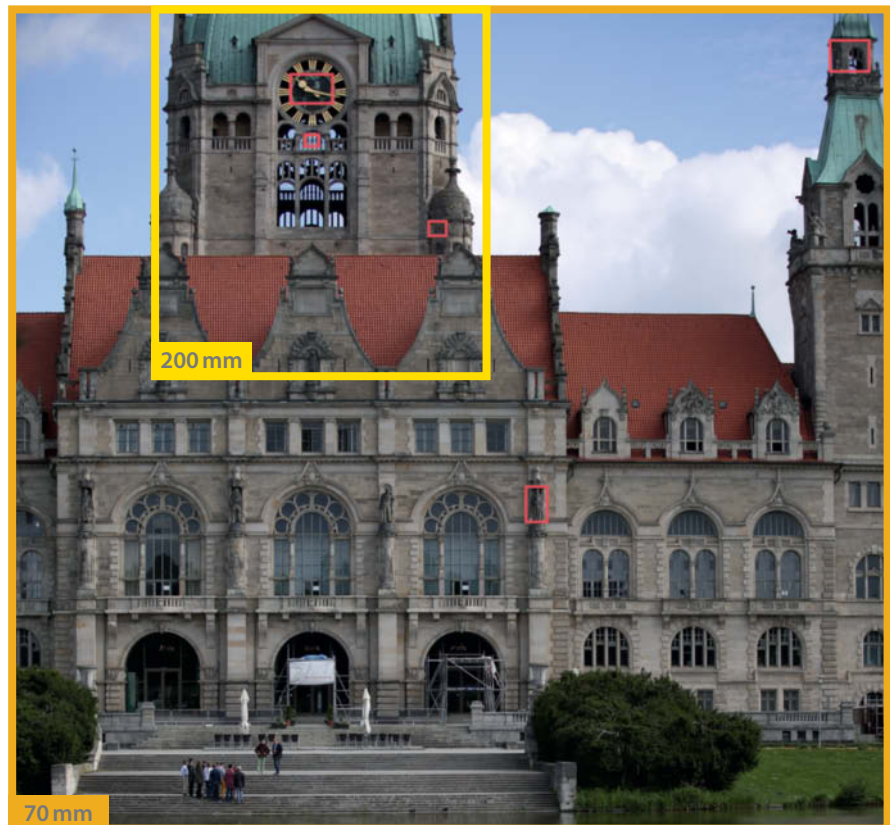
The cutoff frequency (i.e., the maximum number of resolved line pairs measured over the height of the frame) is calculated for various points on each Siemens star and averaged. Because our test cameras have varying resolutions, the results in the tables

are given as an absolute number of resolved line pairs.

Additionally, we use a chart made up of printer's register marks to measure distortion. We measure how far the position of a test point deviates from the position it should have under ideal shooting conditions, and the results are expressed in terms of the degree of warp in a line at the edge of the frame measured against the height of the image.

We use a 10×10 bank of LEDs to measure AF shutter lag. To do this, we focus each lens at infinity and press the shutter button while simultaneously triggering the first LED. The other LEDs then light up in sequence, moving on every one-hundredth of a second. The LED that is captured in the resulting image enables us to precisely calculate how long the camera took to focus and release the shutter. Because shutter lag varies with focal length, we have printed results for wide-angle and telephoto zoom settings.

To help you judge image quality for yourself, this issue's free online content includes a full archive of lab-based sample images captured using every camera/lens combo we tested.



For our subjective image quality tests we took the lenses to the Hannover Town Hall, which is one of our favorite subjects for outdoor test shots under real-world conditions



Canon EF 70-200mm f/2.8L IS II USM

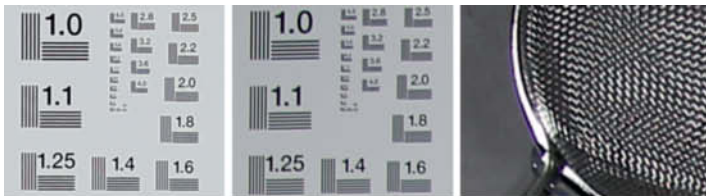
The lens: This is one of the highest-quality lenses we tested and, technologically as well as price-wise, it is squarely aimed at pro photographers. Used with an EOS 5D Mark III, it weighs about 5.4lb, making it unlikely to find favor as a travel photography lens. Build quality is excellent, with broader and grippier focus and zoom rings than the Nikon competition. The focus ring on our test lens was a little too loose for our liking – but this is, of course, purely a matter of personal taste. The lens body houses switches for focus mode, the image stabilizer and distance range selection. The stabilizer has two modes for shooting stationary subjects and horizontal follow shots of moving subjects. The lens is also dust- and moisture-proof.

Test results and image quality: Overall, the lens delivered great results, but was nevertheless choosy. We achieved our poorest results at maximum aperture at the wide-angle end of the zoom range. At these settings, center resolution came in at 76 per cent of the potential maximum resolution offered by the EOS 5D Mark III. However, this

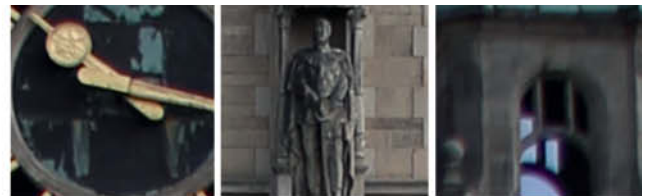
was the only weakness the lens showed. At all other focal lengths, the Canon produced balanced center and edge performance. Unlike many of the other lenses we tested, it also produced excellent results at the longest end of its range, with crisp-looking images and smooth focus gradients.

Canon EF 70–200mm f/2.8L

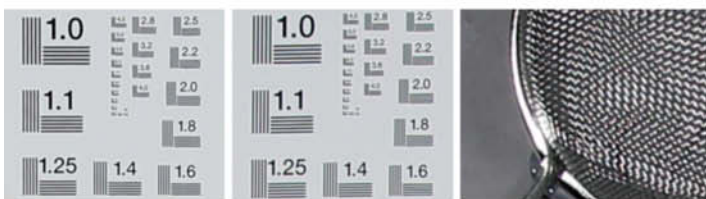
Current price	\$2,100
Max. aperture / No. of blades	f/2.8 / 8
Minimum focus distance	1.2 m
Length / Weight	7.8" / 3.28 lb
Test Results	Wide open / f8
Wide-angle edge resolution ¹	1465 (1197) / 1684 (1572)
Telephoto edge resolution ¹	1666 (1538) / 1681 (1658)
Distortion at max. aperture (w-a/t)	-0.4% / +0.4%
Chromatic aberration at max. aperture ² (w-a/t)	0.29 / 0.2
AF shutter lag	0.39 s / 0.45 s
¹ in line pairs ² in pixels w-a = wide-angle t = telephoto	



EOS 5D Mark III | 70 mm | f/2.8 (c't lab test scene, top left corner)



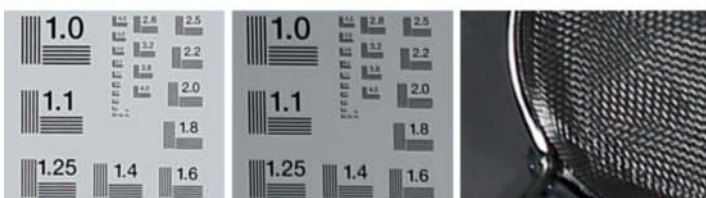
EOS 5D Mark III | 70 mm | f2.8



EOS 5D Mark III | 70 mm | f11



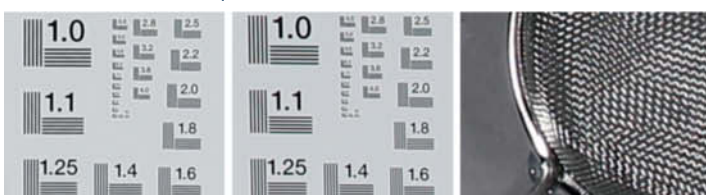
EOS 5D Mark III | 70 mm | f8



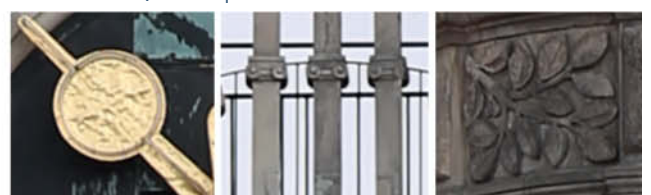
EOS 5D Mark III | 200 mm | f2.8



EOS 5D Mark III | 200 mm | f2.8



EOS 5D Mark III | 200 mm | f11



EOS 5D Mark III | 200 mm | f8

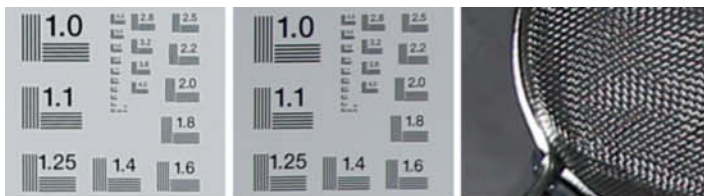
Canon EF 70-200mm f/4L IS USM

The lens: The cheaper Canon lens has one f-stop less maximum aperture than its faster sibling, and is consequently much lighter and easier to handle. It is nevertheless well specified and has the same two-mode stabilizer and focus mode/range switches as the f/2.8 version. It is also just as robust, with built in dust and moisture protection. Build quality is excellent, with smooth precise focus and zoom rings. Our only gripe is the stabilizer which, in our test lens at least, was quite loud.

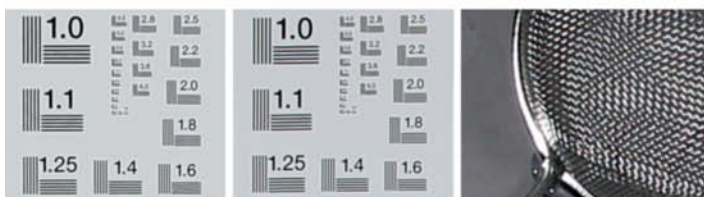
Test results and image quality: The answer to the question of whether \$1,000 less make a real difference to image quality is "kind of". Basically, the lens delivers very good optical performance throughout the aperture range, but doesn't match the f/2.8's quality and also produces obvious pin-cushion distortion at the telephoto end of the scale. In other words, it is typical mid-range telephoto zoom. We also spotted some fringing at the edges of the frame, especially at shorter focal lengths.

Canon EF 70-200mm f/4L

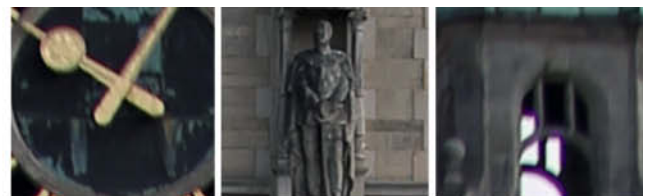
Current price	\$1,200
Max. aperture / No. of blades	f/4.0 / 8
Minimum focus distance	1.2 m
Length / Weight	6.8" / 1.67 lb
Test Results	Wide open / f8
Wide-angle edge resolution ¹	1605 (1455) / 1687 (1600)
Telephoto edge resolution ¹	1479 (1316) / 1561 (1449)
Distortion at max. aperture (w-a/t)	-0.2 % / +0.5 %
Chromatic aberration at max. aperture ² (w-a/t)	0.23 / 0.36
AF shutter lag	0.46 s / 0.35 s
¹ in line pairs ² in pixels w-a = wide-angle t = telephoto	



EOS 5D Mark III | 70mm | f4 (c't lab test scene, top left corner)



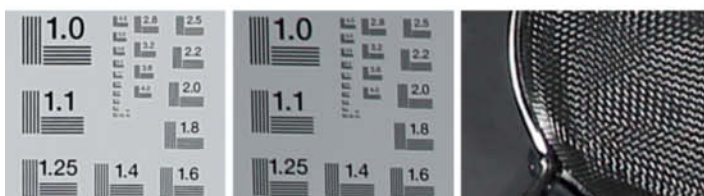
EOS 5D Mark III | 70mm | f11



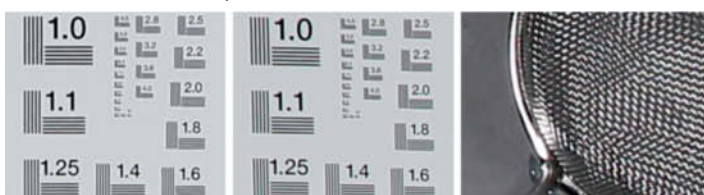
EOS 5D Mark III | 70mm | f4



EOS 5D Mark III | 70mm | f8



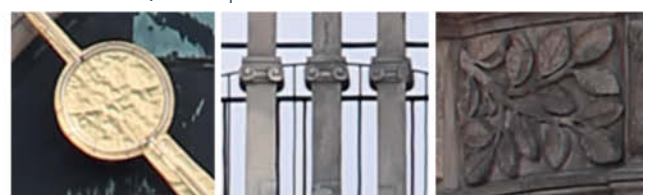
EOS 5D Mark III | 200mm | f4



EOS 5D Mark III | 200mm | f11



EOS 5D Mark III | 200mm | f4



EOS 5D Mark III | 200mm | f8



AF-S NIKKOR 70-200mm f/2.8G ED VR II

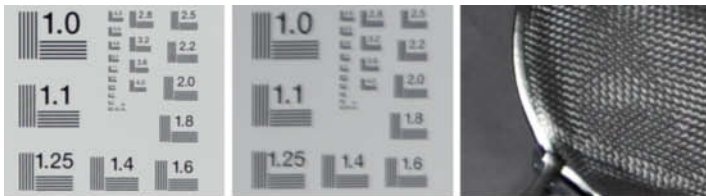
The lens: The NIKKOR is a little heavier than the Canon competition but its build quality is really just the same. There are no loose parts, everything works smoothly and it all fits together perfectly. The bayonet mount is rubber sealed and the barrel is made of extremely robust magnesium alloy. Unlike other 70-200 zooms, only the foot of the NIKKOR's tripod collar can be removed. Overall handling is simple and intuitive with dedicated buttons for focus mode, focus limit and vibration reduction (VR). Like the Canon, the NIKKOR offers VR modes for stationary and follow shots. The focus ring is narrower than the one offered by Canon but has a firmer action in use.

Test results and image quality: This lens is equal to the challenge posed by the D810's ultra-high-resolution sensor, although it does have its weaknesses. It produced its best results at its shortest focal length, recording 80 per cent (1970 line pairs) of center resolution. Stopping down produced better edge performance that virtually equaled center performance at f8. At medium

apertures, performance was solid throughout the zoom range. The long end is generally not as good as the short end, especially at the edges of the frame. At 200mm and wide open, the bokeh the lens produced was visibly less soft than that produced by the Sigma, for example.

AF-S NIKKOR 70-200mm f/2.8

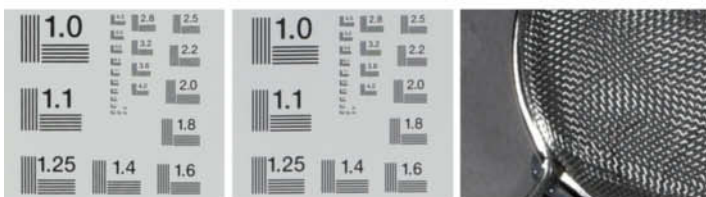
Current price	\$2,400
Max. aperture / No. of blades	f/2.8 / 9
Minimum focus distance	1.4 m
Length / Weight	8.1" / 3.39 lb
Test Results	Wide open / f8
Wide-angle edge resolution ¹	1970 (1612) / 2291 (2075)
Telephoto edge resolution ¹	1862 (1238) / 2240 (1843)
Distortion at max. aperture (w-a/t)	-0.1% / +0.5%
Chromatic aberration at max. aperture ² (w-a/t)	0.17 / 0.17
AF shutter lag	0.29 s / 0.38 s
<small>¹ in line pairs ² in pixels w-a = wide-angle t = telephoto</small>	



D810 | 70 mm | f2.8 (c't lab test scene, top left corner)



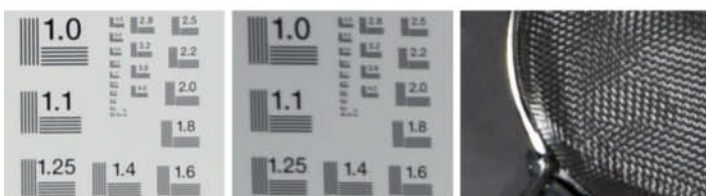
D810 | 70 mm | f2.8



D810 | 70 mm | f11



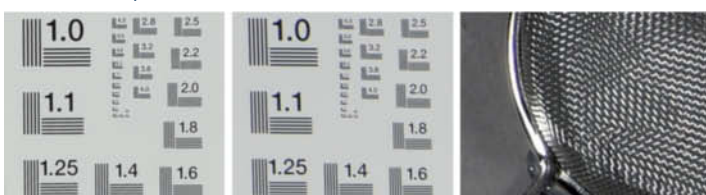
D810 | 70 mm | f8



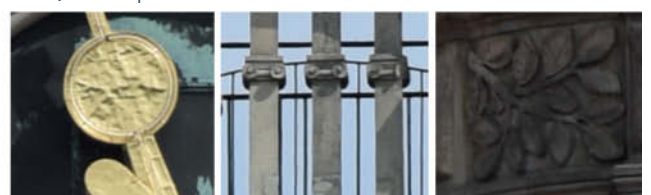
D810 | 200 mm | f2.8



D810 | 200 mm | f2.8



D810 | 200 mm | f11



D810 | 200 mm | f8



A fast telephoto zoom is ideal for capturing sports events like the annual dragon boat race in Hannover. Using a full-frame lens on a crop-format camera lets you get even closer to the action.

Nikon D810 with the AF-S NIKKOR 70-200mm f/2.8G ED VR II | 200mm | ISO 100 | f4.5 | 1/1250 s

AF-S NIKKOR 70-200mm f/4G ED VR



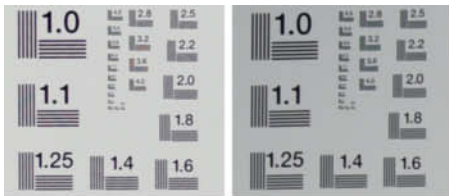
The lens: At \$1,000 cheaper and half the weight of the f/2.8 version, owners of the 'baby' NIKKOR have to make some compromises. Build quality is not as good and the focus ring on our test model was noticeably loose. This model also has no weatherproofing, the barrel is made of plastic and, like with the f/4 Canon, the RT-1 tripod mount is an optional extra that costs an additional \$170. The mount isn't strictly necessary if you use the lens with a heavy full-frame camera, but you might need it if you are shooting with a crop-format camera. The switches on the barrel govern focus mode, focus range limit and two vibration reduction modes. Focus mode can also be selected via the camera menu. The f/2.8 has three focus modes, but the f/4 version only has a choice between manual and AF with manual override/AF priority.

Test results and image quality: The mid-range NIKKOR proved a pleasant surprise, utilizing the D810's full center resolution at maximum aperture and most of its edge resolution too. This excellent performance

drops off at longer focal lengths, with an obvious lack of detail contrast wide open at the long end. This is, however, a minor gripe and overall, the lens produces hardly any distortion or other image errors.

AF-S NIKKOR 70-200mm f/4

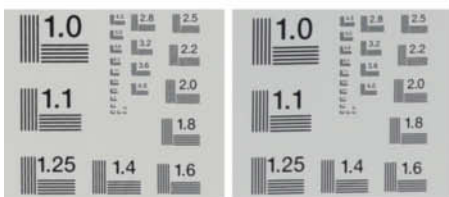
Current price	\$1,400
Max. aperture / No. of blades	f/4.0 / 9
Minimum focus distance	1 m
Length / Weight	7" / 1.87 lb
Test Results	Wide open / f8
Wide-angle edge resolution ¹	2456 (2304) / 2345 (2090)
Telephoto edge resolution ¹	2092 (1673) / 2289 (1903)
Distortion at max. aperture (w-a/t)	-0.4% / +0.6%
Chromatic aberration at max. aperture ² (w-a/t)	0.1 / 0.08
AF shutter lag	0.44 s / 0.76 s
<small>¹ in line pairs ² in pixel w-a = wide-angle t = telephotos</small>	



D810 | 70 mm | f4 (c't lab test scene, top left corner)



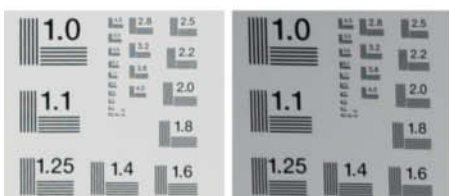
D810 | 70 mm | f4



D810 | 70 mm | f11



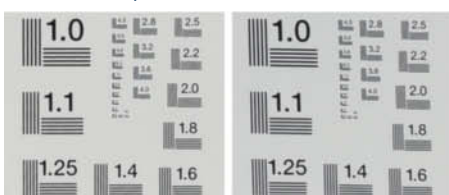
D810 | 70 mm | f8



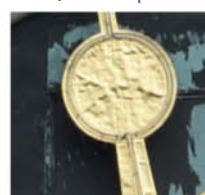
D810 | 200 mm | f4



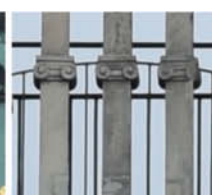
D810 | 200 mm | f4



D810 | 200 mm | f11



D810 | 200 mm | f8



Sigma 70-200mm f/2.8 EX DG APO OS HSM

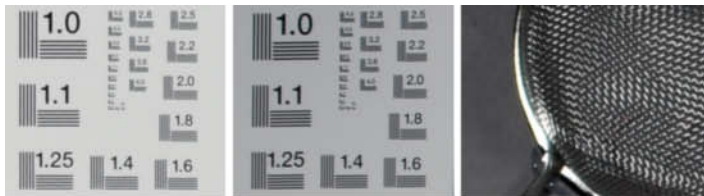
The lens: Same maximum aperture, half the price. The Sigma is available for Canon, Nikon, Sony and Sigma's own-brand cameras and, at a first glance, is of equal quality. However, once you pick up the lens, it is obvious that Sigma uses plastic in a lot of the places where Nikon and Canon use metal and that Sigma has scrimped on weatherproofing. Build quality is nevertheless very good. Switches on the barrel control the focus mode and the built-in image stabilizer, but there is no focus range limiter. Unlike the Canon and Nikon offerings, the Sigma's focus ring is located between the lens mount and the zoom ring. The travel in the focus ring on our test model was a little short, although its movement was firm and positive.

Test results and image quality: The Sigma's weakest point showed up at its widest-angle setting and maximum aperture, where it showed obvious weakness at the edges of the frame that lagged way behind the quality offered by the Canon and Nikon lenses. Otherwise, it performed very well with the Nikon D810. At maximum aperture and its

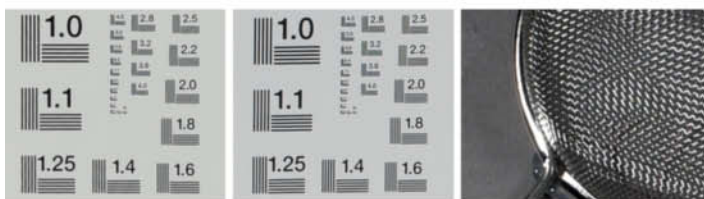
longest telephoto setting, the Sigma is not as good as the major-label competition either, but stopping down improves things considerably and produces fairly well balanced sharpness throughout the frame. We detected no significant distortion or other lens errors, but the Sigma's performance with the Nikon D810 was more sluggish than that of the other third-party lenses used with the same camera.

Sigma 70-200mm f/2.8

Current price	\$1,200 (for Nikon)
Max. aperture / No. of blades	f/2.8 / 9
Minimum focus distance	1.4 m
Length / Weight	7.8" / 3.15 lb
Test Results	Wide open / f8
Wide-angle edge resolution ¹	1828 (1092) / 2262 (1751)
Telephoto edge resolution ¹	1769 (1566) / 2070 (1981)
Distortion at max. aperture (w-a/t)	-0.4 % / +0.5 %
Chromatic aberration at max. aperture ² (w-a/t)	0.26 / 0.16
AF shutter lag	0.78 s / 0.72 s
¹ in line pairs ² in pixels w-a = wide-angle t = telephoto	



D810 | 70 mm | f2.8 (c't lab test scene, top left corner)



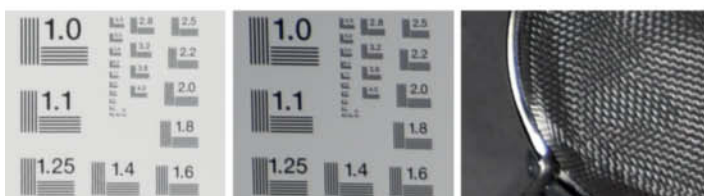
D810 | 70 mm | f11



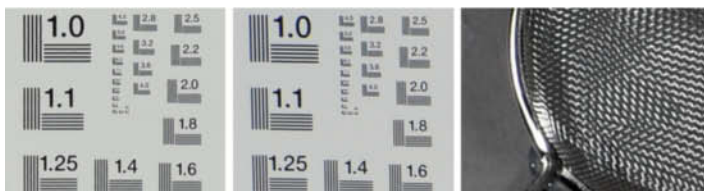
D810 | 70 mm | f2.8



D810 | 70 mm | f8



D810 | 200 mm | f2.8



D810 | 200 mm | f11



D810 | 200 mm | f2.8



D810 | 200 mm | f8



Tamron SP 70-200mm f/2.8 Di VC USD

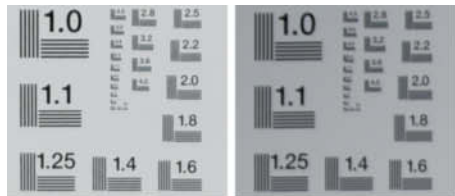
The lens: At a glance, the Tamron is difficult to distinguish from the Nikon competition. Build quality is excellent, with a really smooth focus action that was a pleasure to use mounted on a tripod. Only the focus ring didn't work as smoothly as we would have liked. We found that gripping the lens barrel hard made it more difficult to move the focus ring, making focusing less precise. This is not the case with the NIKKOR lens, and is probably due to Tamron using plastic for some parts of the lens chassis. However, it is still protected against moisture. The removable tripod collar is included with the lens, which also has a built-in image stabilizer.

Test results and image quality: In the lab, the Tamron provided serious competition for the NIKKOR, resolving 2000 line pairs wide open at the wide-angle end. However, sharpness fall-off toward the edges of the frame was significant. Overall, the Nikon performed better and also improved more stopped down. Performance at the long end was similar, with the NIKKOR winning the race with regard to detail contrast and texture

reproduction. Nevertheless, at almost \$1,000 less than the NIKKOR, the Tamron offers great value for money and worked extremely well in tandem with the D810's autofocus system.

Tamron SP 70-200mm f/2.8

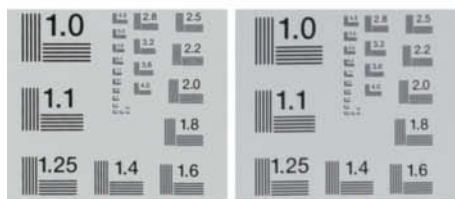
Current price	\$1,499 (for Nikon)
Max. aperture / No. of blades	f/2.8 / 9
Minimum focus distance	1.3 m
Length / Weight	7.41" / 3.24 lb
Test Results	Wide open / f8
Wide-angle edge resolution ¹	1999 (1365) / 2293 (1863)
Telephoto edge resolution ¹	1963 (1459) / 2045 (1700)
Distortion at max. aperture (w-a/t)	-0.2% / +0.3%
Chromatic aberration at max. aperture ² (w-a/t)	0.21 / 0.09
AF shutter lag	0.56 s / 0.51 s
<small>¹ in line pairs ² in pixels w-a = wide-angle t = telephoto</small>	



D810 | 70 mm | f2.8 (c't lab test scene, top left corner)



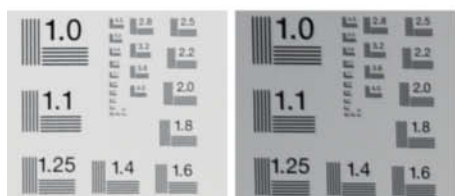
D810 | 70 mm | f2.8



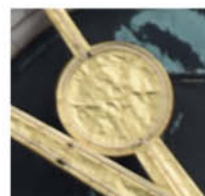
D810 | 70 mm | f11



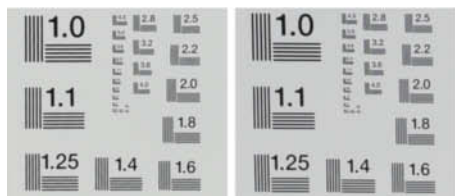
D810 | 70 mm | f8



D810 | 200 mm | f2.8



D810 | 200 mm | f2.8



D810 | 200 mm | f11



D810 | 200 mm | f8



The lenses we tested are true all-arounders that are ideal for use in a wide range of situations, including frame-filling portraits like the one reproduced here. We captured this shot using a Nikon D810 and the lens set to a medium focal length of 135 mm, which created a nice feeling of distance between the subject and the photographer and natural-looking proportions within the frame.

Tamron SP 70-200mm f/2.8 Di VC USD |
185 mm | ISO 100 | f2.8 | 1/1250 s



Tokina AT-X 70-200mm f/4 PRO FX VCM-S

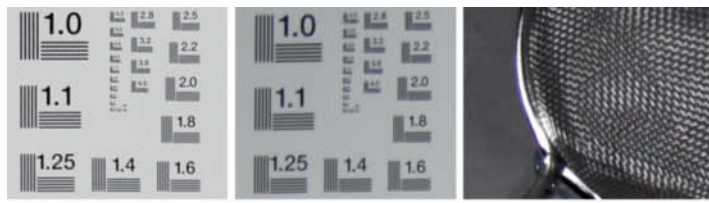


The lens: This model is only available for Nikon, and thus only competes with the NIKKOR AF-S 70-200mm f/4 VR. The Tokina, with its black barrel and gold lettering, looks a lot like a NIKKOR at a first glance and has about the same size and weight. Build quality is fine but, with just two switches for focus mode and stabilizer on/off, offers fewer options for making settings directly on the lens. The NIKKOR has additional focus range and stabilizer mode switches.

Test results and image quality: In the lab, the Tokina held its own with the NIKKOR original lens. Like many of the lenses tested here, it showed some edge weakness at maximum aperture at the wide end, but things improved a lot the moment we stopped down to medium apertures. Overall, the Tokina's image quality lags behind that of the NIKKOR at medium apertures and produces images that are obviously less vivid at wide apertures. However, at the telephoto end of the scale, the Tokina produced results on a par with those from the NIKKOR, albeit with a little pin-cushion distortion.

Tokina AT-X 70-200mm f/4

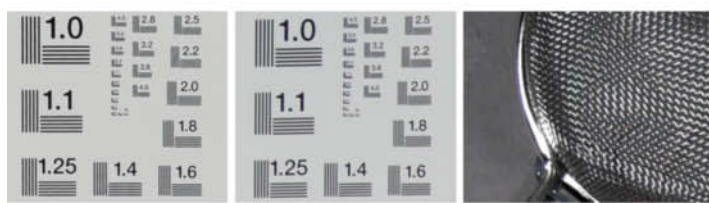
Current price	\$850
Max. aperture / No. of blades	f/4.0 / 9
Minimum focus distance	1 m
Length / Weight	6.59" / 2.16 lb
Test Results	Wide open / f8
Wide-angle edge resolution ¹	1939 (1611) / 2132 (1887)
Telephoto edge resolution ¹	2002 (1752) / 2268 (2065)
Distortion at max. aperture (w-a/t)	-0.4 % / +0.5 %
Chromatic aberration at max. aperture ² (w-a/t)	0.15 / 0.18
AF shutter lag	0.56 s / 0.82 s
<small>¹ in line pairs ² in pixels w-a = wide-angle t = telephoto</small>	



D810 | 70 mm | f4 (c't lab test scene, top left corner)



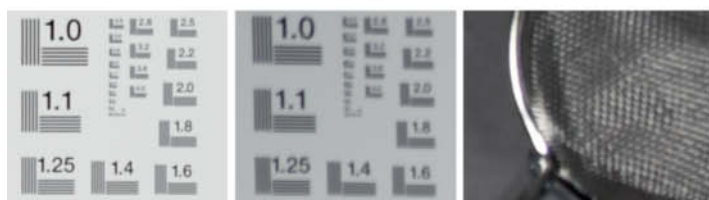
D810 | 70 mm | f4



D810 | 70 mm | f11



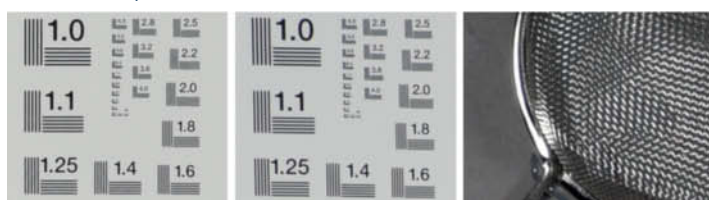
D810 | 70 mm | f8



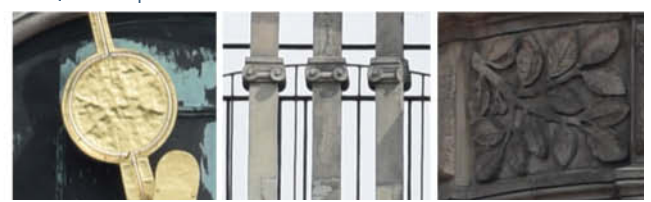
D810 | 200 mm | f4



D810 | 200 mm | f4



D810 | 200 mm | f11



D810 | 200 mm | f8

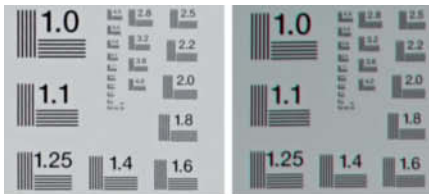
Sony FE 70-200mm f/4.0 G OSS

The lens: This lens is designed primarily for use with the diminutive Alpha a7-series cameras and is Sony's first full-frame E-mount telephoto zoom with a constant maximum aperture. To keep the lens down to a size that matches the small a7 bodies, Sony has stuck to a maximum aperture of f/4.0 and, in spite of a little play in the lens mount, our test camera/lens combo felt well balanced in use. We are used to f/2.8 telephoto zooms having a little looseness, but this is the first f/4.0 lens we have tested that displayed similar symptoms. The lens offers plenty of onboard settings, with dedicated switches for focus mode, focus range, stabilizer on/off and stabilizer mode. The lens also has three focus hold buttons, which lock focus at its current settings. The lens is dust and moisture proof and overall build quality is high. The focus and zoom rings are pleasantly grippy and enable you to work quickly and precisely.

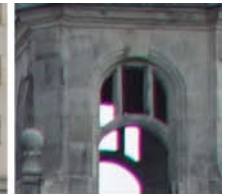
Test results and image quality: The Sony can't quite match the quality offered by the Canon and Nikon competition. It produces its best results in the middle of the aperture

range and focal lengths around 135mm, where it resolves more than 2000 line pairs in the center and almost as many at the edges of the frame. At the long end, the competition is clearly in front. Unlike many of the other lenses we tested, the Sony performs best overall at wide apertures with some improvement in center sharpness at medium apertures up to around f8.

Sony FE 70-200mm f/4.0	
Current price	\$1,500
Max. aperture / No. of blades	f/4.0 / 9
Minimum focus distance	1 m
Length / Weight (ohne Stativring)	6.89" / 1.85 lb
Test Results	
Wide open / f8	
Wide-angle edge resolution ¹	1875 (1361) / 1579 (1536)
Telephoto edge resolution ¹	1533 (1218) / 1980 (1457)
Distortion at max. aperture (w-a/t)	-0.03 % / +0.47 %
Chromatic aberration at max. aperture ² (w-a/t)	0.5 / 0.6
AF shutter lag	0.50 s / 0.57 s
¹ in line pairs ² in pixels w-a = wide-angle t = telephoto	



a7R | 70mm | f4 (c't lab test scene, top left corner)



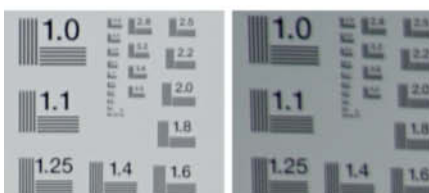
a7R | 70mm | f4



a7R | 70mm | f11



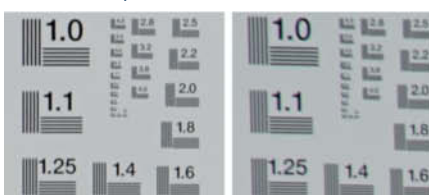
a7R | 70mm | f8



a7R | 200mm | f4



a7R | 200mm | f4



a7R | 200mm | f11



a7R | 200mm | f8

Fujifilm XF 50-140mm f/2.8 R LM OIS WR



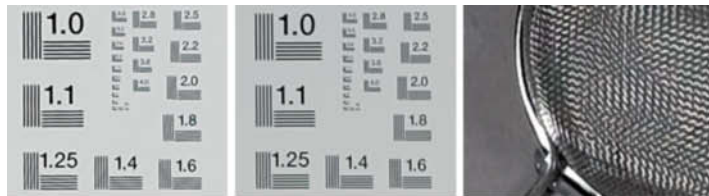
The lens: This lens, designed for use with the X-series mirrorless cameras, has an equivalent full-frame zoom range of about 75-210 mm and a constant maximum aperture of f/2.8. Like the X-T1 body we used, the lens is weatherproof and is cold-resistant down to -10 degrees Celcius. Build quality lives up to the manufacturer's promises and is absolutely comparable with that of the equivalent Canon and Nikon products, even though it is shorter and lighter than both. Like the NIKKOR, the tripod mount can be removed from the built-in collar. The only switch on the lens barrel controls the image stabilizer and the supplied lens hood has a removable cover that makes it easier to use polarizers and other rotating filters.

Test results and image quality: The images we captured were clear and precise throughout the zoom range, with a slight tendency toward better sharpness at the wide end. The lens resolves its theoretical maximum center resolution at maximum aperture, although edge sharpness lags slightly behind throughout the range. Overall,

it produced well-defined textures and no obvious lens errors, although background highlights appear somewhat rough-edged. Used with the X-T1, the lens focused quickly and quietly.

Fujifilm XF 50-140mm f/2.8

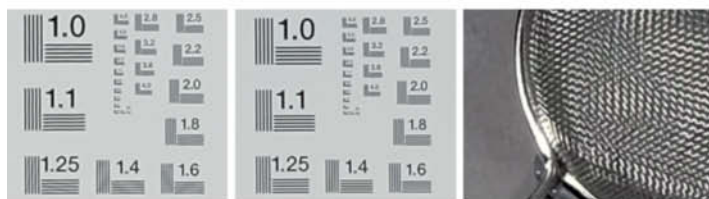
Current price	\$1,600
Max. aperture / No. of blades	f/2.8 / 7
Minimum focus distance	1 m (macro)
Length / Weight	6.93" / 2.19 lb
Test Results	Wide open / f8
Wide-angle edge resolution ¹	1632 (1485) / 1632 (1593)
Telephoto edge resolution ¹	1632 (1314) / 1600 (1406)
Distortion at max. aperture (w-a/t)	0% / 0%
Chromatic aberration at max. aperture ² (w-a/t)	0.06 / 0.05
AF shutter lag	0.37 s / 0.39 s
<small>¹ in line pairs ² in pixels w-a = wide-angle t = telephoto</small>	



X-T1 | 50 mm | f2.8 (c't lab test scene, top left corner)



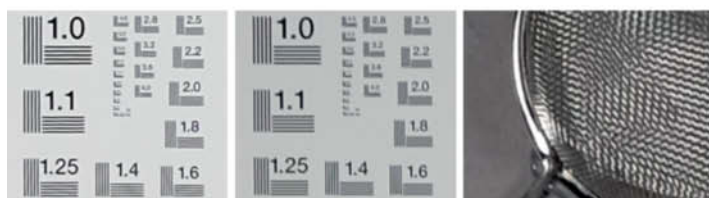
X-T1 | 50 mm | f2.8



X-T1 | 50 mm | f11



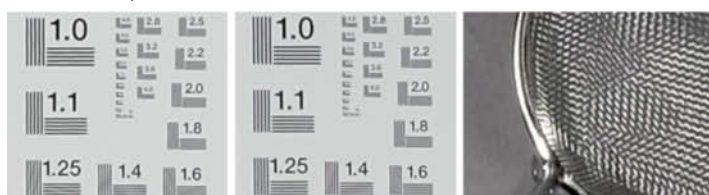
X-T1 | 50 mm | f8



X-T1 | 140 mm | f2.8



X-T1 | 140 mm | f2.8



X-T1 | 140 mm | f11



X-T1 | 140 mm | f8

The Fujinon produces pin-sharp images with beautiful soft bokeh, smooth focus gradients and a unique, highly three-dimensional look

Fujifilm X-T1 with the Fujinon XF 50-140 mm | 140 mm (210 mm equivalent) | ISO 200 | f2.8 | 1/125s



Pentax DA* 50-135mm f/2.8 ED [IF] SDM



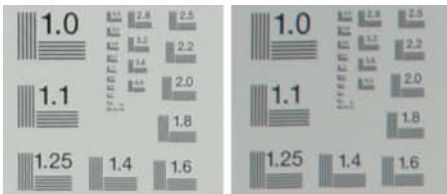
The lens: This is one of the lightest and cheapest lenses in our test field. In spite of its low price, it is dust- and moisture-proof, making it a great lens for taking on hiking trips. Build quality is good, although the focus ring on our test lens had detectable play and was too easy to move accidentally. Only the focus mode can be switched directly in the lens and, like the Fujinon, the supplied lens hood has an opening that makes it easier to operate a polarizer filter while it is mounted.

only metric that let the Pentax down and put it on a par with the third-party lenses we tested rather than the other manufacturer's own-brand products.

Test results and image quality: The Pentax delivered pretty consistent results throughout the zoom range, although we did notice some obvious weakness at the edges and well into the center at 135 mm and maximum aperture, giving the images we captured a somewhat lifeless look. We recorded our best results at the short end, with clear textures and details and only a very few visible fringing artifacts. Stopping down produced more consistent results, with center and edge sharpness that are virtually the same at f8. Shutter lag was the

Pentax DA* 50-135mm f/2.8

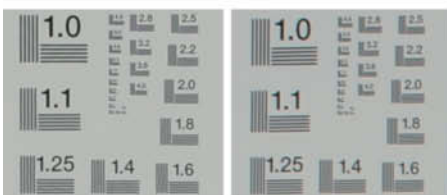
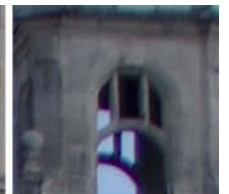
Current price	\$860
Max. aperture / No. of blades	f/2.8 / 9
Minimum focus distance	1 m
Length / Weight	5.35" / 1.51 lb
Test Results	Wide open / f8
Wide-angle edge resolution ¹	1549 (1257) / 1681 (1536)
Telephoto edge resolution ¹	1512 (1059) / 1653 (1357)
Distortion at max. aperture (w-a/t)	-0.3% / +0.4%
Chromatic aberration at max. aperture ² (w-a/t)	0.59 / 0.23
AF shutter lag	0.79 s / 0.64 s
¹ in line pairs ² in pixels w-a = wide-angle t = telephoto	



K-3 | 50mm | f2.8 (c't lab test scene, top left corner)



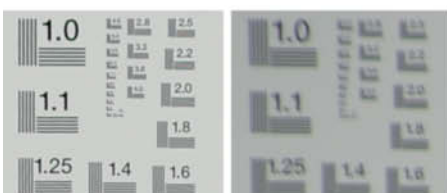
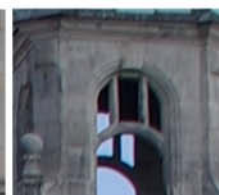
K-3 | 50mm | f2.8



K-3 | 50mm | f11



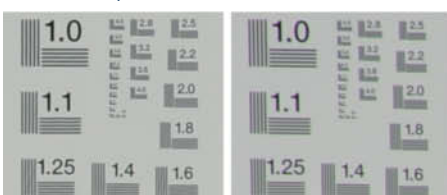
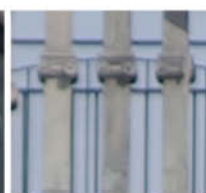
K-3 | 50mm | f8



K-3 | 135mm | f2.8



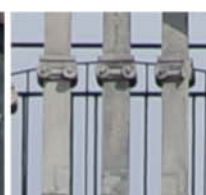
K-3 | 135mm | f2.8



K-3 | 135mm | f11



K-3 | 135mm | f8



Samsung 50-150mm f/2.8 S ED OIS

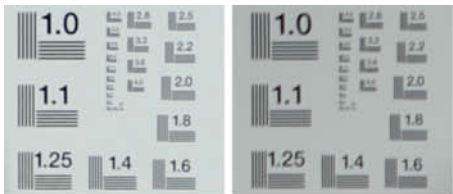
The lens: The design of the Samsung underscores its pro-grade ambitions, and its heavy, semi-matte dust- and moisture-proof body feels good to hold. It has dedicated switches for focus mode, focus range and image stabilization, as well as the Samsung i-Function button with which you can alter major camera settings via the lens. We really liked the finely ribbed rubber grips on the focus and zoom rings, which enabled us to to work quickly and precisely at all times. The built-in tripod mount makes it easier to use this heavy lens with the comparatively small NX-series camera bodies.

Test results and image quality: This is another lens that works best at the short end of its zoom range. Here, it resolved 83 per cent of its potential center resolution wide open, and things improved slightly at f5.6. Edge resolution was consistently good up to f8 but dropped off a little at f11 and beyond. Results were similar at medium and long focal lengths, but were generally not quite as good, with less detail sharpness and a slightly less crisp overall look. It

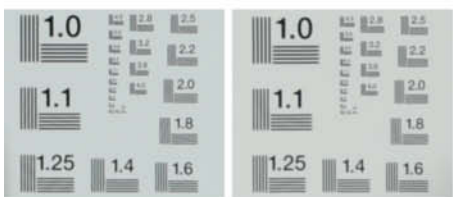
produced no significant lens errors and focused quickly and precisely throughout our test.

Samsung 50-150mm f/2.8

Current price	\$1,600
Max. aperture / No. of blades	f/2.8 / 9
Minimum focus distance	0.7 m
Length / Weight	6.06" / 2.02 lb
Test Results	Wide open / f8
Wide-angle edge resolution ¹	1798 (1630) / 1903 (1765)
Telephoto edge resolution ¹	1523 (1405) / 1801 (1623)
Distortion at max. aperture (w-a/t)	0% / -0.1%
Chromatic aberration at max. aperture ² (w-a/t)	0.3 / 0.16
AF shutter lag	0.25 s / 0.25 s
¹ in line pairs ² in pixels w-a = wide-angle t = telephoto	



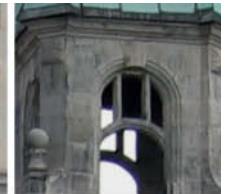
NX1 | 50 mm | f2.8 (c't lab test scene, top left corner)



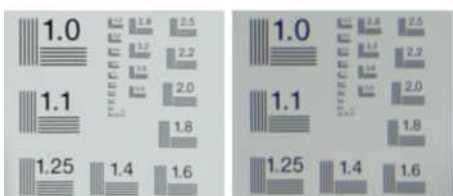
NX1 | 50 mm | f11



NX1 | 50 mm | f2.8



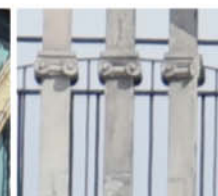
NX1 | 50 mm | f8



NX1 | 150 mm | f2.8



NX1 | 150 mm | f2.8



NX1 | 150 mm | f8

NX1 | 150 mm | f11

Finding the Right Compromise

During our test, no-one at the Heise offices was able to walk past our test setup without asking how many cars we could buy for the money our 11 lenses were worth, or simply which was the best.

Thanks to autotrader.com, the car question was relatively simple to answer: a 1948 Lincoln Continental, two 2007 BMW 525i sedans or four 2001 Toyota Camrys.

The question of which lens is the best is more complex, especially in view of the wide range of manufacturers and systems we tested – from full-frame to APS-C, DSLR to mirrorless, and established manufacturers to market newcomers.

The most impressive-looking lenses are the f/2.8 Nikon and Canon models. Both are much larger than the rest of the competition and have rock-solid reputations that were backed up by the performance we recorded. At 200mm, the Canon produced balanced, pin-sharp images with great contrast and virtually no lens errors to speak of. The Nikon displayed similar performance and was surprisingly fast, even when used with a slower camera such as the D810.



High-quality photos often demand bulky gear, proved here by the Canon EOS 5D Mark III and the EF 70-200mm IS f/2.8L. This particular combo weighs in at over 5 lb.

A Question of Price

The speed of the high-end lenses is backed up by their fast f/2.8 maximum apertures, that give you maximum shooting flexibility in low light, smoother bokeh, unobtrusive focus gradients and images with a highly three-dimensional feel. In practice, however, the difference between maximum apertures

of f/2.8 and f/4.0 probably isn't that great, as demonstrated by the two images opposite, which we took at maximum aperture and 200mm using the two Canon test lenses. Only the most diligent pixel peepers will really be able to tell the difference, even if the f/2.8 model does produce a softer overall look. As far as bokeh is concerned, the range of minimum focus

Three very different approaches to the same basic concept. From left to right: Nikon D810; Fujifilm X-T1; Samsung NX500



distances offered by the lenses we tested makes it tricky to directly compare all the images we produced.

The greatest disadvantage of the top models from the market leaders is that they are heavy and expensive, making them impractical or simply unaffordable for all but the most dedicated photographers. Additionally, their size and weight makes a tripod essential in most situations if you want to make the most of their excellent optical characteristics. And, once you have made a purchase, you will probably have to add the cost of a few weight training sessions to bill!

Own-brand vs. Third-party

Third-party lenses offer the same basic specifications, often for as little as half the price of the camera manufacturers' own-brand lenses. The Sigma and Tamron models we tested produced solid performance, but could match neither the edge nor overall telephoto performance of the NIKKORs when used with the demanding Nikon D810. In the autofocus stakes, too, the third-party models lagged behind the originals, although it has to be said that the Tamron was nevertheless reliable and relatively snappy.

An alternative approach is to take a look at the f/4.0 models from the established manufacturers. These lenses are smaller, lighter and cheaper than their faster siblings, and produce comparable image quality in a wide range of situations. For example, the f/4.0 NIKKOR produced maximum center resolution at f4 when used with the D810. The f/4.0 Canon, however, wasn't able to match the telephoto performance of its f/2.8 counterpart.

The build quality of the f/4.0 models is generally not as high as that of the top-flight lenses, and they often lack details such as moisture-proofing and a choice of stabilizer modes. The f/4.0 NIKKOR also focuses slower than the f/2.8 version.

Pentax is the only manufacturer in this test lineup that has yet to release a full-frame DSLR, and its 50-135mm DA* lens has an equivalent zoom range of 75-200mm. The lens is smaller, lighter and cheaper than most of the competition but nevertheless includes the weatherproofing and fast maximum aperture offered by the more bulky and expensive competition. Apart from a little wide open edge weakness at the long end, it offers great image quality too.

Choices for Mirrorless Camera Owners

Sony, Samsung and Fujifilm all ensure that mirrorless fans don't have to go away



Canon EOS 5D Mark III with the EF 70-200mm f/2.8L IS II USM
200 mm | ISO 100 | f2.8 | 1/1250s



Canon EOS 5D Mark III with the EF 70-200mm f/4L IS USM |
200 mm | ISO 100 | f4 | 1/160s

These two images show the difference between long zoom shots captured at maximum aperture using the f/2.8 and f/4.0 Canon lenses. The bokeh is very similar, but the background in the f/2.8 shot is a little softer. You will have to decide for yourself whether this makes a difference in real-world photographic situations.

empty-handed when it comes to choosing a universal zoom lens. The Sony lens produced solid but unspectacular performance, while the Fujifilm X-T1 with the XF 50-140mm R LM OIS WR proved to be a well-built, highly capable setup that is weather and cold-proof to boot. However, quality once again has its price (and bulk), and the Fuji products are neither lightweight nor cheap.

Samsung's 50-150mm f/2.8 lens is part of its 'Premium' range and has a price to match. It is aimed at cementing Samsung's ambitions in the pro photography segment and is designed to move the NX-series cameras away from their image as pure 'lifestyle' products. We are keen to see which direction Samsung takes in the further development of its mirrorless system cameras. (ssi) **ct**



Sophia Zimmermann

Pentax K-3 II

The K-3 II is not just an update of the much-loved K3, it is a new camera in its own right with new features and functions, including GPS and 'Pixel Shift Resolution' functionality for capturing enhanced-resolution images. We take a look at what the new camera has to offer.

Just over a year after the introduction of the K-3, Pentax has brought its new top-of-the-range K-3 II APS-C model to market. What sounds like a run-of-the-mill update in fact heralds the introduction of a camera with the all-new 'Pixel Shift Resolution' function that promises images with greater resolution and sharpness, as well as more vibrant colors and improved noise characteristics. To achieve this, the K-3 II uses its shake reduction system to capture four separate images, each offset by a single pixel upward, downward or to the side and the camera's firmware uses the resulting image files to create a more precisely rendered final image. The system is designed to overcome the comparatively poor color reproduction caused by conventional Bayer pattern sensors, which record only red, green or blue color data for each pixel and interpolate the other

two colors from neighboring pixels. It is also said to utilize the full potential resolution of the sensor more effectively.

Pixel Shift and GPS

The Pixel Shift system is similar to the High Res feature built into the mirrorless Olympus OM-D E-M5 Mark II, which captures eight exposures in 0.5-pixel steps and merges them into a single 40-megapixel photo. However, our tests showed that it is virtually impossible to shoot successful High Res shots handheld, and all our attempts turned out to be a gamble at best.

We expected to run into similar issues with the K-3 II, although with only four separate files per Pixel Shift shot, the margins for error are smaller than those inherent in the

Olympus system. Assuming you shoot at the camera's maximum burst rate of 8.3 fps, a four-image Pixel Shift shot should take about half a second to capture – a handheld exposure time that is a real challenge for most photographers, especially when you consider that shake reduction itself is not available in Pixel Shift mode. All in all, Pixel Shift isn't really practical for real-world use, and it only really works under precisely controlled lab conditions. Furthermore, each raw Pixel Shift image takes up more than 100 MB of memory. See the *Test Results and Image Quality* section below for more details on the quality of the images we captured during our test.

The K-3 II has built-in GPS functionality, enabling you to add geodata to your image files. It also has an electronic compass and an ASTROTRACER function that uses the shake reduction system to move the sensor to



Built-in GPS

The Mark II's body differs from its predecessor only in the details like the new GPS button on the side of the viewfinder housing.

match the movement of celestial bodies during nighttime long exposures.

Market Position

The basic technical specs are almost identical to those of the previous model. The APS-C CMOS sensor offers 24 megapixels of resolution and ISO sensitivity of 100-51 200. The 27-point AF system has 25 cross sensors, the pentaprism viewfinder offers 100 percent image coverage and the 3.2" monitor has 1.04 million dots, equivalent to about 720x480 pixels. The stainless steel body is protected against dust and moisture with 92 individual

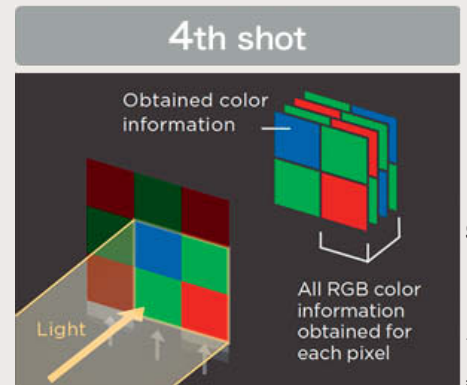
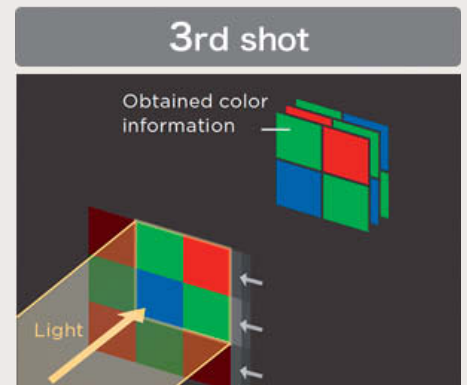
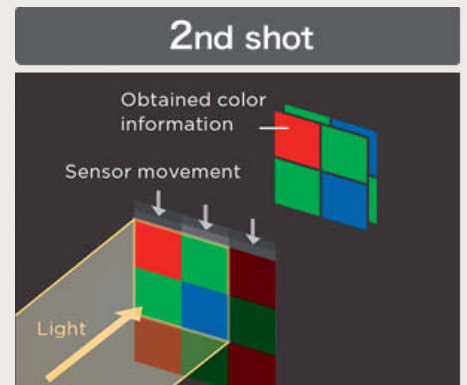
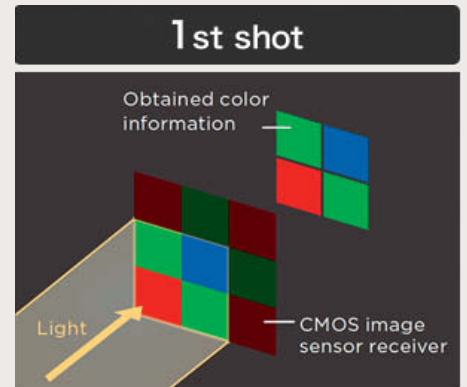
seals and, according to the manufacturer, is cold-resistant down to -10 degrees Celsius (14 Fahrenheit).

The K-3 II's overall build and resolution are designed to compete directly with the Nikon D7200 and the Canon EOS 7D Mark II. Burst-wise, the Pentax, with its maximum rate of 8.3 fps, is slower than the Canon (10 fps) but faster than the Nikon's 6 fps performance. The Canon's AF system has 65 cross sensors and is the most sophisticated of the three, although at around \$1,000, the Pentax is a bargain compared with the Canon, which currently costs around \$1,500. The Nikon D7200 lies between the two at about \$1,200.



Camera Back and Status Screen

The back of the K-3 II is tidy, with large, clearly-labeled buttons and controls. The 'status screen' is a display of all the camera's major settings in a single, easy-to-read summary and enables you to alter them to taste.



Illustrations courtesy of Pentax

Unlike the High Res mode built into the Olympus OM-D EM-5 Mark II, which increases the number of megapixels in an image file, the Pentax Sensor Shift Resolution function is designed to utilize the sensor's existing resolution to the full

Handling

At a glance, the K-3 and K-3 II look identical, but if you look carefully, you will see that the Flash button on the viewfinder housing has been replaced by a GPS button and the mode dial now has white rather than silver lettering.

These details make no difference to the camera's handling, which is every bit as solid as that of its predecessor. The ergonomically shaped, rubberized grip and the generous thumb pad on the back ensure that it sits snugly and safely in your hands. The body is relatively compact, quite chunky and, at nearly 800 grams (1.76 lb) is heavier than it looks.

Build quality is excellent, with no loose buttons or seams. Everything fits together perfectly. In addition to its hidden dust and moisture proofing, the Pentax has external rubber caps for the memory card slot and the connectors on the left-hand side of its body. The battery compartment, too, has a heavy-duty locking knob to keep out dust and dirt.

The menu system is virtually identical to its predecessor, and the camera is controlled using a main mode dial alongside subsidiary 'e-dials' and buttons for the individual functions. A couple of controls (such as the RAW/Fx button) can be customized, giving you plenty of control and enabling you to work fast once you are familiar with how the camera works.

The new Pixel Shift Resolution function can be found in the first menu tab, but can also be accessed via the control panel menu revealed by pressing the INFO button. Switching Pixel Shift on automatically switches off Shake Reduction.

GPS Now On Board

Pressing the dedicated button on the viewfinder housing switches on GPS, and the action is confirmed by a beep and a satellite icon on the monitor. GPS status is also displayed in live view mode – in green for 3D positioning, yellow for 2D positioning or red if no position data is available.

The camera's GPS module adds geodata to stills but not to video footage, and you can select the logging interval and a logging period of up to 24 hours via the GPS Logging menu item. Log data can be saved to either of the camera's twin memory card slots.

Test Results and Image Quality

Alongside other lenses, we tested the K-3 II with the DA 70mm f/2.4 Limited lens which

worked extremely well with the K-3 II in our lab tests. The new version's noise characteristics are very similar to those of the original camera, delivering a signal-to-noise ratio of 80 at ISO 100. Our subjective visual noise test returned a value of 0.7, which is below the threshold value of 0.8 that signifies practically noise-free images. At ISO 1600, we measured visual noise of 1.5, which is still a fair way below the threshold value of 2.0 for acceptable noise, although above ISO 3200, it delivered a value above 2.0.

In the resolution stakes, the K-3 II recorded 1720 line pairs of a theoretical maximum of 2000 at ISO 100, and this value dropped off to 1600 at at ISO 400. We measured 1580 line pairs at ISO 1600 and 1530 at ISO 3200, which means that resolution fall-off is moderate throughout the usable, everyday ISO range.

Although the camera is technically capable of capturing images all the way up to ISO 51 200, detail rendition begins to drop off at ISO 1600. Images captured at ISO 6400 are OK for full-screen viewing but, on closer inspection, reveal some washed-out colors, poorly defined textures and color noise, resulting in pale, rather lifeless images.

Pixel Shift Mode

The difference between normal and Pixel Shift images couldn't have turned out greater. The edges of Pixel Shift images benefit especially from the process, which produces an extremely sharp, highly three-dimensional look. The center of Pixel Shift images, too, have greater detail contrast than their standard counterparts. Our measurements confirmed that the Pixel Shift technique maximizes the sensor's potential resolution at ISO 100 and continues to do so in the center of the frame all the way up to ISO 3200. However, the difference between normal and Pixel Shift detail is less significant at higher ISO values (see the examples on the next page and the test image archive included with this issue's free online content).

Overall dynamic range remained at around 10 stops, regardless of which mode we used to capture images.

One obvious downside of the Pixel Shift technique is its tendency to produce purple fringing artifacts in fine patterns and lined textures throughout the frame. These artifacts were especially obvious at angled edges and in the highlights.

Conclusions

The K-3 II is a nice addition to the Pentax high-end APS-C range and offers functions that many are sure to have missed in the

PENTAX K-3 II

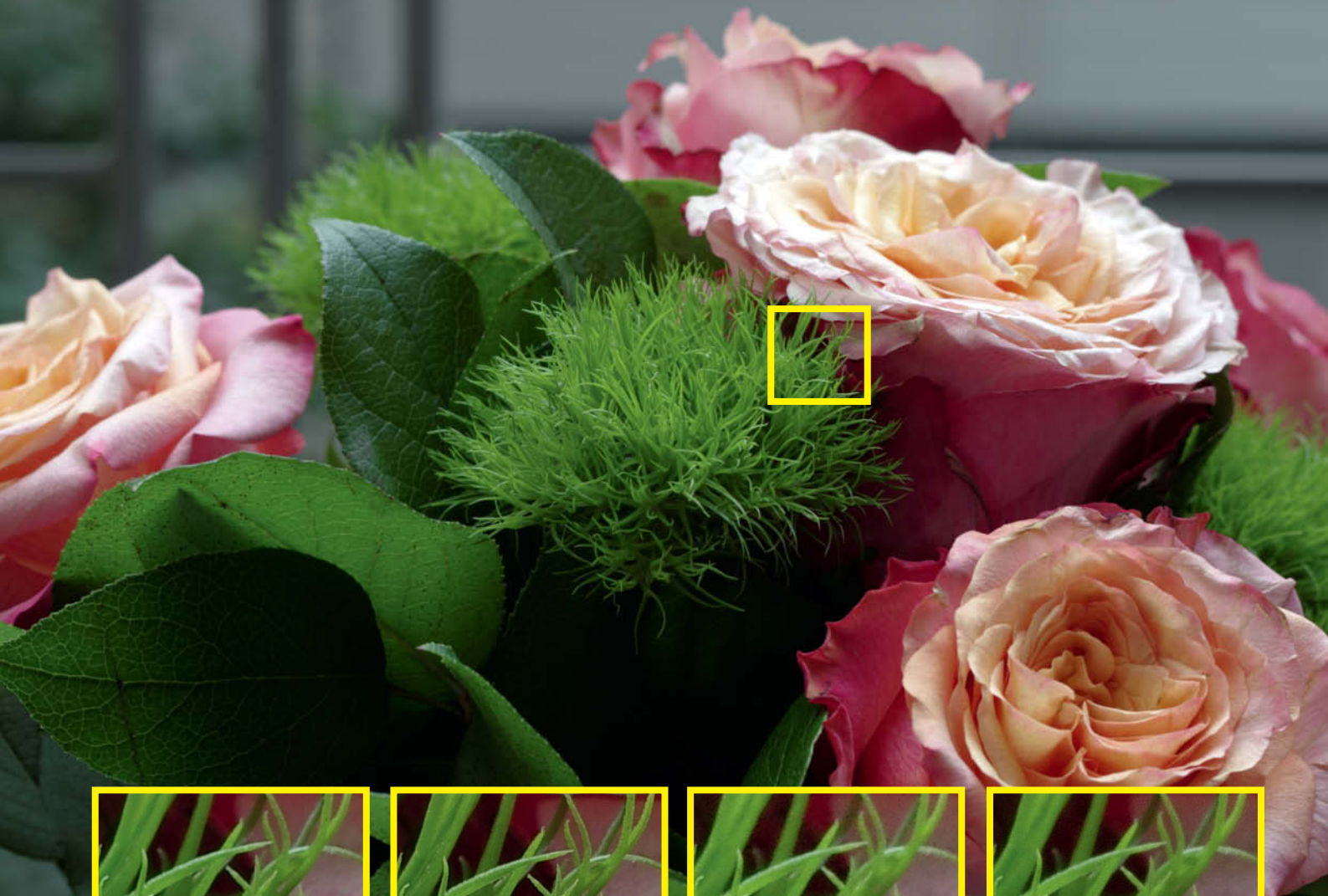


Technical Data

Sensor resolution	6016 × 4000 pixels
Megapixels	24
Low pass filter	no
Sensor size	APS-C (23.5 × 15.6 mm)
Crop factor	1.5
Raw capture	yes
AF system	phase-detection
AF points	27 (25 cross sensors)
Shortest / longest exposure time	1/8000 s / 30 s (Bulb)
Sensitivity	ISO 100-51 200
Viewfinder	optical pentaprism (100%)
Monitor type, size	LCD, 3.2"
Monitor resolution	1.04m dots
Body construction	stainless steel/magnesium alloy
Waterproofing	92 individual seals
Dimensions (W/H/D)	132 × 103 × 76 mm
Weight (body only w/ memory card and battery)	799 g (1.76 lb)
Memory card support	SD, SDHC, SDXC (twin card slots)
Interfaces	USB 3.0, HDMI (Type D), microphone, headphones, GPS, Wi-Fi
Power source	Li-Ion battery D-LI90, optional battery grip for 6 AA batteries
RSP body only	\$1,000

Test Results

	better ▶
Sensor resolution (line pairs)	2000
Center (ISO 100)	1720
Center (ISO 400)	1596
Center (ISO 1600)	1580
Center (ISO 6400)	1464
Dynamic range (ISO 100)	10.3
Dynamic range (ISO 400)	10.4
Dynamic range (ISO 1600)	10.3
Dynamic range (ISO 6400)	9.9
	◀ better
Visual noise (ISO 100)	0.7
Visual noise (ISO 400)	0.9
Visual noise (ISO 1600)	1.5
Visual noise (ISO 6400)	2.8
Shutter lag at 1000 lux	0.67 s



70 mm | ISO 100 | f8 | 1/8 s |
Tripod-mounted, 400% (normal)



70 mm | ISO 100 | f8 | 1/8 s |
Tripod-mounted, 400% (Pixel Shift)



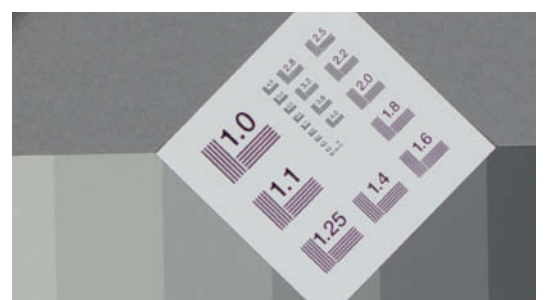
70 mm | ISO 1600 | f8 | 1/100 s |
Tripod-mounted, 400% (normal)



70 mm | ISO 1600 | f8 | 1/100 s |
Tripod-mounted, 400% (Pixel Shift)

Here, you can see the difference between normal and Pixel Shift images captured at ISO 100 and ISO 1600. Our low-sensitivity Pixel Shift test images were clearly sharper and more three-dimensional than their normal counterparts, while the difference was not so pronounced at higher ISO values.

In our lab test, Pixel Shift images showed obvious fringing throughout the frame. These were particularly evident at diagonal edges.



original model. Nowadays, GPS really should be standard in this class of camera. Even if it has few practical applications, Pixel Shift Resolution is a clever technology that really does coax extra image quality out of the camera's sensor, and the free Pentax Digital Camera Utility software removed the fringing artifacts it causes with ease.

This is a true outdoor camera that is quite at home in bad weather, although Pixel Shift mode only really works under controlled studio conditions. However, the feature sends a clear signal to other manufacturers that Pentax is keen to innovate, and neither Canon nor Nikon currently offers anything like it.

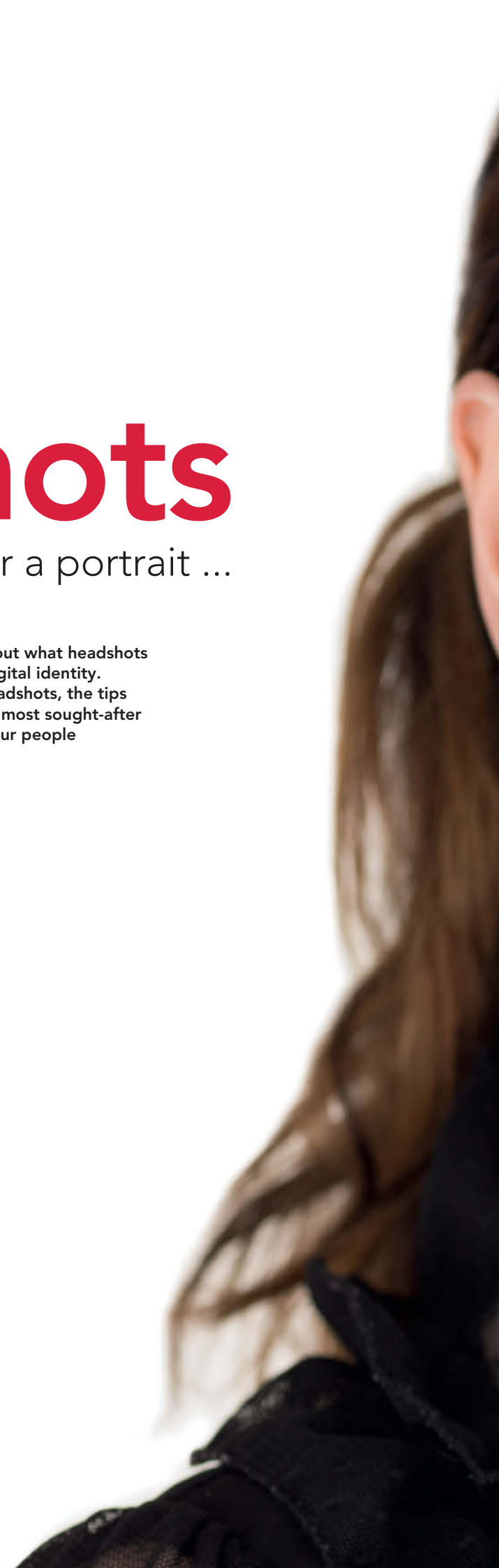
Overall, the K-3 II is a well-built, solid and reliable DSLR, and features like twin memory card slots, a choice of raw formats, USB 3.0 and interchangeable focusing screens underscore its pro-grade ambitions. Additionally, the fact that it is cheaper than the Canon and Nikon competition should help it gain traction in the market. (ssi) **ct**

Gabriel Hill

Headshots

not just a passport photo or a portrait ...

This article by Peter Hurley's star student Gabriel Hill is all about what headshots are, why you need one and what they have to do with your digital identity. Whether you are a beginner or are already up to speed on headshots, the tips and techniques introduced here are based on the work of the most sought-after headshot photographer in the world and will help you take your people photography to the next level.





Headshots originated in the movie industry and are often used by actors and models in a casting context. Many hopefuls attach several headshots to their resumé to give the casting director a better idea of their flexibility.

Headshots are increasingly being used in the business world too, and dedicated headshot studios can be found in most cities.

Passport Photo 2.0?

A conventional passport photo fulfills official criteria and is captured in a way that makes it as easy as possible to identify its holder. Every country has its own guidelines for passport photo capture, although the introduction of biometric ID documents that simplify machine-based face recognition has brought about some degree of standardization around the world. Passport photos generally have to show a neutral expression, which is one of the major factors that differentiate them from headshots.

Headshots are anything but neutral and expressionless because they are not designed for identification purposes. Rather, their intent is to put a face to a virtual identity and convey an individual's personality. This means that they also go beyond just capturing a 'nice' photo.

We all have highly personal expressions and we all use body language in a way that identifies us as unique. A successful headshot should capture that uniqueness in an authentic way and use it to grab the viewer's attention. Whether in the entertainment or business worlds, a photo is of no use to anyone if it conveys a different character from that of the person who actually walks through the door.

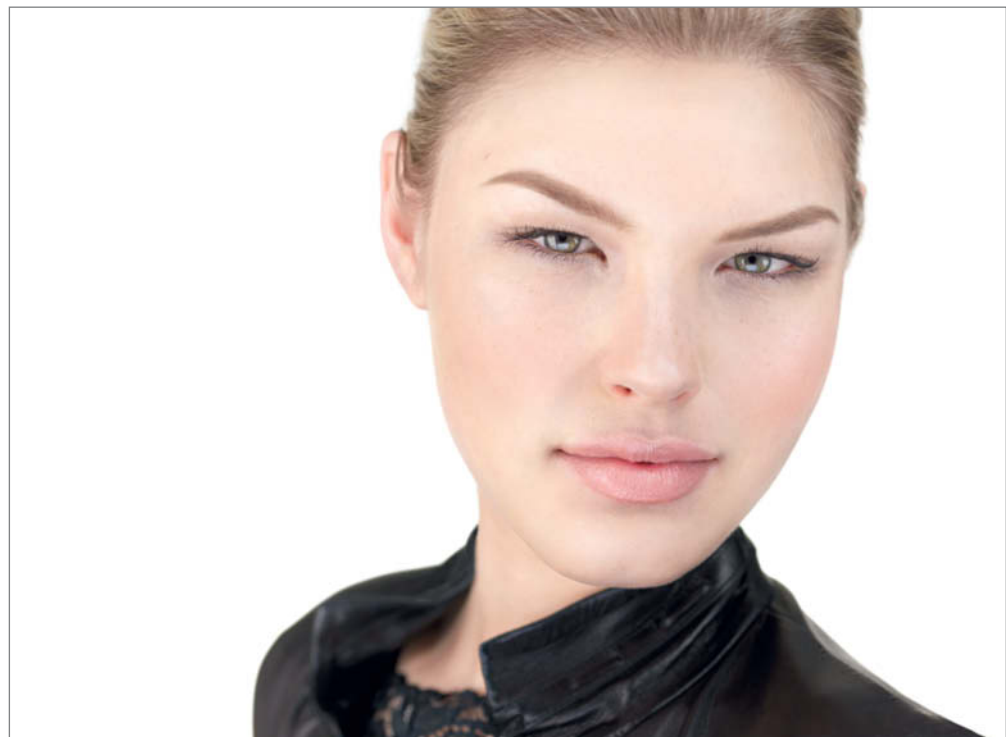
More Like a Portrait?

Headshots are often lumped in with portrait photography, although they actually constitute an entirely separate genre. Both types of photo exist to capture the subject's personality, although business portraits often include props to give clues to a person's occupation.

Portraying a watchmaker with her tools, a painter in a studio or a musician playing immediately puts the emphasis on the subject's job rather than their personality. Some business portraits even ignore work and concentrate on underscoring how successful the subject is by portraying them in a grand



A conventional, natural-looking headshot in which the makeup and post-processing are so subtle that they are almost undetectable



A typical model headshot in which the overall look, the makeup and the post-processing are all deliberately eye-catching

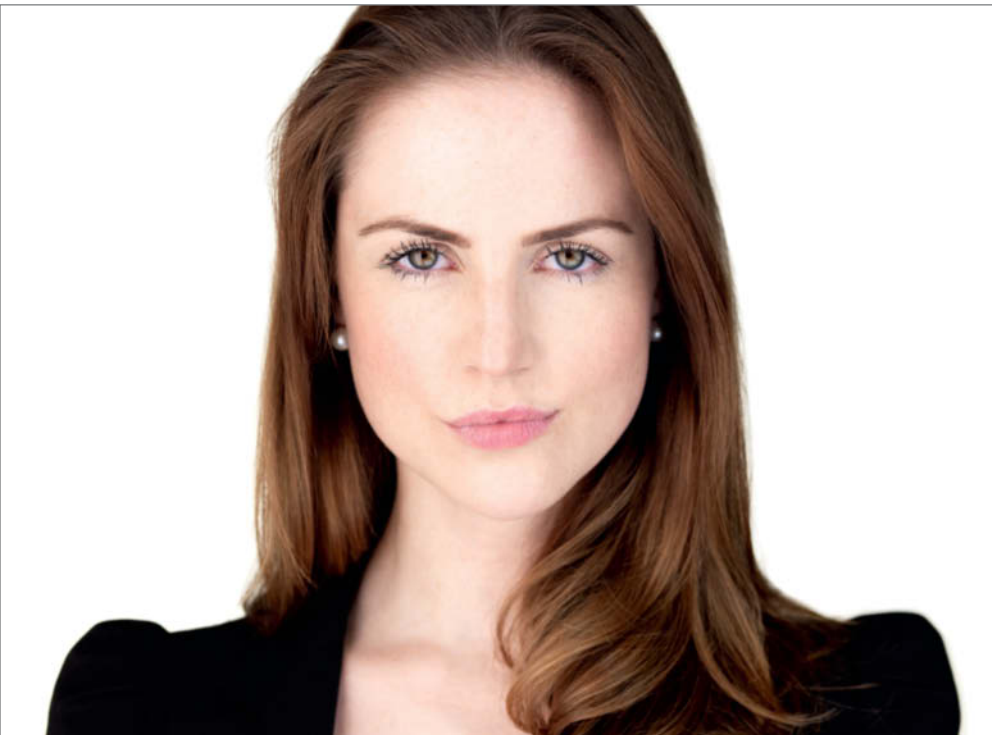


office, near a company building or with expensive artworks in the background. Other popular setups position the subject, whose clothing often makes it possible to guess their occupation without the help of additional props, in front of a monotone (usually gray) background or in outdoor situations with plenty of bokeh.

Headshots are different. In my headshots, clothing and hair styling are only hinted at. The subject's face takes up most of the frame so that their charisma takes center stage. The entire setup is designed to convey a self-confident yet appealing impression.

Headshots are not about the subject's job or personal achievements – it's all about personality!

This headshot for an actor uses plenty of shadow to emphasize his rugged expression. The colors, too, are unusual for a headshot and create a more cinematic feel.



Another typical headshot that is neither completely natural-looking nor excessively posed

Gabriel Hill

Gabriel Hill is a commercial and editorial portrait photographer who has looked at the world through a viewfinder since he was a child. He learned his trade with star headshot photographer Peter Hurley and quickly became the shooting star in Hurley's community. He now lives and works in Switzerland and runs the Head Quarters studio in Basel together with his partner.

www.thegabrielhill.com

Neither passport photos nor portraits, headshots are designed to put a face to a virtual identity



As a comparison, this image represents mixed passport and portrait photo attributes. The subject is facing the camera head-on and has a neutral 'passport-style' expression.

Your Digital Identity: Why Headshots Are so Important

The boundaries between the online and offline worlds and between work and leisure are becoming increasingly blurred. We are all connected to the Web, and our online activities can quickly have offline consequences. Headshots are there to help you build up your online image.

Searching for yourself on the Web has less to do with vanity than it does with establishing your digital identity. Studies in various countries show that a majority of HR departments use online resources to support their recruitment decisions, and this is obviously a growing trend. Figures published by www.saferinternet.at revealed that 76% of HR departments use search engines such as Google or Bing, while 61% use social networks and 44% use business networks like linkedin.com.

Almost every third HR representative said that their online research had a direct effect on the application process. Most queries are related to the applicant's personality rather than their professional life, so it follows that your digital identity can improve (or damage) your prospects of getting a job. Headhunters tend to give special emphasis to an applicant's comments, postings, hobbies, interests outside of work and, of course, their photos.

Business networks are used to search directly for suitable candidates, and here too, if a first look doesn't leave a good impression, people will be less interested in looking further.

Authenticity

Digital identities aren't just a topic for job seekers. Everywhere we go online, we can upload images of ourselves, whether at Facebook, LinkedIn, Trip Advisor, Tinder or wherever. Of course, no-one is obliged to use a photo, but what does it say about you if you don't and what are the consequences of doing without?

Because a photo connects a virtual identity with a real face, it lends any content you publish an air of authenticity. Imagine you are asking for help or advice in the real world and the person you are consulting is wearing a mask. How likely is it that you will trust what this person says?

Establishing Your Image

With more than 200 million members on LinkedIn, more than 350 million on Google+, 500 million on Twitter and at least a billion on Facebook, your profile picture and what it says about you plays an important role. Your profile picture is the

21st century equivalent of a visiting card, and this is where headshots come in.

Profile pictures generally have either a highly positive or a highly negative effect on the viewer, and there is no gray area between the two extremes. This is just as true for companies as it is for individuals. Did you know that 'About Us' pages are some of the most often viewed on the Web? We all want to know who we are dealing with, whether in our personal life or in the business world, and the old cliché really does hold true: a picture says more than a thousand words.

Return on Impression

Investing in a headshot definitely pays off. In the business world, people talk about ROI, or 'return on investment', but I prefer the term 'return on impression'. A high-quality headshot really helps you stand out from the crowd and take your digital identity up a notch. No-one gets a job on the strength of a photo alone, but if you are competing with others who are just as well qualified, a professional, likeable appearance can make all the difference. If you want to know how effective your current profile picture is, visit photofeeler.com to get some unbiased feedback.

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The Anatomy of a Headshot

The following sections explain how I create my headshots. There are, of course, no hard-and-fast rules about how to capture headshots, but the following pages provide answers to the questions I am most frequently asked.

Landscape Format

I always shoot headshots in landscape format. This is because human beings view the world horizontally and because I personally love the negative (i.e., white) space surrounding the subject. After all, headshots originated in the movie industry, where a 4:3 aspect ratio ruled the roost for decades and has only recently been superseded in most cases by 16:9.

Catchlights

Reflections of my lights in the subjects' eyes are a central element of my headshot style. I use Kino Flo continuous lights, and my 'wall of

light' approach ensures that the pupils in my subjects' eyes stay nice and small and reveal plenty of the color in the irises. The catchlights are the brightest spot in the frame and ensure that the viewer immediately makes eye contact with the subject.

In business headshots, I usually use square catchlights for men and triangular ones for women, and I prefer a shadow-free look for both. For actors, I tend to use slightly less light and more shadow effects.

I recently received an e-mail from a photographer who told me how awful and unnatural my catchlights look, and that the Sun is circular. This last is of course true, but when was the last time you saw the Sun reflected in the eyes of a studio portrait subject? If anything, it is windows that get reflected in a subject's eyes, or a mixture of natural and studio light.

As ever, such aesthetic decisions are a matter of taste. It's entirely up to you how you handle your catchlights.

Croptimize!

My critics often say, "But half his head is missing!" This too, is true visually, but as we have already seen, headshots are all about personality, not about the background or someone's figure or suit, or the top of their head (unless the subject happens to be Mikhail Gorbachev).

A headshot exists to give the viewer a positive impression of the person being portrayed. Take a look at the two photos opposite. These are, in fact, one and the same photo but the lower one has been cropped more tightly and shows the subject's face about 40 per cent larger. This makes the subject appear closer to the viewer and makes it much easier to establish eye contact. A subject can quickly be subsumed by a single-color background, especially if it takes up too much space within the frame, and too much single-color background is simply not very interesting.



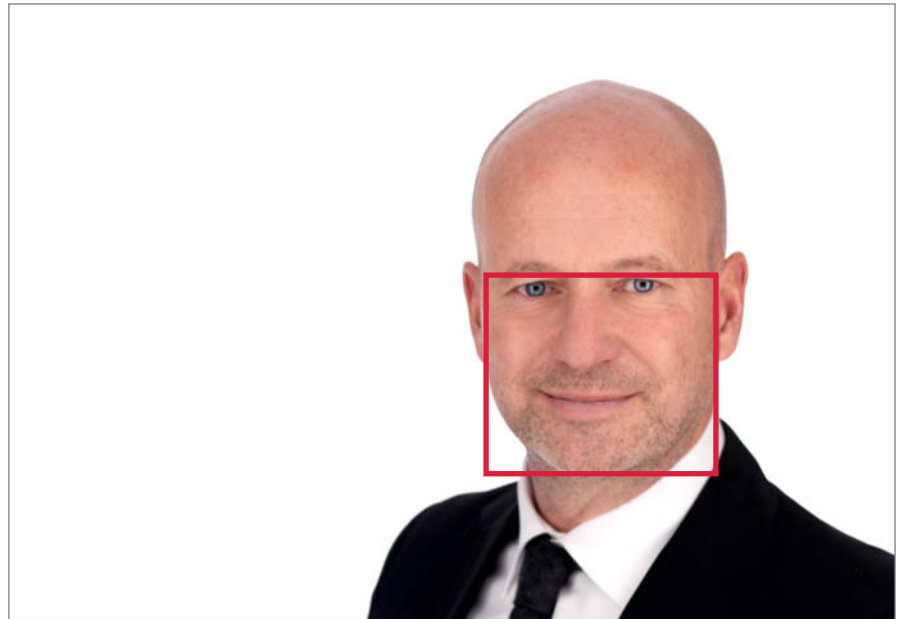
I always capture headshots in landscape format

Alongside the aesthetic issues, the crop I have chosen has a practical side too. The size of most online profile pictures is quite limited, so it makes sense to fill the available space with as much face as possible.

I crop carefully to make it clear what type of hairstyle a person has, even if the hair itself is not fully visible. This means cropping about an inch above the hairline. Cropping at the bottom of the frame follows the same rule for the subject's clothing. I advise women not to wear spaghetti-strap tops, as these quickly give a headshot a 'beach party' look, which isn't terribly professional.

Shoot at Eye Level

I always place my subjects' eyes just above the center of the frame. This is a personal compositional preference which I think emphasizes the subject's eyes very nicely.



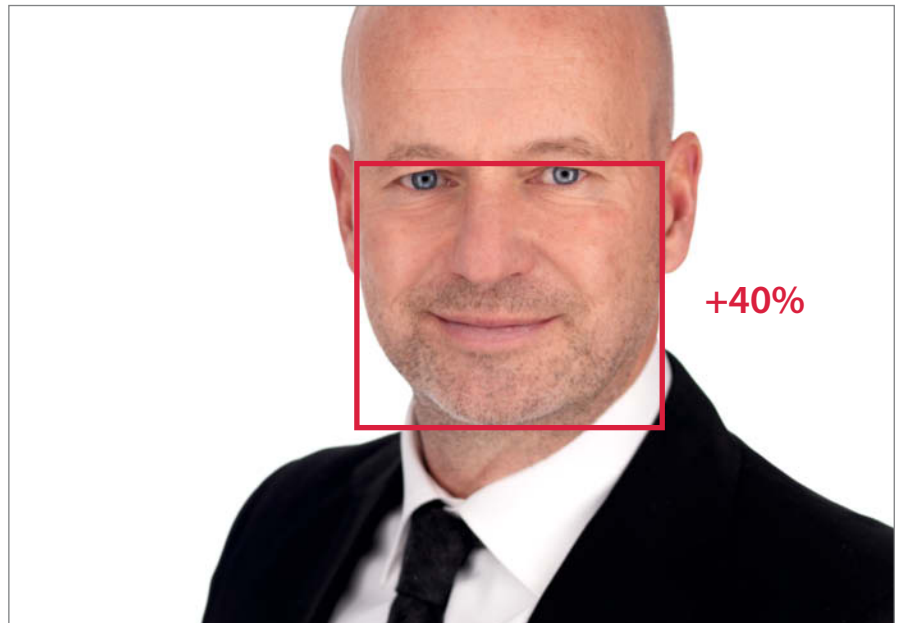
Jewelry

Unless they feel very strongly about it, I always advise my clients not to wear any jewelry. Our aim is to establish eye contact, and earrings and necklaces simply draw the viewer's attention away from the main subject.

I have often been told that my subjects have half their heads missing. However, the space available for most profile pictures is limited, so it is best to squeeze in as much of the subject's face as possible. These two pictures are two different crops taken from the same image – the difference is obvious.

Backgrounds

I prefer white backgrounds, which have a more subtle, modern-looking effect than gray or black. White is timeless too – many of Richard Avedon's most famous portraits were shot against white, and I don't think too many people consider them outdated. Some business clients explicitly request a black or gray background, and I won't refuse if that's what they need. Otherwise, I stick to white. I think gray is dull and old-fashioned and black tends to make images look too harsh. Textured backgrounds are a no-no in my headshots, as they tend to compete with the subject for the viewer's attention.



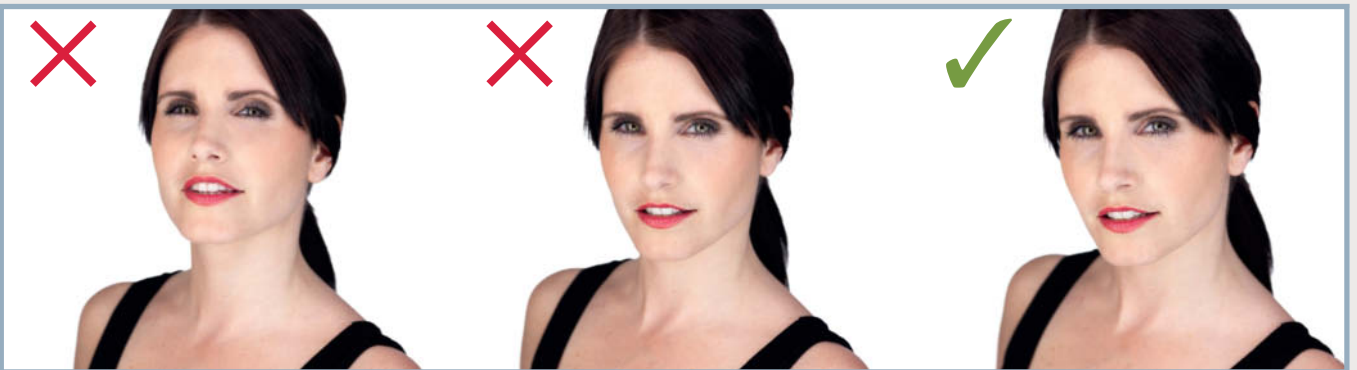
Makeup

Use makeup as sparingly as possible. In a situation in which we only have a face and white background to work with, every additional detail runs the risk of outshining the real subject.

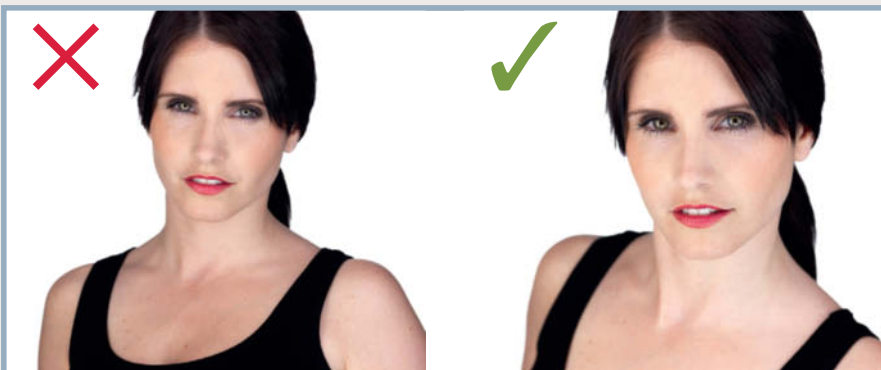
Five Simple Tricks for Better Headshots



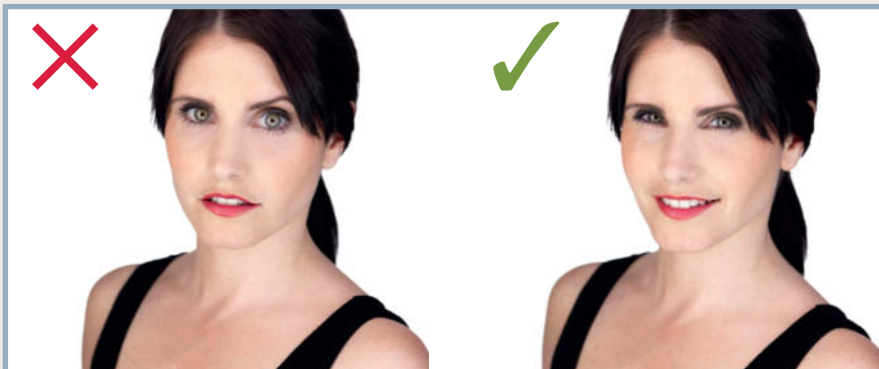
If the subject is standing diagonally, never have her hair down at the front on both sides (left). This covers the subject's neck and blocks the view of her face. But don't put her hair over her ear either (center). The image on the right shows the optimum position for long hair.



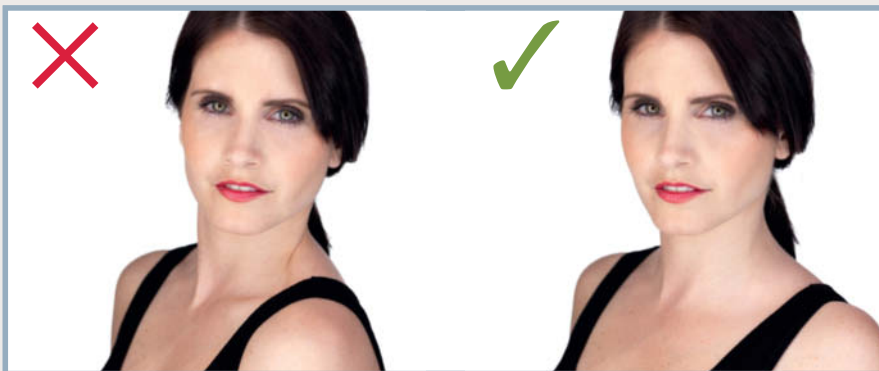
A raised chin often conveys arrogance, an attribute we really want to avoid in a headshot. Have your subject lower her chin, as shown in the center image, and then ask her to move her head slightly forward, as shown on the right. A bit more of a smile wouldn't do any harm, but the illustrations here are aimed at demonstrating what to avoid rather than how to create the perfect headshot.



Never let your subject lean backward (left). This creates a reserved impression and makes the subject's head appear too small. The photo on the right shows how it should be done.



Wide open eyes make the subject look scared. Closing the eyes a little raises the lower eyelids, creating a more focused, self-assured look.



Turning one shoulder toward the camera can make the subject appear slimmer, but take care that the movement doesn't produce an unwanted crease in the skin of her neck (left). This movement also tenses the long muscle in the side of the neck, which isn't always a positive thing – unless you are photographing a bodybuilder. Rotating the shoulder slightly away from the camera almost completely negates this effect.

Heartfelt thanks go to model Tabea Damaris and makeup artist Rebecca Vionnet, who put in a lot of work creating this sequence

How to Succeed in Headshot Photography

Successful headshots involve more than just placing a subject in front of a white background and shooting away. Here are some tips on how to get started and how best to capture a subject's personality in a photo.

Teamwork is essential. Give your subject clear instructions. No-one knows how to pose properly without help, and if you don't direct a session, it will look like you don't know what you're doing. It is your job to make your subject feel comfortable.

The effect of the finished photo. A white background alone doesn't turn a portrait into a headshot. A great headshot gives the viewer the feeling of direct contact with the subject without the camera as intermediary.

Practice, practice, practice! The moment you begin to charge for your work, you have to be in complete control and work without hesitation.

If you keep adjusting your camera or the lighting, your subject is sure to get the impression that you are still learning your trade. There is nothing worse than a client who questions your professionalism. Practice on friends or shoot for free until you have mastered your art.

Communication. Photography itself is only a small part of a successful headshot session. I always use the same setup to ensure consistent results, as the most complex aspect of a session is the interpersonal communication it involves.

The moment you decide to 'go commercial', you have to be prepared to deal with all kinds of total strangers. A musician may be easier to photograph than a corporate boss, and an attractive young person easier than someone who doesn't fulfill society's current ideals of good looks, but whoever you work with, you have to get the best out of every situation.

Once again, the magic word is 'practice'. I photographed more than a hundred people before I started charging for my services.

Shoot at eye level. Using a setup with the camera at the subject's eye level is usually the best approach. Shooting from below often makes the subject look stand-offish, while shooting from above means the subject has to look up at you.

A natural-looking smile is really important. Nine out of ten portrait subjects have forced smiles. Never demand a smile from your subject – getting him or her to laugh naturally by telling a good story or a joke is always a better option.

Technical stuff. You will need to use a lens with a focal length of 85 mm or more for headshots, just as you would for a conventional portrait photo. Shorter focal lengths distort the proportions in a subject's face.

Headshot Setups from Cheap to High End

You don't always need expensive gear to produce professional-looking headshots. In fact, just a few dollars is all you need to get started. The following sections describe three effective setups that range from virtually free to one based on professional gear that costs many thousands of dollars.

The \$10 Deal

The cheapest and simplest headshot setup consists of a large piece of white paper, although fabric will do too. The most important thing is that your chosen material is clean and free of folds or creases. The only other things you need are tape and something white to use as a reflector.

Look for a shady outdoor location near a wall – direct sunlight produces too many shadows in a subject's face. Shadows emphasize creases and rings around a subject's eyes, so the face in a headshot needs to be as well lit as possible. A cloudy sky is the best source of light, as it works like a giant softbox.

Tape the white paper to the wall and place your subject as close as possible to it. If you are using a gray background, have the subject stand a little further away from it.

Because outdoor light comes mainly from above, working without a reflector will produce photos with obvious shadows around the subject's face and chin. To eliminate these, use a piece of white card as a fill reflector from below. You can ask your subject to hold the card or, as in our example, ask your makeup artist to help out.

Setup #1

Nikon D3S, 85mm f/1.4G lens,
ISO 250, f4.5, 1/100 s
Savage background paper
Painter's tape

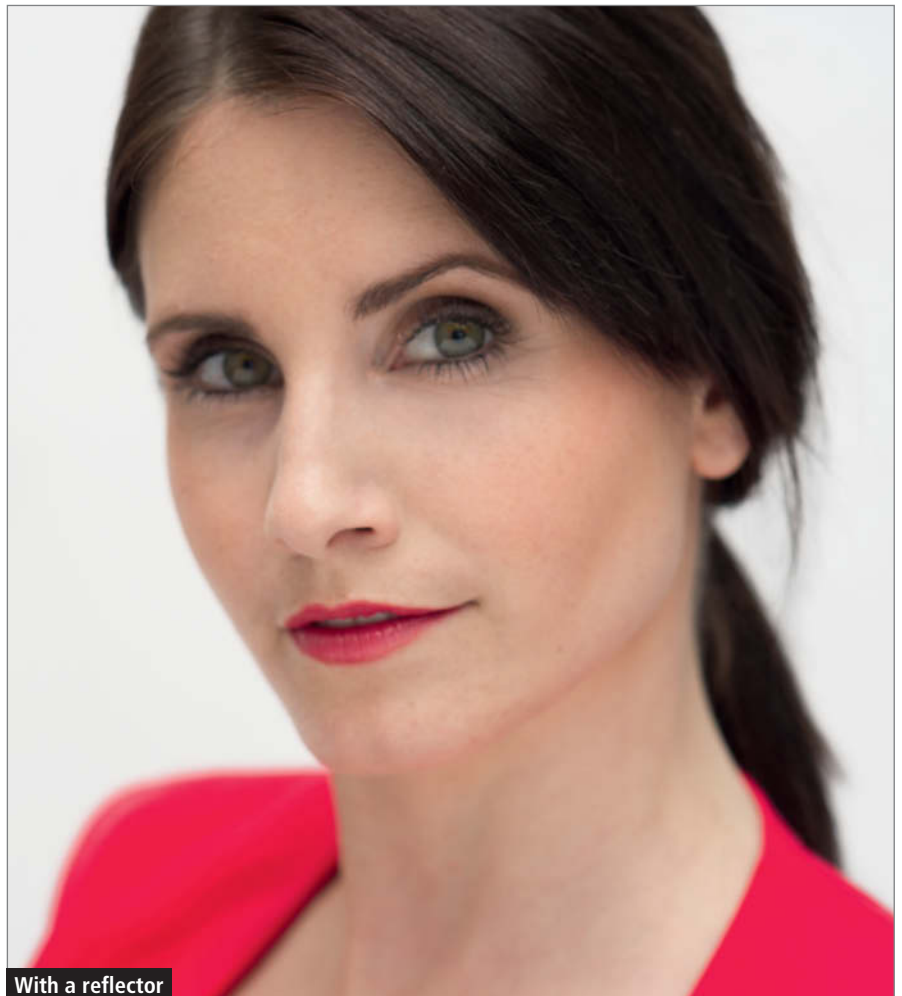
- ➔ Highly cost efficient
- ➔ No guarantee of consistent results due to changing light
- ➔ No catchlights in the subject's eyes



Even this super-simple setup can produce great-looking headshots



Without a reflector



With a reflector

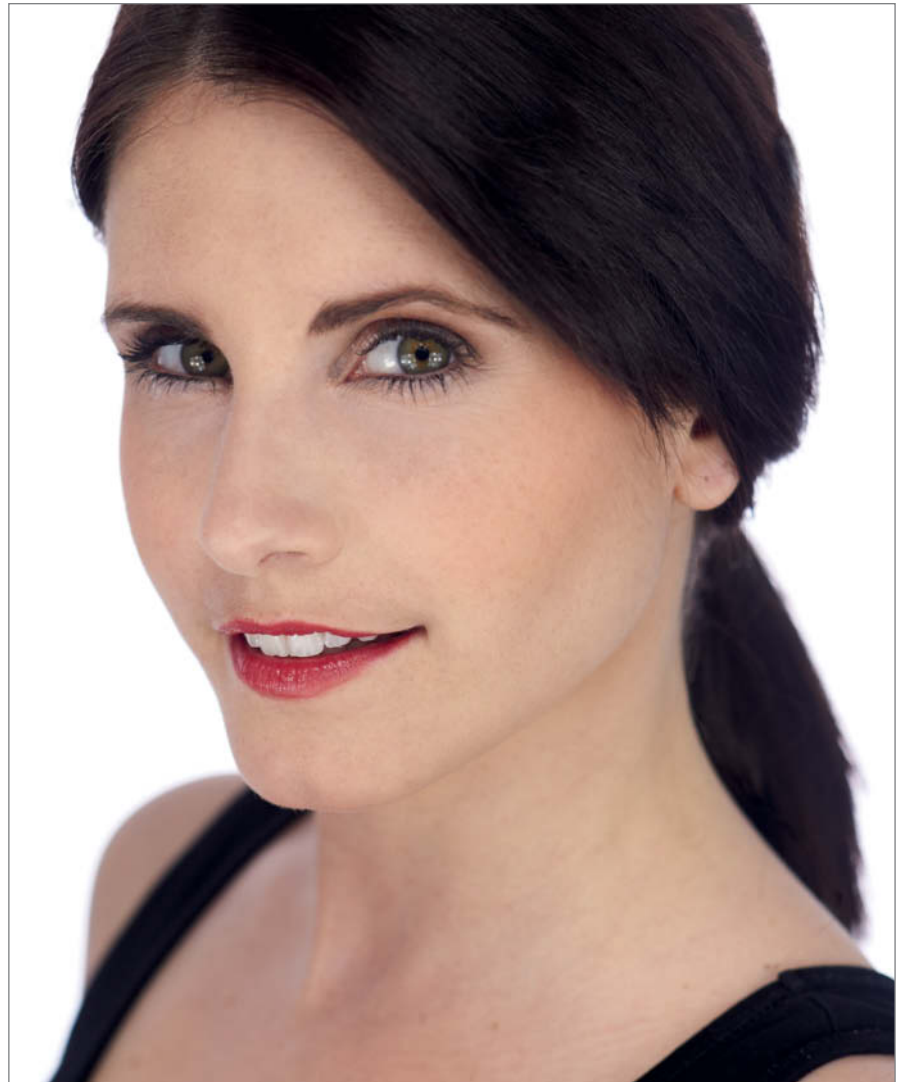
Cheap Studio Setup for around \$100

I purchased this 'Studio Lighting Set' with lights, stands and a bag for \$100 on eBay. At this kind of price, you can't expect high-end quality, and I won't be using this setup commercially, but it still enabled me to shoot indoors, which meant I could work independently of the weather and create images of consistent quality. I was also able to produce the all-important catchlights in my subject's eyes.

This compact setup is great for practicing and is small enough to be used at home. If you want to use a setup like this with a white background, you will need an additional studio or accessory flash.

Set up your lights and place them as close as possible to one another to ensure that your subject's face is fully and evenly lit. The additional flash is placed behind the subject and aimed at the white background. If the background flash produces unwanted stray light, reduce its output. An alternative way to avoid stray light is to use 'V-flats' – these are large, hinged Styrofoam or card panels that can be used as as reflectors or flags, as shown in the photo bottom right.

There are countless setups like this for sale online. When making a purchase, make sure that the set you buy has daylight lamps with a color temperature of 5000-5600K.



One of the headshots we captured using our cheap studio setup

This studio setup cost around \$100 in an online auction. This isn't high-end gear but it's perfect for experimenting with.

Setup #2

Nikon D3S, 85mm f/1.4G lens
 ISO 250, f4.5, 1/100 s
 Elinchrom D-Lite RX2 studio flash,
 three 5000K softboxes, energy-saving
 lamps, white wall

- ⬆ Cost efficient
- ⬆ Consistent image quality
- ⬆ Weather-independent
- ⬆ Catchlights included
- ⬇ Poor-quality, low-power gear



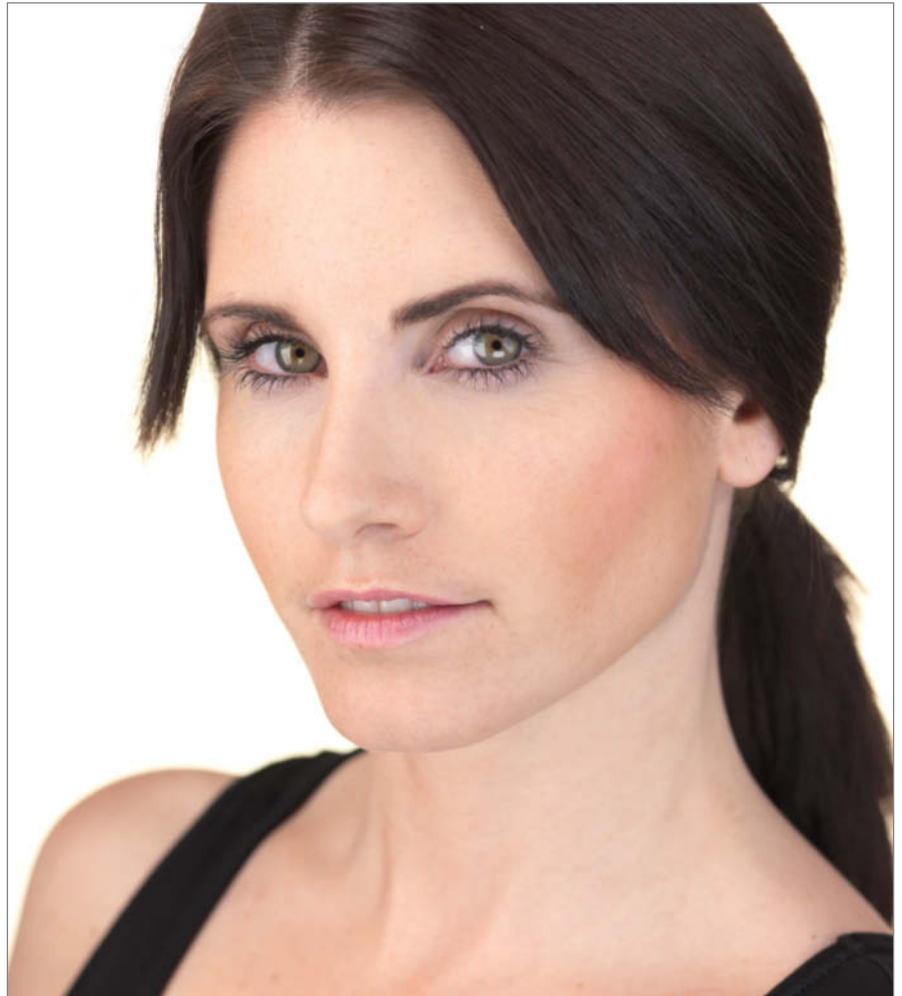
Pro Setup for \$13,000

This is the most expensive setup and the one I use every day. If you earn your living making headshots, you definitely need pro-grade equipment. Most of my clients are top-flight businesspeople who work for one of the two global pharmaceutical companies based in the town where I live.

Kino Flo lights, which come from in the movie world, have calibrated flicker-free fluorescent tubes that guarantee precise color rendition. Build quality is excellent, and each of the four tubes is individually earthed. Gear has to be totally reliable, especially when you are shooting on location at a client's site. I use two or three Kino Flo lights, and you can see their distinctive shape in the catchlights in the subject's eyes. I also use two studio flash heads positioned at shoulder height outside the camera's field of view to illuminate the background. On location shoots, I often use the collapsible Lastolite HiLite illuminated background system and robust Avenger Century stands to hold the heavy lamps. A pro-grade setup like this certainly means you have a lot to carry!

Using a Hasselblad camera to capture headshots may sound like overkill but is actually a deliberate strategy. Many of my clients own pro-grade, full-frame cameras, so making sure I have an even better camera is an important factor when it comes to convincing my clients of the quality of the services I offer.

(jr) **c't**



A perfectly lit headshot with attractive catchlights in the subject's eyes

My pro-grade studio headshot setup

Setup #3

Hasselblad H3DII-31, HC f/4 120mm macro lens; ISO 200, f6.3, 1/60 s; Arca Swiss p0 Monoball on a Manfrotto 055 tripod; Tether Tools, 15' Firewire 800; two Kino Flo 4' 4Bank lights, two Kino Flo 2' 4Bank lights; Hensel Porty with two EHT flash heads; two black V-flats; four Avenger Century Stands

- ➕ Top quality and reliability
- ➖ Very expensive
- ➖ Complicated to use
- ➖ Challenging for very light-sensitive clients





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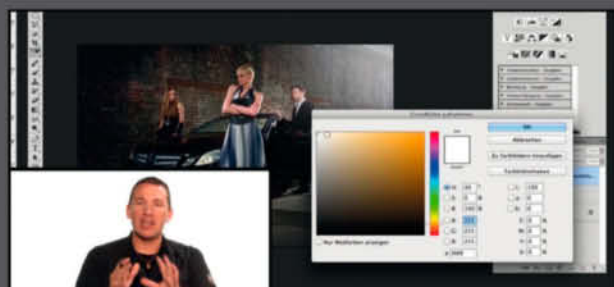


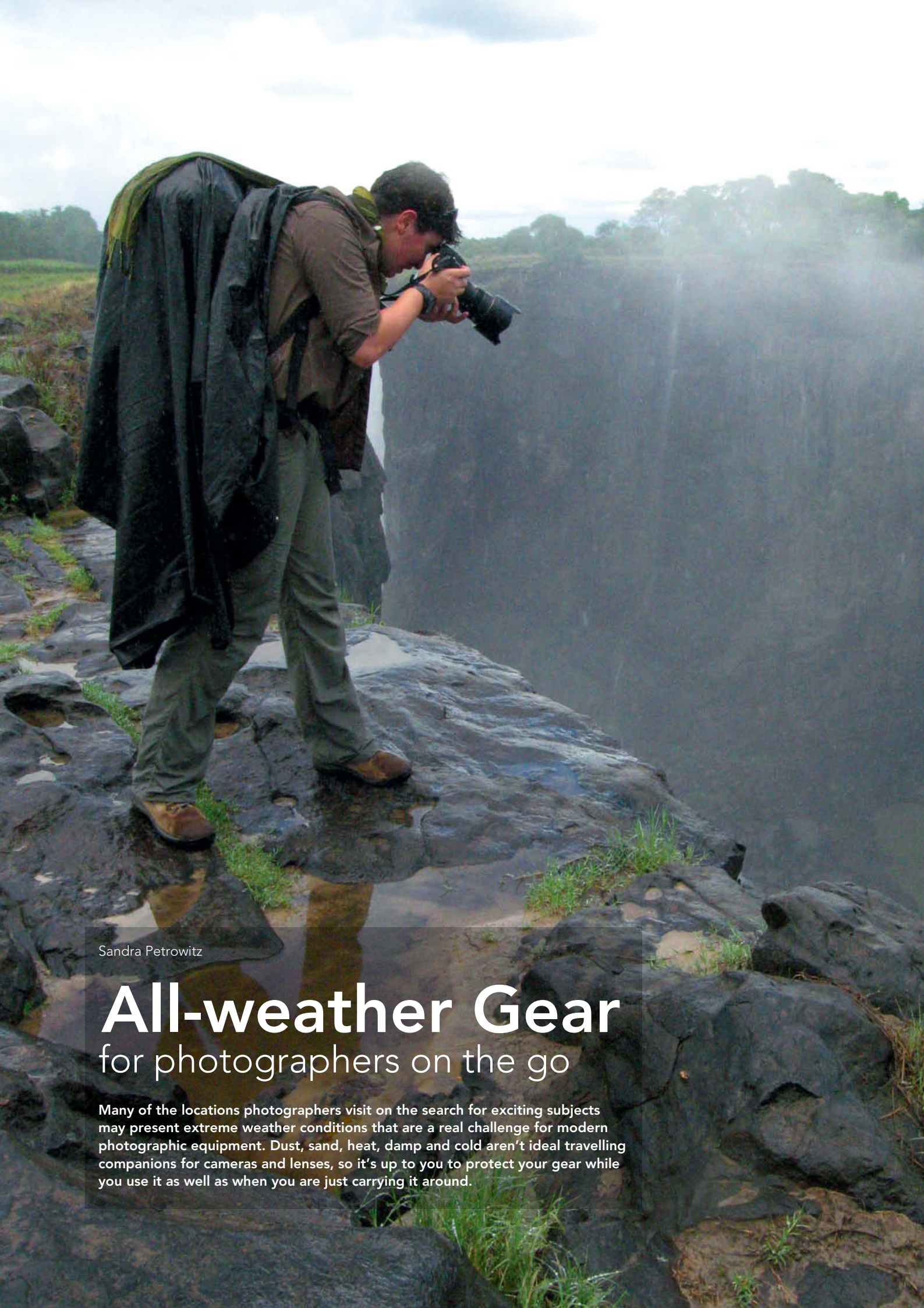
Image editing tutorials

Master Photoshop, Lightroom and other software to create stunning images.



Meet photo legends

Watch interviews with star photographers and learn how they shot their most famous photos.



Sandra Petrowitz

All-weather Gear

for photographers on the go

Many of the locations photographers visit on the search for exciting subjects may present extreme weather conditions that are a real challenge for modern photographic equipment. Dust, sand, heat, damp and cold aren't ideal travelling companions for cameras and lenses, so it's up to you to protect your gear while you use it as well as when you are just carrying it around.



Photo: Joerg Ehrlich

According to their manuals, most cameras are not suitable for use in rain forests, deserts or sub-zero temperatures. The operating environment of today's high-end cameras is often given as 0-40°C (32-104°F) at a non-condensing humidity of 85% or less. Moreover, manufacturers don't guarantee that their products will work properly if used under circumstances that do not adhere to these guidelines. Nevertheless, Nikon's service portal offers tips on using its products in sub-zero conditions, which seems to indicate that adverse weather conditions aren't as deadly for a camera as the specifications imply. After all, how do all the wonderful photos we see of wintery mountain landscapes, the Arctic and Antarctic regions, deserts, rain forests, the low-lying salt flats of Ethiopia and the unbearable dry heat of Death Valley get captured if not using modern camera technology?

Pentax has recently begun to make a name for itself in weather-protected camera gear and advertises products that enable you to keep shooting when competitors' products are better left in the safety of their protective cases. However, there is no cause for panic, even if various manufacturers' cameras react differently to exposure to dust and moisture. The relatively narrow range of specified working temperatures has more to do with legal restrictions than mechanical shortcomings. In my experience, DSLRs put up with rougher treatment than some users are prepared to believe, and it is often the photographer who gives up long before a camera threatens to stop working.

I have taken Nikon's D70, D200 and D300 models on numerous trips to the Sahara, up to over 16,000 feet in the Andes and the Himalayas, and have used them to capture countless images of the rain forests in Peru



The Pentax K2 is especially well protected against environmental influences, but other cameras also stand up to more punishment than their specifications would lead us to believe

and Venezuela. I spend several months of every year traveling with my D700 and D800 bodies in the polar regions, the deserts of Jordan, the Savannah in Botswana, the West

Coast of New Zealand's South Island and other similarly challenging locations. I assume that comparable cameras from other manufacturers are just as hardy.

But Accidents Do Happen ...

There are, of course, times when my gear gives up the ghost. For example, a Leica compact of mine broke due to moisture that got in through the bottom of a supposedly waterproof backpack. I also had to spend several hundred dollars having one of my lenses taken apart and freed of sand following a trip to Mauritania. I am constantly battling with steamed-up lenses, damp eyepieces, dripping water, sand where it shouldn't be, suspect crunching sounds when I rotate my cameras' dials, salt water spray that wrecked the contacts on my flash shoe and all manner of similar environmental challenges.

But I have always found that there is no need to worry too much about my gear. Of course, you shouldn't deliberately expose your cameras to the elements, but a little common sense and a few sensible preventative measures that have proved their

worth in the course of my years on the road are all it takes to protect your gear against most of what the world can throw at it.

Quite apart from saving yourself the expense of having to replace your gear, you need to make sure it works reliably when you are traveling in places where there is no hope of finding spare parts or replacement lenses.

Over the years, I have learned that there is nothing more frustrating than ending up with broken gear in the middle of a long-planned tour. I remember well how utterly disappointed one member of a group was when he returned from a hike to a penguin colony on the island of South Georgia in the Southern Atlantic with a camera that had capitulated to driving rain, sleet and wind. We removed the battery, saved the photos captured before the camera stopped working and dried it out in the ship's cabin overnight. Fortunately, it worked again the following day, but things could easily have turned out differently. For trips to remote and environmentally harsh areas, I recommend that you carry a replacement set of gear or at least a reserve camera body with you at all times.

Many DSLRs are more robust than their owners think, and it is often the photographer rather than the camera who gives up when the going gets tough





Water droplets can produce beautiful visual effects but are better kept away from your lenses. Constant checks and a soft cloth are usually enough to keep them at bay.

Water and Moisture

Clouded lenses, fogged-up viewfinders, broken cameras ... moisture is not good for optics or electronics, and a water stain can spoil even the most exquisitely composed photo. Using a lens hood is an effective way to fend off raindrops and snowflakes and, used with telephoto and super-telephoto lenses, makes it possible to shoot in constant rain without any water hitting the front element of the lens. However good your protective gear, it is still essential to regularly check your lens or filter for droplets and wipe them off using a soft cloth if necessary – it can be extremely frustrating to discover the water on your lens when you are viewing your images on your computer at the end of a session. If you have to swap lenses in rain or snow, always check that the rear element is free of raindrops and snowflakes too.

Praise Be to Everything that Keeps You Dry

Clear plastic sleeves that are thin enough to allow you to control your camera as usual are a great way to keep water and some dust or sand at bay. These sleeves are usually fixed to the hood mount of the lens and the viewfinder, and the cheapest models start at

around \$7 for a pack of two. Sleeves made of waterproof nylon with a separate viewing window for the camera controls are more expensive (see the table below).

Some plastic housings, such as those from ewa-marine, are available in a range of sizes for various combinations of camera, lens and flash, and can even be used under water. They have an optically neutral sheet of glass mounted in front of the lens and cost up to

\$400, making them a relatively high-cost solution for use in the wet.

Home-made Solutions

A great way to prepare for unexpected showers is to carry a clear plastic bag and rubber bands or cable ties in your camera bag. An impromptu camera cover can be a useful weapon against dust too. The cover I made

Sleeves, Underwater Housings, Bags and Wraps				
	Manufacturer	Product	URL	Price
Rain covers and sleeves	OP/TECH	Rainsleeve	www.optechusa.com	Starting at \$6.50
	Ruggard	Rain cover	www.ruggard.com	\$9.49-\$89.95
Flexible plastic underwater housings	ewa-marine	Dive-capable models for DSLRs and compacts	www.ewa-marine.com	Starting at \$69 for compacts, up to \$500 for DSLRs
	Aquapac	Waterproof bags and cases for smartphones, tablet computers, cameras, camcorders etc.	www.aquapac.de	Starting at \$25.95
Waterproof bags	Ortlieb	Dust- and waterproof bags with roll-type closure in various strengths	www.ortlieb.com	Various sizes and materials starting at around \$60
	Sea to Summit	Dry Bag, Dry Pack, Dry Sack – light, waterproof bags in various sizes	www.seatosummit.com	Starting at \$11.95
	Exped	Waterproof backpacks and packsacks with roll-top closure	www.exped.com	Starting at \$22.95
Wraps	Novoflex	Protective Wrap (neoprene)	www.novoflex.com	Starting at \$16.99



The snow on this shoot in the Antarctic wasn't nearly as perilous as the sea water spray. Although this image was shot using a conventional DSLR, I always carry a completely waterproof camera with me for use in hardcore situations.

from a freezer bag, a piece of neoprene and cable ties wasn't exactly pretty, but it kept my camera safe during a trip in the Sahara. A little improvisational talent and some ingenuity will take you a long way. Neoprene wraps also do a god job of keeping unwanted moisture at bay if you are prepared to fiddle around a bit.

On numerous trips in the Arctic and Antarctica, I have found that it pays to zip the camera hung around my neck in to my jacket when getting in and out of rubber dinghies. This leaves both my hands free and protects the camera against rain and spray. I have even used the plastic bags provided by the

onboard laundry service to protect my gear – at the end of the day, anything that keeps a camera's expensive electronics dry is a worthy tool.

A rain cover doesn't necessarily make a photo backpack truly waterproof but is definitely better than nothing at all. Heavy-grade trash bags with a drawstring are also very effective for keeping backpacks and camera bags dry. For trips in regions where constant rain is on the cards, the best solution is to use waterproof bags with roll-type closures, like those made by Ortlieb and Exped. If you take this route, make sure your

bag is large enough to hold all your gear when the top is rolled down. Roll-top bags are relatively cheap and heavier-grade models make extremely effective weather protection.

For a genuinely waterproof transport solution that still allows relatively easy access to your gear, you will need high-quality waterproof bags and backpacks or expedition-grade cases. I can thoroughly recommend the custom bags made by König Photobags in Germany (www.koenig-photobags.de), which are made from tarpaulin combined with custom foam inserts. Ortlieb and Lowepro also make



effective waterproof photo backpacks. A good supplier of general-purpose bags is Sagebrush Dry Goods in Alaska (www.sagebrushdrygoods.com), who also offer clever waterproof gear bags for water sports enthusiasts and anglers.

In case you were wondering, in the context of this article the term 'waterproof' refers to products that effectively repel moisture but aren't necessarily designed for use in or under water. Always check the manufacturer's specifications carefully when you are considering acquiring an item of equipment described as 'waterproof' or 'water-resistant'.

And by the way, a simple umbrella is a great help in many situations, and there are even adapters available for attaching umbrellas to tripods to keep your hands free while you work. Of course umbrellas are less useful in high winds or if you are shooting handheld.

Silica gel packs are great for absorbing any moisture that does find its way into your bags and can be dried out and recycled

when they are full. Look out for sealed silica gel packs in the packaging of any electronic devices you buy.

Underwater Housings

I am often asked about the usability of underwater housings at the beach or in the desert. Unfortunately, genuinely waterproof DSLR housings are bulky and expensive and are only really useful for snorkelers and divers who can cancel out the weight of a housing in the water and offset the cost involved against the money they make from their photos.

Flexible plastic housings are a simpler solution for use in the desert or heavy rain, and some models can be used under water for short periods.

Because my job as a guide takes me to the Arctic and Antarctic regions for several months of every year, I have acquired a water, dust, shock and freezeproof Nikon 1 AW1 for regular use under tricky conditions. I haven't managed to break it so far, and it still

A little improvisation goes a long way toward protecting your gear against all sorts of adverse conditions



This 'emergency set', consisting of a plastic bag, cable ties and a strip of neoprene, is easily stowed in any camera bag and fits together in seconds.

produces images of a quality that should satisfy most DSLR enthusiasts, despite having taken a dive or two.

How to Deal with a Wet Camera

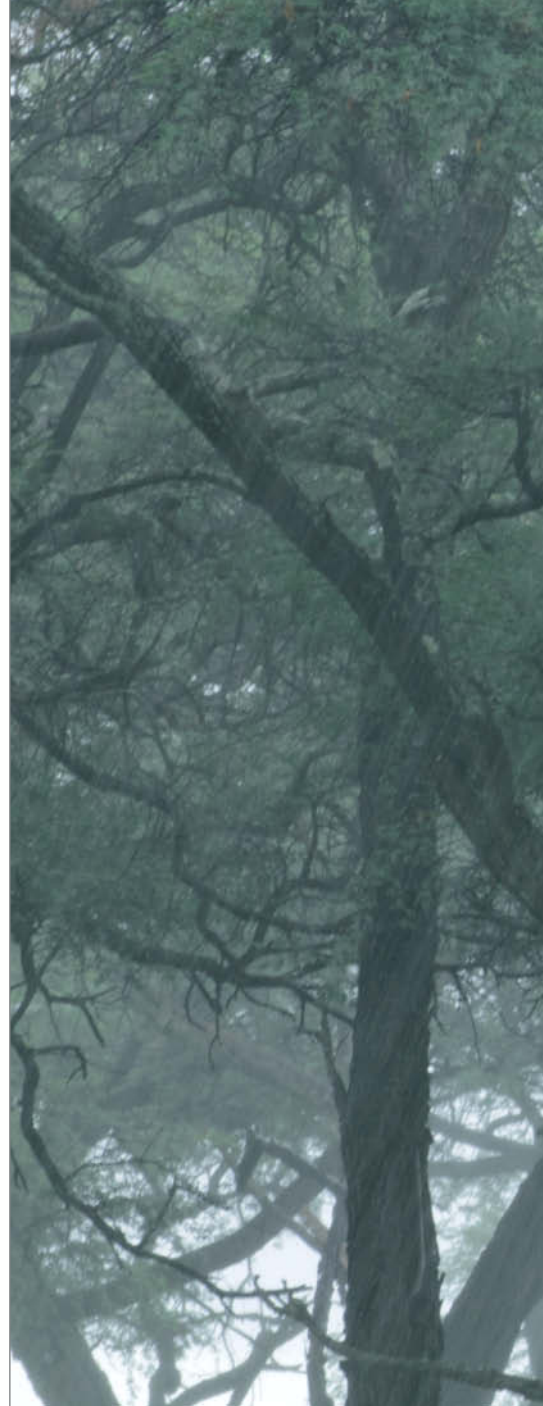
Photographers are naturally cautious when it rains, as even a short downpour can completely ruin a camera if you are not careful. It doesn't take long for a mass of tiny droplets to form larger drops that can easily get into a lens or camera body, and the ability of drizzle to wreck electronics is often underestimated.

If your camera or lens does get wet, dry it off as soon as possible. Always carry one or two clean, dry microfiber or lint-free cotton

cloths with you for removing water droplets from your lens, the lens barrel and the camera body. Remove water from the lens by dabbing it, as rubbing can cause tiny scratches.

I have found that zoom lenses dry out faster if you fully extend them. If a lot of water has got between the components, I zoom in and out several times, removing moisture with a cloth each time.

Once you have removed any external moisture, the inner workings of your camera or lens will need time to dry out too. If your camera is so wet that it doesn't work, remove the battery and memory card, save your images and leave the camera switched off for a while. Switching on a damp camera can permanently damage its electronics. If possible, leave it to dry thoroughly overnight



A Selection of Waterproof Photo Backpacks						
Manufacturer	Model	Capacity	Material/Closure	Protection offered (standard adhered to)	URL	Price
König Photobags	foto Rucksack	2 DSLR bodies, lenses up to 800mm (or 500mm with camera attached), 3-4 additional lenses, flash, accessories	Tarpaulin/Watertight zipper	Dustproof, waterproof to a depth of 1 meter (IP67)	www.koenig-photobags.de	Starting at around \$450
Loweepro	DryZone Backpack 40L	Pro DSLR with lens (up to 70-200mm), 1 or 2 additional lenses, flash, accessories	210D TPU tarpaulin/Wide-mouth roll-top	100 liters per minute water spray for at least 3 minutes (IPX-6)	www.loweepro.com	\$150
Loweepro	DryZone 200 Backpack	Pro DSLR, 4-5 lenses (up to 300mm f/2.8 with hood)	600D TCXP and 2000D nylon /Watertight zipper	Water resistant, ballistic nylon (-)	www.loweepro.com	\$260
Ortlieb	Day-Shot	DSLR with zoom lens, two additional small lenses + 1 medium telephoto, flash, 10" notebook/tablet computer	Tarpaulin/Watertight zipper	Dustproof, waterproof to a depth of 1 meter (IP67)	www.ortlieb.com	\$300

A Selection of Waterproof Photo Bags						
Manufacturer	Model	Type and Capacity	Material/Closure	Protection offered (standard adhered to)	URL	Price
König Photo-bags	liteBag	Shoulder bags. liteBag 1: Rangefinder or mirrorless camera with lens plus 2 lenses. liteBag 2: Rangefinder or mirrorless camera with multiple lenses or DSLR with standard zoom and 1 other lens. liteBag 4: Pro DSLR and 3 lenses (incl. 70-200mm f/2.8) and accessories or two pro DSLRs with lenses attached.	Tarpaulin/Roll-top	Dustproof, waterproof to a depth of 1 meter (IP67)	www.koenig-photobags.de	liteBag 1: \$185 liteBag 2: starts at \$185 liteBag 4: starts at \$320
Loweepro	DryZone Duffie 20L	Shoulder bag for for a pro DSLR with a 70-200mm lens, 1 or 2 other lenses, flash and accessories	210D tarpaulin/Wide-mouth roll-top	100 liters per minute water spray for at least 3 minutes (IPX-6)	www.loweepro.com	\$110
Ortlieb	Digi-Shot	Shoulder bag. Medium holds a DSLR with a zoom lens and 2 other lenses. Large holds the same plus a second body, one lens and a flash.	Tarpaulin, main compartment with watertight zipper	Dustproof, waterproof to a depth of 1 meter (IP67)	www.ortlieb.com	Medium: \$195 Large: \$215
Ortlieb	V-Shot	Holster for a DSLR with a telephoto or zoom up to 200 mm and accessories	Tarpaulin with watertight zipper	Dustproof, waterproof to a depth of 1 meter (IP67)	www.ortlieb.com	\$160

and only try switching it on again once it is as dry as possible.

Watch Out for Salt Water

Salt water is a real problem for camera gear. If your camera has been sprayed with salt water – for example, during a walk on a beach – you need to clean it immediately and thoroughly to prevent the salt from sticking in place and eating into the material of the camera or lens. Too much contact with salt water or an impromptu ocean dive usually kills a camera, so take special care when shooting from boats, piers, and jetties. If the situation makes it impossible to hang the strap around your neck, wrap it around your



A relatively long exposure time of 1/25 s made these raindrops look like diagonal stripes

wrist a couple of times to maximize your chances of saving it in an emergency.

If you are shooting in a location where the water has a high mineral or sulfur content (in areas of volcanic activity, for example), remove any moisture immediately before it begins to eat its way into your equipment.

Olympus suggests cleaning dirty cameras using a mild detergent and a soft, slightly damp cloth followed by a second round of cleaning with a dry cloth.

Always clean underwater housings and waterproof cameras in fresh water after use in a salty environment and carefully inspect all seals for dirt, dust and hair. Even the tiniest foreign bodies can prevent a water seal from working properly.

Home-made solutions are often more effective than you may think, but for reliable protection from water and dust on long trips, consider a pro-grade solution from a specialized manufacturer

Photo: Joerg Ehrlich



Extreme Cold and Heat

Sub-zero temperatures are a big challenge for a camera's power supply. Whether you are high in the mountains, on a trip to the Antarctic, photographing the Northern Lights or simply out on a cold winter's day, low temperatures significantly shorten a battery's lifespan. However, my experience has shown that this well accepted rule of thumb doesn't always apply to the same degree. On shoots in the Arctic summer with an average temperature around zero Celsius, I have never had serious problems with short battery life.

Nevertheless, if you are shooting in sub-zero temperatures, always carry spare batteries and stow them close to your body in a pants pocket or the inside pocket of a jacket or fleece.

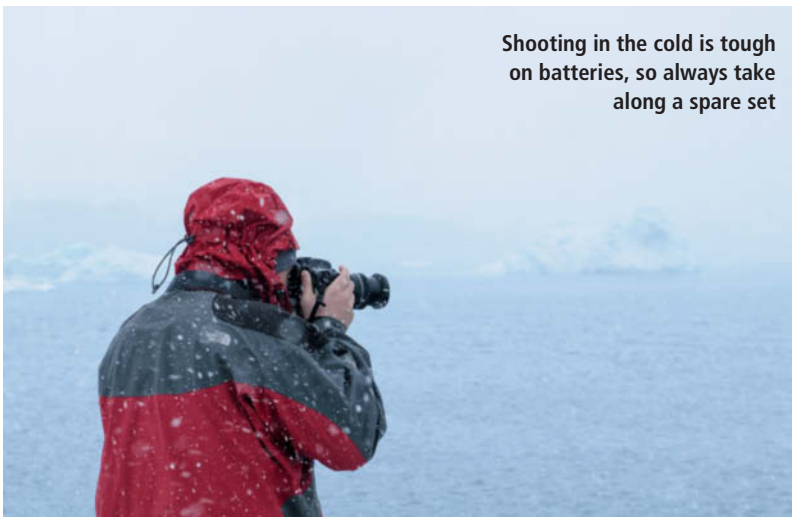
Using an additional battery grip not only makes it simpler to shoot in portrait format, it also means you have to swap out your batteries less often, which is a real boon in the cold. I always use original manufacturer's brand camera batteries and Sanyo 'eneloop' batteries for my battery grips, as these provide the best performance I have discovered.

Condensation is the other major issue that occurs at extreme temperatures. When you enter a warm room from cold surroundings, the moisture in the air immediately condenses on or in your camera, often causing serious damage. The solution here is either to leave your gear in the cold between sessions or let it slowly acclimatize in a slightly warmer place (hall, stairwell, trunk of

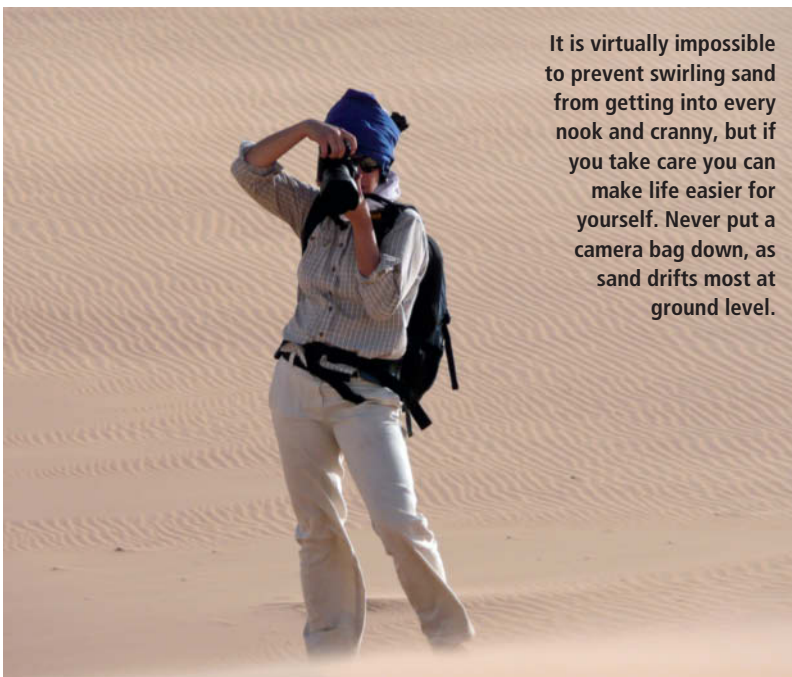
the car etc.) in a closed plastic bag or backpack before getting it out in the warm. Never swap lenses until your camera is fully acclimatized or you will end up trapping condensation in the camera body.

In the desert, photographers usually crumple in the heat long before a camera fails, and I assume that most photographers don't expose their sensitive gear to harsh sunshine for long periods anyway.

On one trip to the Sahara, we left a thermometer out in the sun while we ate lunch in the shade. After our break, the thermometer was showing over 50 degrees Celsius (125 Fahrenheit). On that particular trip, none of our cameras failed to cope with the heat, although some did develop problems due to dust and sand.



Shooting in the cold is tough on batteries, so always take along a spare set



It is virtually impossible to prevent swirling sand from getting into every nook and cranny, but if you take care you can make life easier for yourself. Never put a camera bag down, as sand drifts most at ground level.

Photos: Ehrhard Fritz



Dust and Sand

Dusty and sandy environments require the same basic approach as for water and moisture. Deserts and dirt roads everywhere produce fine grains of dust and sand that get into even the tiniest openings in vehicles, cameras, lenses, clothing and photo bags.

The Big Scrunch

You would think that waterproof bags should be dustproof too, but there really is no such thing as 100 percent dustproof. On a recent trip to Mauritania, a coating of extremely fine sand found its way into all of our bags.

The best way to combat the effects of dust and sand is to adjust your behavior to

reduce the length of time your equipment is exposed to the elements. Keep bags and backpacks closed when you are not actually using the gear stored in them. However, this is often easier said than done, and you will have to practice to find out which gear you use most often and how you can best protect the rest.

Even your 'always on' camera requires protection, and an old pillow case or towel is a great way to keep the worst dust off a camera with a telephoto lens in safari situations. Stuff sacks with roll-top closures are great too and can be opened fairly quickly when you need to grab your camera in a hurry. If you have your camera on your lap in a moving vehicle, you can always use your jacket or any other piece of clothing to

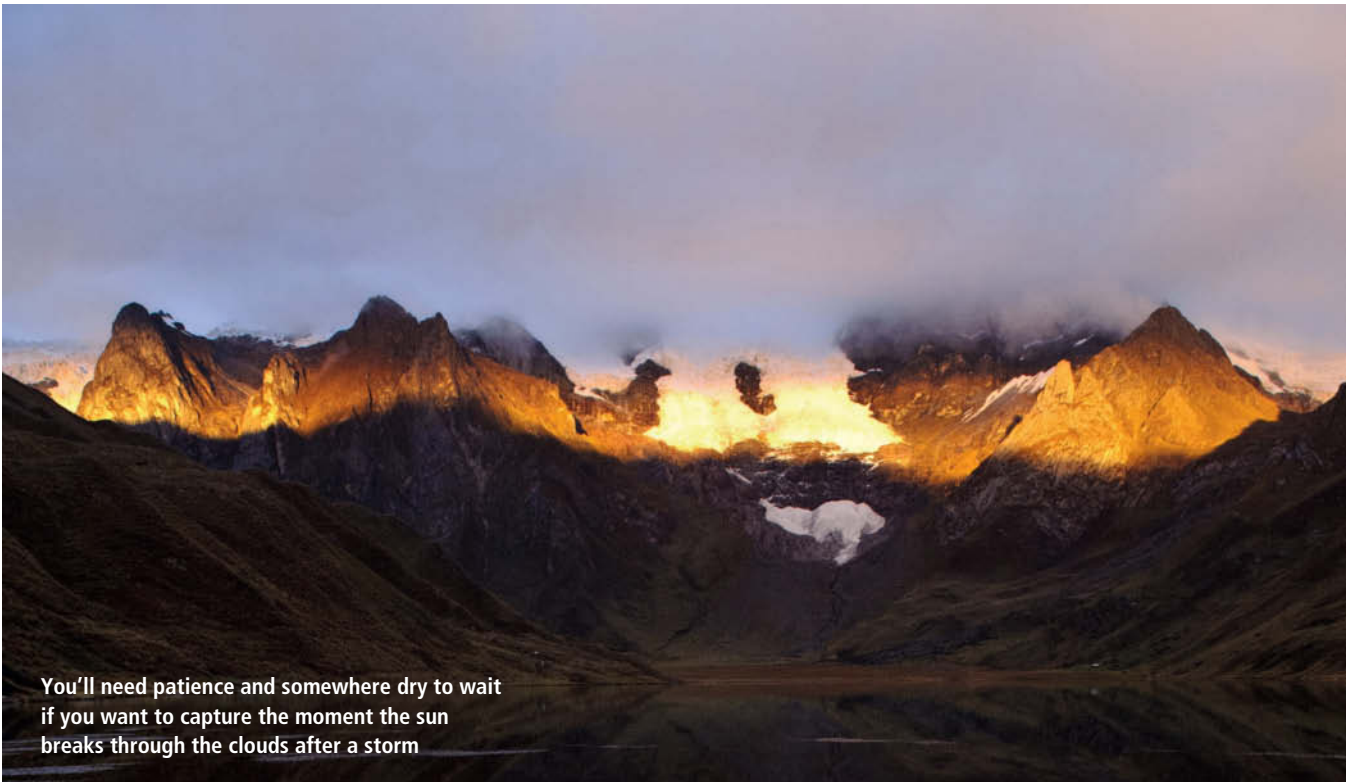
cover the front element of the lens – provided your jacket isn't covered in dust too!

Avoid putting your camera bag on the ground in any sandy environment where the wind is blowing. The wind is always strongest at ground level and the lower layers of air always carry the most sand. If you have to shoot from a low viewpoint, either lying down or crouching, you and your gear are sure to feel sandblasted afterward.

If your gear is well protected you will spend less time worrying about it and more time concentrating on your subject



Bad-weather Shooting Tips



You'll need patience and somewhere dry to wait if you want to capture the moment the sun breaks through the clouds after a storm

'Bad Weather' is often synonymous with dramatic light and unusual atmospheres. People tend to associate vacation and travel photos with sunshine and great weather, so it can be really annoying if it rains when you're on the road. However, since we can't influence the weather, it is often better to accept what it throws at us and use adverse conditions to capture spectacular photos that aren't possible in sunny weather.

Gray, overcast sky with low cloud isn't usually ideal for capturing wide-angle landscape images. The nuances between gray tones that the human eye can differentiate usually disappear completely when captured in a photo, while raindrops veil the landscape and restrict visibility. Such conditions usually produce sad-looking images that lack color and contrast. Although a monochromatic landscape on a gray day sometimes has a

melancholy charm, the great contrast between the sky and the landscape is often too much for the camera's built-in metering systems to cope with. Without the use of a neutral density (ND) filter or subsequent image processing, the resulting photos are often difficult to pull into shape.

One way to work around these issues is to leave the sky out of the picture – but only, of course, if doing so doesn't ruin the concept or the composition. Many outdoor subjects look fine without a horizon. Including brightly clothed people is a great way to bring the dimensions of a scene into perspective, and signal colors such as red and yellow show up best against a muted background.

Dull weather can actually be quite helpful when it comes to shooting close-ups. Soft, diffuse light is perfect for accentuating small details, and the reduced contrast it provides is easier to capture than subjects lit by the sun. The closer you are to your subject the less rain, snow or sleet can get in the way and the clearer your photos will be. A fill flash is a useful accessory for brightening details and



Photo: Joerg Ehrlich

The high degree of contrast between bright backgrounds and dull foregrounds is especially accentuated in dull weather. Rather than using all the gray filters you have, the simplest way to get great results is to leave the sky and the horizon out of the frame.

accentuating colors in close-ups, but take care when using flash in rain or snow. Raindrops or snowflakes captured with flash tend to overexpose and produce bright white specks that blot out the real subject. This can be used to produce creative effects but can also ruin a photo if you don't keep it under control.

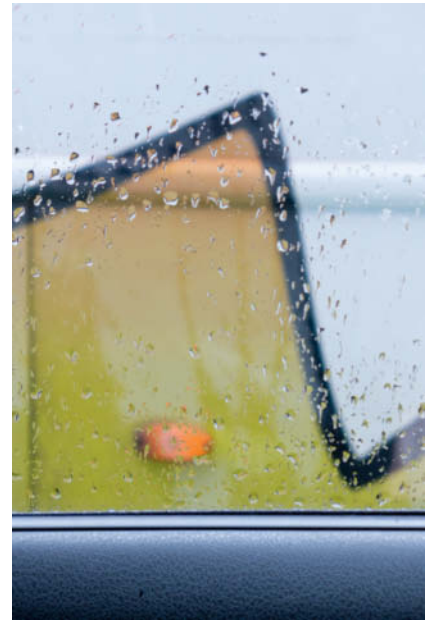
The clouds that accompany storms often make a spectacular subject in their own right. They can be captured factually to document a coming storm, creatively as abstract colors and shapes, or as studies of movement using long exposures. Natural light is often at its most dramatic when the sun breaks through the clouds after a storm, but to capture the right moment you need patience and a dry place to wait. With a little luck, Mother Nature will reward you with wonderful views, clear air and intense colors.

Like any other moving subject, rain, snow, wind and waves require short exposure times to 'freeze' the action. Branches of trees bending in the wind, spume on the crest of a wave and fluttering flags make effective subjects when frozen in time, but you can also use longer exposure times to capture the movements they make. To capture the rainstorm in the image on page 61 in Hwange National Park in

Zimbabwe, I used an exposure time of 1/25 second. The individual raindrops are transformed into ethereal streaks that give the image fascinating additional texture. Alternatively, using an exposure time of 1/200 second allows you to capture individual snowflakes as fluffy white dots, while using a telephoto lens compresses perspective and accentuates the effect.

Fog and mist can create intense moods too, but these are almost impossible to capture using autofocus, which cannot identify details that are sharp enough to lock onto. In situations like this, you can either focus on a subsidiary subject located at the correct distance or simply focus manually. Fog and snow can also cause the camera's light meter to underexpose, so check the histogram to see if you need to compensate. I often find that a half or even a full stop of exposure compensation is required to keep snow shots properly exposed.

Bad weather can be inferred in an image by portraying the effects of weather rather than the weather itself. Colorful umbrellas, warmly dressed people with their breath condensing in the air around them, puddles, reflections on wet tarmac, raindrops running down a window pane, a rainbow in the desert, the foaming crest



Bad weather throws up a wealth of interesting subjects – some figurative, some abstract

of a wave snatched by the wind, snow-covered trees, spider webs covered in dew... the list is virtually endless.



Fog and mist can cause autofocus to fail, so you will often have to focus manually in these kinds of conditions

Accessories

Don't Scrimp on Accessories

When you are shooting in tricky conditions, only change your lens if you really have to. It is much better to use separate bodies with their own dedicated lenses for wide-angle and telephoto shots than it is to constantly swap lenses. If you have to swap lenses, do it in a closed space such as a tent, a vehicle or a sleeping bag. Even if it does not seem to be windy, there will always be dust flying around wherever you happen to be.

Always screw loose body and lens caps together. This makes it more difficult for dust and sand to get in and also makes it easier to find a matched pair when you need them.

Clean your camera regularly with a blower brush wherever you are shooting. To get tough dirt off a lens or filter, use a lint-free cloth or a LensPen (a kind of extremely fine eraser). To clean your filters, use a couple of drops of optical cleaning fluid on a soft cloth and rub them gently using a circular motion from the center to the edges. A clean, soft cloth is the best tool for cleaning a camera monitor.

Use a new toothbrush to remove grains of sand from the grooves in the focus and zoom rings on your lenses. Dust, dirt and scratches on the rear element of a lens have a much greater effect on the quality of your results than those on the front element, so take special care when cleaning this part of your lens. I recommend using just a blower brush and no other tools at all.

Before and After a Trip

Because I am never anywhere dust-free, I don't usually clean my cameras' sensors when I am away on a trip. I have never had any problems using the camera's own built-in sensor cleaning mechanism, backed up by a quick clean of the mirror box using a blower brush. I clean the sensor properly before every major trip and again when I return.

Generally speaking, high-end DSLRs stand up to the elements much better than simple compacts. A single grain of sand is often all it takes to jam a compact's shutter or lens, so it is doubly important that you clean your smaller cameras regularly and pack them away carefully when they are not in use. Even then, you cannot be sure your compact will survive unscathed. If you are planning to spend time in a desert environment, it is much better to acquire a purpose-built weather-sealed camera.

If things do get out of hand and your equipment begins to click and crunch when it shouldn't, the answer is to have it thoroughly cleaned once you return home. I have an authorized repair shop dismantle and clean my cameras and lenses. This is not the cheapest approach but is definitely better value than buying a new camera every time some sand gets in the works.

And by the way, don't forget to protect your memory cards from the elements too. I keep my SD and CF cards in cases with transparent sleeves for up to 10 cards. This

Sandra Petrowitz

Sandra Petrowitz is a journalist and photography tour guide who spends several months a year working all over the world and on Arctic and Antarctic cruises. She also leads photo workshops and is the author of the book *The Traveling Photographer*, published by Rocky Nook.

www.sandra-petrowitz.de



saves fiddling about with individual cases for each card and makes it easier to keep full and empty cards separate. (jr) **ct**

A single grain of sand can stop the lens in a compact camera from working properly, whereas most DSLRs are usually quite robust and stand up to a fair amount of harsh treatment



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Ralph Altmann

Keeping Things Sharp with **Autofocus**

Autofocus is a standard feature in all contemporary cameras, and aging phase-detection technology is still considered to be the most reliable method of autofocus control, even though the technology is complex and prone to errors. This article takes a close look at autofocus technology and the latest developments that are finding their way into today's DSLRs and mirrorless system cameras. We also show you how to check the precision of your own camera's AF system and explain how to test and improve it using our custom tools.



The Konica C35 AF, introduced in 1977, was the first commercially available autofocus camera in the world. This revolutionary technology has since been a raging success, making life much easier for legions of amateur photographers, while professional sub-genres such as sports, wildlife and action photography wouldn't exist in today's form without automatic focusing. Autofocus is a necessity in any situation in which you need to capture fast-moving subjects, especially when you are working with wide apertures and the shallow depth of field this entails.

Measuring Distance

To capture an in-focus image of a subject on film or an image sensor, you can measure the camera-to-subject distance, set the lens appropriately and hope that the results are sharp, or you can simply inspect the entire image area and keep adjusting focus until you achieve maximum overall detail contrast, which always gives you maximum optical sharpness. The second method requires no knowledge of the distance to the subject. Early autofocus systems were based on **active distance measurement** using infrared light, laser or ultrasound like the Polaroid cameras built in the early 1980s. However, these techniques no longer play a role in today's camera technology. Modern autofocus systems are **passive** and are based on either phase- or contrast-detection technology. Most cameras use one or other of these two systems, although some more recent cameras have hybrid systems that combine both. Phase-detection AF has long been considered the faster of the two, but is less precise. It is also more complex, requiring extra sensors and mirrors, and is therefore more expensive to build and is used more often in DSLRs than other types of camera. The earliest analog AF cameras, such as the Minolta Maxxum 7000, employed the phase-detection technology still found in many of today's DSLRs.

Contrast-detection autofocus analyzes image data directly in the image plane, so it simply wasn't possible to implement back in the analog days. Contrast-detection AF is often used in mirrorless system cameras because there isn't enough space within the camera body for a phase-detection system. It is also used in live view mode in many DSLRs. Contrast-detection AF is less prone to errors, but phase-detection systems are usually faster. In practice, the speed of an AF system also depends on other factors such as the type of subject and the quality of the lens.

Canon's latest Dual Pixel CMOS AF system is said to combine the advantages of both

systems. The following sections explain the various systems in detail, but we can tell you this much in advance: traditional phase-detection AF is still a force to be reckoned with in a whole range of situations.

Autofocus Modes

Depending on the type of subject, you can choose between **single** and **continuous AF**, and many cameras offer the option of switching automatically between the two. Contemporary cameras have many AF areas distributed across the image area, so you can always select an appropriate one for the subject at hand. Touch screen control like that offered by the Canon EOS 70D makes selecting AF areas a lot easier than it is with button-controlled systems. Depending on which mode you use, the camera can automatically select one or more AF areas and, in the case of contrast-detection AF, can detect and focus specifically on faces and even the eyes of a subject. Continuous AF can track moving subjects when they move out of the current AF area and can

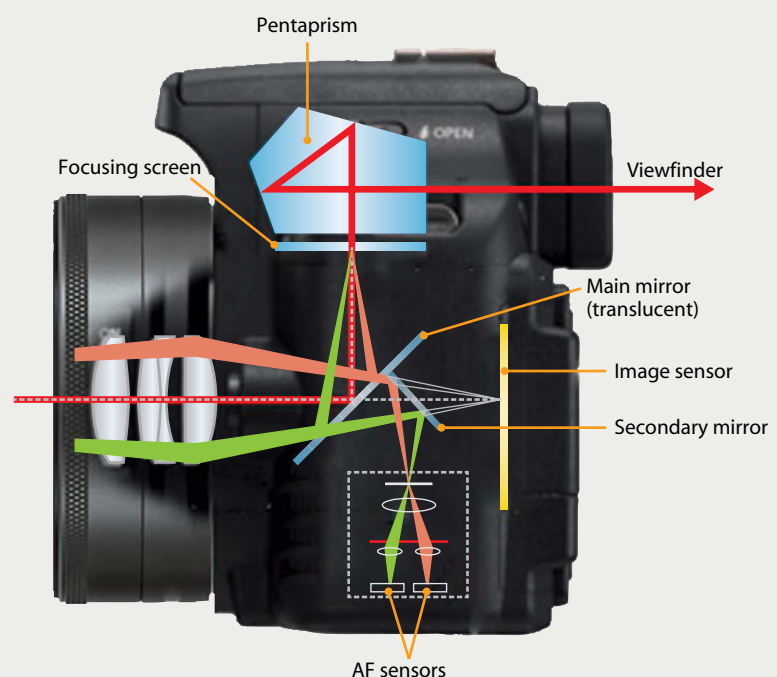
even follow them if they are momentarily covered by other objects within the frame. By default, single AF usually works in **focus priority** mode, which prevents the shutter from firing if the subject isn't in focus. The alternative is to use **shutter priority**, which enables you to shoot even if the subject isn't perfectly sharp. Some cameras and lenses allow you to make manual focus corrections in auto mode by rotating the focus ring on the lens, while others require you to set a dedicated mode (Sony, for example, calls it Direct Manual Focus). In Nikon cameras, focus behavior depends on which lens you use. Newer lenses with built-in AF motors can be manually focused at any time, whereas older lenses that focus using the motor built into the camera body don't support this kind of adjustment. In such cases, it is better to set focus to manual before rotating the focus ring.

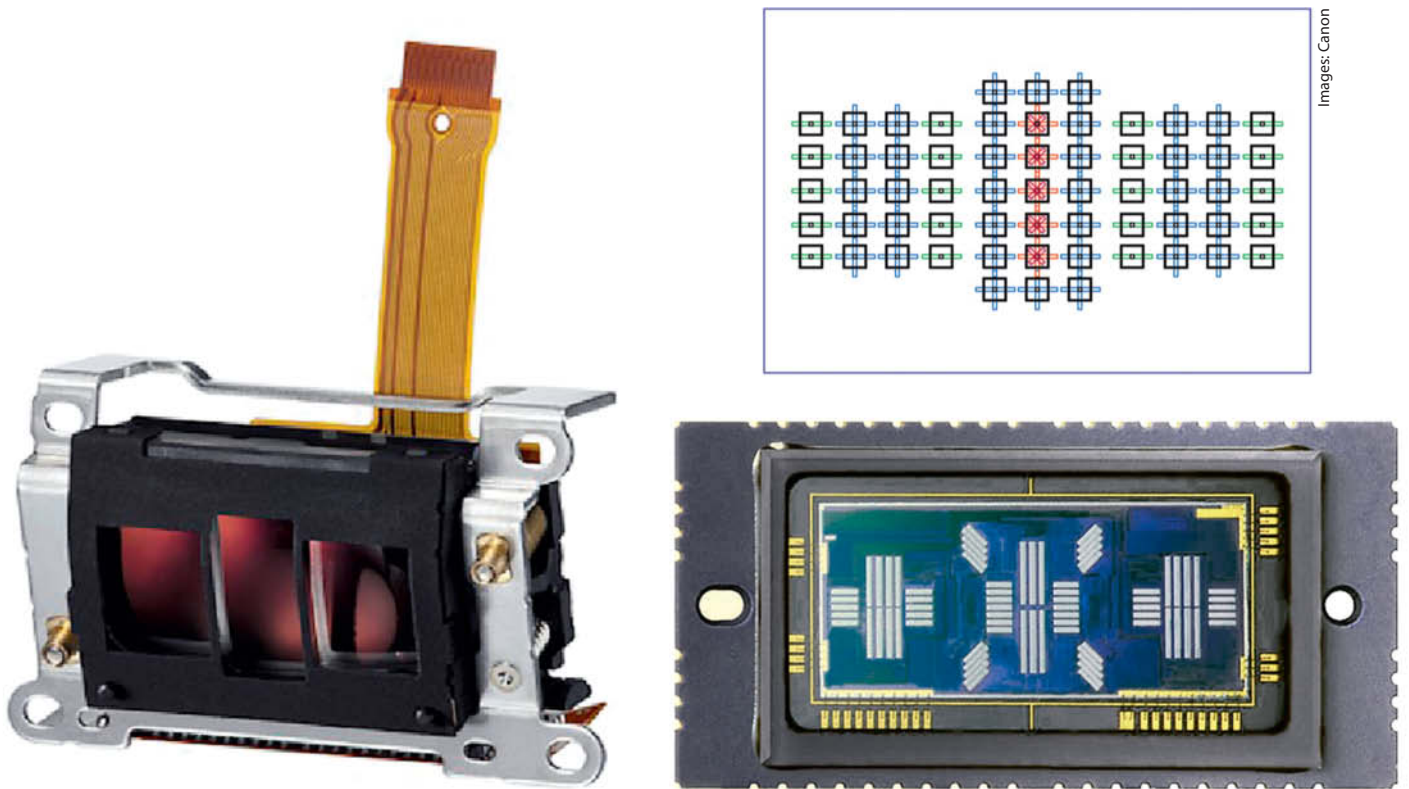
Focusing in Low Light

Due to the lack of subject contrast, phase-detection AF has a hard time focusing

How Phase-detection Autofocus Works

Phase-detection uses separate sensors to capture light from parts of the lens light path that are as far apart as possible. The mirrors and lenses required to make the system work are complex to build and take up a lot of space within the camera body.





Images: Canon

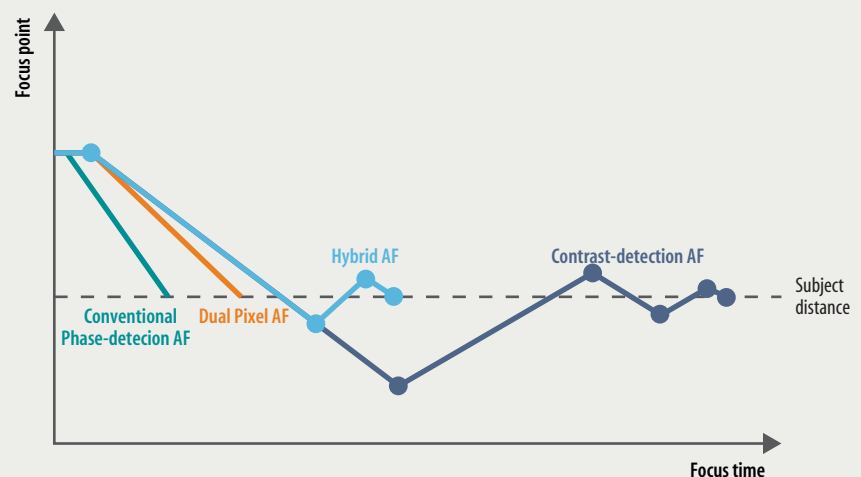
Alongside the actual sensors, a phase-detection AF module also includes a beam splitter, a field lens and an infrared cut-off filter. The AF sensors shown here are from a Canon EOS 1D X, in which 41 of the 61 sensors are of the cross type.

in low light, although it still works, albeit slowly, even in moonlight. The limit of an AF system's sensitivity is stated in terms of logarithmic exposure values (EV). Zero EV represents a level of brightness that requires an exposure time of 1 second at ISO 100 and f/1.0 to reproduce medium gray. In photographic terms, this is equivalent to 8 seconds at f2.8, which is pretty dark. The best AF sensors work at levels as low as -3 EV (1 minute at f2.8), and even contrast-detection AF works at these and lower levels. It is important to have a large AF area when focusing in low light, and a wide maximum aperture helps dedicated AF sensors to work effectively. Spot metering in the dark isn't recommended as this uses only a limited number of AF sensors and reduces its sensitivity accordingly.

Many cameras have a built-in **AF assist lamp** that can be used when the ambient light isn't bright enough for accurate focusing on nearby subjects. Accessory flash units usually have more powerful AF assist lamps that are effective over greater distances.

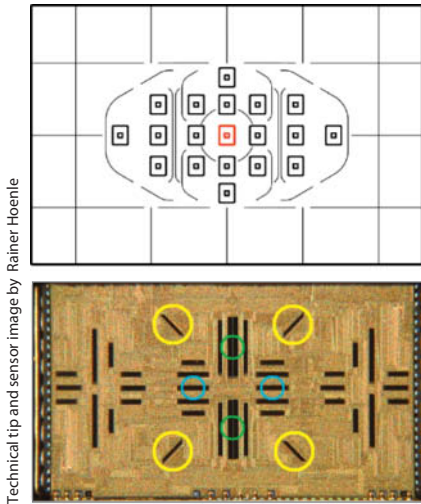
Comparing Dual Pixel AF with Other Systems

This graph shows Canon's own speed test results for its new Dual Pixel CMOS AF system compared with the hybrid system in an EOS Rebel T5i/700D and a camera with simple contrast-detection AF.



Source: Canon

Phase-detection Autofocus – Fast but Error-prone



Technical tip and sensor image by Rainer Hoentle



Groups of four sensors in the AF sensor unit from a Canon EOS 7D (below left) are used to form various cross sensor configurations, of which the EOS 7D has 19. The center AF area in the viewfinder (marked in red in the upper diagram) has two cross sensors associated with it, made up of the eight individual sensors circled in color in the lower diagram. The diagonal sensors marked in yellow detect image areas close to the edges of the lens and are therefore more sensitive than the others. However, they only work with lenses that have a maximum aperture of f/2.8 or larger. The sensors marked in blue and green work at maximum apertures of up to f/5.6.

Phase-detection AF has been the standard system in reflex cameras since the 1980s. However, in cameras with articulated mirrors, the system only works as long as the mirror isn't flipped up. As soon as the mirror moves out of the light path, the AF sensors no longer receive any light so, in live view mode, camera manufacturers have to use contrast-detection AF or other techniques that utilize the main image sensor to set focus.

Phase-detection AF works like a pair of micro-cameras that view a scene through different parts of the lens. If both cameras view the same point on a surface, they capture the same detail. However, if they are viewing a point in front of or behind the surface, the captured details will be slightly offset. This occurs because the two sensors view the subject from different angles. The resulting effect is called parallax and is the basic principle behind stereoscopic and '3D' photography. In this case, the effect is used to help the camera focus. The two sensors are set up so that their light paths meet at the distance at which the lens is focused, making the details captured by both identical. If the two details are offset, the result will be an out-of-focus shot, although the direction and degree of offset can be used to precisely calculate the adjustments required to capture the subject in sharp focus. This makes it possible for the camera to set focus directly without having to zero in on the correct setting.

A simple AF sensor consists of two strips of photodiodes coupled with a mirror and special lenses that split off two narrow beams

from the light entering the lens. The farther apart the two beams (i.e., the distance between the system's 'eyes'), the more sensitive the system and the greater the offset between the twin captured details for a certain degree of defocusing. This means that the system achieves its best results when the

sensor strips are placed as close as possible to the edges of the image projected by the lens. However, in cameras with interchangeable lenses, the maximum aperture of the lens plays a role in determining the number and sensitivity of the AF sensors it can effectively use. All-around AF sensors are arranged so

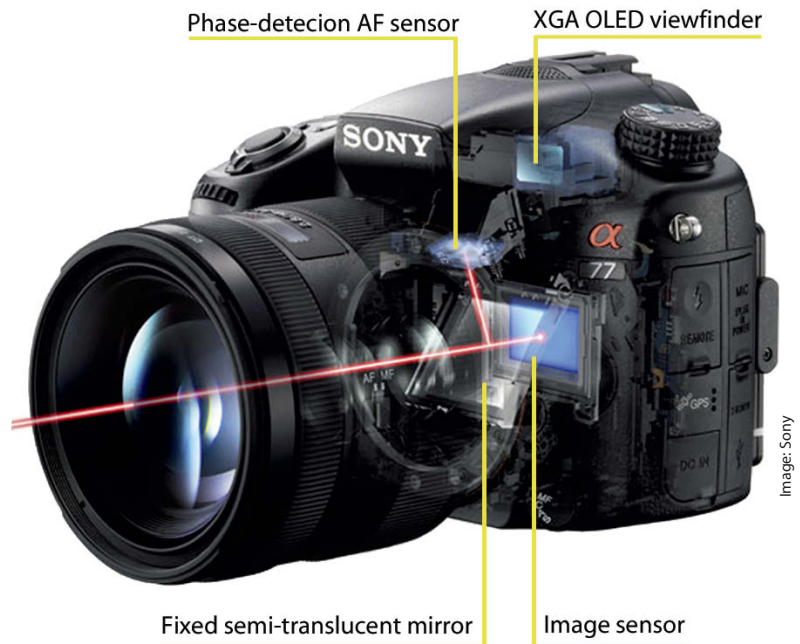
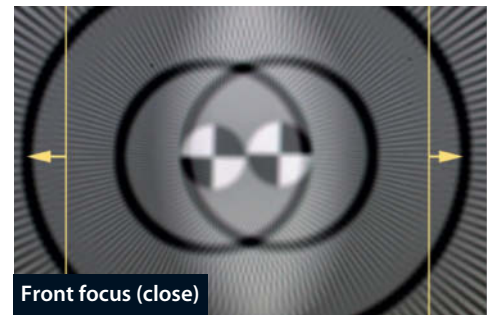


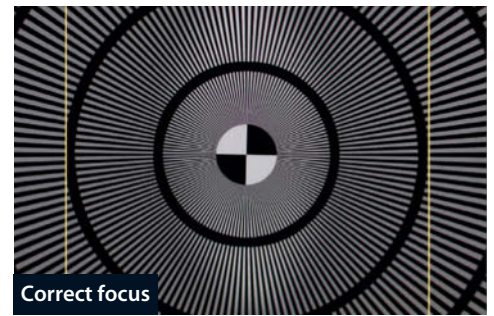
Image: Sony

The fixed, semi-translucent mirror built into the Sony Alpha a77 steers light toward the image sensor and the AF sensors. Although the mirror is fixed, the system requires just as much space as one with an articulated mirror and actually transmits slightly less light to the image sensor than a conventional setup.



Front focus (close)

Front focusing reveals that the two test images are not congruent. The plane of focus is in front of the subject.



Correct focus

Focused correctly, the twin test patterns appear as a single image

A piece of card with two pinholes mounted on the lens makes a great tool for visualizing the principle of phase-detection autofocus

Test shots captured using an APS-C camera and a Tamron SP AF60mm lens

that they can be used by lenses with a maximum aperture of f/5.6 or even f/8, while quality cameras have additional sensors that can only be utilized by lenses with maximum apertures of f/4, f/2.8 or, occasionally, even larger. If the camera detects a lens with a smaller maximum aperture, these sensors lie in the shadow of the lens barrel and are automatically deactivated.

Because autofocus sensors view the world through a tiny portion of the lens opening, their effective aperture is very small indeed. In turn, this means that they have extreme depth of field and produce much sharper images than the camera's main image sensor. This is essential if they are to produce usable signals when focusing on heavily defocused subjects. This tiny effective aperture means that the aperture in the lens plays virtually no role at all and it is simply a myth that fast (i.e., large-aperture) lenses can focus faster or 'better' than ones with smaller maximum apertures when they are used with identical AF sensors. However, even if the maximum aperture is irrelevant, light itself is extremely important to the success of the autofocus process. If there is too little light available, the AF sensors can no longer differentiate between degrees of contrast. In such situations, an AF assist lamp creates artificial contrast by projecting a striped pattern onto the subject.

AF sensors that consist of two strips of photodiodes are called **line sensors** and can only detect horizontal or vertical differences in contrast. They work by measuring the signals produced by the distribution of

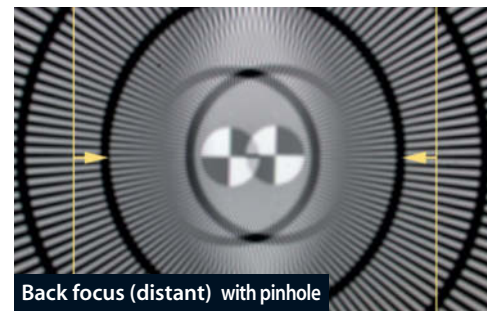


Back focus (distant) without pinhole

This example, shot without using a pinhole, shows just how much using a pinhole can improve depth of field

brightness levels along the two strips and calculating the phase shift that exists between them – hence 'phase-detection' autofocus. Higher-quality cameras also have **cross sensors** that consist of combined horizontal and vertical strips or pairs of diagonal strips. The latest type of AF sensor to hit the market are **on-sensor** models whose characteristics can be altered using the camera's software.

Because the distance between the two AF images can be precisely measured, it is theoretically possible to set focus to precisely the right point using a single AF measurement. In practice, however, measurements are usually repeated several times during the focusing procedure to increase accuracy. Conventional phase-detection AF systems have to ensure that the distance between the subject and the



Back focus (distant) with pinhole

Back focusing, too, reveals two incongruent patterns. In this case, the plane of focus is behind the subject.

AF sensors is identical to the distance between the subject and the image sensor – otherwise the system will register correct focus even if the image on the main sensor isn't sharp.

This issue and variations in tolerances during lens manufacture are the reasons phase-detection AF can produce inaccurate results. In the early days, errors could only be rectified by having the manufacturer make appropriate mechanical adjustments, but today's cameras often have menu options that enable the camera to automatically adjust focus to suit the lens you are using. Some Sigma lenses can even be 'personalized' independently of the camera using a supplied USB dock. This enables you to tweak the lens firmware to fix focusing issues and adjust other lens parameters too.

Contrast-detection AF – Slower but more reliable

Compared with phase-detection AF, using image contrast gleaned directly from the image sensor to determine the focus setting appears a much simpler solution. This approach requires no additional components, you can select AF points via the camera's software, and there is always a usable degree of contrast to be found somewhere within the frame – provided of course that the camera can 'see' details that are better defined than the surrounding noise. The AF points used for phase-detection AF are hardwired into the camera's hardware, whereas using contrast-detection AF enables you to position them anywhere within the frame and to move them at any time – for example, using a touch gesture on the camera's monitor or by switching in a face recognition algorithm. Additionally, because it uses the image itself to check focus and requires no hardware fine-tuning, contrast-detection AF is extremely accurate. Nevertheless, there are one or two drawbacks that have so far made contrast-detection AF most camera

manufacturers' second choice. Firstly, a blurred subject cannot be used to determine how much and in which direction focus has to be adjusted. The camera's focusing mechanism has to make some trials to see whether the direction it uses is the right one (i.e., contrast increases) or the wrong one (i.e., contrast drops off further). The required degree of adjustment, too, can only be determined once an initial attempt has been made and, because local contrast is a value that is not set in stone, focus 'success' is subjective, especially if you are photographing a low-contrast subject. In some cases, you can only detect the point of sharpest focus once you have passed it. This is why contrast-detection AF systems 'pump' back and forth when they begin to focus and again just before the shutter is released. This approach is just as complicated as it is for a human being to focus manually using just the viewfinder image and no other focusing aids. Today's mirrorless system cameras often incorporate extremely fast and sophisticated contrast-detection AF systems.

While phase-detection AF needs to take a single reading to establish focus, contrast-detection systems have to make several, each of which requires the camera's firmware to analyze at least some of the pixels detected by the sensor. This process simply takes time.

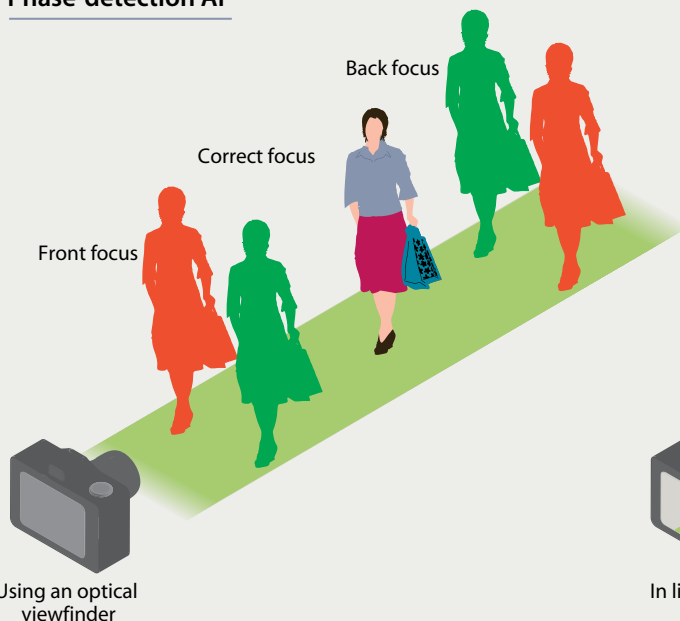
Slow DSLRs

For a long time, the inherent weaknesses of contrast-detection AF made it unsuitable for high-speed photography and relegated it to use in consumer-grade compacts with no space for a complex phase-detection system within their bodies. It was only with the introduction of mirrorless system cameras that manufacturers like Panasonic, Fujifilm and Samsung began to work hard on improving the performance of their contrast-detection AF systems. Around the same time, the first DSLRs with live view began to appear. Live view requires the reflex mirror to remain in its raised position, making phase-detection AF impossible.

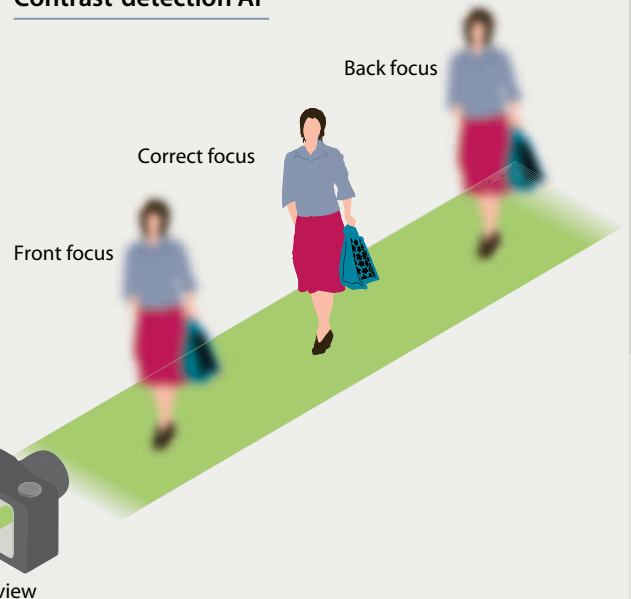
Phase-detection vs. Contrast-detection AF

A phase-detection AF system sees two versions of the out-of-focus subject and uses the distance between the two images to calculate the correct focus setting. The twin AF images are sharp, even if the subject itself is out of focus. To a contrast-detection AF system, a defocused subject is simply blurred, making it impossible to tell whether it is front or back focused.

Phase-detection AF



Contrast-detection AF



Initially, the live view functionality built into DSLRs was used to aid manual focusing and check focus in captured images. Contrast-detection AF in DSLRs remains a somewhat half-hearted additional feature that is too slow to be much fun. In spite of all these shortcomings, contrast-detection AF still has great potential. Because light of different wavelengths refracts differently, the chromatic aberrations produced by most lenses can be used to overcome the uncertainty regarding the direction in which the lens has to focus. Green fringes usually signify front focus, whereas pink fringes signify back focus. Patents have already been filed that exploit this technique, but we have yet to hear of its real-world use in a production camera.

Depth from Defocus

With the Lumix GH4, Panasonic introduced the Depth From Defocus (DFD) method of contrast-detection AF, which uses data from the sensor to estimate the point of focus even before the focusing process begins. The technique uses the known bokeh characteristics of the lens in use and helps the camera to zero in on the true point of focus more quickly than conventional contrast-detection systems. However, precise focusing using just one reading is still not possible using DFD. Even if it estimates the focus point correctly, DFD still has to focus

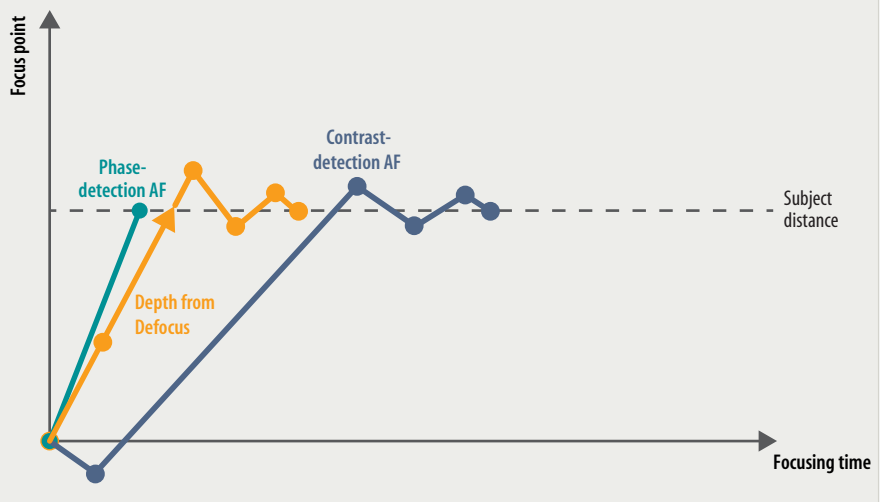
back and forth a couple of times to be sure of hitting exactly the right spot, which in practice makes it only slightly faster than conventional contrast-detection systems.

Another drawback of DFD is that Panasonic only has access to the bokeh

characteristics of its own lenses, so third-party lenses cannot take advantage of the new technology. This is a shame in view of the high degree of manufacturer-independence of the Micro Four Thirds sensors Panasonic bases its cameras on.

Comparing Depth from Defocus with Other Techniques

While conventional contrast-detection AF systems zero in on the true point of focus using a series of slow steps, Depth From Defocus can roughly predict where it lies in advance of focusing. Phase-detection AF is the only system that can focus directly on the correct point without having to search for it first.





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Hybrid Autofocus

Hybrid autofocus is designed to combine the best parts of contrast-detection and phase-detection systems and do away with complex moving mirrors.

Phase-detection AF is based on the simple idea of using selected sensor pixels to aid focusing, but successful implementation is not as simple as the concept itself. AF pixels work best if they only detect light from one side or just a small portion of the field of view of the lens. Fujifilm solved this challenge using a technique that temporarily masks some of the AF receptors. Sony, Canon, Nikon and other manufacturers soon followed suit and dedicated **phase-detection pixels** can nowadays even be found in the cameras built into high-end smartphones and tablet computers. The masked pixels reduce the amount of light hitting the sensor, so the data they record cannot be used without first being corrected. The simplest way to deal with these pixels is to treat them as dead and interpolate data from neighboring pixels during demosaicing.

To prevent too great a reduction in image quality, this mapping process must not be applied to too many pixels, so it is impossible to reserve entire strips of pixels for autofocusing. According to Fujifilm, its AF pixels are distributed over 40 per cent of the surface of its X-Trans sensors, and we estimate that the distance between an AF pixel and the corresponding portion of the image is six pixels. Olympus uses a system

with a distance of five pixels. This offset is simply too great for the system to be really accurate.

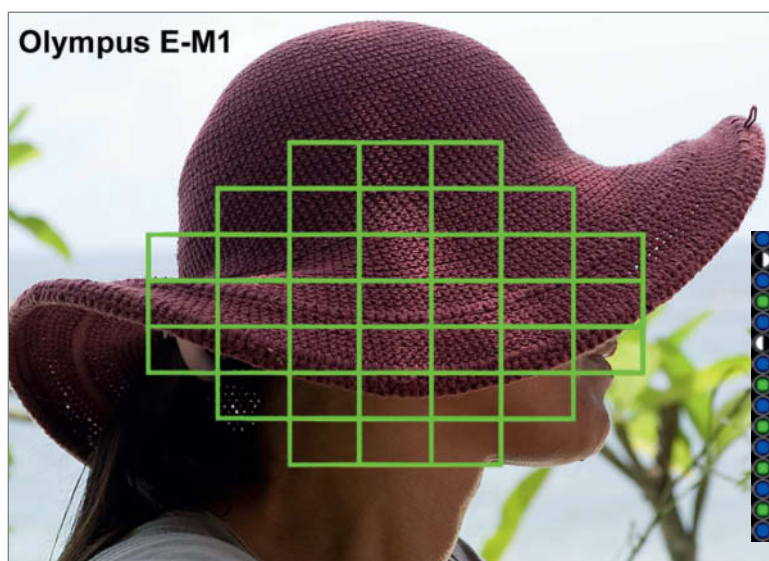
Combined AF Systems

Sensor-based phase-detection AF therefore performs only the donkey work in a hybrid AF system, detecting and passing on the rough direction the lens has to look in. This means the camera no longer has to experiment to find out whether the subject requires back or front focus. Once this part of the job is done, the contrast-detection part of the system takes over and fine-tunes the focus setting by taking a couple more readings. Although direct focusing is still not possible using hybrid systems, some mirrorless system cameras can focus as fast as, or even faster than, many DSLRs with pure phase-detection systems. At its introduction, Sony claimed a focusing time for its Alpha a6000 camera of just 0.06 seconds. Of course, other manufacturers, too, claim to make the 'fastest camera in the world', but test results are highly dependent on the conditions under which they are produced, the lens being used and the type of subject. Unfortunately, contrast-detection AF still has its drawbacks, even when it is used as part of a hybrid system. Every time the shutter button is pressed, it has to 'pump' a little to see whether the current focus setting can be improved, whereas a high-quality phase-detection system can

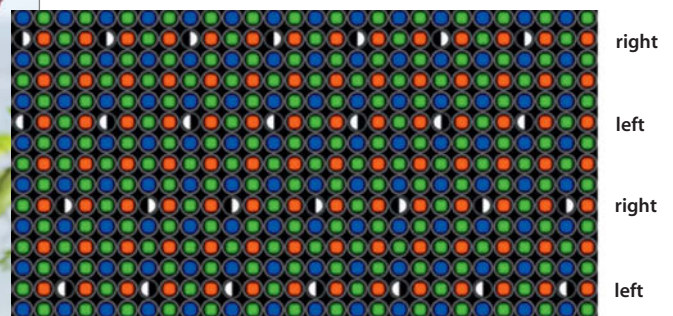
focus immediately, sometimes without having to move any lens elements at all. During our tests, we found that the Sony Alpha a7 II actually took more time to check an existing focus setting than it did to focus properly on a new distant point.

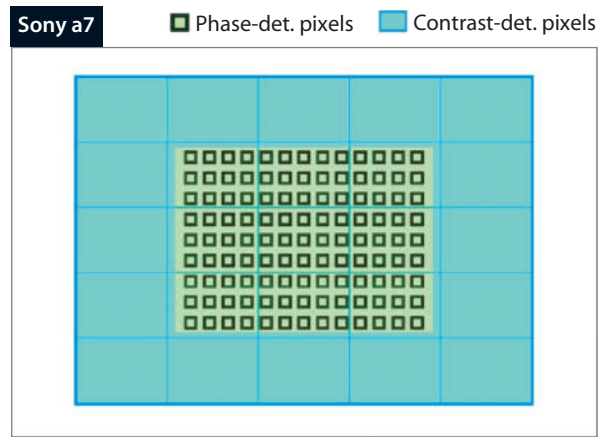
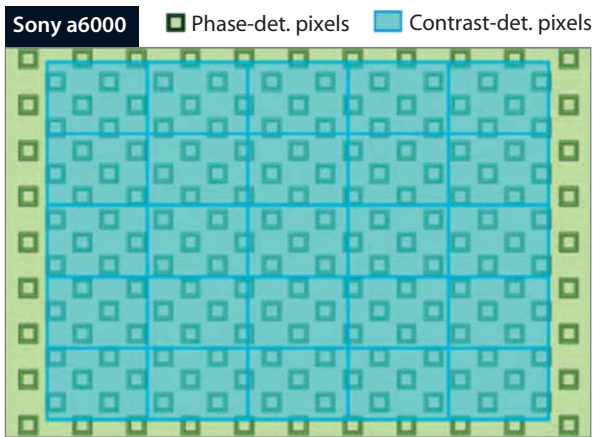
Canon Dual Pixel CMOS AF

Canon has further developed the idea of sensor-based phase-detection AF, and its 'Dual Pixel CMOS' system reduces light loss and uses all the pixels in the sensor to aid the phase-detection process. A 'dual' pixel is located behind each of the sensor's microlenses, which ensures that each pixel receives light from both sides of the lens. If the camera's firmware reads each half of the dual pixels separately, the result is a pair of images that can be used to perform phase detection, whereas reading each dual pixel as a single unit creates a normal image at full brightness. According to Canon, The EOS 70D's conventional contrast-detection AF is no longer required in live view mode and the focus overshoot common in contrast-detection systems is no longer present. Focus fine-tuning in already sharp subjects disappears too. The system is ideal for shooting video, as all you have to do to perform smooth, natural-looking focus tracks is tap the appropriate place on the touch screen monitor. The system is even said to be able to track subjects



Temporarily masked phase-detection AF pixels (shown here in black and white) can be placed virtually anywhere on the sensor's surface, but shouldn't be distributed so broadly that they impair the quality of the resulting image. The illustration demonstrates the principle involved and the portion of the frame that is covered by the contrast-detection implementation used in the Olympus OM-D E-M1.





In the APS-C Alpha a6000 (left), Sony covers the entire frame with phase-detection pixels. To preserve image quality in the full-frame Alpha a7 (right), the phase-detection pixels are located in the center of the frame. Unlike phase-detection systems, contrast-detection AF doesn't require the use of dedicated pixels, so the AF points can be located anywhere and can be redistributed using the camera's software.

that are moving along the optical axis of the lens, either toward or away from the camera.

No Cross Sensors

Like masked hybrid AF pixels, dual pixels are only right/left sensitive, and thus form virtual horizontal line sensors that can only detect vertically oriented edges. The system doesn't include vertical line or cross sensors, so the EOS 70D's live view autofocus doesn't work for subjects that consist exclusively of horizontal patterns. In this respect, the camera is no better than the very first autofocus SLRs such as the Minolta Maxxum

7000 or the Nikon F-501. (Cross sensors were first introduced in analog SLRs in the early 1990s.) However, the fact that the Canon's dual pixels cover around 80 per cent of the frame means that you can distribute AF points just about anywhere to help you track all manner of stationary and moving subjects.

Dual pixel technology is still in its infancy, but nevertheless offers plenty of potential for further development. It could, for example, be used to record separate depth data for each pixel that could then be used to aid image processing, adjust depth of field, simplify object selection or recognize certain types of subject.

The Downside of Phase-detection AF

The major issue facing sensor-based phase-detection systems is that they 'see' the subject with the same degree of sharpness as the image sensor. If the lens is sufficiently defocused, the camera can no longer detect the details necessary to detect phase differences. In contrast, conventional dedicated AF sensors have a comparatively small effective aperture and have greater depth of field than the image sensor. This means that both hybrid and dual pixel systems tend to 'pump' more than conventional phase-detection systems while searching for the correct point of focus.

The two halves of the 'dual' pixels in the Canon EOS 70D's 20-megapixel sensor can be read together or separately. When used separately, they collect data from both sides of the lens and can thus act as phase-detection AF sensors.

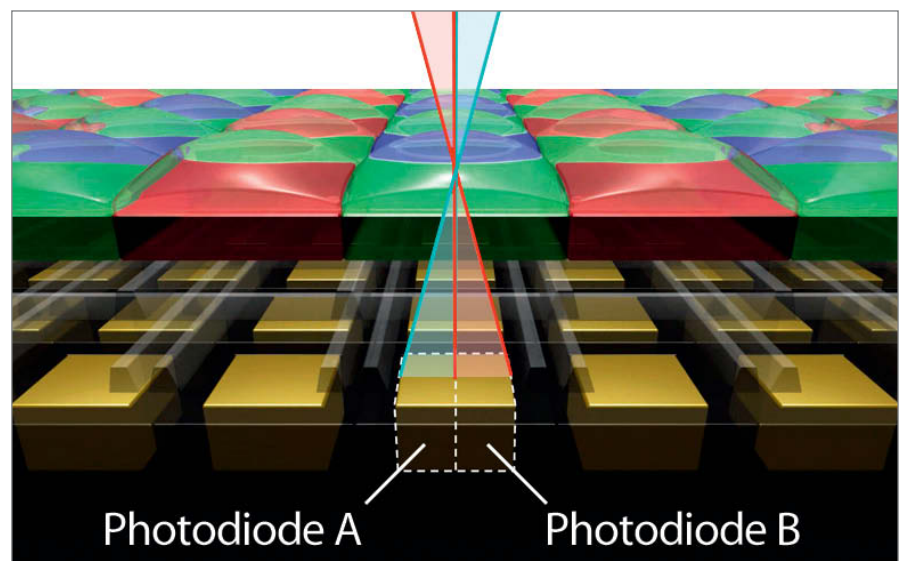


Image courtesy of Canon, edited by Ralph Altmann

Autofocus Calibration Tool Test

It is relatively simple to check how precisely your camera's autofocus works and you can often compensate for lens-specific inconsistencies using the tools included in the camera's menu system. There are many free and commercial calibration tools available, and the following sections take a detailed look at some of the more popular models.

The simplest way to test your camera's autofocus is to mark a focus target point on a ruler leant diagonally against a wall. The problem here is that the diagonal surface can too easily cause unwanted focus shifts, so the solution is to combine a diagonal ruler with a vertical focusing target. There are various commercial products that take this route, such as the [Datacolor SpyderLensCal](#) (\$64) or the [LensAlign MkII](#) (\$85). These devices are, of course, much more expensive than a ruler, but are also much more capable. There is also a [Long Ruler Add-On](#) available for the [LensAlign](#), with a 32" ruler for testing at greater distances or using longer lenses. To achieve the best possible results with this type of tool, you have to ensure that the camera's sensor is parallel to the target. The easiest way to do this is using a small mirror, although none of the tools we tested has one built in. We decided to improvise and glued a pocket-sized mirror to the target. To align your camera using this method, set it up so that you can see the half of the lens cut off by the edge of the mirror in the viewfinder. Our tests showed that such a high degree of precision is only really necessary at close distances – for instance, when calibrating a macro lens. In such cases the available depth of field covers just a few millimeters and even small deviations from parallel cause focus errors.

Manufacturers of calibration devices recommend shooting at a distance of 25-50x the focal length of the lens. Note that the greater the distance, the greater the depth of field, which can make it tricky to find the point of sharpest focus. Online tools such as [dofmaster.com](#) help to precisely calculate depth of field. Let's look at an example: using a factor of 50 at f2.8 with a full-frame camera gives us a depth of field of around 20cm, regardless of the focal length of the lens, but the SpyderLensCal has a total depth of just 13cm. Even accounting for a reduction of depth of field to about 15cm at 100% magnification, the device can only be used to detect rough focus errors. Using a longer ruler doesn't help much either, simply because it is difficult to pinpoint the exact center of a long, soft focus gradient. Unless you are checking a really fast lens, you should stick to using short

subject distances to run your tests. Focus errors are more critical at close distances anyway, where depth of field is at its shallowest.

Free Test Charts

There are plenty of free autofocus test charts available online that you can print out and stick to a piece of card for home use. The one at regex.info/blog/photo-tech/focus-chart is a great example that includes comprehensive instructions for setup and use.

However, because cameras don't allow you to directly enter focus adjustment values, accurate detection and measurement of focus

errors is only half the battle. This means you have to use trial and error to find out which values work best, so make sure you note which values you measure using which particular camera/test chart setup. Using the Canon *EOS Utility* software, you can enter the number of steps that are necessary to achieve your target value in the form of an AF microadjustment value.

FocusTune by Michael Tapes (www.michaeltapesdesign.com) is a software solution for measuring and entering AF microadjustment values and is designed to work as a standalone tool or in conjunction with the LensAlign MkII focus calibration device.



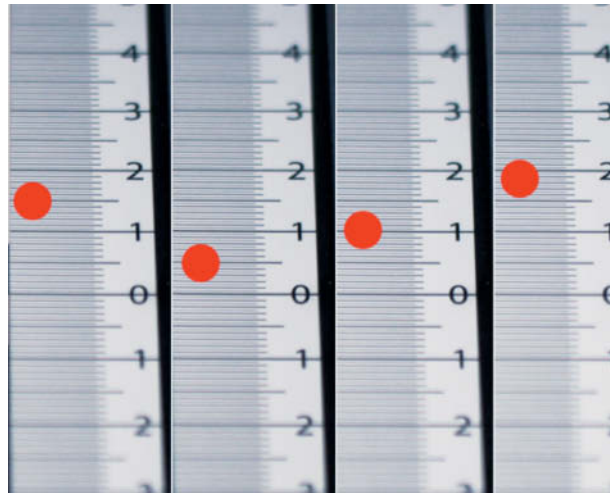
The Datacolor SpyderLensCal is a commercial calibration tool with a built-in vertical focusing target

Image: Datacolor

FoCal (www.reikan.co.uk) is an automated focus calibration system available in a number of different versions that includes its own printable test charts. The system can automatically enter microadjustment values into a wide range of Nikon and Canon cameras via a USB connection.

Checking Focus using Moirés

Moiré effects are normally one of a photographer's worst enemies, but they can also be used to check the accuracy of an autofocus system. Moirés occur where regular patterns with similar frequencies are superimposed on one another, such as the pattern in a piece of clothing and the pixel



This series of SpyderLensCal test shots was captured using a Sony A580 fitted with a Tamron 60mm f/2 macro lens. This particular combo shows an average back focus of about 1 cm.

Sources of AF Errors

Autofocus precision depends on a number of factors, some of which have to do with physics and cannot be corrected by making adjustments to your hard- or software. The following are some of the more important factors influencing the autofocus process.

Correct hardware adjustment: To avoid systemic focusing errors, a camera's AF and image sensors have to be positioned on the same optical plane. This is automatically the case for all sensor-based contrast-detection, hybrid and dual pixel AF systems. The AF sensors used in most DSLR phase-detection systems are located away from the image sensor beneath the mirror box and have to be extremely precisely adjusted in order to work correctly.

AF system precision: Focus anomalies that go undetected cannot be adjusted. All AF systems have limits to their resolution, and in phase-detection systems, this is determined by the distance between the sensors (the 'baseline'). And by the way, one hundred percent accuracy isn't actually a good thing, as the AF motor can only come completely to rest if the system has a built-in degree of tolerance.

Working vs. actual aperture: Spherical lenses (i.e., those in which both surfaces are curved) refract light more strongly at

their edges than in the center. The focusing inconsistencies that result from these differences are known as spherical aberrations and are a common error in many lenses. Because focusing takes place with the aperture wide open, the edges of the lens play a significant role in determining the focus setting. If the photo is then captured using a smaller aperture, light only enters the center portion of the lens and the point of focus will be more distant than the one measured at maximum aperture.

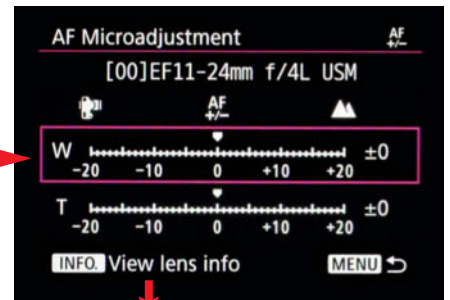
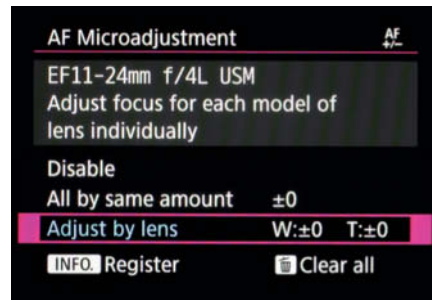
Differences in color: Light rays of varying colors (i.e., with differing wavelengths) are refracted to different degrees when they pass through glass. The resulting image errors are called chromatic aberrations and often cause unsightly colored fringes at high-contrast edges. AF sensors detect the same color differences as the image sensor and adjust focus according to the dominant color. Theoretically, camera firmware can compensate for these types of errors using the color temperature of the light entering the lens as a guide – we were, however, unable to confirm whether this technique is actually used by camera manufacturers. For example, in warm, reddish light, focus needs to be shifted slightly rearward.

Imprecise focus travel: Modern AF lenses are designed for speed and are consequently fitted with high gearing and short focus travel. This makes it tricky to find precisely the right focus point when focusing manually using the focus ring on the lens. With some cameras, such as the mirrorless Panasonic Lumix DMC GM1, you can operate the focus motor using a lever or by way of touch screen gestures, although this can be quite fiddly. Mechanically focused lenses such as the Zeiss Otus series, with their long focus travel, are much easier to adjust accurately. Focusing AF lenses manually always involves compromises.

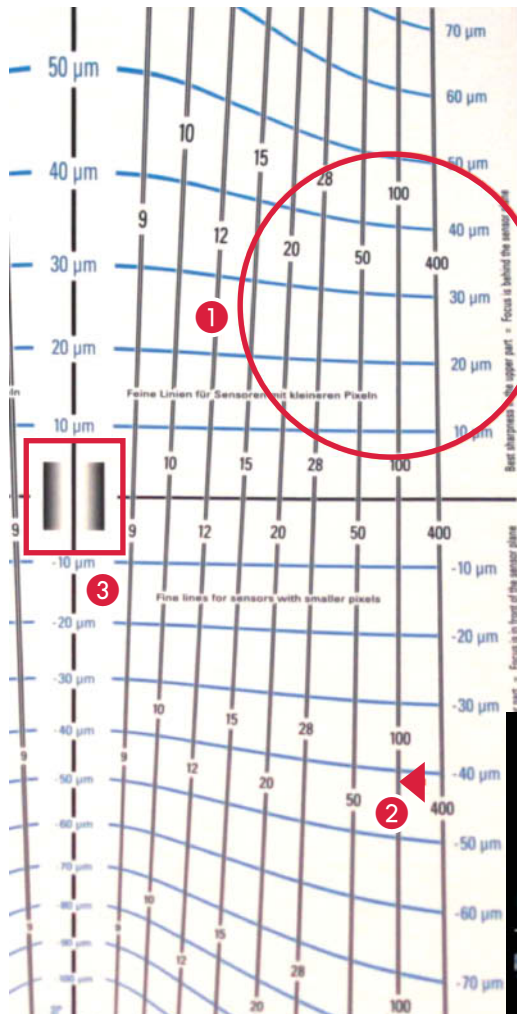
Mechanical play: Especially with older, well-used lenses, focus accuracy depends on whether it has to be adjusted from a distant or a nearby point. Autofocus mechanics simply wear out with frequent use and excessive play affects the precision of the results.

Heavy lens elements: The elements used in telephoto lenses can be quite heavy and, once they are in motion, can cause AF systems to overshoot the point of focus they are targeting. If this overshoot is within the tolerances of the lens, a focus error will result.

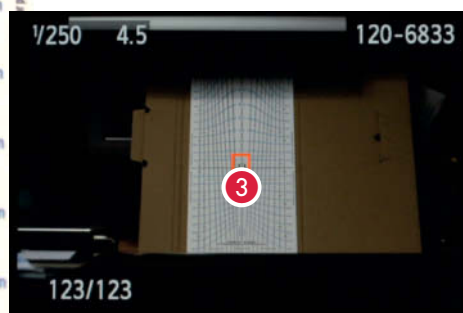
grid in a camera's image sensor. When it comes to checking focus, patterns that are similar to the sensor grid (i.e., with consistent horizontal and vertical stripes or regularly distributed dots) are particularly useful. Check out www.komar.org/faq/camera/autofocus-test/ for some test patterns that produce mild moirés. Our own test pattern (included with this issue's free online content) produces strong, striped moirés and can be used for checking focus and other aspects of a camera's functionality. To use them, these test charts have to be displayed on a computer monitor, where the monitor pixel grid compounds the moiré effect. You can then observe the moirés on your camera's monitor or in its electronic viewfinder. The effect is not visible if you view the test pattern through an optical viewfinder. This technique works best in the small camera monitor/viewfinder because it superimposes the patterns from the chart, the image sensor grid, the pixels selected by the camera and the pattern of the



Most high-quality camera have a menu item for entering lens-dependent AF microadjustment values. The Canon EOS 70D even enables you to enter separate values for the wide and telephoto settings in a zoom lens. The camera uses serial numbers to differentiate between lenses of the same type.



The AF test chart offered by Walter E. Schoen at www.weschoen.de/af-testtafel.html has sets of double lines and multiple scales for use with the distortion produced by various focal lengths. The area of maximum sharpness ① lies between the points where the double lines meet – in this case, between about -40µm ② and +100µm (not shown in the illustration). The in-focus zone is quite large at f4.5, making it tricky to zero in on the sweet spot. Because it is positioned diagonally, it is also quite tricky to focus precisely on the relatively small focus target ③.



monitor/viewfinder's own pixels to create the displayed image. This multiplicity of patterns ensures that moirés are produced at varying magnifications (i.e., at different zoom settings or different camera-to-monitor distances) that can then be used as effective focus indicators. The moirés are not visible viewed at 1:1 in live view mode or in the photo itself, although in both these cases, you can judge focus visually anyway. If you set up your camera to reproduce the points on the chart at life size on the sensor, the resulting photo will also contain obvious moirés. In this case, the low pass filter whose job it is to prevent moirés doesn't really help, and we captured all our moirés using cameras with low pass filters.

To check focus, set up your camera on a tripod in front of a monitor with the moiré test pattern displayed at 100% magnification. If necessary, you can set magnification to 200% for greater camera-to-monitor distances or if you are checking focus in a wide-angle lens. Whichever option you choose, do not use magnifications between these two values. Select your distance (or zoom setting) so that a striped moiré appears in the 100% live view image of the computer monitor. Everything is set up correctly if the stripes are horizontal and distributed evenly across the frame. The broader the stripes, the better the superimposed patterns coincide. However, stripes that are too broad are less useful when assessing focus accuracy, so it is best to select a camera position that produces a total of five

or six stripes. Ignore any dark flickering stripes that race across the image, as these are a product of the monitor's refresh rate coinciding with the camera's live view sampling rate and have no effect on the test.

Once the camera is set up, switch live view off, or at least make sure that only the phase-detection part of the AF system is in operation. Some cameras have some kind of 'Quick AF' function that aids focusing by lowering and raising the mirror to give the AF sensors a brief look at the world outside. The camera monitor now displays the image as it has been targeted by the camera's AF system. Now switch to manual focus and observe how the moirés change when you adjust the focus setting. If the contrast in the moiré stripes increases, the camera has failed to find the point of maximum sharpness, or 'sweet spot' as it is often called.

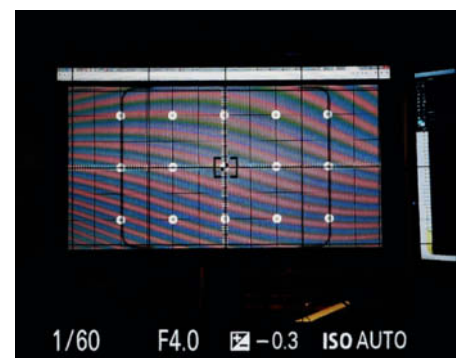
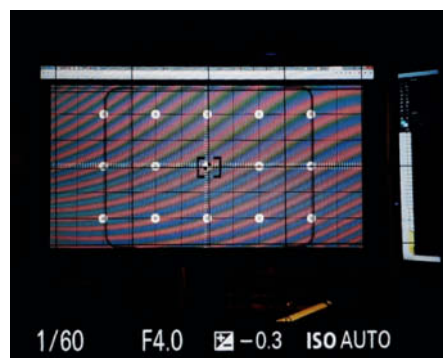
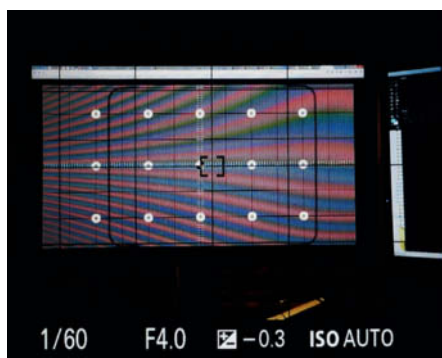
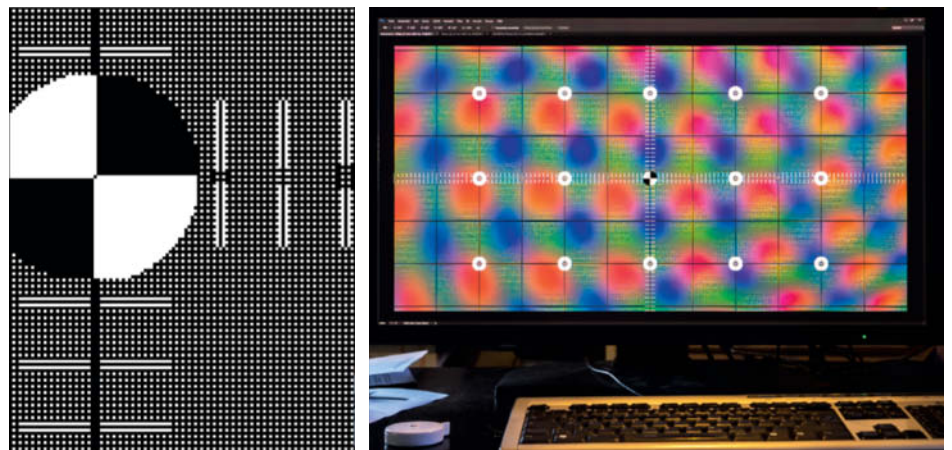
If you have to rotate the focus ring toward infinity to achieve correct focus, the AF system is suffering from front focus, whereas if you have to rotate it toward its close focus setting, the camera has back focus. Set focus manually to infinity and repeat the experiment. If several consecutive attempts produce the same type of focus error, chances are you will be able to correct it using AF microadjustments.

Readjusting Autofocus

Mid-range and high-end DSLRs usually have a built-in AF microadjustment function, whereas mirrorless cameras with contrast-detection AF or sensor-based phase-detection AF don't. The function enables you to set values for a range of lenses identified automatically using either the

model or the serial number. Legacy lenses are identified by way of their maximum aperture and focal length. Our Nikon D750 supports up to 12 lenses, while the Sony Alpha a99 supports 30 and the Canon EOS 70D up to 40. The Canon system also enables you to set separate microadjustment parameters for the long and short ends of the zoom range and automatically interpolates an appropriate value for zoom settings between the two extremes. The Canon microadjustment setting has a scale from -20 to +20 but doesn't let on which units it uses. Positive values shift focus toward infinity (i.e., for correcting front focus) and negative values correct back focus. The only way to find out which values correct which focus errors is by trial and error. According to Canon, the degree of correction required also depends on the maximum aperture of the lens in use.

Bright circular moirés like the ones shown on the right (captured using a Sony Alpha a7 II) are a sure sign that the patterns on our test chart have been reproduced at 1:1 on the sensor. The enlarged detail on the left shows part of the chart as it appears on the computer monitor. Near-perfect camera-to-monitor alignment causes the camera to reproduce a highly magnified view of its own Bayer pattern sensor pixels.



The stripes produced by correct use of our moiré test pattern make it possible to set up the camera and monitor extremely precisely – an ideal setup produces uniform horizontal stripes. Any remaining pin-cushion or barrel distortion is due to inherent lens errors that are greatly magnified by the process.

How To Measure and Compare Deviations in Focus

We have developed a custom technique for assessing autofocus precision using a specially designed image displayed on a computer monitor. The method is quick and, because the focus gradient in the resulting images can be extracted in the form of a curve using a Photoshop Action, it is extremely accurate too. The technique simplifies the laborious task of searching for the sweet spot. All of the files mentioned in the following tutorial are included with this issue's free online content.

Our custom focus test chart is an animated GIF designed for display in a web browser. If your browser is set up to prevent web-based animations from playing, check the 'Play animations in web pages' option in the Multimedia section of the Internet Options > Advanced tab in *Internet Explorer*. The GIF has to be displayed at 100% magnification, so make sure that automatic image resizing is disabled. The *Toggle Animated GIFs* add-on for *Firefox* lets you play and pause GIFs with a mouse click, which makes using our tool simpler but is not essential when performing the test.

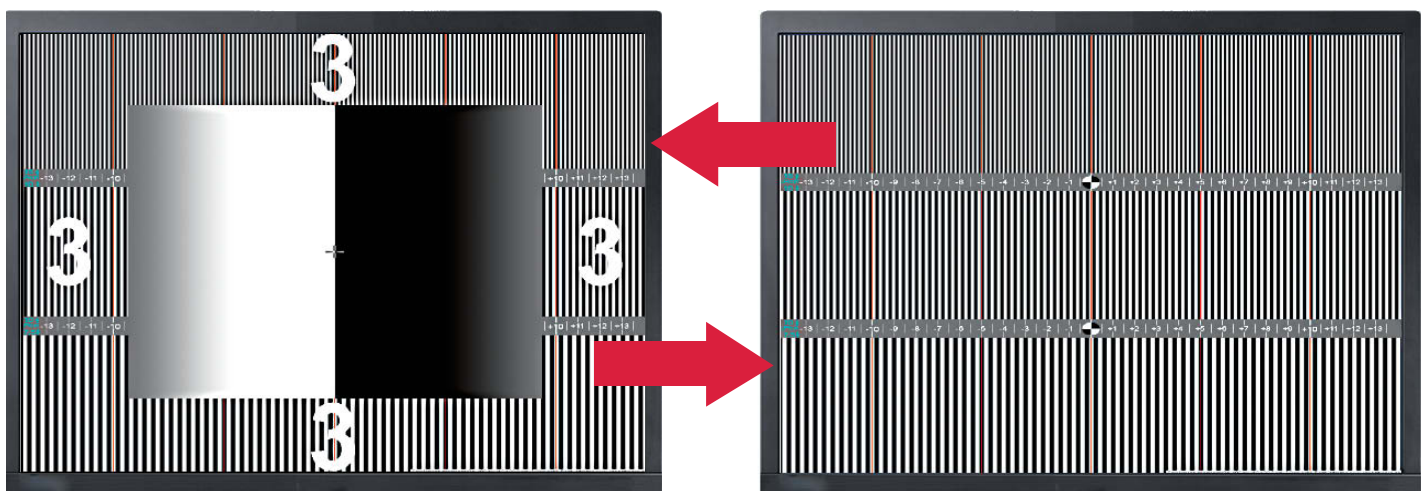
The test GIF measures about 1700×1200 pixels and is divided into three sections with vertical stripes of differing thickness. On a monitor with 108 ppi pixel density, the two scales display the focal depth (in centimeters) when you view the monitor at a 45-degree angle. Every six seconds, the GIF displays a

large black-and-white rectangle in the center of the test image to ensure that the camera has a predefined focus target located in the center of the screen. Three seconds later, the focus target disappears and gives the camera an unhindered view of the test image.

Set your monitor up vertically and check it using a spirit level. Mount your camera on a tripod so that it is aimed at the center of the monitor at a 45-degree angle. This angle of view visually shortens all horizontal lines to about 70 percent of their original length. The test image and the focus target are designed to appear virtually square to the camera. Use a camera-to-monitor distance of 25-50× or, alternatively, the distance at which you most often use your lens (i.e., close up for a macro lens). Note, however, that the closer your camera to the monitor, the more perspective distortion comes into play and the larger the stripes at the end of the monitor image closest

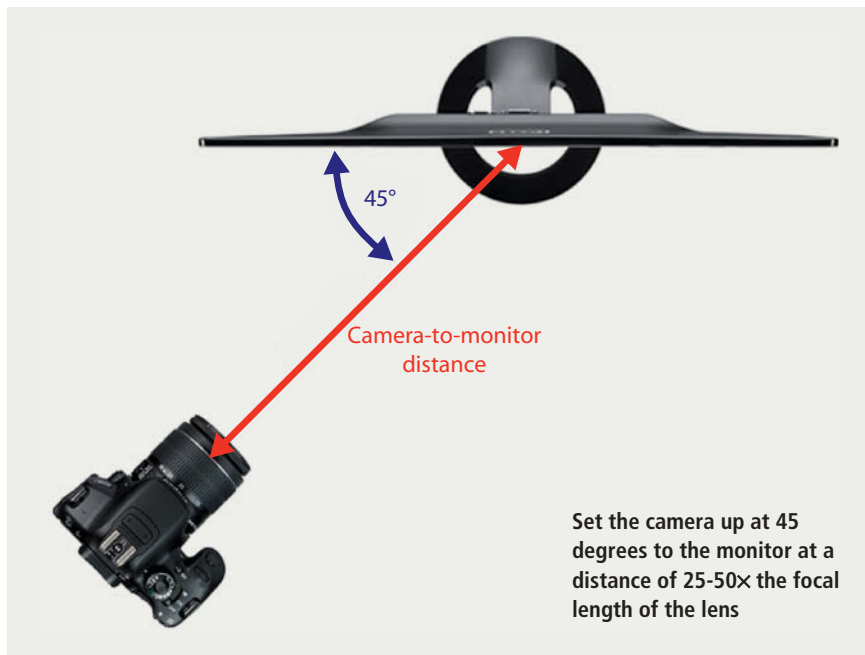
to the camera will appear. This effect produces results that give preference to the test stripes closest to the camera, which appear larger and therefore sharper. This is an issue in all conventional focus test charts and tools, and only Walter Schoen's chart (see page 80) takes distance-related distortion into account.

Before you start the test, make sure you load the accompanying *Photoshop* Actions by double-clicking the <ctDP_AF.atn> file included with this issue's free online content.



Our focus test pattern consists of two images that alternate every three seconds. The left-hand image is the focus target and the shutter is released as soon as the right-hand image appears.

Setting the Distance and the Size of the Test Image



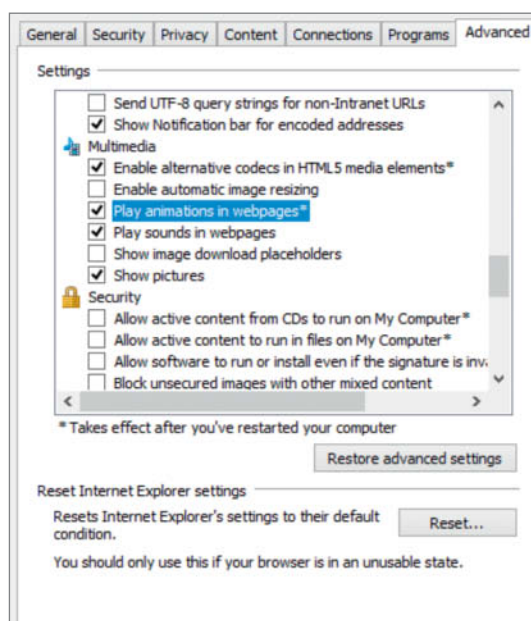
If you shoot at a distance that is constant relative to the focal length of the lens (30× for example), the test image will always be captured at around the same size. This is because the reproduction ratio at relatively close distances is determined by the ratio of focal length to subject distance. At a distance of 30× focal length, the

reproduction ratio is about 1:30. This means that our test image, which is 28 cm high on a 108 ppi monitor, will be reproduced approximately 1 cm high on the sensor. The size of the test image in the resulting photo depends on the size of the sensor. For example, in an **APS-C camera** such as the Canon EOS 70D, the sensor measures

22.5×15 mm and the test image covers about two thirds of its height. This equates to a height of 2158 pixels on the Canon's 5472×3648-pixel sensor. In turn, this means that every pixel of the monitor-based test image is captured by almost two sensor pixels. The black and white line pairs in the test image are 4, 6, and 8 pixels wide but are compressed by the 45-degree angle of view to $1/\sqrt{2}$ (about two thirds) of their original size. As a result, each line pair is captured by 5, 8, or 10 sensor pixels. At this kind of resolution, any lack of sharpness can only be a result of focus errors, not inadequate sensor resolution.

The math looks a little different if you use a **full-frame camera**. At the same reproduction ratio, the test image covers less than 39 per cent of the 24mm height of the sensor. Using a Canon EOS 5D Mark III, with its 5760×3840 22.3-megapixel sensor, this gives us a subject height of 1498 pixels, which is dangerously close to the 1:1 reproduction ratio that would plunge the image into a mass of blurry moirés. This issue is less critical for a 50-megapixel camera like the Canon 5DS because the 8688×5792-pixel sensor provides more pixels per line pair. Moirés can, of course, be used to judge sharpness, but cleanly resolved line pairs are usually the better option. The best way to avoid this type of issue is to move the camera closer to the test image or use broader stripes for your final assessment. Remember that the object of the test is to check autofocus precision, not measure the resolution of the camera's image sensor.

The centimeter units on the scales located between the stripes in the test image are displayed at life size on a 108 ppi monitor, so you can read any front or back focus values directly from the image. If you prefer to use one of the 300 ppi versions included with this issue's free online content, print it at 40×28.3 cm (15.75×11.1") on a sheet of ledger/A3 paper. Viewed at a 45-degree angle, the print will contain 15 of the finest line pairs per centimeter and is ideal for testing an APS-C camera at a distance of 30× focal length. The other line patterns (with 10 and 7.5 line pairs per centimeter) are better suited to testing at greater distances or for cameras with larger sensors, and are also less prone to producing moirés.



For the test to work, you have to enable web-based animations in your browser and disable automatic image resizing. The illustration shows the setting in *Internet Explorer*.

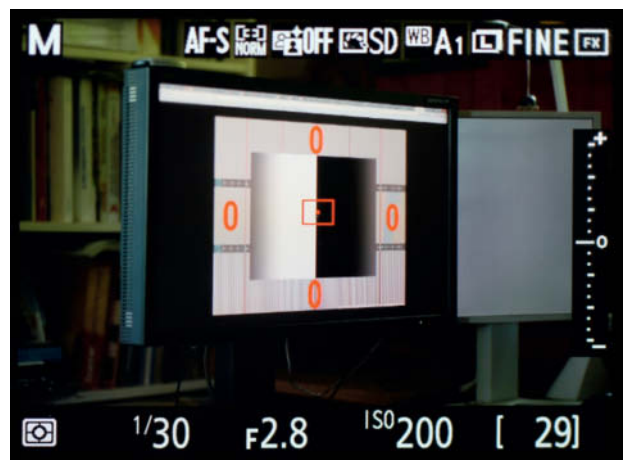
Tutorial: How to Measure Focus Deviation

1 Set up the camera. Because the camera is mounted on a tripod, you can switch the stabilizer off. Select one-shot AF and set the camera up so it points precisely at the center of the focus target that appears every three seconds on the monitor. Select JPEG format and the highest resolution and quality settings available (raw isn't necessary for this test). Switch off any automatic image enhancements such as in-camera sharpening and lens corrections. Now set the camera to single shooting mode, set a

low to medium ISO value, switch exposure metering to 'spot' and open the aperture to its widest setting. Take a test shot in aperture-priority mode. If it is correctly exposed, switch to manual (M) mode and use the exposure time determined by the camera to ensure that all your shots are exposed the same. To avoid camera shake, use mirror lockup and a remote release (or the self-timer).

2 Shoot a sequence of test images. Press the shutter button halfway while the animated GIF is showing the focus target and only press it all the way once the GIF has reverted to the striped test image. This is then captured using the focus setting you have locked in. Set focus manually to close focus or infinity before each shot to ensure that the autofocus mechanism switches in, then shoot at least three shots from each focus 'direction'. This ensures that your results provide meaningful data for any consistent focus deviations and on the precision of the repeated focusing process.

Use your camera's viewfinder or monitor to focus but only release the shutter once the focus target disappears and the striped test image is displayed

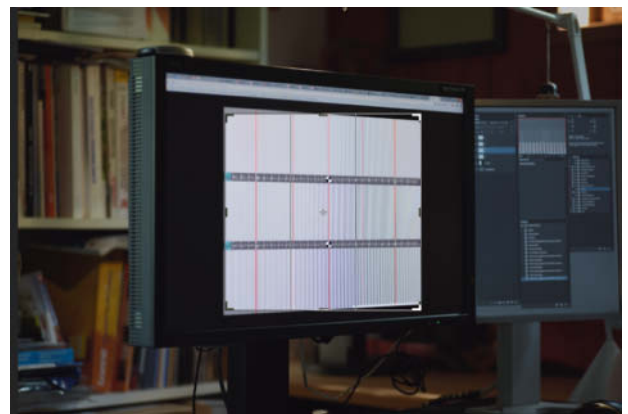


3 Rename your test images and load them into a stack. If you are shooting multiple sequences to test various lenses, it is a good idea to rename the resulting image files accordingly. Load the sequence into a layer stack in *Photoshop* or any other layers-capable image processing program. In *Photoshop*, use the File > Scripts > Load Files into Stack command or in *Bridge* use

Tools > Photoshop > Load Files into Photoshop Layers. Alternatively, open one of your images in *Photoshop* and drag the remaining files onto it from the *Windows Explorer* window. The resulting layers will be automatically named using the filenames. This method also works with *Photoline* and possibly other image processing programs too.

4 Crop your images. The test pattern often takes up only half of the width of each frame, so it is safe to crop the rest of each image. This saves computing power while you work and disk space when you archive your stacks.

The rectangular test pattern appears almost square when photographed at a 45-degree angle

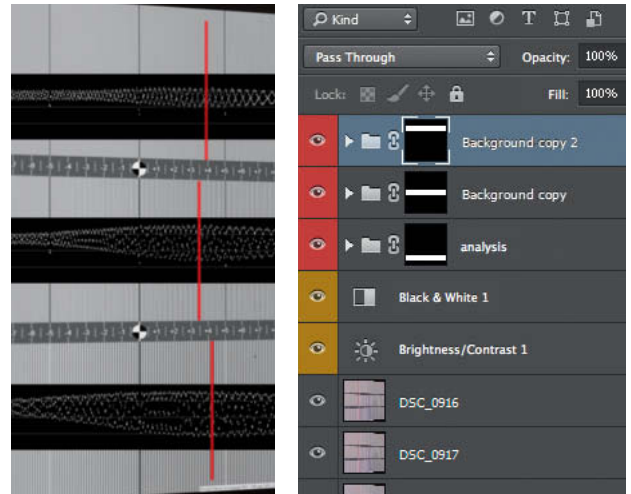


5 | Run our custom Action. Select the uppermost layer in your stack and start the *AF_analysis* Action. This creates two adjustment layers for optimizing contrast and grayscale conversion and a layer group called *analysis*. The Action extracts the contrast data from the uppermost layer in the stack and

inserts the result in the form of a curve into the new layer group. By default, the tool is located on the medium-resolution line pair pattern in the middle of the image. You can, however, drag it to one of the other patterns or duplicate it to simultaneously display the curves for all three.

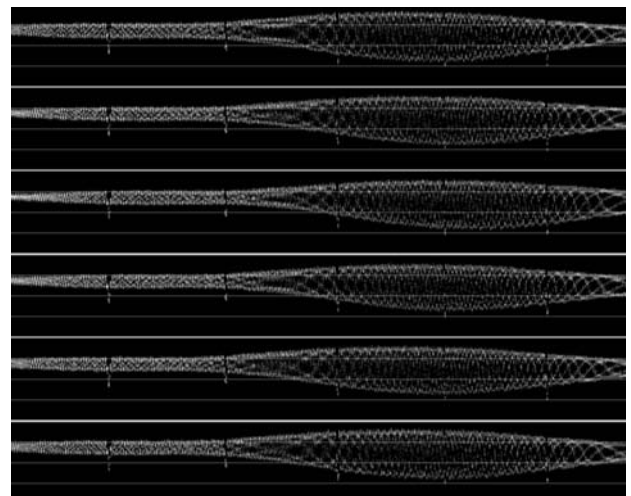
6 | Analysis. We performed step 5 for all three line pair patterns and marked the position where the curves were broadest. These were consistently located at around +4 on the scale, indicating that our Nikon D750/Tamron 90mm F/2.8 Macro test setup has a front focus shift of about 4 cm. The other images in the stacks, captured with the lens set initially to infinity or close focus, confirmed this. Mark the point of focus with a red dot above or below the curve on each layer.

To check our results, we generated the curves for all three test patterns. It is best to assess the position of the focal point at 100% magnification.

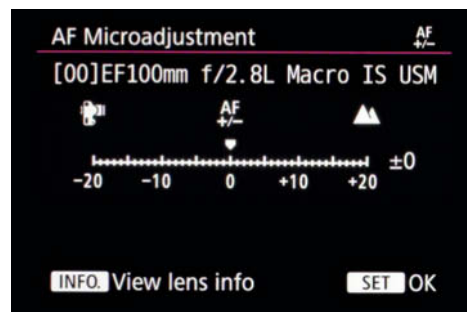


7 | Extract the curves. The other *Photoshop* Action provided with this issue's online content extracts the curves generated by the first Action so that you can save them separately and superimpose them on one another for comparison purposes. To do this select the *analysis* layer group and run the *AF_extract_curves* Action. This creates a new layer containing the currently displayed curve above the selected group. Repeat this step for each layer in your test image stack and arrange the resulting layers in the correct order. These new layers are arranged in the order you create them using our Action and are automatically labeled Layer 1, Layer 2 etc., so it is best to rename them immediately before you lose track of which is which.

Once you have created and renamed all your curve layers, unhide them and place them next to each other for comparison. The illustration shows a sequence captured using a camera that consistently produces images with front focus.



8 | Determine and save the microadjustment value. Once you have established how your camera's autofocus system behaves, you can use its AF Microadjustment function to enter an appropriate correction value. These values have no units, so you will have to use trial and error to find out which values correspond to the focus deviation you have determined. Try shooting a sequence of test images at 5-point increments to cover the entire range from -20 to +20. Note which value corresponds to which image number, as these usually end up being saved as proprietary Exif tags that not every program can read. The *ExifTool* freeware is a notable exception.





Rudolf Opitz

Pro-grade 13" Photo Printers from Canon and Epson

High-end printers produce print quality at home that many specialized photo labs cannot match. With up to ten individual ink cartridges, comprehensive color management functionality and dedicated software, these printers give you complete control over your paper-based results.

Inkjet printers are ideal for making high-quality prints of digital photos. They have ultra-precise print heads that use ink droplets between 2 and 4 picoliters (pl) in size to faithfully reproduce even the finest details. Up to ten separate ink cartridges provide a huge range of printable colors and make it possible to reproduce ultra-fine color nuances and grayscale gradients. Pigment inks ensure high color density and saturation, while color profiles fine-tuned to suit individual print media make printing on even the most exotic fine-art papers a

precisely controllable task. Additionally, the many software-based print options give you an unprecedented degree of control over the look of your prints.

We tested the high-end PIXMA PRO-10 and PRO-100 models from Canon and the Epson SureColor P600, which is the follow-up model to the popular Stylus Photo R3000. With an RSP of \$499.99, the PIXMA PRO-10 is the cheapest of the three, while the PRO-100 goes for \$699.99 and the P600 for \$799.99. Canon's three-year-old top-of-the-range

PIXMA PRO-1 (see *A3 Printers in Practice* in Issue 13 for a detailed review) has an RSP of \$999.99. As ever in the electronics market, heavy discounts can be found if you shop around.

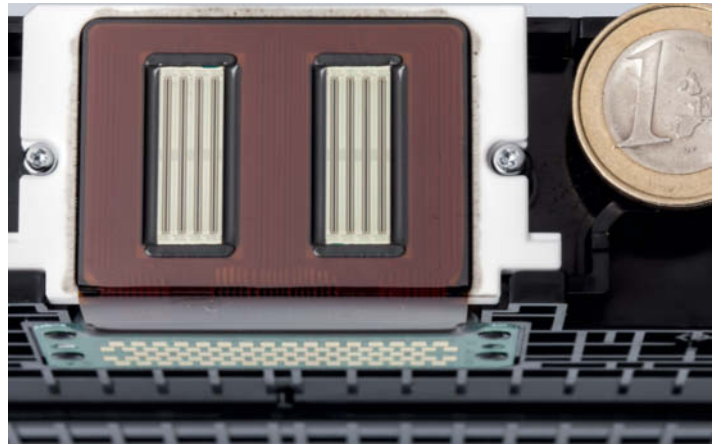
The two Canon printers look identical but have different print mechanisms. The PRO-100 uses eight separate cartridges of ChromaLife100+ dye-based ink, whereas the PRO-10 uses nine of Canon's LUCIA pigment inks plus a tenth cartridge of 'Chroma Optimizer' – a specially developed fluid that fills the spaces between ink droplets on glossy paper, providing uniform ink height and preventing the unwanted reflections that reduce the visual saturation of dark colors. The PIXMA PRO-1 uses additional light and dark gray inks, giving it a total of 12 cartridges and print heads.

Like the PIXMA PRO-10, the Epson SureColor P600 uses pigment inks. The new UltraChrome HDR inks are said to provide extremely dense blacks and smooth color gradients, especially when used with glossy papers. It also uses two black inks: photo black for glossy papers and matte black for deep, saturated blacks on normal and fine-art papers.

While the PIXMA PRO-10 has a separate print head for both blacks, The Epson P600 has just one black print head for use with its two black cartridges – an annoying feature inherited from its predecessor, the Stylus Photo R3000. The paper settings in the printer driver usually determine which black is used, although you can choose which to use yourself if you are printing on normal paper. You can also switch blacks using the controls built into the printer but, depending on the settings you are using, the driver often resets user-controlled settings automatically for the next print you make. Every switch between photo and matte black involves cleaning the black print head and wastes costly ink, so it is best to avoid switching if you can. During our test, switching to matte black took about 90 seconds and switching back to photo black took almost three minutes of head cleaning, so patience is required when switching modes.

There's Ink, and then There's Ink ...

Dye-based and pigment inks have their own specific advantages and disadvantages. Cheap and mid-range printers usually use dye-based



The Canon PIXMA PRO-100's print head has 6,144 separate nozzles, which equates to 768 for each color

inks, which are absorbed by the surface of normal paper and dry quickly. Colors are mixed by applying multiple layers of different colored inks.

In contrast, the colored particles in pigment inks remain on the surface of the paper, so adding a layer of another color would simply cover the previous layer. To produce mixed colors, the printer therefore has to place ink droplets next to each other. The major advantage of this system is that the resulting colors have better coverage and don't bleach out as fast as their dye-based counterparts. Different ways of mixing colors have little effect on the available color space, so using additional inks (such as the red available for the PIXMA PRO-10) is a more effective way to enhance color reproduction.

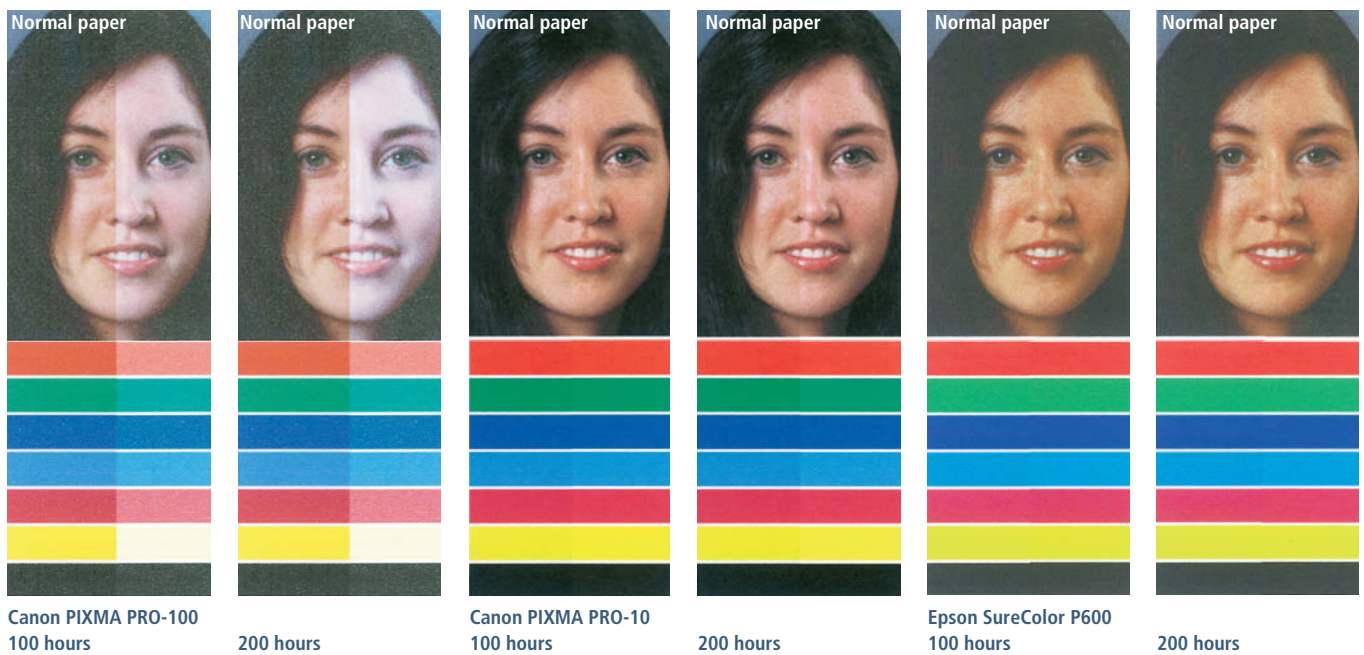
The stability of printer ink in sunlight depends very much on the paper you use. Sensitive dye-based inks are well protected by the



The Epson SureColor P600 has nine separate ink cartridges but only eight print heads. Switching between photo and matte black mode involves cleaning the black head, which wastes precious ink.



The PIXMA PRO-10's print head houses ten ink cartridges. Nine are color inks and the tenth is the 'Chroma Optimizer' fluid that ensures uniform ink height in prints.



The dye-based inks used by the Canon PIXMA PRO-100 faded visibly during our sunlight test, and yellows especially suffered from the treatment. The pigment inks used by the PIXMA PRO-10 faded only slightly, and the Epson inks weren't visibly affected, even after 200 hours of exposure.

carrier layer in photo papers but fade more quickly when used with normal paper. We used a xenon lamp in our lab to emulate 100 and 200 hours of exposure to sunlight, and our sample prints on normal and Canon Pro Platinum photo paper confirmed these assumptions.

Canon's LUCIA and the Epson Ultrachrome HDR pigment inks both proved extremely stable when used with Canon Pro Platinum and Epson Premium Glossy photo papers and showed no significant signs of bleaching on normal paper (in our case, a no-name 'premium' paper) following 100 hours of exposure. The samples we made using the PIXMA PRO-10 only began to show slight signs of fading in the red tones when we extended our test to cover 200 hours of exposure to simulated sunlight, whereas the samples we printed on photo paper using the PIXMA PRO-100 showed significant fading after just 100 hours, and those printed on normal paper turned out even worse. Nevertheless, the Canon ChromaLife100+ inks proved to be much more fade-resistant than the standard inks Canon uses in its entry-level and mid-range PIXMA printers, especially in the more sensitive red tones.

Ink Costs

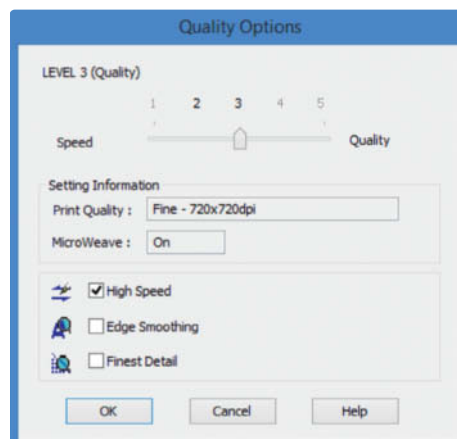
It is always difficult to estimate the ink costs involved in printing photos, as the amount of ink required depends on the type of subject and the paper being used. Generally speaking, photos printed on glossy paper use less ink than those printed on normal or fine-art matte papers.

Measured using the ISO/IEC 29102 standard for determining photo yield for color inkjet printers, a 6x4" print made using ChromaLife (CLI-42) ink on a PIXMA PRO-100 costs about \$0.38, while the same print costs about \$0.47 using LUCIA (PGI-72) inks with the PIXMA PRO-10. These estimates do not include paper costs. The larger ink cartridges

used in the PIXMA PRO-1 make a standard print slightly cheaper, at about \$0.41.

Strangely, Epson quotes print capacity for the SureColor P600 using the ISO/IEC 24711/24712 standard, which covers text and graphics printing. While this results in an estimate of 12,000 pages of text, it sheds no light on its photo printing capabilities. We tried to find out from the manufacturer why the more relevant photo standard isn't used, but our query remained unanswered as we went to press.

We compared the prices and the amount of ink contained in Epson and Canon LUCIA cartridges and concluded that, milliliter for milliliter, both types of ink cost about the same.



Inkjet printers cannot usually print at maximum resolution on normal paper. In the Epson P600 driver interface, the higher-quality settings are simply grayed out.

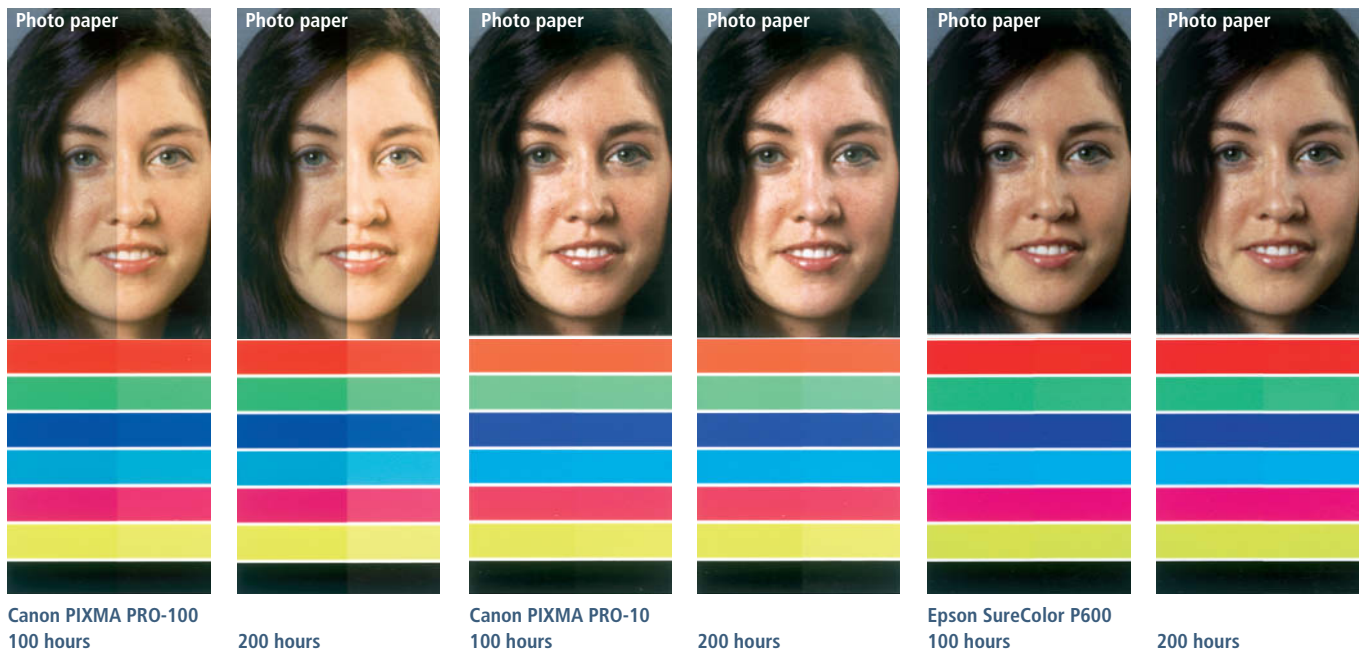


Photo paper helped protect the PIXMA PRO-100's dye-based inks from fading but didn't completely eliminate the effect. Both types of pigment inks we tested weren't visibly affected, even after 200 hours of exposure.

The high ink costs make these devices unsuitable for printing 6×4" vacation snaps, as you can get prints made at a drugstore for \$0.10 or less. The price differential is smaller for 8×11.5" prints and, when it comes to making prints that are 11" or 13" wide, it is nearly always cheaper to print at home. Remember too, that most printers produce their best results on the manufacturer's own-brand paper, and home-printing enables you to select the paper yourself. Perhaps most significantly, home printing gives you complete control over every step in the print creation process, enabling you to fine-tune the process to suit your own personal requirements, just like in an analog darkroom.

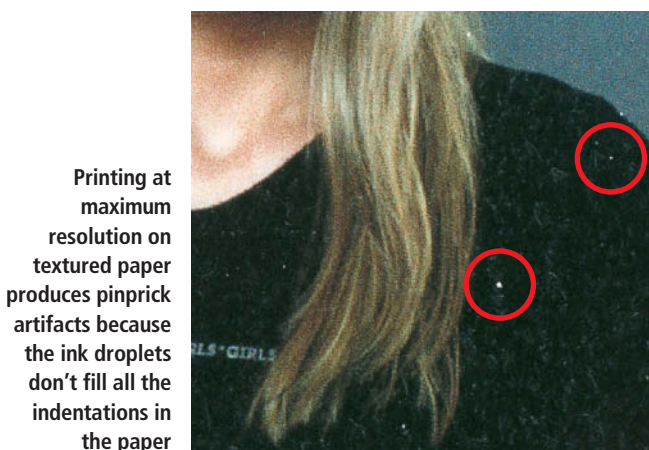
Choosing the Right Paper

The choice of paper is key to the success of a high-end photo or image-processed art print. The paper you use determines the maximum resolution the printer can use and the effect produced by the inks. Inkjet printers cannot usually print at maximum resolution on normal paper. In the PIXMA PRO driver dialog, for example, you can only select 'Fine' resolution if you first select a glossy photo paper. If you select normal paper in the Epson SureColor P600 driver dialog, print quality levels 4 and 5 are simply grayed out.

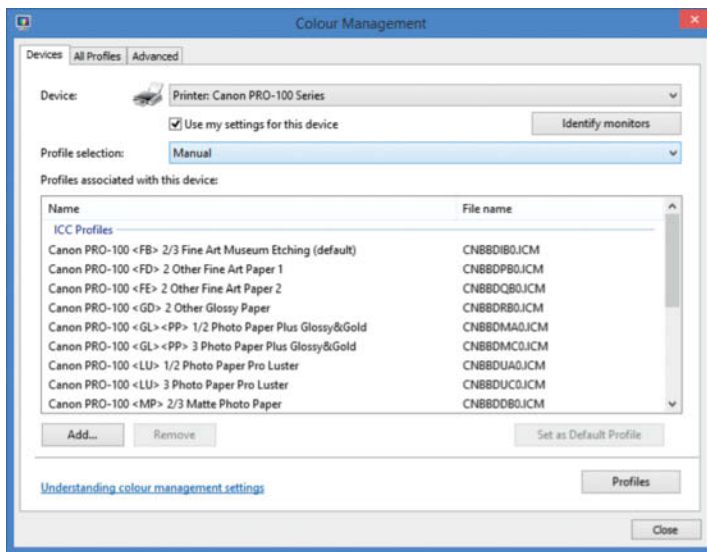
Many paper manufacturers recommend that you stick to 'high' or '720 dpi fine' resolution when using fine-art and other textured photo papers. Our test showed that using the Canon devices at maximum resolution with fine-art paper produced pinprick-sized blank spots where the ink wasn't able to completely fill the deep indentations in the surface of the paper (see the example below left). Such artifacts are very small but, in a finished print, can be just as distracting as dead pixels on a monitor.

Inkjet printers generally produce their best resolution on glossy photo paper although in this respect, paper manufacturers' own figures are often highly theoretical. Canon often quotes maximum resolution for its low-end printers at an unbelievable 9600 dpi, but only 4800 dpi for the high-end models tested here. However, our real-world tests and close inspection using a microscope proved that the high-end printers produce much finer details than their cheaper counterparts.

The Epson P600 didn't quite equal the resolution produced by the Canon printers, probably due to the 768 nozzles per color built into the Canon print heads, compared to the Epson's 180 nozzles per color. Note, however, that Epson uses its proprietary 'Micro Piezo' technology in its print heads, enabling them to produce much finer droplets than the Canon 'Bubble Jet' print heads. Epson advertises its products with



Printing at maximum resolution on textured paper produces pinprick artifacts because the ink droplets don't fill all the indentations in the paper



In Windows, ICC color profiles are found in the Color Management section of the Control Panel

the slogan “variable-sized droplet technology”. Canon’s technology heats up the ink to produce a tiny bubble of gas that propels the ink onto the paper and cannot be regulated as finely as the piezoelectric crystal used by Epson. As far as absolute resolution is concerned, Canon more than compensates for its less sophisticated technology by using more nozzles.

Color Fidelity

Print color management is controlled either by the printer driver itself or by your image processing program. The color space specified in the input color profile – usually sRGB or Adobe RGB – has to suit your printer and paper. The program responsible for rendering the image uses ICC (International Color Consortium) output profiles, which exist

for every type of paper supported by the system. These profiles contain color lookup tables (LUTs) of adjustment values that the printer driver uses to ensure that the printed hues turn out as authentically as possible on the paper you select.

The ICC profile usually controls the operating system’s color management module. In Windows, the settings can be found in the Color Management section of the Control Panel. A generic paper profile and ICC profiles for manufacturer’s own-brand papers are automatically installed when you install the printer driver, and profiles for third-party papers and high-end printers are usually available from the paper manufacturer’s website.

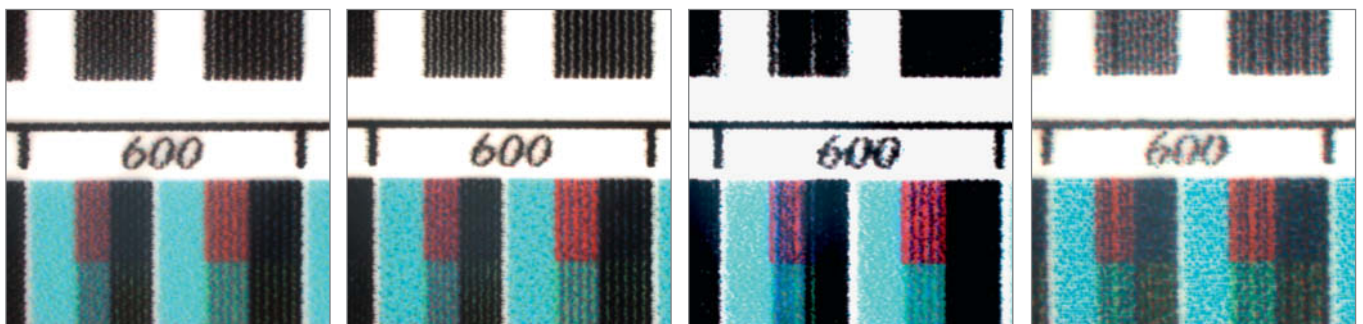
Canon offers its own profiles for its PIXMA PRO printers and a wide range of popular papers. We tested the Canon and Hahnemühle profiles with Hahnemühle German Etching 310 fine-art paper, and found that while the Canon profile produced stronger, more detailed blacks, the Hahnemühle profile produced more authentic colors.

The quality of an ICC profile depends on the size and degree of precision of its LUTs, and you can create your own profile for your favorite paper using a photospectrometer. Canon’s *Color Management Tool Pro* software (downloadable for free from the Canon website) can be used to calibrate Canon printers, and Epson offers its own free *ColorBase 2* software for calibrating the P600. The Epson software cannot, however, be used to create custom ICC profiles, and both programs only work with the ColorMunki and i1-series photometers from X-Rite. The Canon tool requires you to print a color target on your chosen paper and measure the resulting colors using the photometer. It then enters any discrepancies between the standard and measured colors in an LUT and saves it to a new ICC profile.

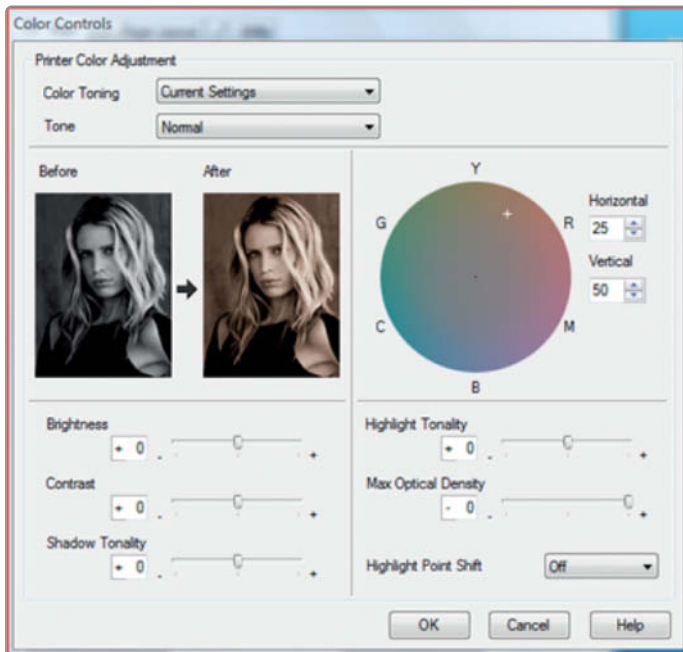
If you don’t wish to purchase a photometer or if the calibration process is too complicated, you can always use a Web-based service such as *printerprofilesonline.com* instead. All you have to do is print a target on your chosen paper and send it to the service provider, who then sends you a custom ICC profile. Typical profiles cost around \$100, but they vary from provider to provider and according to the number of color fields in the target (the more fields, the more precise the results will be).

Hard- and Software

The two Canon printers we tested are almost identically equipped and handling is the same too. Both have a rear tray for 150 sheets of paper up to 13” wide and a dedicated manual feed for thicker papers.



Canon’s PIXMA PRO printers offer extremely fine resolution that the Epson P600 can’t quite match. From left to right, these samples are from the PIXMA PRO-100, the PIXMA PRO-10, the Epson SureColor P600 and, as a comparison, Canon’s value PIXMA iP2700.



Tonality, optical density and the highlight point can all be precisely controlled in the Epson driver dialog, although there is only one generic image available for checking the effects of your settings



The Canon *Print Studio Pro* plug-in's 'pattern print' function enables you to print a sheet of thumbnails with varying color, brightness and contrast settings. This is a great aid to selecting the appropriate settings for a particular paper type.

The Epson SureColor P600's top-loading feeder can handle up to 120 sheets of 13" normal paper or 30 sheets of photo paper, while its front-loading manual sheet feed can handle paper up to 1.3 mm thick. Such media have to be aligned by hand and the feed activated using the printer's touch screen controls. For media up to 0.7 mm thick, the P600 feeds finished prints into the single sheet feed holder, whereas thicker media are fed directly out the back of the device, so you have to make sure you have enough space behind the printer to catch your work.

The Canon printers can only print the paper formats listed in the device driver, whereas the Epson P600 can also print on roll paper up to 13" wide using the holders supplied with the device.

The P600 has a tiltable 2.7" touch screen control panel and three large buttons. The menu displays remaining ink levels and tips for loading custom media and also includes settings for a Wi-Fi connection and switching between photo and matte black modes.

The Canon printers have just three buttons: ON, RESUME/CANCEL and Wi-Fi for automatic WPS-based network setup. The lack of a monitor makes some settings quite tricky – for example, to switch from Wi-Fi to LAN-based printing, you have to keep the RESUME button pressed until the LED in the power button blinks 11 times.

The Canon Printers have a USB socket on their front panels for direct printing from PictBridge-compatible cameras, but USB sticks are not supported (the lack of a monitor makes this impractical anyway). The P600 does not have the PictBridge-compatible USB connector that was included in the earlier Stylus Photo R3000.

Both PIXMA PRO printers are Apple AirPrint-compatible and can print borderless prints on compatible papers. The Google Cloud Print

feature included in 4.4 (KitKat) and later versions of Android requires you to install the *Canon Print Service* plug-in from the Play Store, which allows you to select custom paper type, format and setup settings. The free *Pixma Printing Solutions* app is also available for earlier versions of Android.

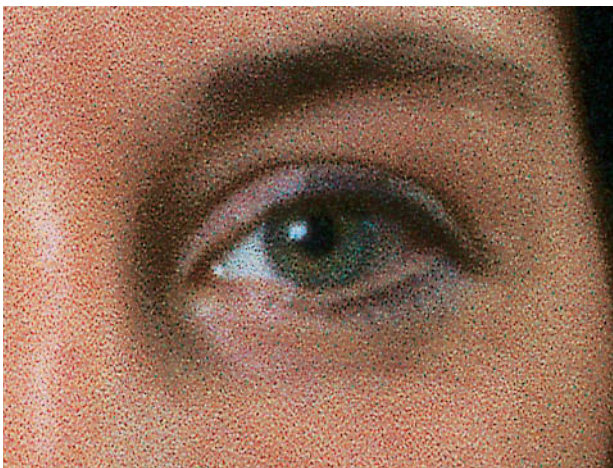
The P600 uses Epson's own Wi-Fi Direct functionality for connecting to mobile devices. The default setting in AirPrint creates borderless prints from Apple devices. The *Epson Print Enabler* plug-in for Android scaled our test photos incorrectly during our test, whereas the *iPrint* app for Android versions prior to 4.4 worked without any issues and offers more paper and print quality options than the newer app.

Results in Detail

All three test printers produced excellent quality borderless 13×19" prints using each manufacturer's own-brand luster paper and Canon's Pro Platinum and Epson's Premium glossy papers. They all produced bright, authentic-looking colors with great detail rendition and shadow detail. The PIXMA PRO-10 and the Epson both took 10 minutes or more to create a borderless 8.5×11" print, compared with the dye ink-based PIXMA PRO-100, which took only three and a half minutes to do the same job.

The Epson produced the most neutral monochrome grayscale tones and the deepest blacks, although these showed slightly less detail than those produced by both Canon printers. The PIXMA PRO-100 produced cool, almost blue-tinted grays, while the PRO-10 produced warmer

tones more in line with those of the Epson. For monochrome printing, the Color Controls dialog in the Epson driver offers a comprehensive range of settings for fine-tuning your results (see the screenshot on page 91).



Using additional ink cartridges enables you to produce finer color nuances than normal, and the raster effects they produce only become visible at high magnifications. From top to bottom, these details come from the PIXMA PRO-100, the PIXMA PRO-10 and the Epson P600.

The P600 and the PIXMA PRO-100 print borderless on normal paper, although the Canon only offers this option at its rather pale, stripy-looking 'Normal' quality level. At the 'High' setting, too, results from the PIXMA PRO-100 looked rather weak, and the results from the P600 showed slight vertical stripes. In contrast, the PIXMA PRO-10 prints at its highest possible quality on normal paper, but with a 0.5 cm border.

Both Canons print on fine-art paper with a broad border of at least 1", while the Epson's more flexible driver enabled us to make borderless prints on fine-art paper too.

Alongside its standard driver, Canon also offers the *Print Studio Pro* plug-in for *Photoshop (Elements)* and *Lightroom*. This useful piece of software combines the Canon and Adobe print options in a single easy-to-use interface and offers a few features of its own, including the 'pattern print' function that enables you to print a sheet of thumbnails with varying settings (see page 91, top right). For added clarity, the corresponding settings are printed beneath each thumbnail. *Print Studio Pro* adds real value for free, while *Mirage Small Studio v15*, a similar offering for Epson, costs around \$135.

The devices tested here are not really suitable for printing letters or other office-based tasks. Even in fast mode, the PIXMA PRO-100 takes two minutes to print 10 letter pages, while the P600 takes two and a half minutes and the PIXMA PRO-10 more than three. None of these devices offer duplex printing, although they do produce pin-sharp, laser-quality type when you need high-class results for important documents. For these types of jobs, the pigment inks used in the PIXMA PRO-10 and the SureColor P600 produce deeper blacks and more vivid colors on normal paper than the PRO-100's dye-based inks. For optimum results, use the P600's matte black cartridge and deactivate bidirectional printing for type.

All three can print appropriately coated CDs, DVDs and Blu-ray discs using the supplied templates, which are inserted between guides into the front of the Canon machines and into the single sheet feeder on the Epson.

For printing CD labels, Canon supplies its *My Image Garden* software, which has virtually no user-adjustable settings. The print area cannot be altered, although the default *Standard disc 4.7" (small inner circle)* setting prints all the way up to the margin around the hole in the middle of the disc and leaves a 3mm margin at the outer edge. Epson supplies its own *Print CD* software, with which you can alter the print area to suit your own particular needs.

The PIXMA PRO-10 delivered excellent quality CD prints, but the PRO-100 produced results with an obvious green cast in grayscale image areas. Checking the auto color correction option alleviated the problem but did not eliminate it. The Epson delivered good color rendition but quite a coarse raster in our sample CDs.

Conclusions

All three printers offer extremely high-quality results and a wide range of options for tweaking the look of your prints. The cheaper PIXMA PRO-100 is faster than the other two, but it is worth investing in the more expensive PIXMA PRO-10 or the Epson P600 if you plan to exhibit your prints or hang them on your walls at home, as the pigment inks these two devices use offer better color stability and print longevity.

If your work involves printing on unusually thick paper or roll media, the Epson is the best choice. The Canon printers cannot feed thick paper without bending it, so they cannot print on papers with a thickness of 0.6 mm or more.

If you need to make even larger prints, check out the Epson SureColor P800, which can print up to 17" wide and costs about \$1,200. (rop)

HIGH-END PHOTO PRINTERS

Device	PIXMA PRO-100	PIXMA PRO-10	SureColor P600
			
Manufacturer	Canon (www.canon.com)	Canon (www.canon.com)	Epson (www.epson.com)
Printing			
Print technology	Bubble Jet, 8 × 768 nozzles	Bubble Jet, 10 × 768 nozzles	Piezoelectric, 8 × 180 nozzles
Number of cartridges	8 (ChromaLife100+ dye-based)	10 (9 LUCIA pigment inks + Chroma Optimizer)	9 (Ultrachrome HDR pigment inks)
Smallest droplet	3 pl	4 pl	2 pl
Max. photo resolution ¹	4800 × 2400 dpi	4800 × 2400 dpi	5760 × 1440 dpi
Paper weights	64 g/m ² ... 350 g/m ² , Single sheet feed max. thickness 0.6 mm	64 g/m ² ... 350 g/m ² , Single sheet feed max. thickness 0.6 mm	64 g/m ² ... 255 g/m ² (main tray), Single sheet feed max. thickness 1.3 mm
Paper feed	150 sheets of normal paper up to 13" wide (A3+), manual feed	150 sheets of normal paper up to 13" wide (A3+), manual feed	120 sheets of normal paper up to 13" wide (A3+), roll media holders, rear single sheet feed
Borderless printing	✓	✓	✓
Automatic duplex printing	–	–	–
CD printing	✓	✓	✓
Network and Cloud Functionality			
Network printing	✓	✓	✓
App	Pixma Printing Solutions (Android, iOS)	Pixma Printing Solutions (Android, iOS)	Epson iPrint (Android, iOS)
NFC	–	–	–
AirPrint / Android Print (Mopria)	✓ / ✓ (–)	✓ / ✓ (–)	✓ / ✓ (–)
Manufacturer Cloud service	IJ Cloud Printing Center	IJ Cloud Printing Center	Epson Connect
Google Cloud Print	–	–	✓
Other Features			
Interfaces	USB 2.0, Ethernet, Wi-Fi (IEEE 802.11n, 2.4 GHz)	USB 2.0, Ethernet, Wi-Fi (IEEE 802.11n, 2.4 GHz)	USB 2.0, Ethernet, Wi-Fi (IEEE 802.11n, 2.4 GHz)
Dimensions in use (W × H × D)	27.2 × 8.5 × 15.2"	27.2 × 8.5 × 15.2"	24.2 × 32 × 16.6
Weight	43.2 lb	43.9 lb	35 lb
Monitor	–	–	6.8 cm touch screen
Windows drivers	Windows XP (SP3, 32 Bit) and later, .NET Framework 4 or 4.5 required Windows XP: XPS Essentials Pack required	Windows XP (SP3, 32 Bit) and later, .NET Framework 4 or 4.5 required Windows XP: XPS Essentials Pack required	Windows XP and later
Mac / Linux drivers	OS X 10.7.5 and later / –	OS X 10.7.5 and later / –	Mac OS 1.6.8 and later / –
Software	Print Studio Pro, My Image Garden, Quick Menu, IJ Network Tool	Print Studio Pro, My Image Garden, Quick Menu, IJ Network Tool	Epson Easy Photo Print, Print CD, Software Updater
PictBridge / DPOF	✓ / –	✓ / –	– / –
Ink Cartridges			
Black ²	CLI-42-ChromaLife100+: CLI-42BK (810 prints), CLI-42GY (452 prints), CLI-42LGY (855 prints)	PGI-72-LUCIA: PGI-72PBK (430 prints), PGI-72MBK (1100 prints), PGI-72GY (172 prints)	T760x Ultrachrome HD: T7601 (Photo Black), T7607 (Light-BK), T7608 (Matte Black), T7609 (Light Light Black)
Color ²	CLI-42C (484 prints), CLI-42M (410 prints), CLI-42Y (279 prints), CLI-42PC (269 prints), CLI-42PM (206 prints)	PGI-72C (452 prints), PGI-72M (685 prints), PGI-72Y (430 prints), PGI-72PC (346 prints), PGI-72PM (303 prints), PGI- 72R (1,000 prints), PGI-72CO (Chroma Optimizer, 181 prints)	T7602 (C), T7603 (M), T7604 (Y), T7605 (Light Cyan), T7606 (Light Magenta)
Cartridge capacity	13 ml	14 ml	25.9 ml
Price per ISO print ²	\$0.38	\$0.46	No ISO/IEC 29102 data available
Results and Ratings			
Power consumption	0.42 W (off), 1.2 W (standby), 16 W (print)	0.45 W (off), 1.3 W (standby), 16.4 W (print)	0.3 W (off), 1.4 W (sleep), 4.8 W (standby), 18.7 W (print)
Noise level	38.5 dB(A)	33.9 dB(A)	38dB(A)
Color deviation (ΔE)	Minimal: 0.7 (average: 6.1, max.: 29.3)	Minimal: 1.0 (average: 6.5, max.: 30.9)	Minimal: 0.5 (average: 6.2, max.: 24.9)
Text / Graphics printing	⊕ / ⊕	⊕⊕ / ⊕⊕	⊕⊕ / ⊕⊕
Photo print Color / Normal paper / B+W	⊕⊕ / ⊕ / ⊕	⊕⊕ / ⊕ / ⊕⊕	⊕⊕ / ○ / ⊕⊕
CD labels	⊕	⊕⊕	⊕
Color permanence Photo-/ Normal paper	⊕ / ○	⊕⊕ / ⊕	⊕⊕ / ⊕⊕
Manufacturer's guarantee	1 year	1 year	1 year
Current price	\$400	\$700	\$770
¹ Manufacturer's figures ² 6 × 4" prints made according to ISO/IEC29102, 29103			
⊕⊕ excellent ⊕ good ○ satisfactory ⊖ poor ⊖⊖ inadequate ✓ included – not included n/a not applicable			



Martin Vieten

Risk-free **Sharpening** and **Contrast Enhancement**

Without sharpening, digital images look dull and lifeless, with poor contrast and low detail rendition. Every digital image is sharpened – either in the camera immediately after shooting or later using dedicated tools on a computer. Photoshop’s Smart Filter technology is one of the most versatile sharpening tools available, and this article tells you all about how to apply it.



The unprocessed images that digital cameras capture are innately quite dull and often appear blurred. This is mainly because the sensor can only capture differences in brightness but cannot capture color data. There are various ways to combat this limitation, most commonly by inserting red, green and blue filters in front of each pixel, with half the pixels used to collect green color data and the other half split between red and blue. In order to create a full-color image from the data thus recorded, the camera's firmware (or a computer-based raw converter) has to interpolate the full range of color data for each pixel from that contained in the surrounding pixels, and the rounding errors involved in this process affect image sharpness.

The rules of optics are also partially responsible for variations in image sharpness. A lens can only reproduce points that lie on

the plane of focus with absolute sharpness, and the farther a point lies from the plane of focus, the less sharp it will appear in the final image. However, the ability of the human eye to resolve sharpness is limited, so a slight lack of sharpness in details that are close to the plane of focus is not usually visible. This means that the plane of focus is effectively transformed into a kind of three-dimensional focal space which is usually referred to as the "depth of focus" or "depth of field" in an image. How far this zone stretches in front of and behind the plane of focus depends on a number of factors, the most important of which is the aperture setting – the smaller the aperture, the greater the depth of field. The physics of light causes 'refraction blur' where light rays hit the edges of the aperture opening and prevent depth of field from stretching to infinity. This limits the optical resolution of the system in question, thus

reducing its effective (i.e., perceived) sharpness. Chromatic aberrations, another important factor affecting image sharpness, are caused by the variations in refraction produced by the lens for differing wavelengths of light. Fringing effects at high-contrast edges result, and these are often more pronounced at the edges of the frame than in the center. For completeness' sake, we also need to mention the motion blur that occurs when the camera or the subject moves during an exposure.

Sharpening can be performed either directly in the camera or later using computer-based image processing software such as Adobe *Photoshop*. The latter method offers two significant advantages over the former. The first is Smart Filter technology, which enables you to apply non-destructive adjustments to your images (i.e., you can alter or reverse your changes at any time), and lets

you limit sharpening to precisely selected image areas too. ‘Optimum’ sharpening is a matter of taste, and only the photographer can decide how much or how little to sharpen a photo.

Shooting raw is the best way to maximize your sharpening options. If your camera has no raw capture option or if shooting raw is too complex for you, you can make things easier by limiting the processing effects your camera applies automatically. Select a neutral image style and, if the option is available, reduce the amount of automatic sharpening in the camera menu. You can always sharpen an image later but you cannot undo oversharpening applied by the camera during a shoot.

Raw image files require three sharpening steps, whereas JPEGs require only two. The initial sharpening of a raw image that takes place during conversion in *Adobe Camera Raw (ACR)* or *Lightroom* doesn’t apply for JPEG files. Both programs automatically sharpen images during conversion, and although you can

regulate the effect, you can’t switch it off completely.

In the Detail panel in *ACR*, set an Amount value of 50-80 (the default value of 25 is too low for most subjects) and leave the Radius value at its default 1.0. The Detail slider improves the overall sharpening effect, while the Masking slider is used to determine which image areas are left untouched by the settings you apply. Keeping the Alt key pressed while you move the Masking slider reveals precisely which areas will be affected.

Chromatic aberrations can be eliminated using the tools in the Lens Corrections panel. Select the Color tab and check the *Remove Chromatic Aberration* option before shift-clicking ‘Open Image’ to hand your file over to *Photoshop* as a Smart Object. In *Lightroom*, use the Photo > Edit In > Open as Smart Object in Photoshop command to achieve the same thing.

The next step (the first step for JPEG files) involves sharpening your subject to taste and, if necessary, altering microcontrast. The

workshop sections starting on page 98 explain in detail how to perform these steps. Once this is done, you need to sharpen your image for monitor viewing or print output. To create a copy in *Photoshop*, use the Image > Duplicate command and check the *Duplicate Merged Layers Only* option in the dialog that follows. Reduce the duplicate’s resolution using the Image > Image Size command (for example, 10×7 inches at 300 ppi for prints or 1920×1280 pixels and 96 ppi for presentation on a computer monitor). Generally accepted rules of thumb for sharpening using the Filter > Sharpen > Unsharp Mask tool involve setting an Amount value of less than ppi/2 and a Radius setting of ppi/200. In other words, if you wish to print an image at 300 ppi, set Amount to 150% and Radius to 1.5 pixels. The equivalent settings for viewing on a standard 96 ppi monitor are 50% and 0.5 pixels. Always set the Threshold value as low as possible and only increase it if your sharpening settings produce obvious noise or other artifacts. (tho)

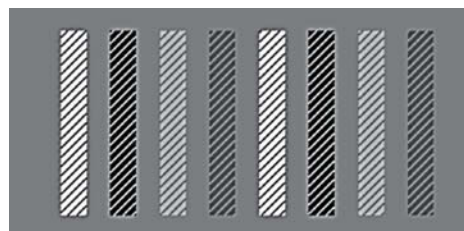
How Does Sharpening Work?

To achieve their effects, most sharpening tools increase the contrast at detail edges, thus emphasizing the contrast between light and dark elements. In *Photoshop* and other popular image processing programs, the most common way to do this is using the Unsharp Mask tool, which emulates an analog darkroom technique that subtracts a blurred copy of the image (or selected image details) from the original. In other words, the process of sharpening is really a local manipulation of tonal values that makes details seem sharper rather than actually adding image data.

The *Photoshop* Unsharp Mask tool offers Amount, Radius and Threshold settings. The Amount value determines the percentage by which edge contrast is to be increased, the Radius value (denoted in pixels) regulates the width of the area in which contrast is increased and the Threshold value is used to determine the degree of edge contrast that is necessary for a detail to be

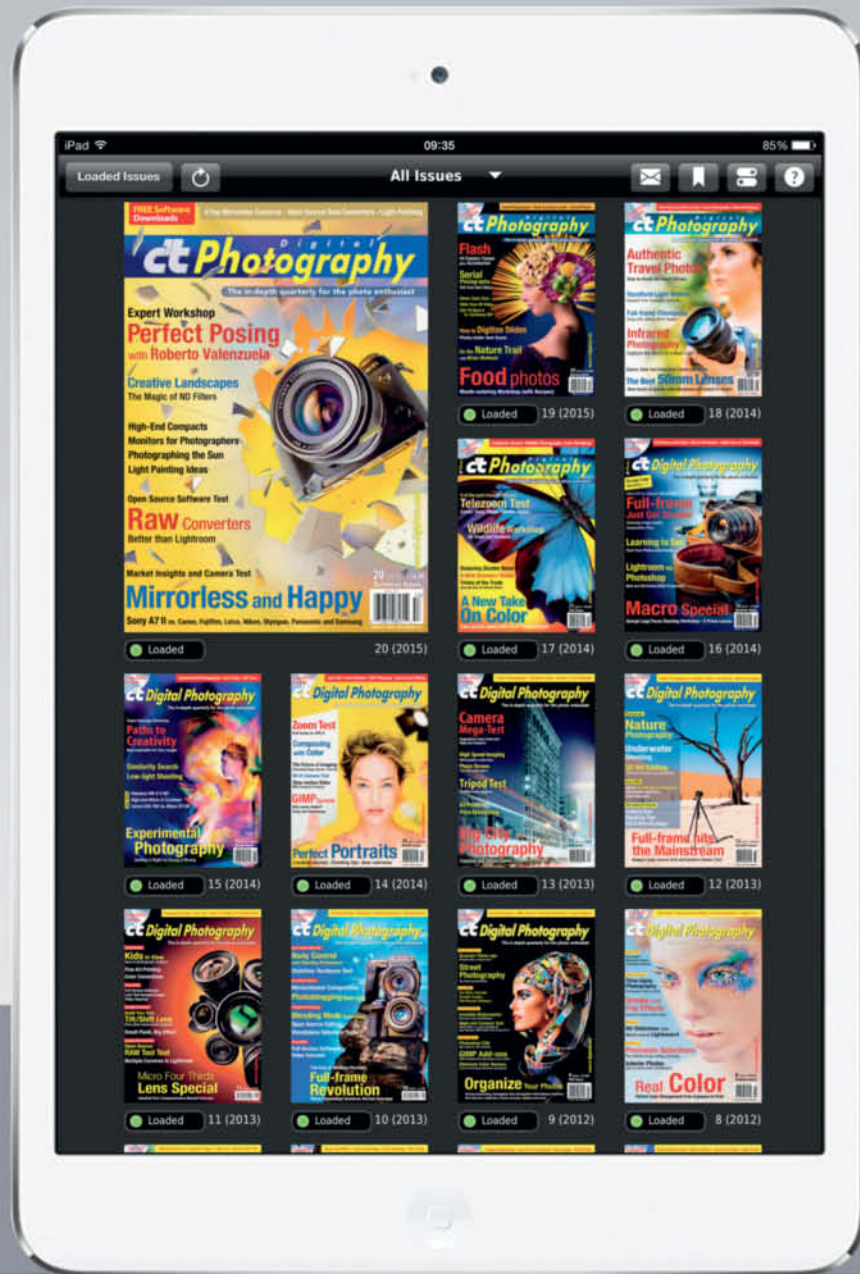
included in the sharpening process. The most obvious disadvantage of this approach is that it produces additional light or dark fringing artifacts. This effect can be reduced by using a low Radius value and a high Amount setting. Other existing artifacts, such as noise, are emphasized by additional sharpening, although these can be attenuated by using a higher Threshold value. The only disadvantage in this case is that fine image details are no longer sharpened along with the rest of the image.

For everyday sharpening purposes, we recommend that you use relatively high Amount and low Radius values. The reverse – using a low Amount value of 30-50 and a high Radius value of 25-40 increases microcontrast in a similar way to the Clarity sliders in *ACR* and *Lightroom*. A second application of the Unsharp Mask filter using these kinds of settings often makes an image noticeably sharper.



Sharpening an image involves increasing contrast at the edges of details (right) and makes the new version of the image appear sharper than the original. The downside of this process is that it often produces visible fringing artifacts.

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Using Unsharp Mask as a Smart Filter

Sharpening at the post-processing stage is all about increasing visual sharpness without creating additional artifacts such as halos or noise. It is always a good idea to apply Photoshop filters as Smart Filters, as this enables you to adjust or undo an effect at any time, while masks and blend modes give you a wide range of options for fine-tuning your effects and applying them to selected areas only. Smart Filter technology has been available since the release of Photoshop CS3 and the screenshots here were made using Photoshop CC 2014.

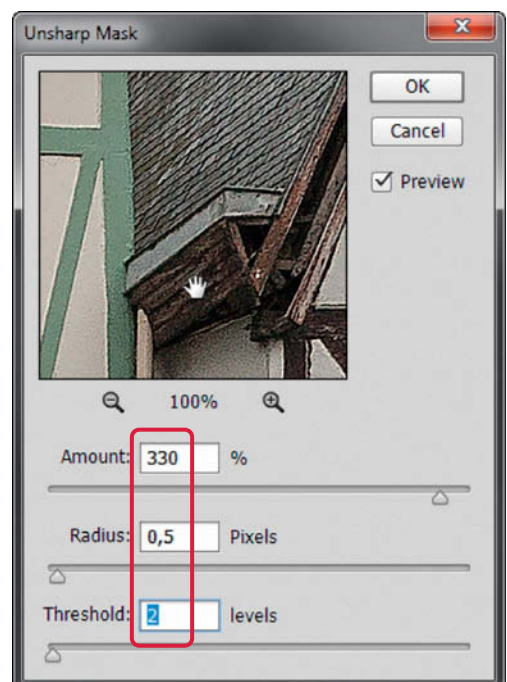
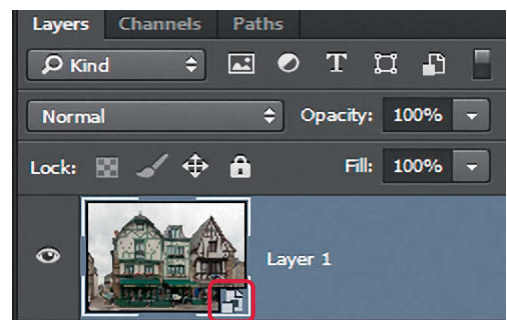
1 | How to use Smart Filters: Open your file using the File > Open as Smart Object command or, if it is already open, convert it using the Filter > Convert for Smart Filters command. In *Adobe Camera Raw (ACR)*, click the 'Open Object' button at bottom right of the program window. If the button is labeled 'Open Image', press the shift key to convert its action to 'Open Object' before clicking it. To open a file as a Smart Object from *Lightroom*, use the Photo > Edit In > Open as Smart Object in Photoshop command. Smart Objects can be identified in the *Photoshop* interface by the icon at the bottom right-hand corner of the thumbnail in the Layers panel (see the screenshot on the right).

It is essential to check image sharpness at 100% magnification, as one pixel in the original file is then equivalent to one pixel on the monitor. To switch to the 100% view, either double-click the Zoom tool icon at the bottom of the toolbar or use the *Ctrl+Alt+0* shortcut. If you are using an ultra-high-resolution monitor, use the *Ctrl++* keystroke to switch to a 200% view. To view the entire image, use either *Ctrl+0* or double-click the Hand tool.

2 | Accentuate details: Begin by accentuating the finer details in your image. In our sample image these are the roof tiles and the textures in the plaster on the house walls and the wooden beams. Use the Filter > Sharpen > Unsharp Mask command to open the Unsharp Mask filter and set a Radius value of less than 1 pixel with a high Amount value (in our example 330%) to achieve extremely finely nuanced results.

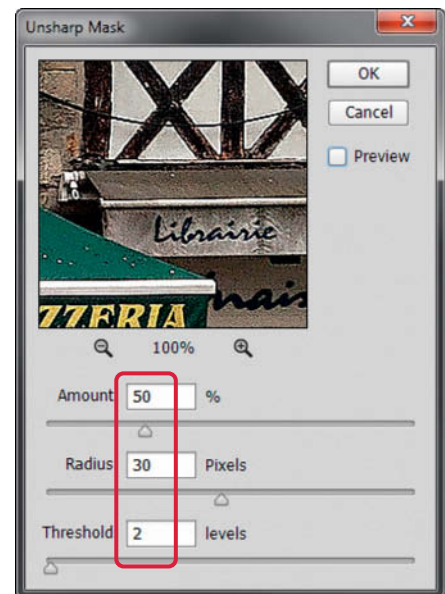
The Threshold slider determines the fineness of the details that are affected by the sharpening process. Increase the value as far as you can without producing additional visible noise. In our example, a value of 2 produces the best result.

The preview image in the tool window shows a center detail by default, but you can move the image around by dragging it with the Hand tool that automatically appears when you move the cursor over the preview image.

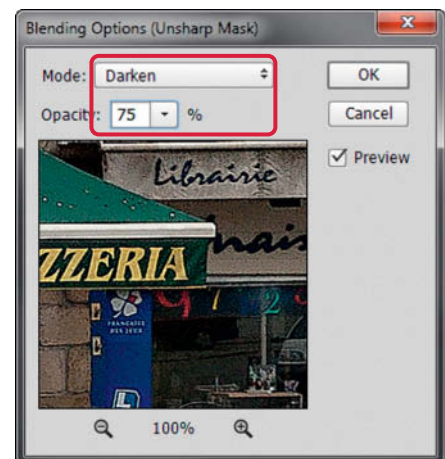


- 3 | Improve microcontrast:** Our sample image was captured in very diffuse light and shows little contrast as a result. To improve this situation, we used the Unsharp Mask filter again. In this case, we set a low Amount and a higher Radius value. The Screenshot shows the 50% and 30-pixel settings we used.

To better judge the results of your changes, switch the preview image off. This returns the main image window to its original state so that you can compare it directly with the preview in the filter window. This clearly shows how strongly image contrast is increased. The downside of this effect is that it reduces detail sharpness in the highlights (in our sample image, at the bright edge of the marquee). The word 'Librairie' is now surrounded by a bright fringe that didn't exist before. But never fear – we will tackle these issues later on. For now, click 'OK' to continue.

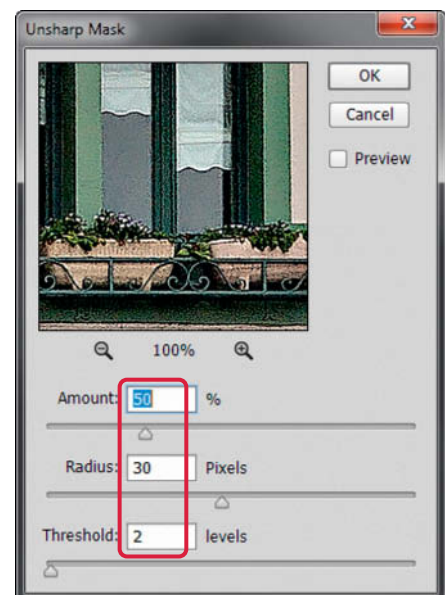


- 4 | Switch the blend mode:** Our contrast correction has already achieved the right basic result, and only the highlights still look a little too 'hard'. The image would look better if we could apply our sharpening effect to the shadows and midtones too. To achieve this, double-click the blending options icon at the right-hand end of the Smart Filter entry in the Layers panel and switch Mode to Darken. This makes the highlights softer but emphasizes the shadows, which lose detail as a result. To counteract this, reduce opacity to 75% and check your results by unchecking the preview box.

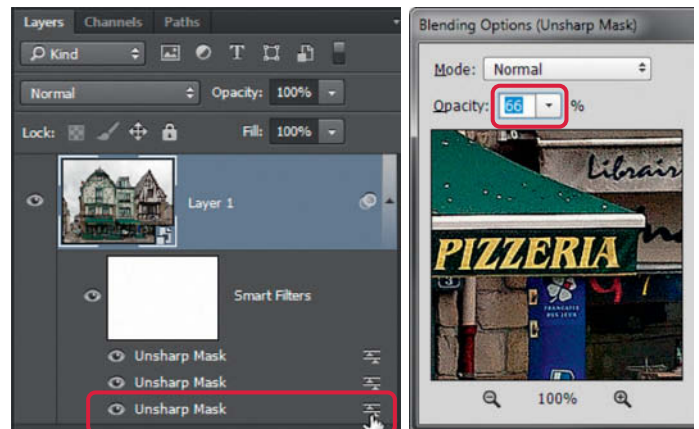


- 5 | Enhance brightness:** Shadow brightness, contrast and sharpness are now well balanced, but the highlights could still do with a touch more sharpness – just not as much as in step 3 above, before we changed the mode of the Smart Filter layer. To do this, re-open the Unsharp Mask filter (use the shortcut Ctrl+Alt+F to speed things up) and apply the same values as before, but this time switch Mode to Lighten and opacity to 25% to ensure that the effect is only applied gently to the highlights.

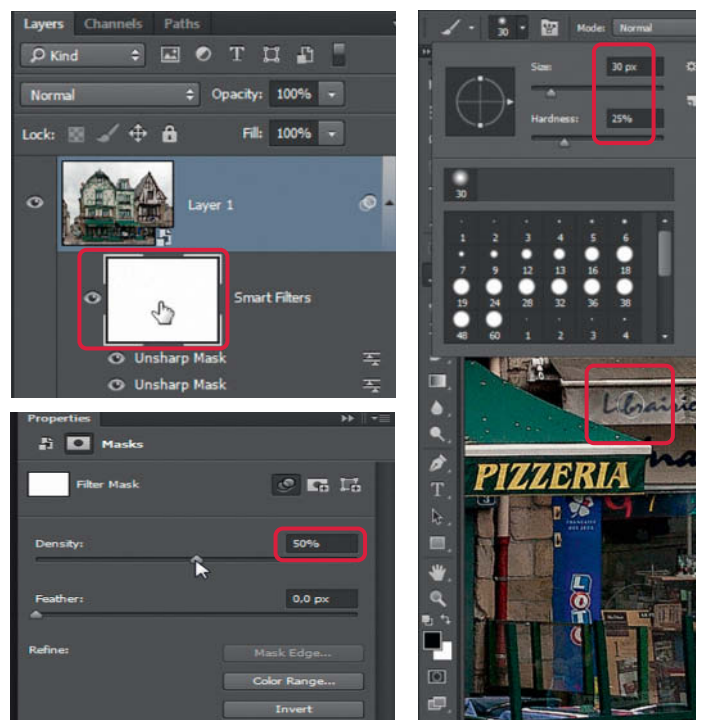
The last two layers we created enable us to apply the Unsharp Mask filter separately to the shadows and highlights. When performing this type of adjustment, it is better to use opacity settings on the Smart Filter layers that don't exceed 100%. Lower values are generally less critical.



6 | Optimize your settings: Our image now has three separate Unsharp Mask layers, with the most recent at the top of the stack. If you haven't yet achieved the result you are looking for in your own image, you can always experiment with the opacity and mode settings in all of your Smart Filter layers. In our example, there is still too much noise and there are too many sharpening artifacts. We combated this by reducing the opacity of the bottom layer (i.e., the basic sharpening layer) to 66%.

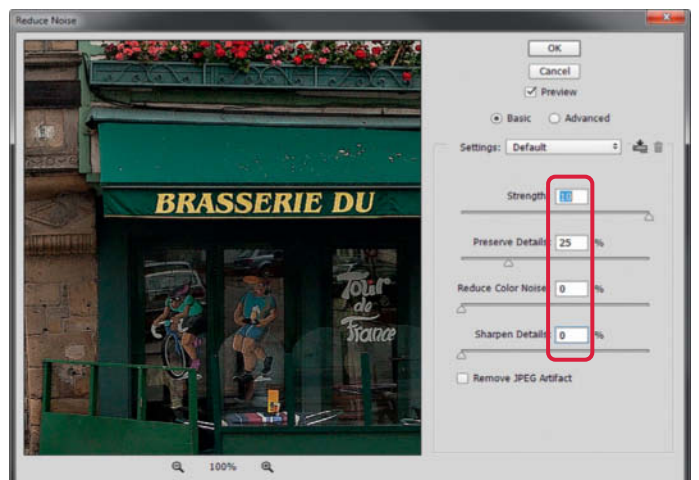


7 | Enhance contrast and sharpness: You may find that your image still shows some unwanted side effects in spite of all your attempts at balancing the highlight and shadow effects of the Unsharp Mask filter. In our example, the word 'Libraire' still has a bright fringe. To counteract this type of effect, you have to selectively reduce the sharpening effect in the areas where it produces unwanted artifacts. To do this, click on the (white) Smart Filter thumbnail and select a black brush either in the toolbox or by pressing the B key. We set the brush size to 30 pixels and set Hardness to 25% and used it to mask the affected areas of the marquee. You can adjust any other problem zones in your image in the same way. 100% black areas in the mask completely suppress the effect of the filter, whereas reducing the mask's Density in the Properties panel attenuates the effect while keeping it visible.



8 | Reduce noise levels: Sharpening tends to accentuate noise, especially in high-ISO images. If this is the case, you need to denoise your image too. Open the Filter > Noise > Reduce Noise dialog and make the following settings: Strength, 10; Preserve Details, 25%; Reduce Color Noise, 0%; Sharpen Details, 0%. Here too, you can attenuate the effect of the new filter by reducing its opacity.

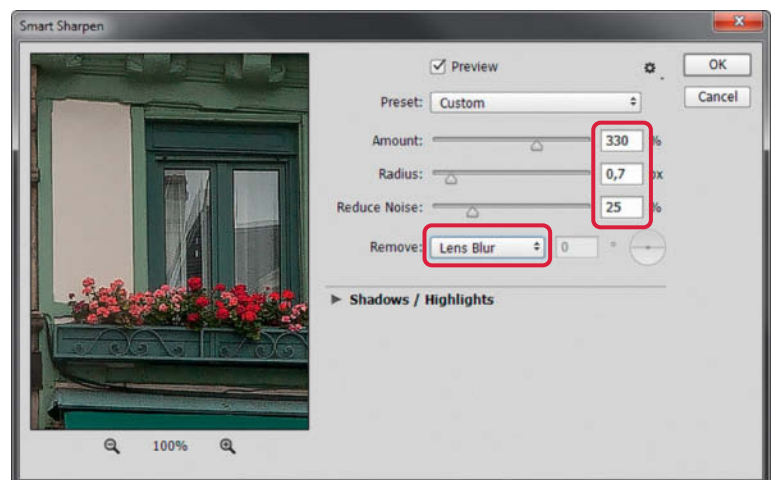
Quick Tip: In *Photoshop CS6* and later versions, Camera Raw can also be used as a Smart Filter (Filter > Camera Raw Filter), which makes it much easier to reduce image noise.



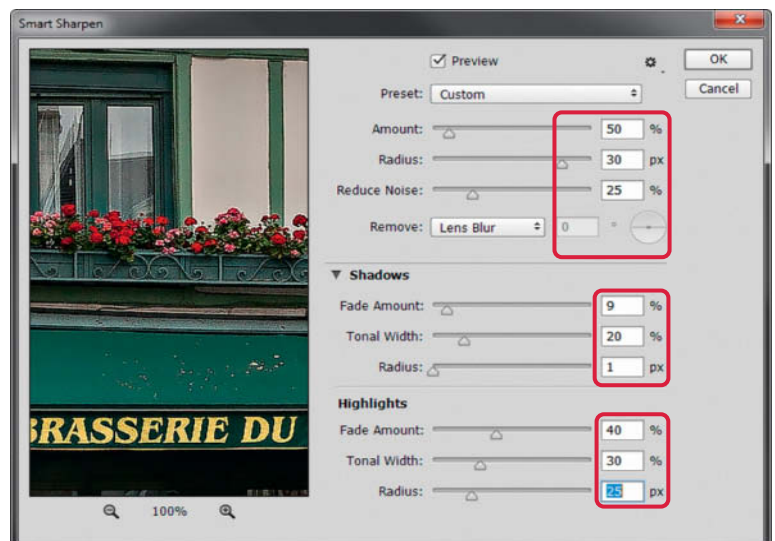
An Easy Way to Apply Selective Sharpening

The best way to achieve balanced sharpness and contrast corrections is to adjust shadows and highlights separately. Thanks to Smart Filter technology, even old-school filters like Unsharp Mask can be selectively applied. The Smart Sharpen filter in the CC version of Photoshop works even better than its earlier iterations.

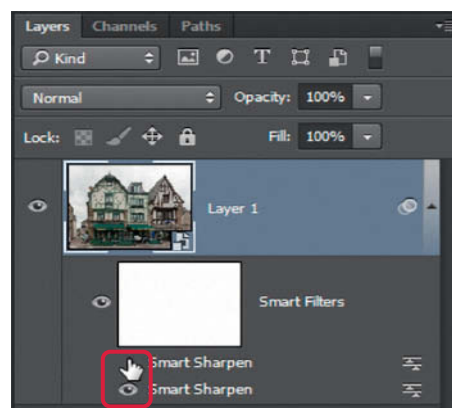
1 | Apply the Smart Sharpen filter: Begin by sharpening your image the normal way and, if necessary, transform it into a Smart Object (Filter > Convert for Smart Filters). Now navigate to Filter > Sharpen > Smart Sharpen. Unlike the Unsharp Mask window, the size of the Smart Sharpen window can be adjusted to give you a large preview image that is easier to work with. By default, the preview image is displayed at 100% magnification. Select Lens Blur in the Remove drop-down menu, set an Amount value of 320% and set the Radius to 0.7 px. Instead of a Threshold slider, Smart Sharpen has a Reduce Noise slider which we set to 25% in our example.



2 | Improve contrast: To improve the contrast in your sharpened image, open the Smart Sharpen filter again (Ctrl+Alt+F) but this time, set the Amount to 50% and the Radius to 30 px. These settings accentuate the highlights too much, but you can counteract this effect directly within the filter dialog using the additional Shadows/Highlights sliders. To protect the darkest shadows from the effects of the filter, set Fade Amount to 9%, Tonal Width to 20% and Radius to 1 px. More importantly, you need to adjust the highlight effect. For our sample image, we set values of 40%, 30% and 25 px.



3 | Compare your results with the original: To check the effect of a Smart Filter, click the eye icon in its Layers panel entry to toggle it on and off. *Photoshop* takes quite a while to apply Smart Sharpen adjustments, so subtle adjustments aren't always immediately obvious. Once again, you can lessen the effect of any Smart Filter layer by reducing its opacity. This is often a lot simpler than readjusting the filter settings.





Audio

- Analog
- Digital
- Input
- Mic Power
- Headphone
- Headphone
- Speaker
- Beep, tone

Movie

- Bit Rate (CBR)
- REC key
- Gradual Exposure
- FPS override
- HDR video
- Vignetting
- Image Fine-tune
- Creative Effect
- Movie Tweaks

Expo

- White Balance
- ISO
- Shutter
- Aperture
- Picture Style
- Expo. Lock
- Expo. Preset
- Expo. Override
- ExpSim

Overlay

- Global Draw
- Zebras
- Focus Peak
- Magic Zoom
- Cropmarks
- Ghost image
- Spotmeter
- False color
- Histogram
- Waveform
- Vectorscope

Shoot

- Advanced
- This feature
- OFF
- OFF

Change H.264 bitrate. Be careful, recording may stop!
This feature only works in movie mode.

Adjust Kelvin white balance and GM/BA WBSHift.
Advanced: WBSHift, RGB multipliers, Push-button WB...

Enable/disable ML overlay graphics (zebra, crop)
OFF / LiveView / QuickReview / ON, all modes.



Audio

- Beep, te
- Speaker
- Headphone
- Headphone
- Headphone
- Input
- Digital
- Analog

MOVIE

- MOVIE Tweaks
- Creative Effect
- Image Fine-tune
- Vignetting
- HDR video
- FPS override
- Gradual Exposure
- REC key
- Bit Rate (CBR)

Expo

- ExpSim
- Expo. Overri
- Expo. Preset
- Expo. Lock
- Picture Style
- Aperture
- Shutter
- ISO
- White Balance

Overlay

- Vectorscope
- Waveform
- Histogram
- False color
- Spotmeter
- Ghost image
- Cropmarks
- Magic Zoom
- Focus Peak
- Zebras
- Global Draw

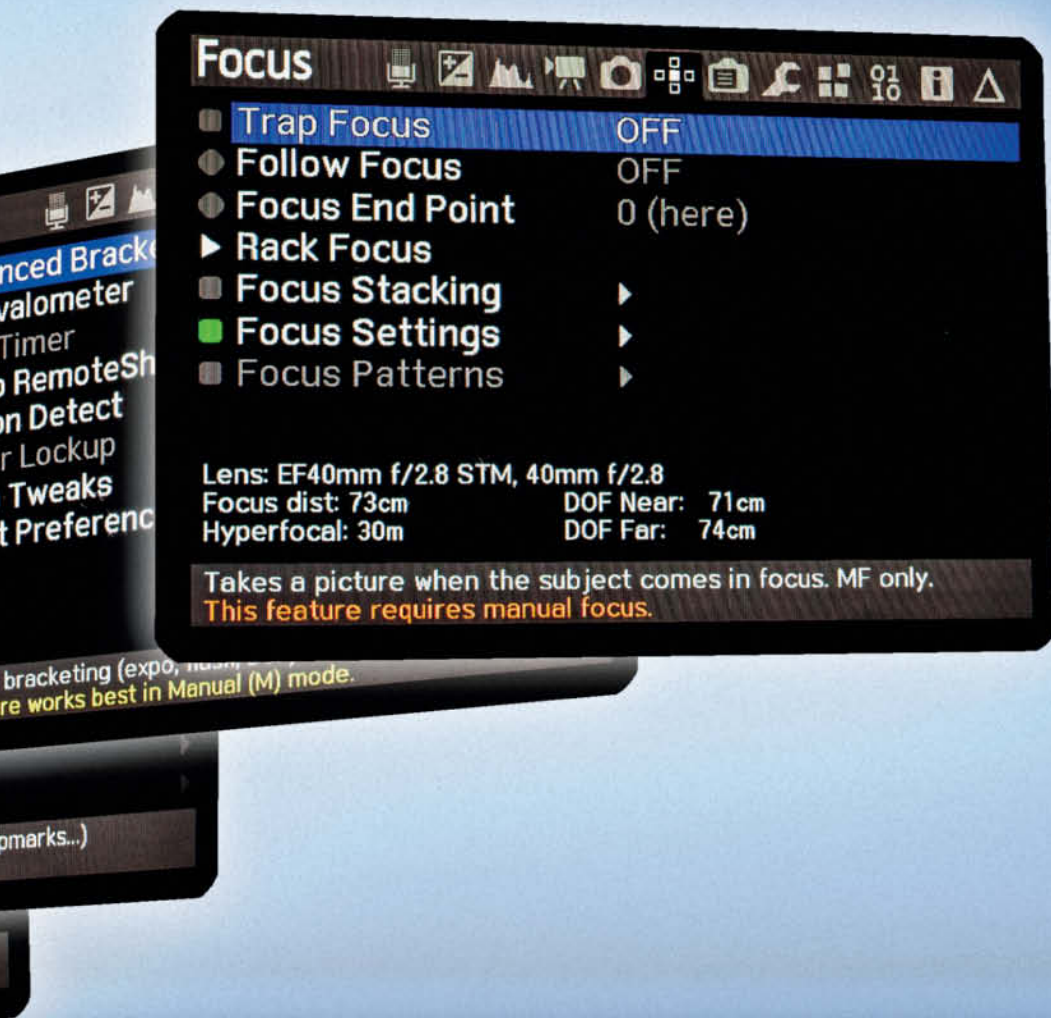
Shoot

- This feature
- Advanced
- OFF
- OFF

Change H.264 bitrate. Be careful, recording may stop!
This feature only works in movie mode.

Adjust Kelvin white balance and GM/BA WBSHift.
Advanced: WBSHift, RGB multipliers, Push-button WB...

Enable/disable ML overlay graphics (zebra, cro)
OFF / LiveView / QuickReview / ON, all modes.



Martin Schwabe

Tweak Your Canon DSLR with Magic Lantern

Focus Stacking, Trap Focus and Magic Zoom are all features that some Canon cameras have but that you can't use unless you unlock them using the free Magic Lantern firmware add-on. A clever piece of software that incorporates a host of additional photo and video functions for a range of Canon DSLRs (and the mirrorless EOS M), it is simple to install, use and uninstall. This article explains how.

Have you ever been annoyed to discover that some of the features built in to your Canon DSLR have been disabled by the manufacturer for some inexplicable reason? Well fret no more! A group of clever programmers has discovered a back door unintentionally left open by Canon's engineers that makes it possible to enhance your camera's feature set to include functions it was never intended to have.

You can even inject your own code into your camera's firmware, and one of the developers associated with the group has created a module that enables you to play Arkanoid on your camera's monitor as the hours tick slowly by when you're out on a wildlife shoot.

This may all sound like a lot of fun, but it is actually highly professionally organized. Models such as the EOS 5D Mark II and the EOS

7D with *Magic Lantern* installed are often used to shoot pro-grade video in spite of the bugs and other faults in the original camera firmware. Increasing numbers of camera rental companies are installing the latest version of *Magic Lantern* in all their compatible EOS cameras. Thousands of adverts and TV shows have now been shot using camera equipped with the software. Read on to find out why it is so successful.

What is Magic Lantern?

Magic Lantern is often referred to as a hack, although this is not a strictly accurate description. Unlike the early hacks out of Russia that completely replaced the original firmware in the EOS Digital Rebel/300D, *Magic Lantern* utilizes a dormant interface to load additional code into the camera's RAM and run it parallel to the installed firmware.

The additional features and functions are saved on a memory card and loaded the same way as a firmware update, although they are written to the camera's RAM rather than its ROM. This subtle difference means that:

1. The existing firmware is not altered and the camera can be used normally, even when *Magic Lantern* is installed.

2. *Magic Lantern* can be completely uninstalled without leaving a trace and, if used properly, won't damage the camera in any way. But be warned: the software is not approved or endorsed by Canon in any way, and using it will probably void your warranty. If damage occurs, you alone are responsible.

In spite of its many benefits, *Magic Lantern* has drawbacks too, chief of which is that it only works with the specific camera model each version was designed for. Hard- and

software for new models with new signal processors have to be analyzed and new versions of the corresponding software written by willing developers. Additionally, the required interfaces have to be located and analyzed to find out if they can be exploited the same way as previous versions. This development process can take up to a year. There is still no final version of the software for EOS 7D, with its twin signal processors, even though the *Magic Lantern* team has been working on it for more than three years.

Before You Begin

It is essential to check that your camera is running the firmware version *Magic Lantern* was written for. If you attempt to load the software with the wrong firmware running, the installation will either simply not work or crash and leave your camera in an undefined state that you can only rectify by switching it off and removing the battery. This flushes the camera's RAM and removes any traces of the failed installation.

The software is available in stable releases and nightly builds for many of the supported

cameras. Stable releases are generally highly reliable, whereas nightly builds (equivalent to software beta versions) include new code and features that have not yet been thoroughly tested and can cause problems during everyday use of the camera.

Alpha builds are early releases that often include just a few basic functions or sometimes only a test pattern to check that the appropriate interface can be addressed. They can be dangerous to install if you are an inexperienced *Magic Lantern* user, so handle them with great care.

Compact Install

Once you have decided whether to run a stable release or a nightly build, you can save the corresponding ZIP file to your memory card. The filename includes the camera model, the version number and the date of the build. The software only requires about two megabytes of disk space so if you own multiple supported cameras, you can load the software for all of them onto a single memory card.

Although *Magic Lantern* utilizes the same firmware exploit as the CHDK (Canon Hacker Development Kit) compact camera hack, it is an independent project specially designed for use with Canon EOS DSLRs and the mirrorless EOS M



Magic Lantern Availability

The following cameras were supported as we went to press:

- EOS 5D Mark II
- EOS 5D Mark III
- EOS 6D
- EOS 7D
- EOS 50D
- EOS 60D

- EOS Rebel T1i/500D
- EOS Rebel T2i/550D
- EOS Rebel T3i/600D
- EOS Rebel T4i/650D
- EOS Rebel T5i/700D
- EOS Rebel T3/110D
- EOS M

Nightly builds that incorporate the latest changes to the main branch are available on a rolling basis for most of the models listed above.

Stable releases are no longer freely available from the project website, but a quick Web search for 'Magic Lantern stable release download' reveals a multitude of links to live sources.

All official downloads are available from <http://builds.magiclantern.fm/#/>

As well as the latest nightly builds, the download page offers earlier versions that have fewer features but are more stable. The official project forums are a great source of

information on the latest features and their stability:

<http://www.magiclantern.fm/forum/>

Facebook users who 'like' Magic Lantern receive regular updates on the latest project developments.

Installing and Uninstalling Magic Lantern

Depending on which camera you use, you need to prepare an SD or CF card for use with *Magic Lantern*. If possible use a freshly formatted card with no more than 32GB of memory, as larger cards sometimes have issues installing the software.

The rest of the procedure is a simple case of copying the contents of the *Magic Lantern* ZIP file (including the 'ML' folder) to the root folder of your memory card, charging your camera battery, switching the camera to manual (M) mode and powering it up.

To continue, navigate to your camera's 'Firmware' menu and continue as you would when installing a normal firmware update. The camera looks for a suitable file with the FIR filename extension and outputs an error message if it cannot find one.

Shortly after the update procedure starts, the camera monitor goes black briefly and

then displays a message that the memory card is now bootable.

This part of the process is necessary to enable the camera to load *Magic Lantern* into its RAM every time it is switched on without having to reinstall the software manually. After about 30 seconds, the SUCCESS message should appear in green type. The camera then displays messages telling you that the required files have been found and that a BOOTDISK flag has been enabled. This is the critical part of the mechanism that allows you to 'hack in' to the camera's internal software.

To complete installation, restart your camera. *Magic Lantern* is now available whenever you use *M*, *AV*, *Tv* or *P* modes. The software is automatically deactivated (but not uninstalled) if you select one of the camera's creative auto modes. Once you have taken

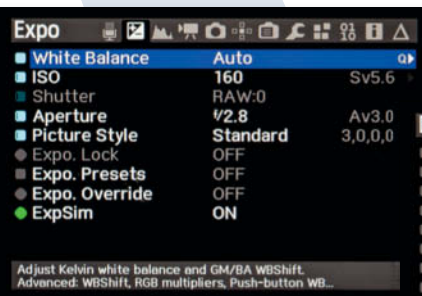
these steps, you can duplicate the card, and the software will work on cards with more than 32GB of memory.

Uninstalling Magic Lantern

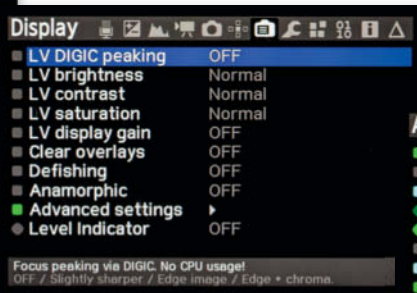
If you press the 'Q' (Quick Control) button while formatting your memory card, the displayed message switches from "Format Card, keep Magic Lantern" to "Format Card, remove Magic Lantern". Confirming this action by pressing 'OK' deletes all data from the memory card, deactivates the boot flag and removes *Magic Lantern* from the camera's RAM. At the next restart, the camera is restored to its original state.

It is always a good idea to uninstall the software if you have to send your camera to an authorized dealer for repairs or maintenance.

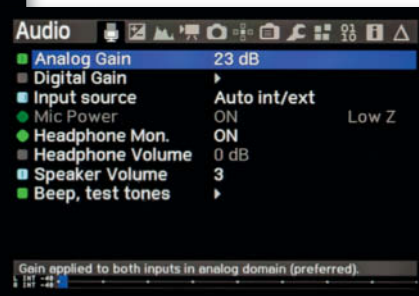
Menus and Nomenclature



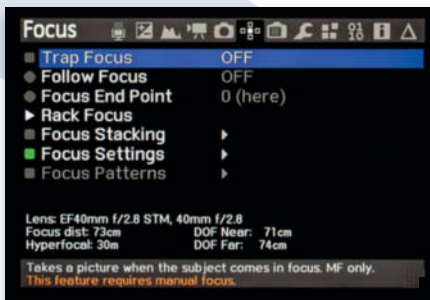
The Expo menu covers all major exposure parameters. The settings vary in their precision and granularity depending on which camera you use. In some cases, the software extends the range of operation of selected functions.



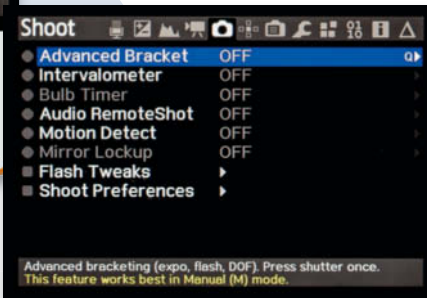
The Display tab is where you can configure the monitor display and the behavior of the framing and composition overlays. Most of the settings are designed for use in Live View mode.



The Audio tab enables you to fine-tune the camera's audio capture parameters. This function is most powerful when used with an external stereo microphone.



The Focus tools include functions like Trap Focus and Follow Focus that are sure to be of just as much interest to videographers as stills photographers



Shoot regulates automatic shutter release via audio or motion detection as well as time-lapse settings and advanced bracketing, giving you plenty of options for getting really creative

When you restart your camera following installation, it will display the normal start screen. After about 1 second of boot time, additional *Magic Lantern* messages appear at the foot of the monitor. These include the remaining battery power (expressed as a percentage rather than Canon's vague bars), a clock (which is more useful than you may think) and the space remaining on the memory card (expressed in gigabytes rather than the number of remaining shots).

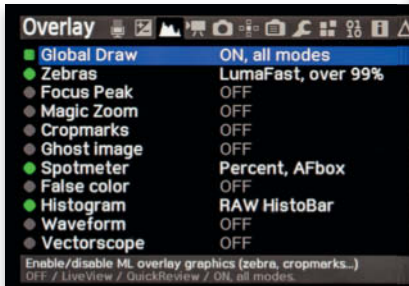
The software makes no changes to the Canon menu system and the *Magic Lantern* menus are called up by pressing the 'Erase' button, which you would not normally use except in an image playback context. To switch back to the camera's own menus, simply press the 'Erase' button again.

To squeeze as many items and as much subsidiary information as possible into the software's menus, the developers sometimes use much smaller typefaces than the familiar Canon ones, but once you know which menu items control which functions, you are sure to find that you can navigate mostly on 'autopilot' without having to actually read every menu entry.

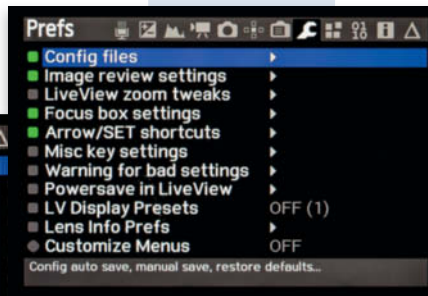
The Magic Lantern Menu System

The top row of the *Magic Lantern* menu consists of icons similar to those found in the conventional Canon menus, which denote tabs with themed groups of functions. The tabs are labeled Audio, Expo (exposure), Overlay, Movie, Shoot, Focus, Display, Prefs, Debug and Help.

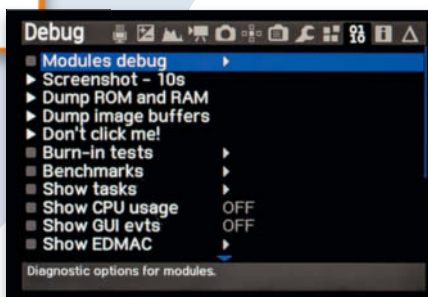
The main part of the display is taken up by the individual menu items, and each tab contains up to 12 items. The foot of the display is used to provide additional information and tips for the currently selected item. The left-hand side of the monitor is taken up by a row of icons that denote the current state of the items in the menu. A green dot means a function is switched on, bars like the signal strength display in a mobile phone show the current setting level for adjustable functions and arrows indicate the presence of sub-menus. The icon system is generally quite simple to use and is largely self-explanatory.



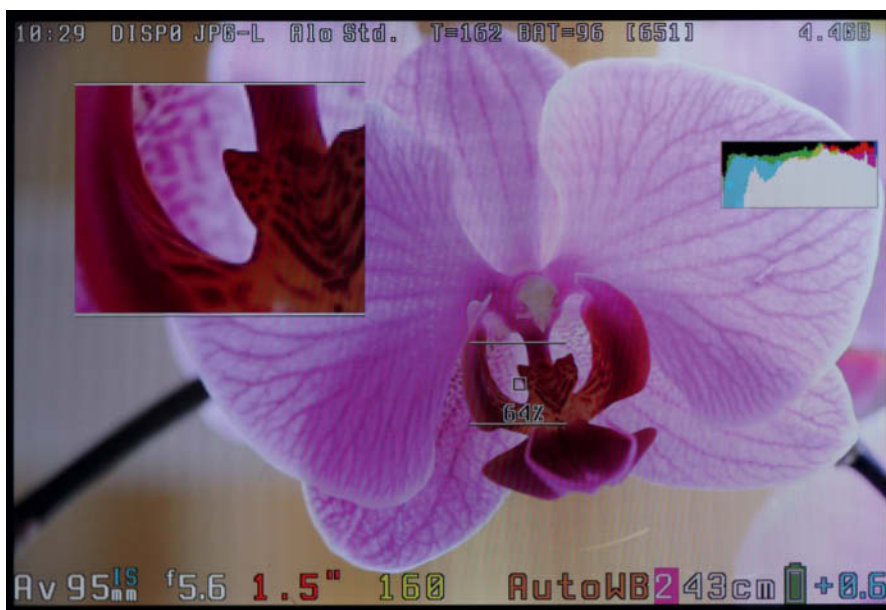
Overlay is for users who take the setup of their photos seriously. The tools on offer include extremely precise histograms, ghost images to aid alignment and various visual focusing aids.



Prefs includes all the basic settings for the software itself, including power saving, button configurations and menu customization



The Debug tab is full of tools to help you develop your own modules or test other people's beta modules



Magic Lantern enables you to add various overlays to the Live View display. These include comprehensive status messages, a permanent histogram and an extremely effective zoom/magnify tool that appears in a separate on-screen window.

To ensure that the *Magic Lantern* commands don't interfere with functions already controlled by the camera's buttons, its handling is not like the conventional Canon system. Additionally, because it is available for a wide range of cameras with varying menu systems, *Magic Lantern* functions differently from model to model.

The Main Dial, Quick Control Dial and Multi-controller are the backbone of the system. Once you have had a little practice, they make it quite simple to use.

The menu items themselves function in a similar way to the camera's own options. Some can only be switched on and off while others have a range of settings. Some functions also have wide-ranging sub-menus with additional user-controllable options. Menu items with sub-menus are indicated by an arrow icon to the left of the item description. To enter a sub-menu, simply press the 'Q' button. The sub-menus themselves work the same way as the main menus.

Keeping Track of Your Settings

The *Magic Lantern* menus and functions are extremely comprehensive and offer many more options than the camera's own system. Because many of the available functions override the camera's native settings, you need to think carefully about which functions you really need. If you are testing a particular function, it is always a good idea to switch it off immediately you have finished testing – otherwise, you will quickly lose track of the functions you have activated and the settings you have made.

Once you have spent a while experimenting, you are sure to find a range of

Magic Lantern settings that you would like to activate permanently as part of the basic configuration. To do this, switch the *Config* file option in the Prefs tab to *Save config now*. The same configuration will be loaded next time you power up your camera (provided, of course, that you use the same memory card). You can use this function to save different configurations to multiple memory cards – for example, to optimize the setup on one card for capturing video and on another for stills.

How to Get Help

Most versions of *Magic Lantern* have a comprehensive built-in user guide that you can access either by navigating to the Help tab or by hitting the INFO button with the appropriate menu item selected. The Key Shortcuts item in the Help menu offers a complete list of all the functions controlled by the camera's buttons when *Magic Lantern* is installed. This list covers all supported camera models.

Live View

Magic Lantern significantly alters the Live View display and uses all the available screen space to provide permanent displays of a number of major camera functions.

The uppermost line of data includes the clock, the monitor brightness setting, the file format and the amount of memory remaining, while the lower display offers a number of items that are much more useful than those included in the normal Canon Live View. The current focal length and shooting mode (P, Av, Tv or M) are also displayed. Colored entries for

the exposure time, aperture and ISO setting makes them much easier to read than the usual view. The white balance display includes a colored digit to indicate any compensation values you have dialed in, and the subject distance display is much more accurate and precise than the Canon version. To use the focal length and subject distance displays, you will need a lens with a CPU.

In Live View mode, *Magic Lantern's* greatest strength lies in the options it offers for the Live View image itself. The Display tab offers a huge range of functions and settings to aid manual focusing, setting the right exposure parameters and even image composition.

Using 'Zebras'

The 'zebras' are another really useful *Magic Lantern* feature. When it is activated, diagonally striped shading indicates potentially under- or overexposed image areas. You can set the color of the zebra display and the threshold value at which it kicks in. You can also opt to display a histogram with clipping warnings for the separate RGB channels – i.e., when colors tend toward oversaturation. The built-in spot meter can be set to take readings for a user-defined area.

As well as helping you to set the correct exposure, *Magic Lantern* offers a number of visual focusing aids. The Focus Peak display uses high-contrast lines to indicate the parts of the image area that are in sharp focus and, if the lens you are using has its own built-in motor, you can use the arrow keys or the multi-controller to set focus manually without touching the lens.

Focus Stacking

Macro photography gives you insights into fascinating and almost endless worlds of new and exciting subjects. However, all macro photographers have to deal with extremely shallow depth of field, a problem that can only be moderately alleviated by stopping the aperture down. Magic Lantern's Stack Focus function provides a useful solution to this well-known problem.

The idea behind focus stacking is simple and really effective: instead of capturing a single image with limited depth of field, you capture multiple images with different focal points and combine them to produce a single image with extended depth of field. All you have to do is select the distance at which you wish the focus sequence to begin and end and set the number of exposures you want it to contain. The result is a sequence of images in which the plane of focus shifts slightly between shots. Obviously, this technique only works for stationary subjects photographed using a tripod-mounted camera.

To shift focus between shots, you can use either a macro rail to shift the entire camera/lens combo (the lens is switched to manual and the focus setting remains the same throughout) or adjust focus manually using the focus ring. The focus ring method is not terribly accurate, so you will need mechanical assistance for it to work properly.

One way to do this is to connect your camera to a computer and use the *EOS Utility* software that is supplied free with all Canon DSLRs, which enables you to adjust focus in predefined steps using the mouse. This is a fine solution for use in a studio environment but is not practical when you are out and about.

Alterations to the exposure time have little effect on the results when you are shooting static subjects, so using Av (aperture-priority) mode is the best way to ensure consistent exposures. Set ISO to a fixed value (deactivate Auto ISO) and, to prevent color discrepancies between shots, make sure

that the WB (white balance) setting remains constant too.

Once you have everything set up, switch to the Focus tab in the *Magic Lantern* menu. Use the Multi-controller or the arrow buttons to select the *Stack focus* option and press the 'Q' button to open its sub-menu.



Use the arrow buttons in the Multi-controller to set the Focus End Point. It doesn't matter if you set a rough value that overshoots the exact end point a little.

Magic Lantern's Stack Focus Function

The *Stack focus* option in the Focus tab provides a set of useful tools for automating the focus stacking process without using a computer or any kind of remote release.

The two main menu items required for focus stacking are *Focus End Point* and *Stack focus* (see the illustrations on the right). Although the built-in user guide is a little vague regarding this function, the steps involved are actually quite simple.

Use the viewfinder to set up and prefocus your camera so that the subject distance and angle of view suit the subject, the focal length you are using and the magnification you wish to capture.

To ensure satisfactory results, it is essential to keep the aperture constant throughout the



Sub-menus are opened by pressing the 'Q' button and work the same way as main menus

The *Step Size* option determines the size of the focus increment between shots and offers values between 1 and 10. The value you select here also determines how many shots your sequence will contain. We found that values between 5 and 8 provide a good compromise between image quality and the number of images required to complete a sequence.

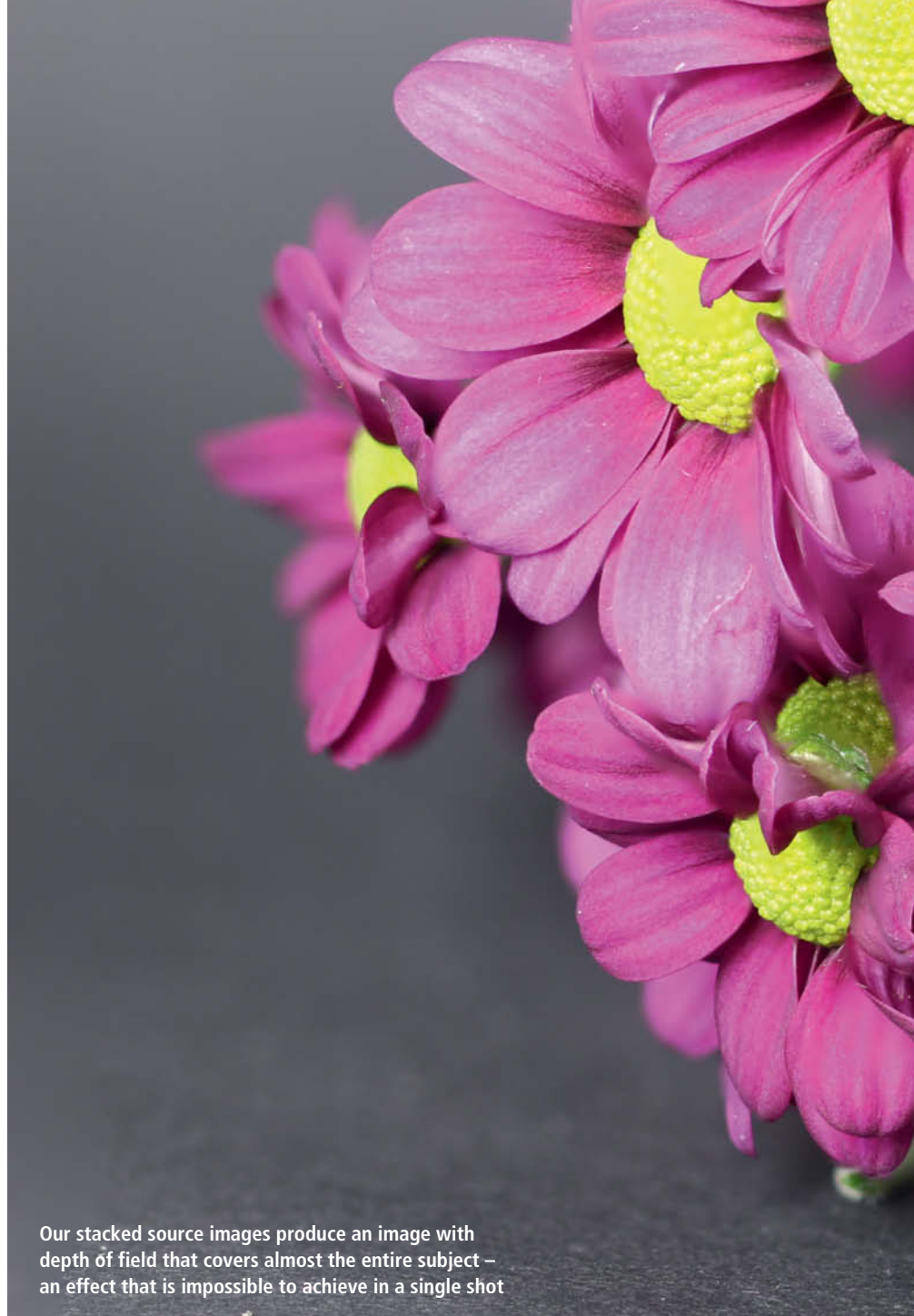
Trigger Mode determines which button you use to start the sequence – the *Take a pic* option means using the shutter button. This option makes sense if you are using a remote release, whereas *Press Play* is a better choice if you want to start the sequence by hand, as the Playback button's position reduces the likelihood of causing unwanted camera shake when you press it. Press the 'Q' button again to save your settings. The zero in the message "will take 0 pictures" changes to a number once you have defined a focus end point.

To get things rolling, you have to select a start point by selecting an appropriate AF point in the Live View image of your subject. You can then call up the Focus End Point function (still in Live View), whereupon *Magic Lantern* hides all text except the line "Focus End Point: 0 steps from here." Now use the arrow buttons or the Multi-controller to shift focus until it reaches your desired end point. You don't have to land exactly at your designated end point; a little overrun doesn't do any harm. The monitor readout increases according to the number of focus steps you have entered (see the upper illustration on page 109). Press SET to confirm your settings.

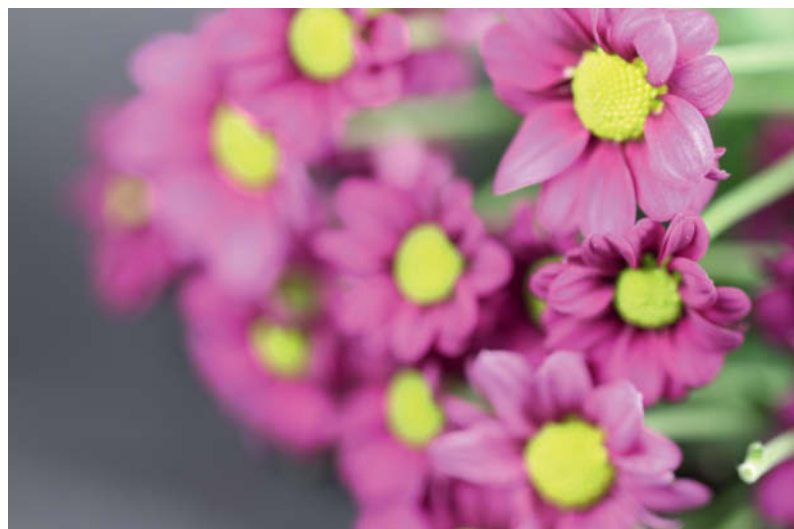
Once you are done, all that remains is to press the Playback button. The number of images the camera captures matches the number of steps to the focus end point.

Stacking the Results

To stack the images you have captured, you can either use free stacking software such as *Combine ZP* or a commercial program like *Photoshop*. In *Photoshop*, load your images using the File > Scripts > Load Files into Stack command and use the Edit > Auto-Align Layers command to eliminate any inconsistencies that may have arisen from the changes in focus distance. Finally, execute the Edit > Auto-Blend Layers command to merge your source images. The blending process can take anything from a few seconds to several minutes depending on the number of source images and the speed of your computer. You can then crop the final image as necessary and save it to the location of your choice.



Our stacked source images produce an image with depth of field that covers almost the entire subject – an effect that is impossible to achieve in a single shot



Our focus sequence begins at the tip of the closest petal ...



... and shifts rearward with each shot until ...



... we reach our predefined focus end point

Trap Focus, Focus Peak and Magic Zoom

Focus stacking requires patience, a stationary subject and an autofocus lens. The manual lenses, bellows units and reversing rings often required for macro photography make automated focus stacking impossible. But never fear – Magic Lantern has solutions for situations like these too.

The photo enthusiasts among *Magic Lantern's* developers have implemented a number of tools that simplify manual focusing, allowing you to capture more in-focus shots. Some of these can be used in conjunction with the viewfinder or Live View, whereas additional data displays mean that others only work in Live View mode.

Trap Focus

Many cameras have a focus priority autofocus setting that allows the shutter to release only if the subject is in focus at a preselected AF point. Trap Focus works on a similar principle. However, conventional focus-priority AF allows the camera to actively search for focus,

so you cannot control the distance at which focus locks and the shutter releases. Theoretically, you could set focus manually to a preset distance and wait until your subject appears sharp in the viewfinder, but this is difficult to execute and doesn't guarantee in-focus results.

To use Trap Focus, all you have to do is set focus manually to the required distance and press the shutter button. The camera then fires the shutter when the subject is in focus at the preset distance. This works by either moving the camera toward the subject or allowing the subject to approach the camera.

In addition to *Off*, the Trap Focus menu also offers *Continuous* and *Hold AF button* options. The first of these makes the camera shoot continually the moment focus is achieved and without the photographer having to intervene. The second requires you to press the shutter button halfway (or press the * or AF-ON button, depending on how your camera is set up). As soon as the camera registers focus at the preset distance, it fires the shutter once.

Trap Focus can be used with any lens that can be focused manually, whether it has its own CPU, no CPU or an AF confirm adapter. Note, however, that it works with any type of lens in Live View mode but cannot be used with fully manual lenses if you are using the viewfinder. Lenses with AF confirm adapters work fine in viewfinder mode.

Remember to deactivate Trap Focus at the end of your session. If you forget, you will probably end up wondering why your camera shoots apparently at random the next time you are out taking photos.

Focus Peak

All of the functions described so far leave the final assessment of subject sharpness to the camera. Depending on the AF points and the AF mode you select, you can specify the point you want to focus on more or less precisely, although the AF points are often not located exactly where you need them. In Live View mode, the focus area is often larger than the area covered by the subject. You can also focus manually in Live



Trap Focus makes it possible to focus precisely on moving subjects. The shutter is released automatically at the moment of maximum sharpness and reacts much faster than a human can.



In this shot, the shutter fired the moment the beetle's head reached the preset focus point

View, although it is extremely difficult to focus precisely with the monitor as your only guide.

The Focus Peak function (located in the Overlay tab) aids manual focusing by assessing contrast within the frame and displaying blinking dots where the subject is in focus so that you can precisely select the point at which you wish to set focus. The fact that the function also displays all other in-focus points is a useful side effect.

The Focus Peak sub-menu contains *Method*, *Threshold* and *Color* options. *Method* determines the algorithm used to distinguish in-focus areas from the rest of the frame. The *1st deriv.* option is optimized for low light situations and noisy images, while *2nd deriv.* works better in normal light. *Threshold* defines the percentage of pixels (between 0.1 and 5%) that have to be in focus for the peak display to kick in. *Color* does just what it says and alters the color of the peak display to help you keep it visible against different-colored subjects. The *Grayscale img* option switches the monitor image to black and white, which makes it easier to see the focus peak display against brightly colored subjects.

We recommend using a tripod when you use Focus Peak, as it is virtually impossible to keep the camera still enough to focus manually if you are shooting handheld.

Magic Zoom

Canon's own zoom function displays an enlarged detail that fills the entire monitor, so you cannot see the non-enlarged parts of the frame while you zoom. This makes shifting the enlarged detail while zoomed a hit-and-miss affair. Additionally, exposure metering is switched off while the image is zoomed and displays the values it recorded before zoom was activated.

Magic Zoom (also located in the Overlay tab) addresses these issues. Once you have selected it using the SET button, press the 'Q' button to reveal the function's options.

Trigger mode determines which action triggers the zoom display. *Always on* is a great option for photographers. *Zoom In (*)* triggers the function via the 'Magnify' button and *Half Shutter* when you press the shutter button halfway. *Focus Ring* only works with lenses that have a dedicated focus ring. You can also adjust the size of the zoomed detail and its position within the frame.



Especially with brightly colored subjects, the blinking dots displayed by the Focus Peak function are often easier to see if you switch the monitor image to grayscale. The photo itself is nevertheless captured in color.



Among other settings, Magic Zoom can display a permanently magnified detail while still displaying the rest of the monitor image

Focus Confirm

Magic Zoom includes a customizable focus confirm signal. *Split Screen* emulates the split circle in the center of the focusing

screen in analog reflex cameras. *Green Bars* is self-explanatory.

Focus Peak and other overlays are deactivated while Magic Zoom is in use.

HDR

High Dynamic Range (HDR) techniques come into play when the range of contrast in a subject exceeds the dynamic range of the camera's image sensor. If you capture a conventional image of such a high-contrast subject, some shadow and/or highlight detail will be lost.

An HDR image is constructed from a sequence of source images that together cover the entire dynamic range of the subject. Smart software is then used to discard the parts of each photo that are too dark or too bright and merge the rest to create a single image with extended dynamic range.

Canon cameras with DIGIC V and later processors have built-in HDR functionality, although it only has genuinely useful user-controllable settings in more expensive models like the EOS 5D Mark III and the EOS 7D Mark II. In general, the Canon function captures HDR sequences with up to three source images, which is often not enough to produce smooth results.

Although it cannot actually merge the source images, *Magic Lantern's* HDR function (located in the Shoot tab) is much more flexible than the Canon version and can write important parameters for the source images to a script that can be read and executed by the open source stacking software *enfuse*.

Using the Magic Lantern HDR Function

The HDR Bracketing Function is located at the top of the Shoot tab. Its sub-menu (press 'Q' to open) comprises the following options:

Frames determines the number of source images (2-9) and can be set to auto detect the appropriate number via the camera's exposure metering system.

EV increment defines the difference in exposure between shots in EV values from 0.5 to 5, where 1 EV is equivalent to 1 f-stop.

Sequence sets the sequence in which the source images are captured following the initial (correctly exposed) shot. You can choose between increasing (0 + ++), decreasing (0 - --) or alternating (0 - + -- ++). Alternating is best if you are shooting in P, Tv or Av mode. The other two are intended for use in M mode.

2-second delay delays firing the shutter to allow the camera shake caused by pressing the shutter button to dissipate.

ISO shifting is for use in M mode only. *Off* means that only the exposure time is altered while the aperture and ISO settings remain constant. *Half* means that half the source

images are shot with varying ISO values and the other half with varying exposure times. Setting the *Full* option captures a sequence in which only the ISO value changes.

Post scripts writes a script that can be used to automatically merge the source sequence using *enfuse*. There is also an option for automatically aligning the source images before merging.

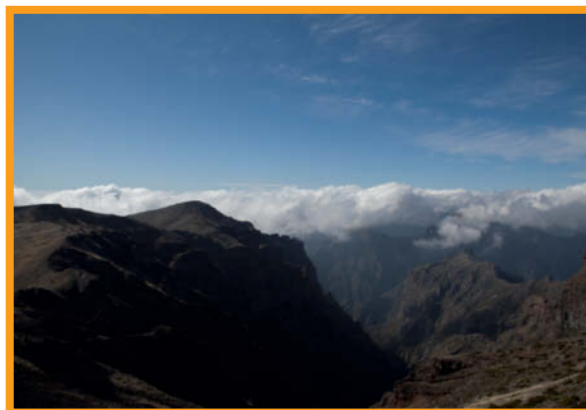
Frames and EV Increment

Beginners tend to assume that more source images means better results and end up selecting too many frames for their HDR

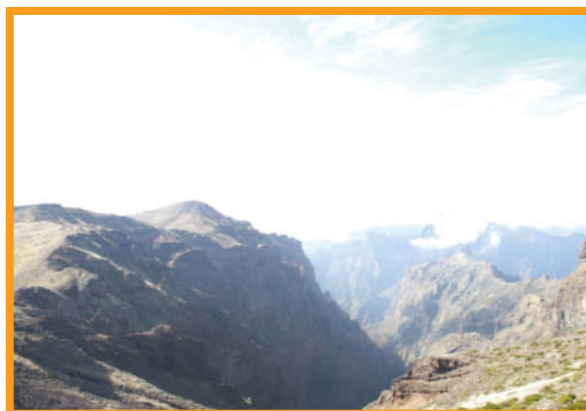
sequences. In fact, having too many images simply increases the amount of time and computing power (and the number of potential merging errors) required to merge the sequence together without necessarily providing more image data. The same is true if you select EV increments that are too large.

If you assume your camera's sensor has a typical dynamic range of about 10 stops, you can use the built-in exposure meter to calculate the number of exposures and the size of the EV increment required. To do this, switch to Spot metering mode, meter for the brightest and darkest points in your subject and note the results.

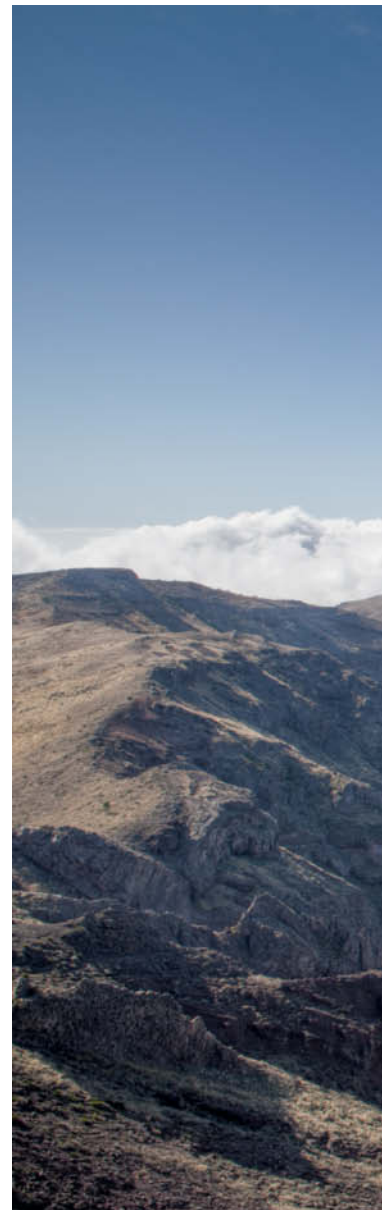
Let's look at an example. An evening cityscape requires an overall exposure time of 15 seconds, while the brightest details (street lamps, for example) require 1/500 second. Doubling the exposure time increases the overall exposure by 1 EV (i.e., 1 f-stop). Our



This version is underexposed and shows good highlight detail



This version is overexposed and displays sufficient shadow detail




sample scene therefore has a dynamic range of 14 stops and cannot be adequately captured in a single exposure.

To be on the safe side, you should normally shoot with one extra stop of exposure at each end of an HDR sequence, so our sample scene requires a total exposure range of 16 stops. Because our camera's sensor has a dynamic range of 10 stops, we need to shoot a sequence that adds 6 stops of exposure. If we shoot using an EV increment of 1, we need to shoot a total of seven source images (the 'correctly' exposed image plus three under- and three overexposed images) to be sure of capturing the entire dynamic range of the subject. If we increase the increment to 1.5, we only need to shoot five source images.

Obviously, you need to switch off all other variable shooting parameters such as Auto WB, Auto Picture Style and ALO (Auto Lighting

Optimizer) to prevent exposure or color discrepancies between shots. Once captured, you can merge your source images using *Photoshop*, *enfuse* or any other HDR-capable software.

HDR Preview

Although *Magic Lantern* cannot yet merge HDR source images, it can display an HDR preview. To do this, navigate to the Prefs tab and set the SET+Main Dial function to *Exposure Fusion*. Now switch to playback mode, select the first image in your sequence, press and hold the SET button and select the next photo in the sequence using the Main Dial. Repeat this step for as many source images as required. The monitor image shows a low-res preview of the final merged image so you can assess whether the sequence was successful or whether you need to re-shoot it. (keh) 

If the camera's hardware isn't capable of capturing the range of contrast in the subject in a single image, the solution is to capture multiple under- and overexposed shots and use HDR techniques to merge them into a single well-exposed image





George D. Lepp, Kathryn Vincent Lepp

Creative Panorama Techniques

George Lepp is renowned for his panorama expertise and specializes in creating new and unusual forms of this fascinating photographic style. In this workshop, he explains in detail the gear he uses and how he captures his wonderful images. Read on to learn all about action sequence panoramas, aerial panoramas, macro panoramas and more.



While it may appear that this baboon was playing in the water as it crossed a wetland in Botswana's Okavango Delta, in fact it was attempting to avoid contact with the cold winter stream and whatever predator might be lurking in it. Using every third frame of the 8fps capture sequence produced just the right distance between images of the animal, while careful panning yielded an overlapping and stitchable background. The images were composited using Adobe *Photoshop* and layer masks. Captured with a Canon EOS 7D and a 100-400mm lens set to 400mm.

Exposure for each of the seven images was ISO 250 | f11 | 1/750s

Those who photograph the grand views of nature are always in search of ways to convey this rich vision. Panoramic photography is a useful tool for portraying the broader view, but we can take it beyond the simple capture and assembly of a brief sequence of horizontal images that create a large, or long, photograph. Innovative panorama techniques yield images that tell a more complete, creative and compelling story, with plenty of content that engages the viewer for a longer time and details that emerge as delightful surprises. High-resolution composites and huge prints demand fine compositional features and meticulous capture technique if they are to stand up to close scrutiny. This article presents a variety of advanced approaches to panoramic photography that will help nature photographers to communicate

artistry, narrative and detailed information in their images.

Action Sequence Panoramas

We are constantly pursuing worthy themes for action sequence panoramas, which convey a moving subject's journey across time and space. I discovered this unique panorama technique completely by accident while photographing a baboon crossing a stream in Botswana, Africa. With the camera firing an uninterrupted sequence of images at 8 frames per second, I followed the baboon's trajectory as it scampered and jumped through the water while attempting to stay dry and avoid whatever crocodiles might be looking for a meal. At camp that night while editing the days' images, I noticed that the

baboon's 'water dance' was perfectly captured in the series and that I had held the camera so level as I panned with the action that each background overlapped; suddenly, I saw a panorama. I used every third image to create a composite that told the complete story of the baboon's water crossing. I later found in my files a number of similar sequences that, when composited into panoramas, revealed much more about the subject than any single image could.

It's important to make a distinction here between an action sequence panorama and a single-frame action sequence. The latter typically involves mounting the camera on a tripod, capturing a number of identically framed images of a moving subject, then compositing some or all of the images so that the subject is shown in different positions



Balloon over Bend, Oregon. This action sequence panorama was captured at an excruciatingly slow pace as a hot air balloon drifted peacefully before a backdrop of the Cascade mountain range. As I saw the balloon coming toward me I quickly added an intervalometer to my tripod-mounted camera and set it to fire every 10 seconds. All I had to do from that point was keep the balloon centered in the frame as each image was automatically captured. The camera had been leveled on the tripod, so it was fortunate that the balloon followed its gentle 'S' curve course that kept it within the upper and lower limits of the frame.

Canon EOS 5D Mark III, EF 100-400mm f/4.5-5.6 at 220mm | ISO 400 | 1/500s | f13 | Images composited in Photoshop CC 2014 using layer masks

within the frame. One might, for example, compose an image large enough to incorporate the complete arc of a playground swing, photograph it repeatedly as a child plays on it and then composite images of the child in different positions in the final image. The limitations of this approach are the constant background, the large frame needed to incorporate the range of movement and the resulting low

resolution and corresponding restricted print size. An action sequence panorama portrays the subject's action over a theoretically unlimited distance and the resulting composited file can be printed very large. I've successfully used this technique to photograph a variety of moving subjects such as running cheetahs, birds in flight, dogs competing in agility trials and hot-air balloons floating above the landscape.

The timing of the captures can be accomplished using a DSLR's sequence drive; most have a frame rate between four and twelve frames per second. Even slower drives are usable with most subjects because when the composite is created there needs to be space between each rendition of the subject so that they don't overlap or run into one another. It is imperative, however, that the series of images be captured at consistent,

A French poodle jumps two hurdles in an agility competition. This action sequence panorama was captured at 10 fps using a Canon EOS-1D Mark IV with an EF 70-200mm f/2.8 at 73mm. Every third image was used to compose the panorama.

All photos: ISO 800 | f11 | 1/1500s





uninterrupted intervals; do not lift your finger from the shutter button. In addition, be mindful of the need to overlap images sufficiently to create the panorama background. Because the final composition is a level, horizontal panorama, the subject's movement needs to pass before the camera in a roughly horizontal plane while remaining within the frame. Clearly, this aspect of the capture process is the random,

serendipitous part when working with animals and birds in the wild. When possible, I work from a tripod leveled to the horizon and follow the subject as it moves parallel to me. It is possible to capture panorama sequences handheld, as some of the examples here demonstrate, but the horizontal leveling must be maintained. For this reason, it is often useful to capture the sequence with some extra space above

and below the subject to allow for subsequent cropping.

For sequences of slow-moving subjects, such as the hot-air balloon featured here, an interval timer can be used to produce evenly-spaced captures at longer intervals such as those you might use for a time-lapse sequence. I always carry an intervalometer in my camera bag, and many newer cameras have interval shooting functionality built in.



Egret Flight Pattern. A single cattle egret in flight is photographed with a handheld Canon EOS-1D Mark IV. The composite, created using layer masks in *Photoshop CC 2014*, uses every third image of the series captured at 10fps.

Canon EOS-1D Mark IV and an EF 500mm f/4L telephoto set to ISO 800 | f11 | 1/2000 s

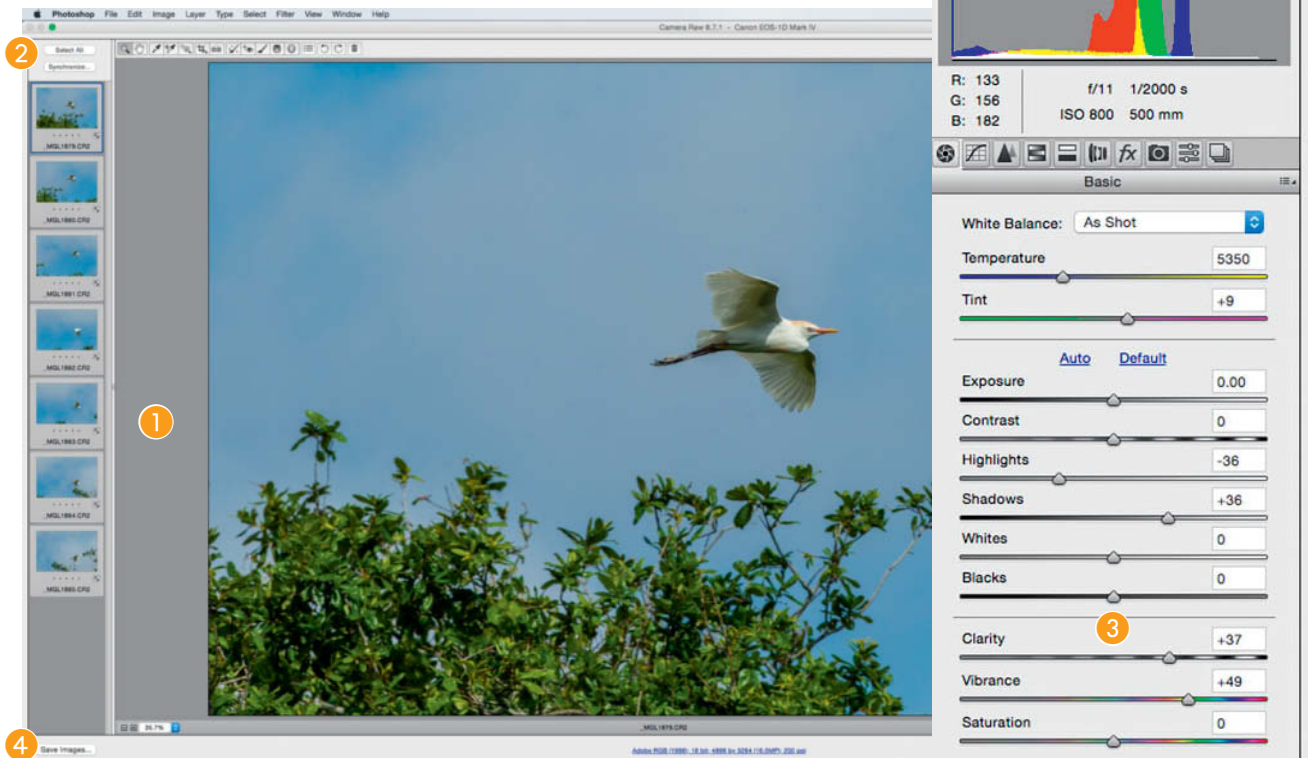
Assembling Panoramas using Layer Masks

Assembling an action sequence panorama is a manual exercise. I use layer masks in *Photoshop* to composite the final image and do some minor positional adjustments of the repeating subject. This tutorial will give you insight into a simple *Photoshop* technique that can be applied to a great variety of projects. And what you learn in post-capture will help you to plan better for your next photography session in the field.

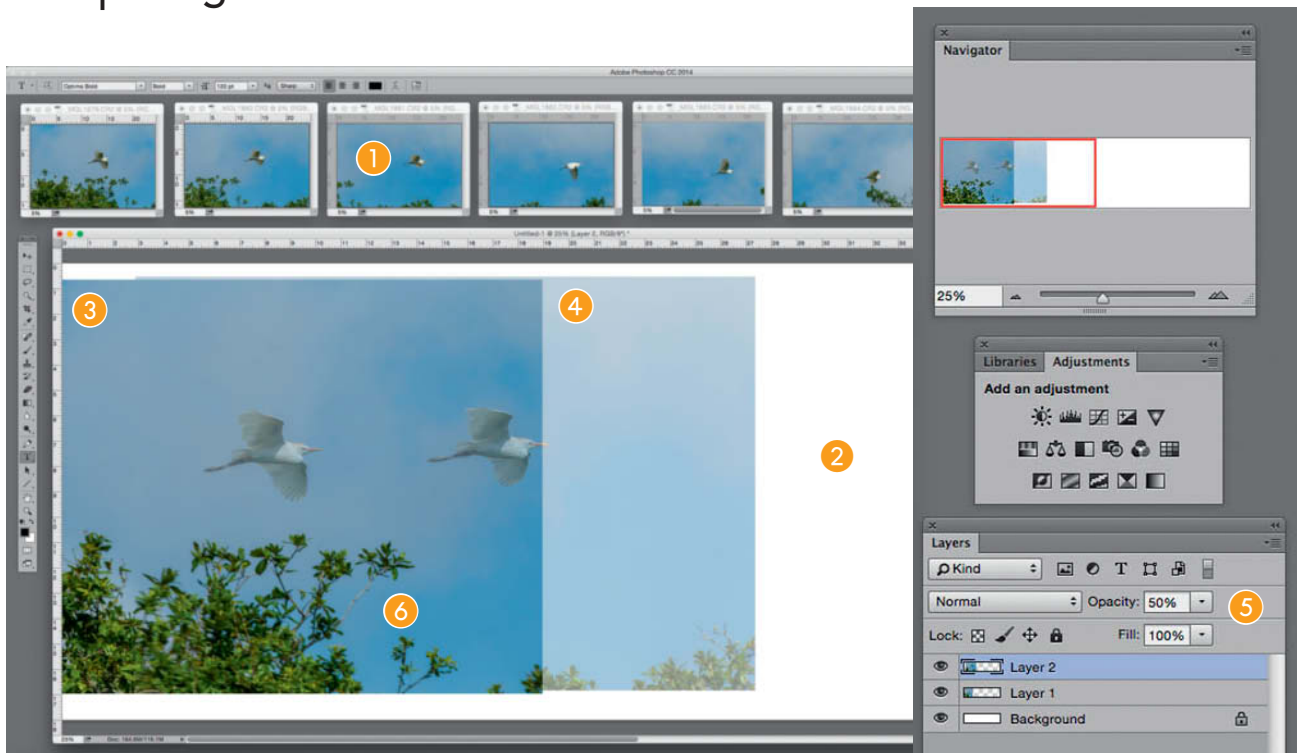
Preparing the Images

Optimize all the images in the sequence as a batch, using either *Adobe Camera Raw (ACR)* or *Adobe Lightroom*. Select all of the images, choose one frame that is representative of the series and optimize it (sharpen, and improve contrast and color). In *ACR*, the changes will be applied simultaneously to all of the selected images. In *Lightroom*, use the Sync function to apply the changes to the remaining selected images. This example illustrates the sequence of steps in *ACR*.

- 1 | Open your source images in *Adobe Camera Raw*
- 2 | Click 'Select All'
- 3 | Use the sliders and controls on the right to optimize all of the images in the same way
- 4 | Save all the images to a new folder



Composing the Panorama

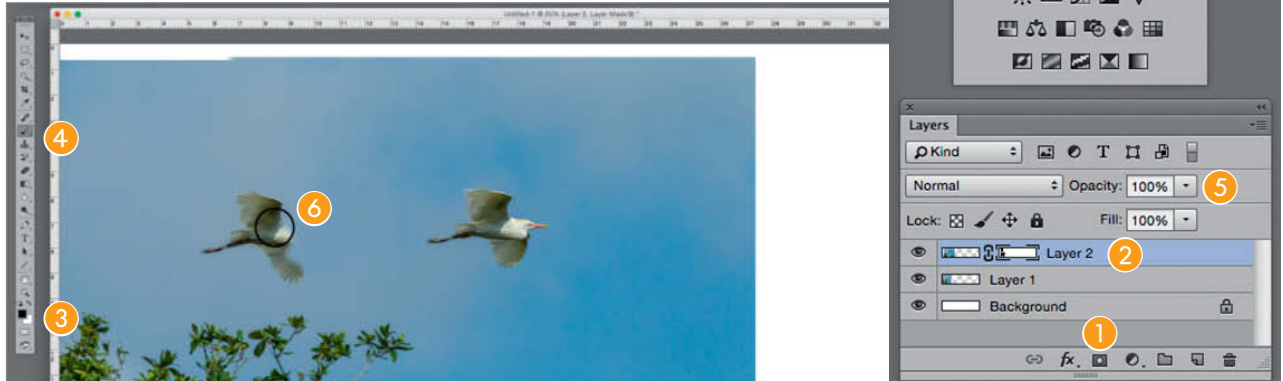


Review the images and select those that will comprise the final composition; create a series that best tells the story of the subject's journey through space and time. This could be every second, third, or even fourth image, but remember that they must be spaced evenly and the backgrounds must match.

- 1 | Open all the images on the *Photoshop Desktop*, select *Window > Arrange > Float All in Windows* and resize your images on the desktop so you can see them all at once
- 2 | Create a new blank image file with a white background canvas large enough to hold the overlapping images that will comprise the action sequence panorama. Make sure the canvas has the same bit depth and resolution as the images that will be placed upon it. In this example, the canvas was created at 200 dpi and 8-bit, as were the seven base images.
- 3 | Select the Move tool and drag the first image into position at the left edge of the blank canvas. I prefer to start on the left and work to the right, but you don't have to do it this way if right-to-left makes more sense to you.
- 4 | Use the Move tool to bring the second image of the sequence onto the canvas. It will be added automatically to the image file as Layer 2, obscuring the first image.
- 5 | Reduce the opacity of the second layer to 50% so you can see through it, then line up features in the two images, such as the branches in the foreground in our example
- 6 | Once the images are aligned, return the second layer to 100% opacity

Adding successive layers

Use a layer mask and brush to process each successive layer and blend the images together.



- 1 | With the second layer at 100% opacity, add a white, default layer mask by clicking on the layer mask icon (square with a hole in it)
- 2 | The mask will be indicated to the right of the highlighted image layer in the Layers panel
- 3 | Select black as your foreground color
- 4 | Choose a brush with a soft edge and, with the layer mask active, paint away (i.e., erase) the edge and other areas of the second layer to reveal the important parts of Layer 1

- 5 | Use the Opacity slider to increase the transparency of the top layer so you can view the details of the layer below
- 6 | Use the bracket keys to make the brush smaller or larger. If you make a mistake, use the X key to change the foreground color to white and paint back (i.e., replace) the top layer.

When this process is completed, two images of the subject will be composited. Repeat the process by bringing the third image into the panorama file (it becomes Layer 3) and continue with each new image until you have completed your composition.

Finishing the image

Touch up, crop and flatten the layers to create the finished panorama.



- 1 | Check the composited panorama carefully for flaws and unwanted elements while still in layers. Saving a copy of the *Photoshop* file with the layers intact will allow you to revisit and rework the composition later if necessary.

- 2 | In the Layers menu, click on Flatten Image to composite the layers into a single small image file
- 3 | Crop the image and optimize it in *Photoshop*, ensuring that the images are merged seamlessly

Mapping Panoramas in the Air and on the Ground

We're all familiar with aerial panoramas, as that's how Google Maps are produced from satellite imagery. The camera captures overlapping images as it moves parallel to the earth below, always positioned perpendicular to the active image area. I employ the aerial panorama concept from airplanes and helicopters and also on the ground and in the studio – in other words, in any circumstance where I can accomplish a series of captures by moving the camera or the subject to keep them on perfectly parallel planes perpendicular to the lens.

The simplest (but unfortunately most expensive) way to capture an aerial panorama is from a small private aircraft or helicopter that allows you to work through an open door or hatch. Taking a quick series of overlapping images – either horizontally or vertically – is relatively easy as the plane's movement in space is minimal in relation to the distance to the subject, rendering the nodal point pivot position irrelevant. Such images will composite nicely for an interesting aerial panorama. A variation on this technique uses the latest multicopter/drone technology combined with a bit of skill. The operator/photographer rotates the aerial vehicle in increments and takes a series of images that are later composited. Some excellent examples from Russell Brown (Adobe's Senior Creative Director) can be seen here: www.photoshop.com/tutorials/20223

A more interesting approach to aerial panoramas yields a perspective the human eye cannot see on its own. Because it applies the concept of mapping to a panoramic subject, I call this approach the 'aerial mapping panorama'. Let's imagine a photographer in a small airplane traveling parallel to a scenic mountain range with the camera pointed out the open hatch or window and the lens perpendicular to the subject. While the airplane's movement constantly repositions the camera, the photographer takes a series of photographs at approximately 5-second intervals, depending on the speed of the plane and its distance from the subject. While an interval timer would work, the most important aspect of the capture timing involves the 50% overlap from one image to the next and maintaining a consistent distance from the camera to the subject (which, of course, is the pilot's job).

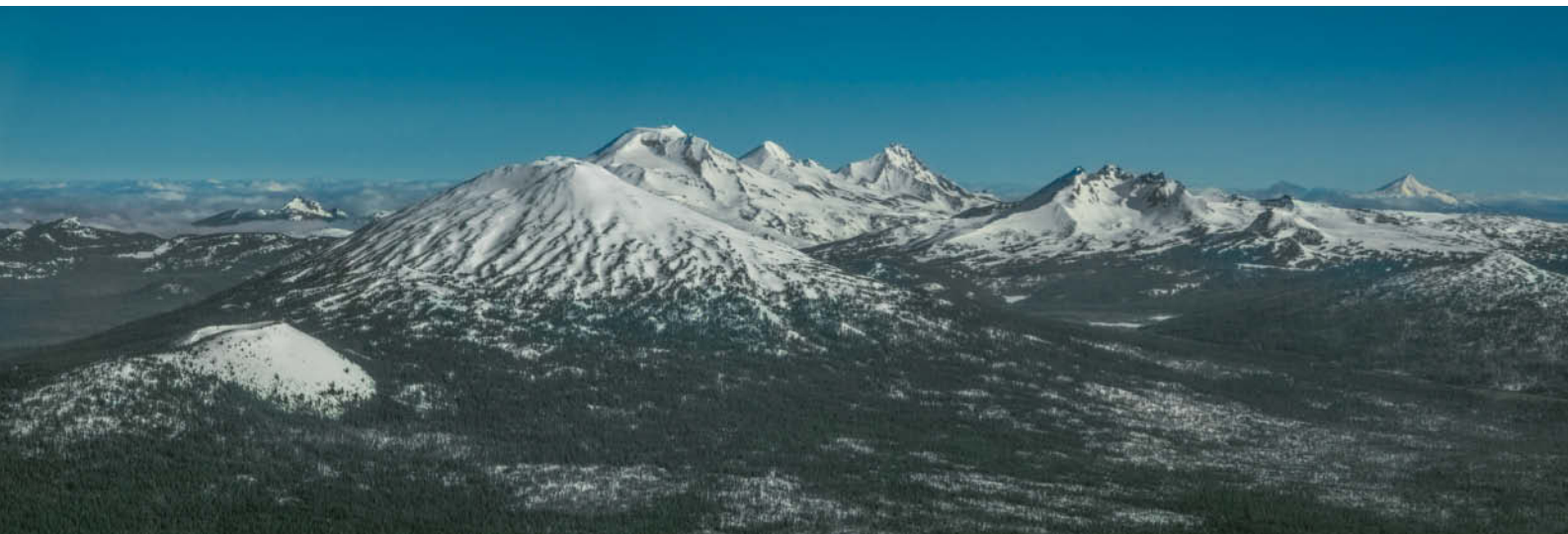
This technique works best with a medium telephoto lens positioned at a generous distance from the subject. I've had good results with focal lengths of 80 to 135mm; close perspectives and wide-angle lenses don't work due to the distortion at the edges of the images, which creates havoc at the assembly stage.

If you don't have a private plane at your disposal, you can use the aerial mapping panorama technique on the ground with

similarly interesting results. As an example, I applied it on an assignment for a landscape architect who wanted to promote work he had done across the front of a large property. A single wide-angle image was not an option, because the distance from one end of the property to the other was too great, and another structure across the street precluded me from moving back far enough to capture a panorama without significant loss of perspective at the edges. The solution was the mapping panorama: I moved along the front of the property on a parallel trajectory, capturing an image every six feet with my 28mm lens perpendicular to the subject. I overlapped each image by 50% (hence six feet between captures). It wasn't easy to composite the captures taken from such a close perspective, but the end result was very satisfying and provided a detailed view of the landscape such as a viewer would see if strolling along the edge of the property.

Excellent ground-level subjects for mapping panoramas include large rock or ice formations and other complex man-made and natural structures. The multiple points of view make for challenging assembly, but several stitching/compositing programs do an excellent job of matching the edges of overlapping images. I've had greatest success with *Autopano/Giga* and *PTGui*.

A standard aerial panorama is similar to taking multiple images from the same location on the ground. For this example, the plane was moving while I shot the six source images, but I took them as fast as possible to minimize the change in the camera's position. Because the camera was so far from the subject, the forward movement of the plane didn't affect the final panorama. This approach works even better from a helicopter because the forward movement can be minimized and the helicopter can be more precisely positioned. These images were taken with a Canon EOS 5D Mark III and an EF 24-105mm lens (1/1000 s, f11, ISO 400). The fast shutter speed was important to minimize vibration and f11 was chosen because it is the sharpest f-stop offered by the lens. The panorama was composited using the Photo Merge tool in *Photoshop CC 2014*.

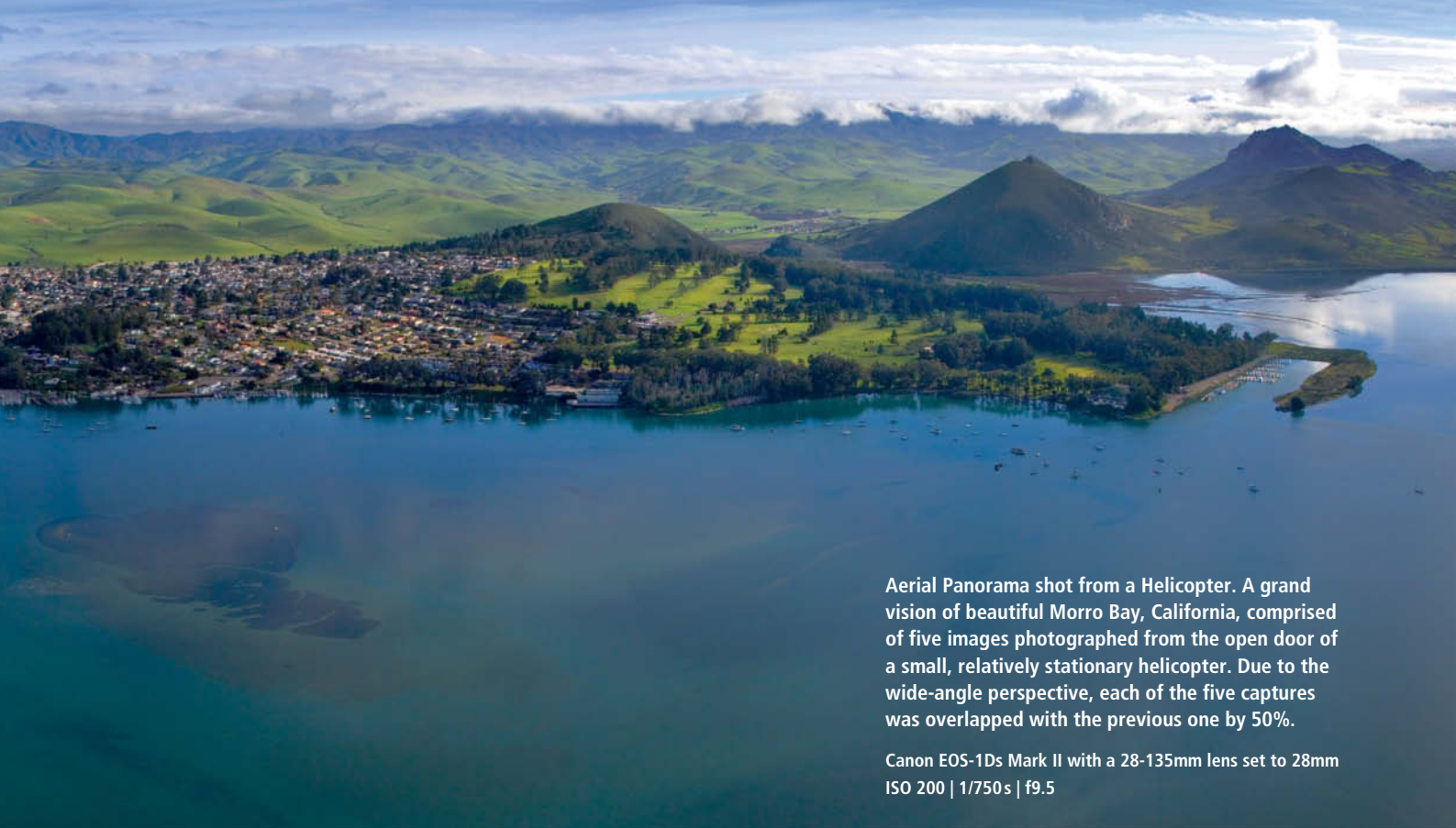




Aerial mapping from a plane. This aerial mapping panorama consists of 55 images captured at 5-second intervals from a plane flying along the Oregon Cascades mountain range. The camera/lens combination was positioned square to the mountains, and the movement of the airplane continuously repositioned it to enable a capture sequence in which each image overlapped the previous one by 50%. The resulting panorama allows the viewer to recreate the perspective of the plane's journey.

Canon EOS 5D Mark III with an EF 24-105mm lens set to 82mm
ISO 400 | f13 | 1/1000s





Aerial Panorama shot from a Helicopter. A grand vision of beautiful Morro Bay, California, comprised of five images photographed from the open door of a small, relatively stationary helicopter. Due to the wide-angle perspective, each of the five captures was overlapped with the previous one by 50%.

Canon EOS-1Ds Mark II with a 28-135mm lens set to 28mm
ISO 200 | 1/750s | f9.5



This 51-image panorama is an example of aerial mapping techniques applied to a ground-level assignment. The unusual perspective is achieved with a 28mm lens at f8, taking overlapping captures at six-foot intervals along the property line and compositing them in *Photoshop* using layer masks.

Multi-camera Panoramas

While a typical panorama is created by capturing two or more overlapping segments sequentially using a single camera, this method doesn't work with multiple subjects that are simultaneously in action throughout the composition. Examples of this type of situation include a flock of birds rising from a field, lightning strikes across a landscape or running wild horses. The way to capture such subjects in a high-resolution panorama that will yield a large print is to position multiple cameras to cover the scene and fire them all at the same instant.

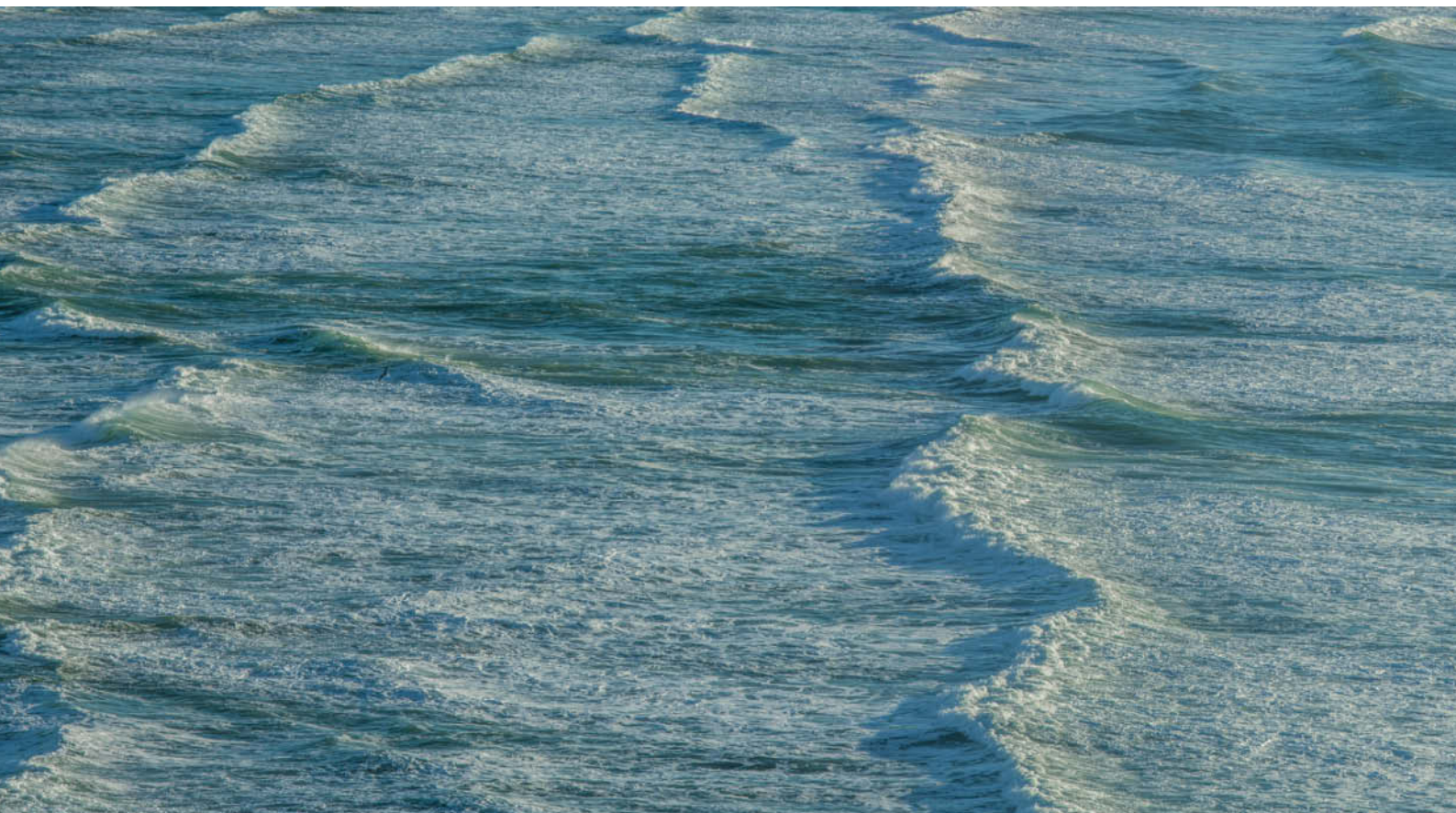
Any combination of two or more matched camera/lens combinations will work as long

as they can be fired simultaneously and provide sufficient overlap (20% to 50% depending on the focal length of the lenses). In the example shown here, I used three full-frame cameras with identical lenses to keep things simple. The cameras are attached to a Really Right Stuff 18" camera bar using three PC-PRO panning clamps with B2-Duo clamps positioned so that the angle of view of the outside cameras overlaps that of the one in the center. This hefty rig is mounted on a very sturdy tripod with a robust ball head and allows the photographer to pan with the action and maintain perfect synchrony among the cameras. You can mount the cameras on

individual tripods set closely together, but this is less than ideal if your subject will be changing position. If you don't have access to all that gear, get a few friends with similar equipment to work together on the project.

To achieve the simultaneous firing of all the cameras, I wired three electronic cable release cords to a single trigger. As an alternative, I also have a wireless trigger system with a receiver that has three cable release outputs to the cameras. This enables me to fire them all at the same time from a single transmitter. This approach is perhaps a solution seeking a photographic problem, but then maybe that's the definition of creativity.

Panorama of Pacific waves. A three-camera simultaneous capture pano system made it possible to photograph this constantly moving seascape in a high-resolution composited panorama. The three Canon EOS 5D Mark III cameras were fitted with EF 200mm f/4L lenses at 200mm and the captures overlapped by approximately 30% to enable compositing using the Photo Merge tool in *Photoshop CC 2014*.



High-definition Composite Panoramas

Ultra-high-resolution composite panoramas literally take images to greater lengths. DSLRs assisted by a variety of equipment options can be used to capture extremely large image files more than a gigabyte in size that can be printed to wall-size or explored in explicit detail online.

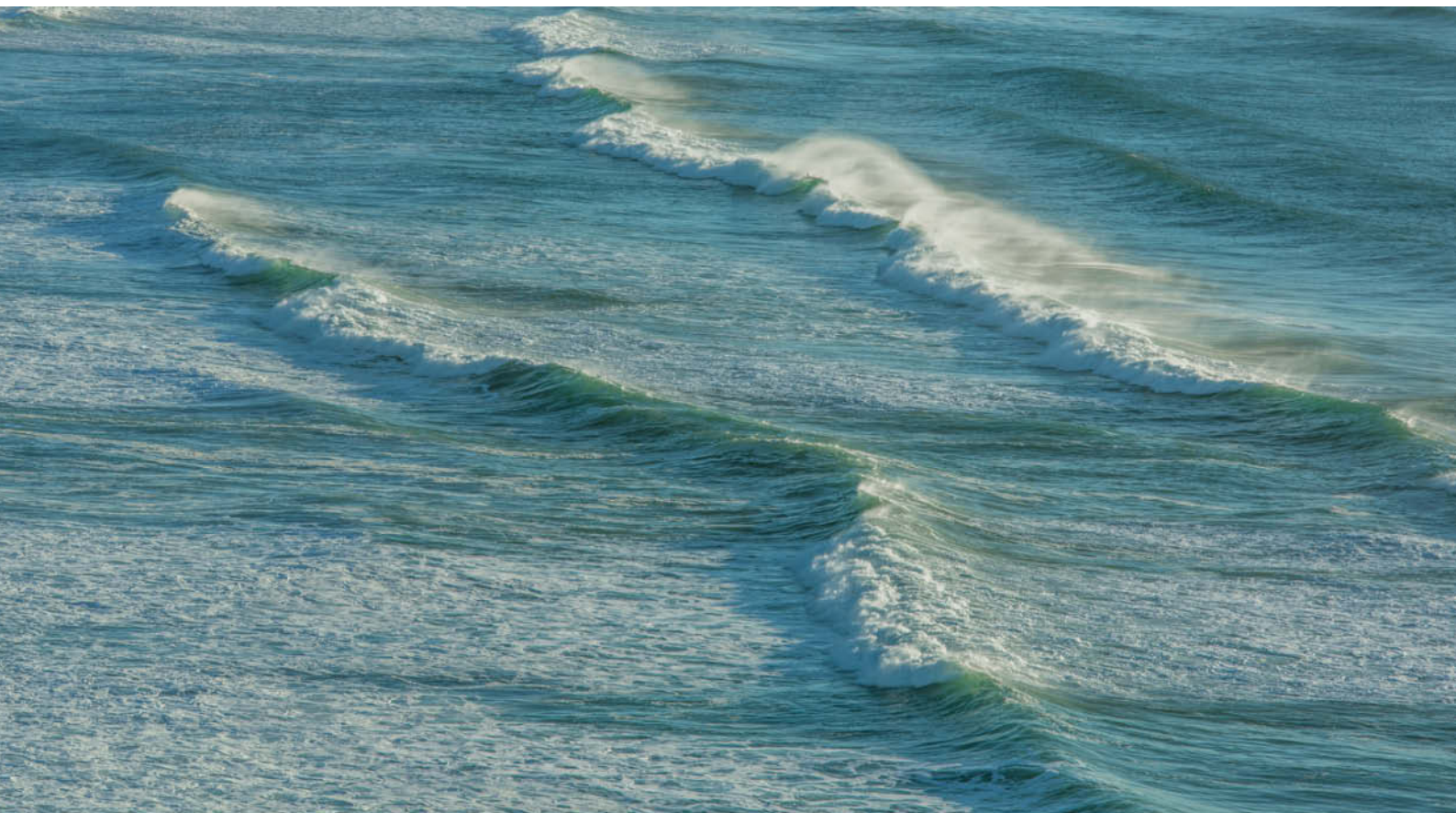
The most difficult aspect of producing an effective and interesting high-resolution landscape is finding a subject worthy of the work that lies ahead. Bigger is not enough and composition counts even more than usual in such situations. Imagine that the viewer, when entering the image from one end, is embarking upon a story: it must have a beginning to capture attention, content and detail to hold that attention throughout and a satisfying ending. A large print with many details can be closely inspected for surprising components or appreciated as a whole if the viewer can move back from it. The better the composition and the more substance contained in the image, the longer you will hold the viewer's interest.

Once you have your subject and vision in sight, capturing a high-definition composite

panorama in a series of precise rows and columns requires meticulous organization and workflow, aided by specialized equipment. The manually operated Lightweight Add-on Pano Package, Pro from Really Right Stuff (www.reallyrightstuff.com) is small and lightweight and can be carried in a camera bag with the rest of your gear. The device keeps each row of captures perfectly aligned, but it is nevertheless essential to proceed methodically and without interruption and take notes to keep track of starting positions and overlaps so that the images will line up properly at the computer-based compositing stage.

For really big jobs, automated systems such as the GigaPan Epic Series (www.omegabrandess.com), and the Clauss Rodeon piXplorer/piXpert (www.dr-clauss.de) are superb tools. I'm most experienced with the GigaPan Epic Pro system, which can handle a camera and lens combination of up to 10 pounds. Really Right Stuff offers an upgrade of the mounting platform for the Epic Pro that goes a long way toward keeping the camera/lens more secure while it is in use.

When working with the GigaPan, my two favorite camera/lens systems are the Canon EOS 5D Mark III with either an EF 70-200mm f/2.8 or EF 100-400mm lens, and the Canon EOS 7D Mark II with the 100-400mm f/4.5-5.6L IS II. The crop factor or angle of view for the latter combination is equivalent to a full-frame camera at 160-640mm. If you're aiming to shoot a high-definition composite, use a telephoto lens for maximum detail. That said, you should choose the camera/lens combination based upon the expected use of the image; capturing hundreds of images with a 600mm telephoto and painstakingly compositing them doesn't make sense if the final print will be relatively small, say, 4 × 12 feet. I seldom use a focal length longer than 200mm on the EOS 5D Mark III, and the maximum size of the resulting print is typically 20 feet by 60 or 44 inches (the width of the paper in my printers). Canon USA has used my big high-res prints in their displays at trade shows to demonstrate the capabilities of the Canon bodies and lenses.



Capturing Gigapixel Images



The GigaPan Epic Pro is now available from Omega Brandess for \$995. The 2-axis bubble level on the camera accessory shoe assists in leveling the camera to the horizon. The attached camera is a Canon EOS 7D Mark II with an EF 100-400mm f/4.5-5.6L IS II zoom lens.

Mount the GigaPan on a sturdy tripod and level it using the built-in indicator. Mount your camera and level it to the horizon. Choose your file format based upon your computer's capability and tolerance for working with huge amounts of data. When I am generating a large number of images, I often work in a JPEG format. Set exposure, focus and white balance manually. You can then program the GigaPan system by following prompts to enter the focal length of the lens and the parameters of your planned composition. The system automatically calculates the number of rows and columns needed to optimally cover the image space and starts work. The photographer steps back and, very often,

spends the next few moments answering questions about the setup from curious bystanders.

For more complex captures, the GigaPan system offers many additional options that can be selected from the front LCD at the setup stage. Some that merit additional commentary are:

Panorama Memory

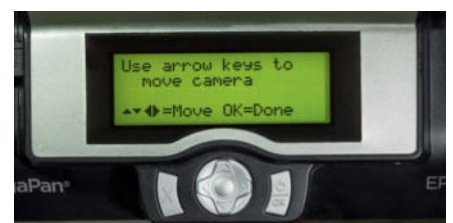
Repeat the last panorama

Time/Exposure

Timed interval between capture positions

Mirror Lockup

Best set manually on the camera before starting



Two of the GigaPan's LCD prompts that help the photographer with the setup process

Start Delay

Delay the start of the series

Pic Order

Very important, as you can order the images in vertical columns beginning at the left margin, or in horizontal rows beginning at the top. I typically choose the horizontal capture option in landscapes that include moving clouds.

Time-Lapse Series

Instructs the system to repeat the GigaPan capture series at intervals of 0 seconds to 99 days. An external power source is advised.

Battery Status

Always carry an extra battery

Shutter Mode

The camera can be fired automatically at each position or set to allow the photographer to manually fire the shutter with a remote. This option facilitates capturing panoramas that use stacking at each position.

Picture Overlap

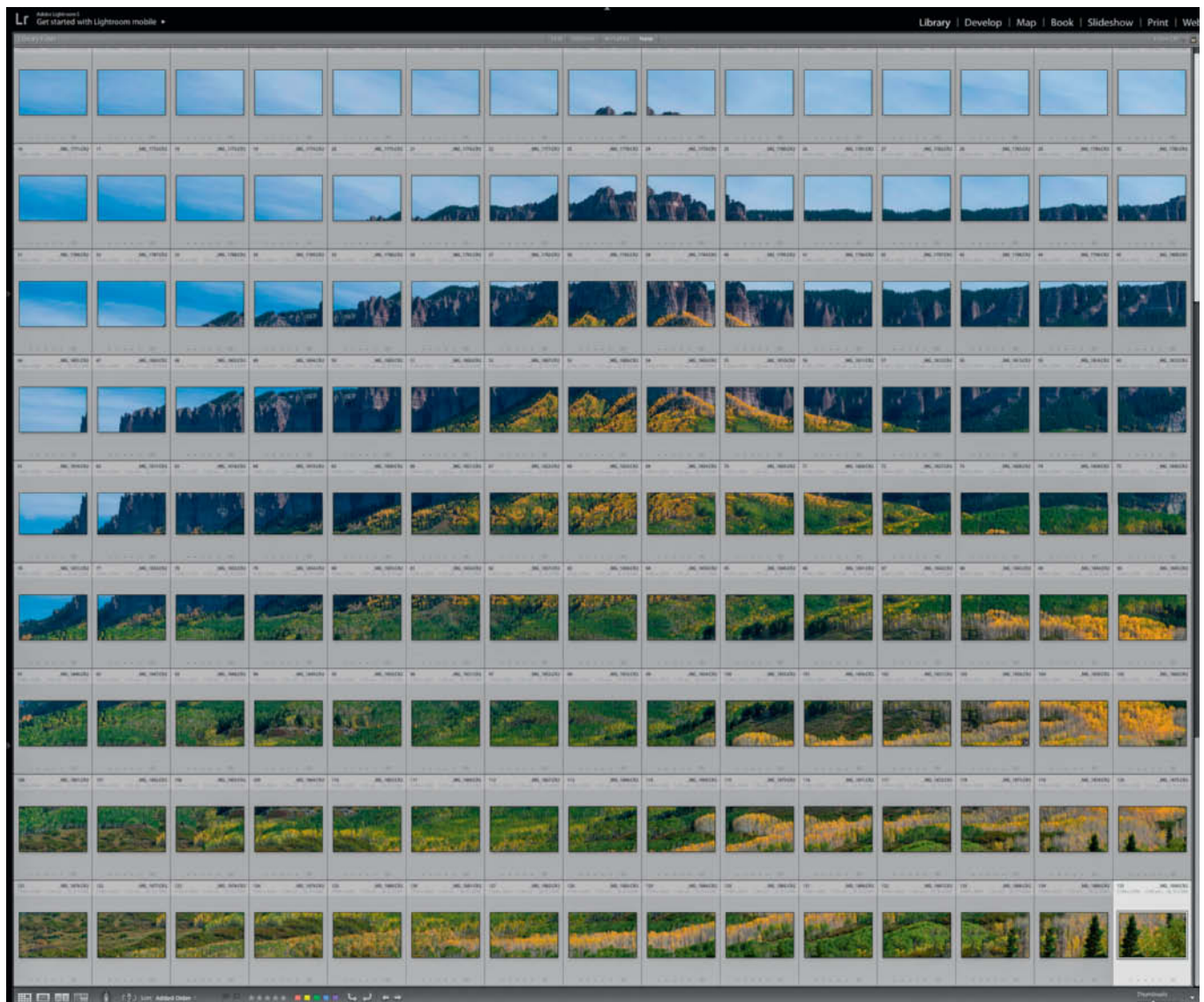
The default horizontal and vertical overlap is 30% from one capture to the next. Overlap can be adjusted from 25% to 75% in 5% increments.

Assembling High-definition Composite Panoramas

Now that you have hundreds of images destined to become a high-definition single composite, how do you handle them? You can either assemble them for printing and/or upload them to the GigaPan website (www.gigapan.com), where a multitude of GigaPan images reside and can be thoroughly explored in minute detail.

The first element of my workflow is to load all of the images (in this case, a total of 135) into *Lightroom*, highlight them all, select one image that is representative of the overall color and tone and optimize it in the Develop module. I then click the 'Sync' button to apply my adjustments to the rest of my images and save them to a single folder.

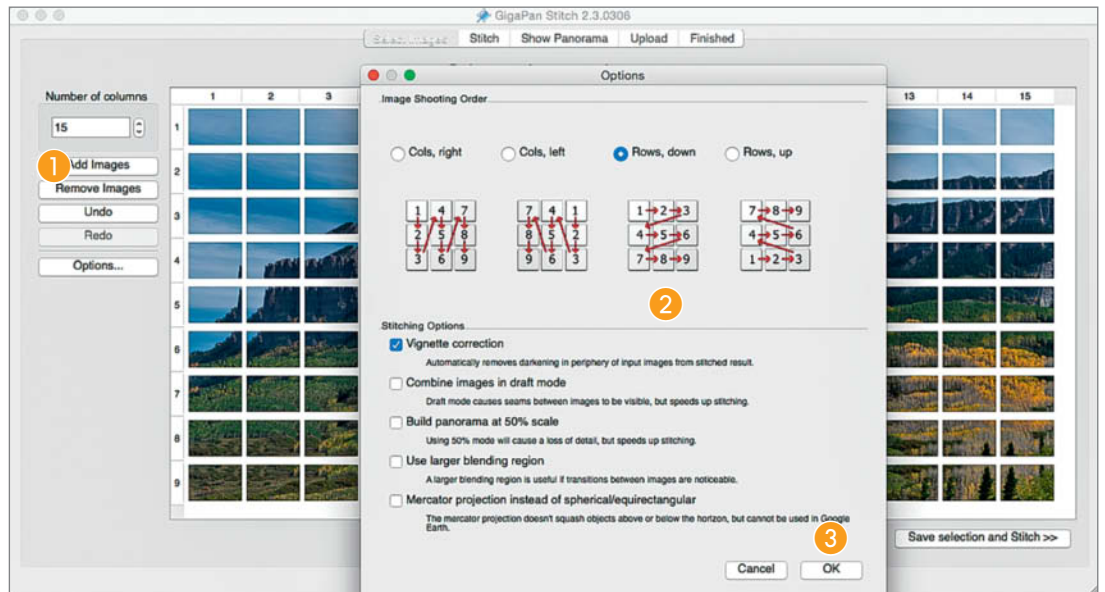
The source images loaded into *Lightroom*



Assembly Using GigaPan Stitch

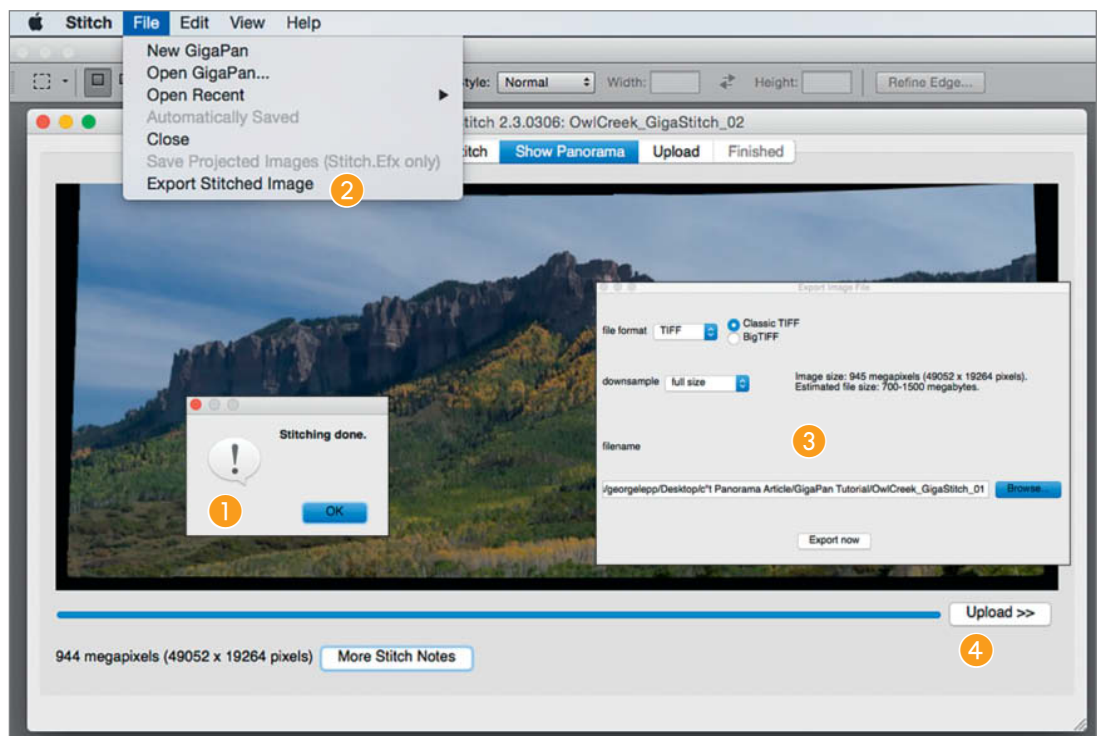
The GigaPan Stitch software comes free with the GigaPan but can be purchased separately. The photographer enters the capture parameters and the software begins assembly.

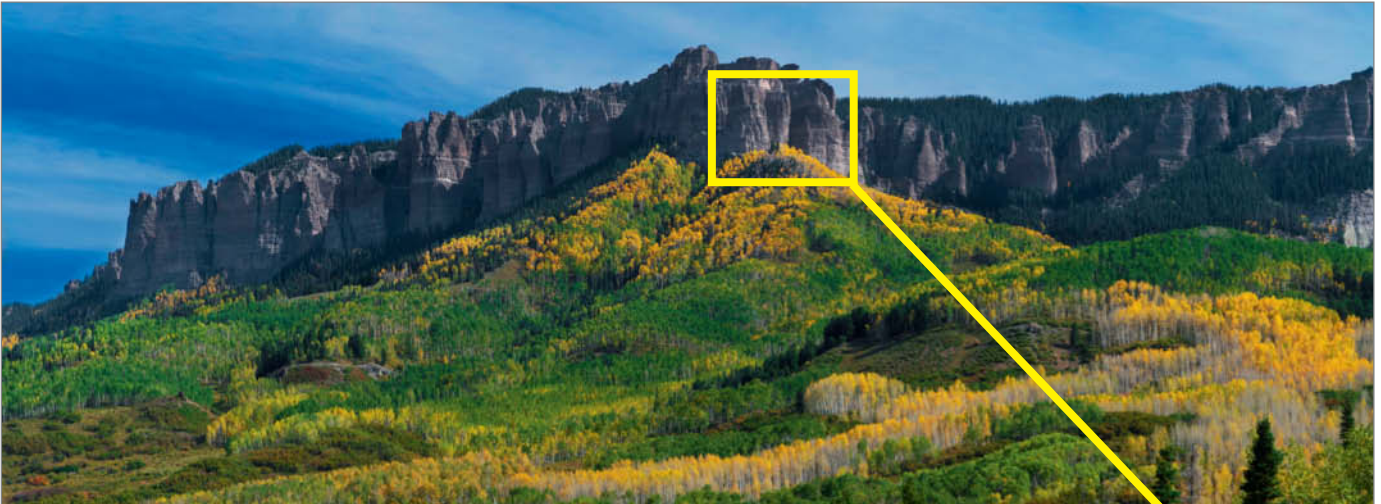
- 1 Click 'Add Images' to find and select the appropriate folder. Enter the number of columns you captured.
- 2 Select the layout that depicts the direction of the capture sequence
- 3 Click 'OK'. The images will be properly ordered and the rendering of the panorama will begin.



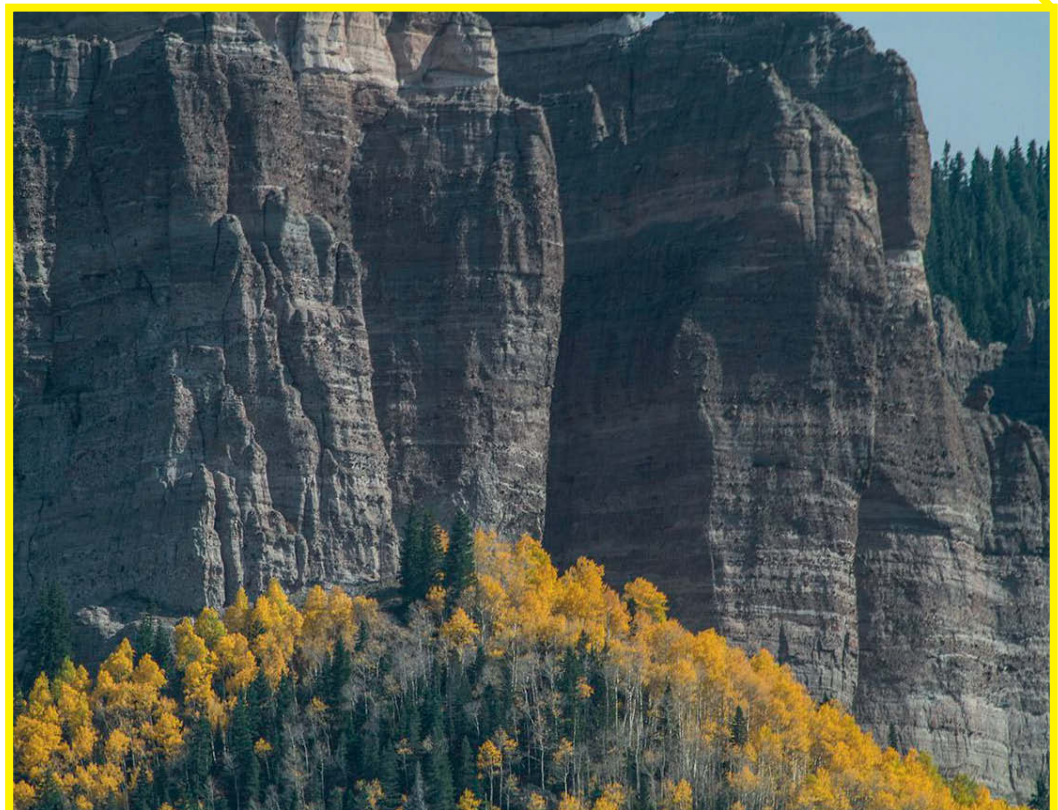
Create the image file and save it to the location of your choice and/or upload it to the GigaPan website

- 1 When compositing is complete, a celebratory message will display along with the assembled GigaPan file
- 2 To export the composited GigaPan to your hard drive click on 'Export Stitched Image'. The menu shown on the right will appear.
- 3 Choose *Classic TIFF* and *full size*, click 'Browse' and choose the location for your GigaPan TIFF file. Then click 'Export now'.
- 4 If you want your image to be immediately uploaded to the GigaPan Website, click 'Upload >>'. However, I suggest optimizing the image in *Photoshop* before placing it on the website.





A GigaPan image of Owl Creek Pass, Colorado. This image was assembled in GigaPan Stich using 135 source captures and finished in *Photoshop*. The final size of the finished 8-bit TIFF file is 1.33 GB.



This single-image capture extracted from the GigaPan image demonstrates the extremely high resolution and enlargement capability of the composited file

Combination Panoramas



A small section of the high-resolution panorama reproduced above is shown here in a cropped detail of three kayakers moving among the tufa formations at Mono Lake, California. Because the kayakers moved during the HDR captures and were blurred in the composite, a mid-range exposure was inserted in the correct position using a layer mask.

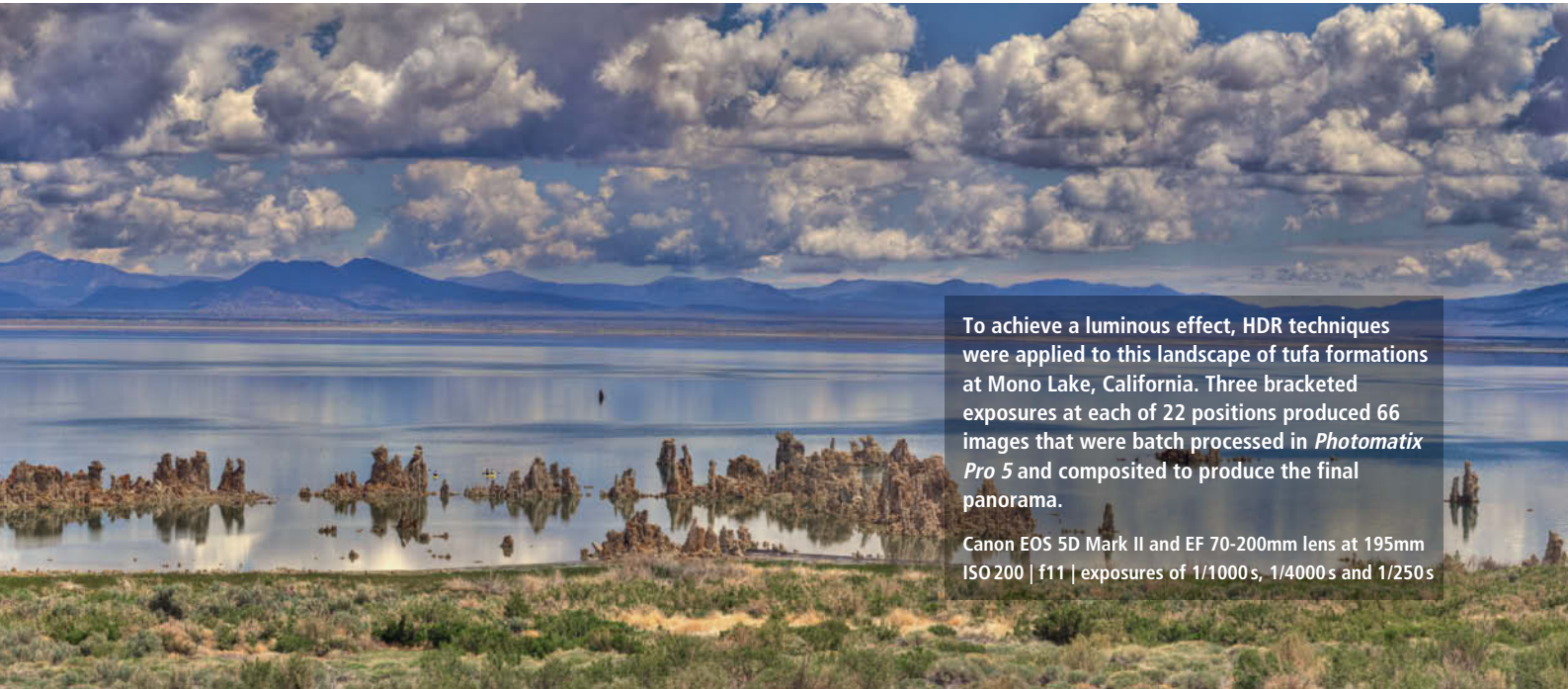
When a photographic situation calls for an extreme range of tonal values or expanded depth of field, HDR and stacking procedures can save the day. Combination panoramas employ these creative and problem-solving techniques to achieve practically limitless tonality and/or sharpness in a panorama.

HDR Panoramas. The example shown here is a multi-row panorama photographed at Mono Lake, California in flat midday light. Applying HDR at capture improved the tonal range, luminosity and texture of the landscape.

The Really Right Stuff (RRS) Lightweight Add-on Pano Package, Pro was used with

The 22 sets of exposures were batch processed in *Photomatix Pro 5* to produce the 22 HDR composites shown here, ready to be combined in a panorama using *GigaPan Stitch*





To achieve a luminous effect, HDR techniques were applied to this landscape of tufa formations at Mono Lake, California. Three bracketed exposures at each of 22 positions produced 66 images that were batch processed in *Photomatix Pro 5* and composited to produce the final panorama.

Canon EOS 5D Mark II and EF 70-200mm lens at 195mm
ISO 200 | f11 | exposures of 1/1000s, 1/4000s and 1/250s

an RRS BH-55 Ball Head to assist in aligning and organizing the capture process in this two-row panorama. A Canon EOS 5D Mark II with an EF 70-200mm zoom set to 195mm were mounted on the RRS rig. At each position, three images were captured with an exposure differential of two stops each. Careful notes of the calibrations on the panorama rig helped to ensure that the starting positions and intervals between captures matched from one row to the next – an important aid to later assembly. Because the clouds were moving, the top row was photographed first and as quickly as possible. The result was 66 images

captured at 22 positions in two rows. The kayaks in the water moved during capture of the three HDR images so, once the panorama was assembled, I used a layer mask to drop in the middle exposure of the three HDR images at that position to get a sharp image of each kayak while preserving the HDR look of the surroundings. Another way to deal with moving objects in an HDR panorama is to capture your source images, re-photograph the moving objects at the same focal length and drop them into the composited panorama at any desired location using *Photoshop* layer masks.

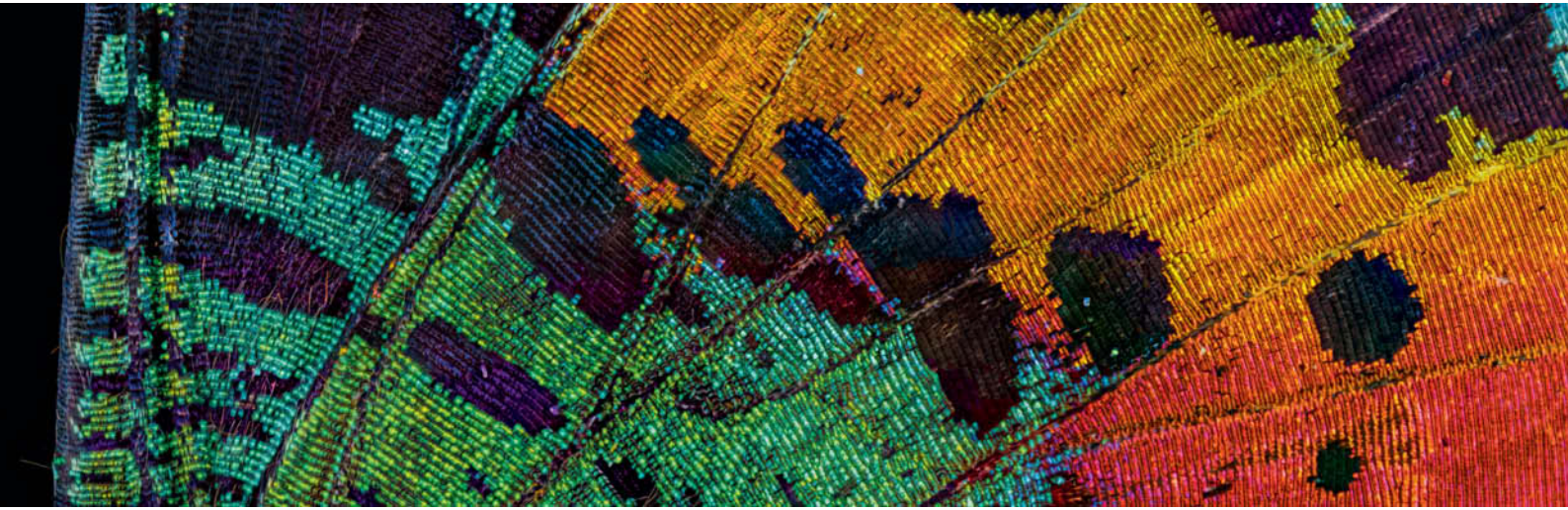
When assembling an HDR combination panorama, the first step is to process the captures for each position. In this case, I used *Photomatix* (www.hdrsoft.com) to combine each set of three exposures using the software's tone mapping capability. The 22 HDR composites were then assembled using panorama software. Because the images contained areas of undetailed sky, I used *GigaPan Stitch* and *Autopano Giga*; these programs are able to make compositing decisions based upon the position of an image within the panorama rather than matching features in adjoining frames.



The Really Right Stuff Lightweight Add-on Pano Package that was used to photograph the Mono Lake HDR panorama. The main advantage of this setup is that it is light enough to be carried in a photographer's backpack.



Macro and High-magnification Panoramas



Our article on macro focus stacking in Issue 16 of *c't Digital Photography* introduced the concept of creating high-magnification composites using focus-stacking techniques. Here we'll take the idea further, expanding both depth of field and image area in a high-magnification combination panorama that portrays a very small subject in a very large, intimately detailed and surprising way.

While the general concept of creating a panorama from a series of composited or layered images is similar to the HDR panorama creation process discussed above, high-magnification panoramas are comparatively labor-intensive and require meticulous execution to successfully bring all the elements together.

Subjects suitable for the high-mag panorama treatment are small and structurally complex, such as butterfly wings, feathers, botanical specimens or crystals. In

this tutorial, we'll photograph a tiny segment of a moth's wing at 8× in each position. This magnification can be achieved with my favorite macro setup, the Canon MP-E 65mm 1-5× macro lens mounted on a Canon EOS 7D Mark II DSLR with its APS-C sensor (1.6× cropped magnification and angle of view). The camera/lens combo is mounted on a solid copy stand or tripod and the small, lightweight subject is placed on a stage that can be moved in precise increments along its x and y axes (equivalent to rows and columns). This enables us to capture a set of focus-stacked images at each position.

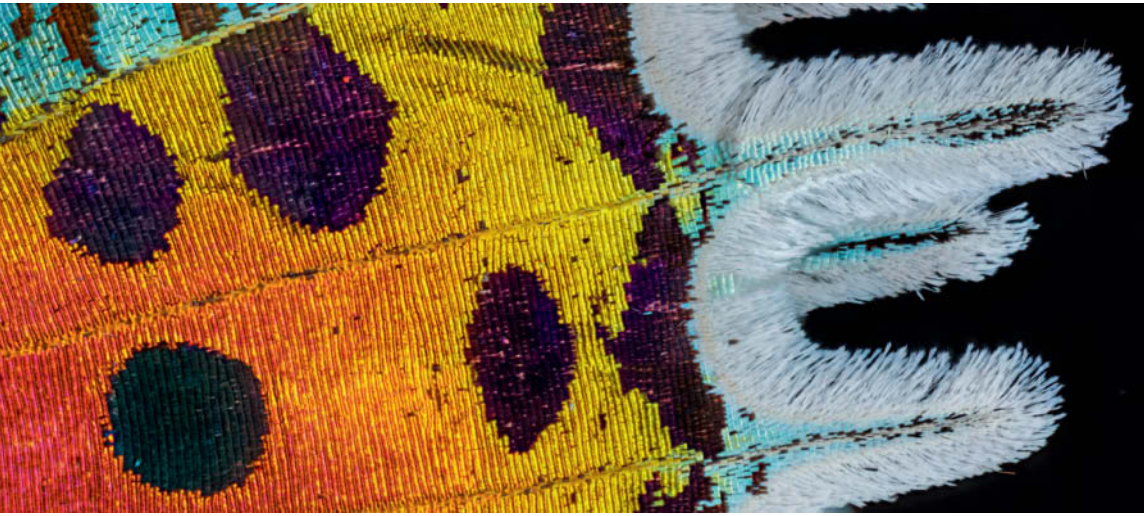
A repurposed microscope stage works well for this method and can be found online at sites like eBay or at universities and research laboratories where old microscopes are being replaced with digital units. Another useful positioning system for panorama capture is the Proxxon KT70 Micro Compound Table,

purchased through amazon.com for about \$100. This device is actually designed for precise milling or drilling, but its stage works beautifully when executing micro x/y movements for small panorama photography subjects.

Focus stacking is best achieved with a StackShot motorized focusing rail (www.cognisys-inc.com) that attaches to the copy stand/tripod and moves the camera in increments from 2 microns to 100 mm using a dedicated controller and a step motor. The system can be programmed to incrementally reposition and fire the camera through a predetermined range, making the entire focus-stacking capture procedure automatic and hands-off. A good focus light, such as a small LED, is necessary for positioning the subject and focusing, and a macro flash system supplies the necessary light at capture.



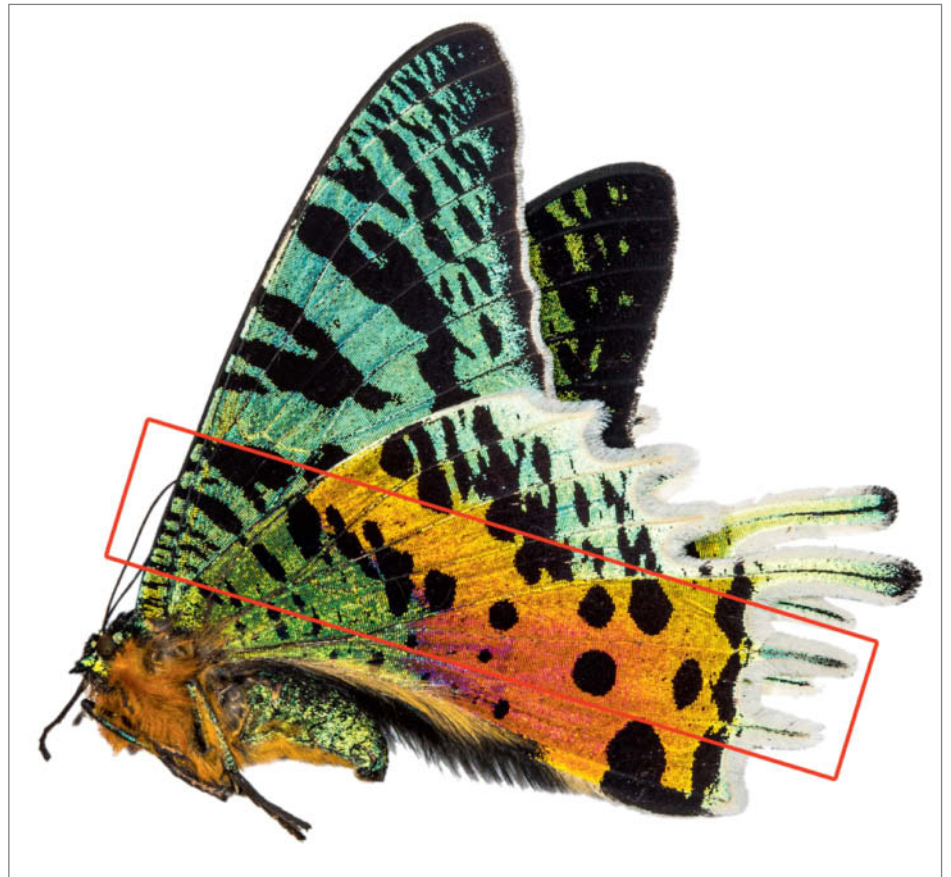
Two tools that can be used to create a macro panorama, both with the capability of making tiny, precise movements on the x and y axes. Pictured are (left) a Proxxon KT70 Micro Compound Table purchased from amazon.com and (right) a re-purposed microscope base that enables not only x and y movements, but also vertical micro movements useful in lower-magnification stacking projects.



The finished macro panorama of the wing of a Madagascan Sunset Moth is comprised of 80 stacked images. The number of captures in each stack varied from a minimum of eight to a maximum of 50, depending on the depth of field necessary for the area being photographed. With a total of 1,438 captures, the composited 8-bit file is 2.13 GB in size.

A high-mag/macro panorama typically comprises hundreds of individual source images, but there really is no limit. At high magnifications, the panorama captures require an overlap of approximately 30%. A series of stacked images is taken at each position before moving the subject (mind the overlap) for a new focus stacking series, and the process is repeated until the first row of stacks is finished. Adjoining rows can be captured to build up a larger finished composite, but this technique works best if you assemble each row and detect any errors before repositioning the stage to shoot the next row. I prefer to use *Zerene Stacker* (www.zerene.com) to composite the individual stacks, but *Helicon Focus* (www.heliconfocus.com) is another excellent option. Composite the group into a one-row panorama using *Photoshop CC 2014* or *Autopano Giga*. Examine your results carefully and only realign the stage to photograph the next row once you are sure that the previous row is complete and perfectly focused throughout. To complete the panorama, stitch the rows together one at a time.

Some of my favorite subjects for high-magnification macro photography are the patterns and textures found on butterfly and moth wings. In this example, I worked with a Madagascan Sunset Moth, one of the most beautiful of all lepidoptera species. The specimen I used was farm-raised, not taken from the wild. (sea)



The color of the Madagascan Sunset Moth (*Urania ripheus*) is produced by iridescence rather than pigments. The red marking shows the approximately 50×10mm area of the moth's wing that was photographed for this project.

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Book Review



Architecture and Landscape in Norway

Ken Schluchtmann
Published by Hatje Cantz
160 pages, 107 color illustrations
Text in English and German
11 × 13.5 inches, Cloth hardcover
\$75.00
ISBN: 978-3-7757-3837-8

Architecture and Landscape in Norway

Nature Contrasts with Modern Buildings

Just like many other popular destinations, Norway has developed routes that enable tourists to visit and enjoy the beauty and culture of its landscape. Its 2,000 km of designated routes take travelers through an ever-changing landscape of coastline, fjords and mountains, and Norway's highway authority has been working since 1994 to keep the views along these roads attractive so that they enhance Norway's reputation as a scenic wonderland.

When 50 top architects, designers and artists were asked to contribute their creative ideas to the tourist route project, the result was a series of innovative structures and installations in which architecture and art express their affinity for and dependence on untouched landscapes. There are sculptures, lookout points, rest areas and walking trails that use natural materials – mostly wood, glass and steel – to underscore the beauty of their surroundings.

Having traveled the length and breadth of Norway for several years, drawn by its

light and landscapes, photographer Ken Schluchtmann first encountered one of these buildings in 2008. The experience set him off on a five-year, 20,000 km journey to visit each and every one of these unique architectural sites.

Rather than aiming for maximum visual impact, his photographs portray the places he visited with an authentic, timeless feel. This was clearly a time-consuming project – the lighting, weather and framing are always just right for the subject, and viewing these photos is almost as good as being there.

The presentation of the book enhances and complements the reader's experience. There is no text apart from the introduction, and the photographs are left to tell their own stories. The cloth binding is decorated with a real photo, and much care has been taken with the high-quality reproductions and the layout, which make the book a pleasure to handle as well as to read and look at. (tho)

Modern architecture is not always at war with nature. Norway has a long tradition of designing buildings that fit in with the rawness of the surrounding landscape.

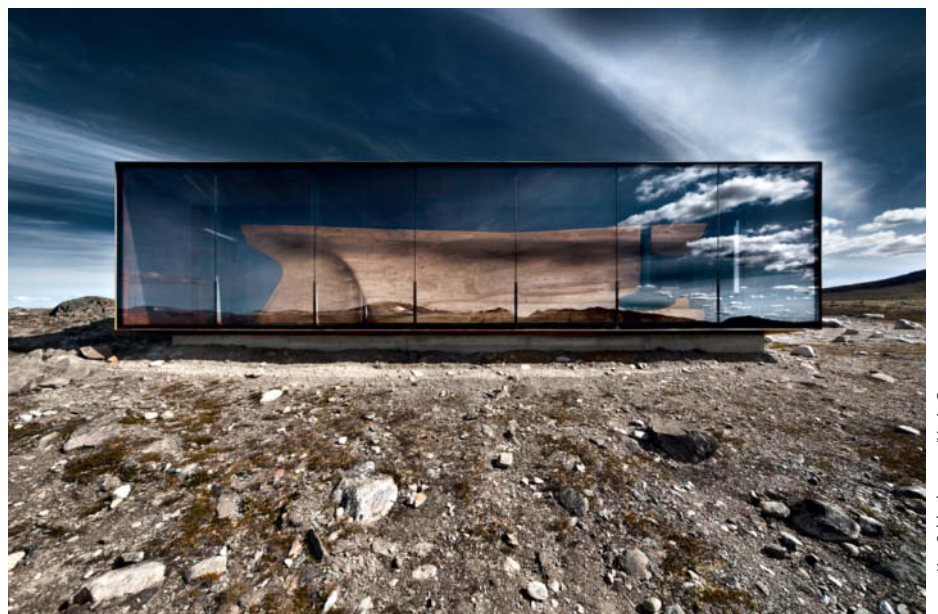
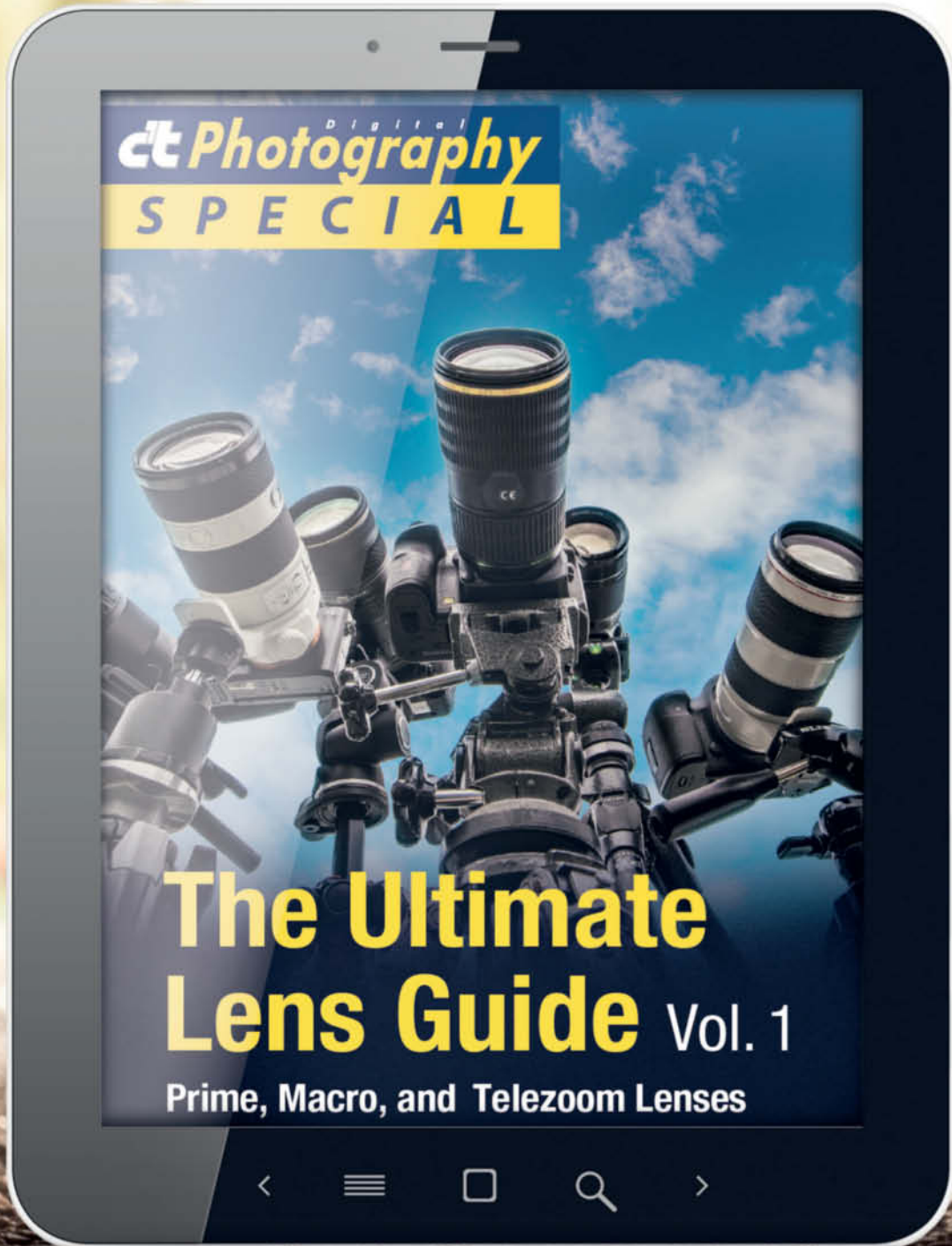


Image: Ken Schluchtmann/Hatje Cantz

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Coming up in Issue 22

● ● ● ● ● available from December 17



Photo: Pavel Kaplun

Artistic Travel Photo Workshop

■ Pro photographer Pavel Kaplun uses photos from a trip to India to demonstrate how to use color as a compositional tool and as a stylistic device when editing your images. His hands-on examples show how a little carefully placed color can radically alter the effect an image has on the viewer.

Canon EOS 5DS R More Pixels than Ever Before

■ Canon's 50.6-megapixel EOS 5DS R takes a big step toward bringing medium-format resolution to full-frame cameras. All that resolution should provide ultra-sharp detail reproduction, so to find out if it really makes the grade, we pit the Canon against the Nikon D810 and the Sony a7R, and investigate which lenses are up to the job of utilizing its mega-resolution to the full.



Image Editing with Raw Converters

■ Today's raw converters are rapidly turning into full-fledged all-in-one image editing solutions, with functionality like selective color and tonal adjustments, lens error corrections and all kinds of retouching tools built in. We test today's most popular raw converters and check which really deserve the 'all-in-one' moniker.

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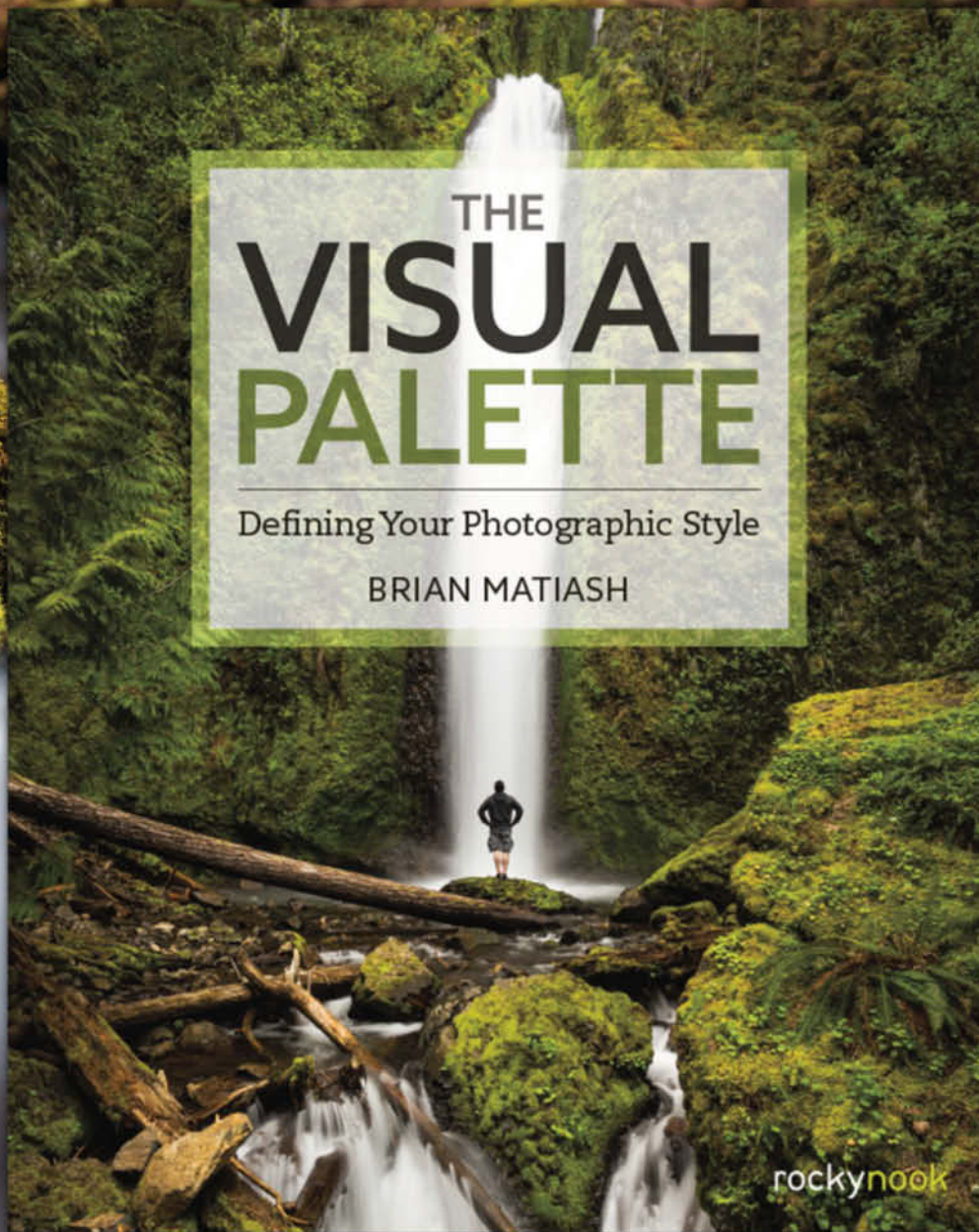
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This fall, author and photographer Brian Matiash delivers photography insight like you've never read before.

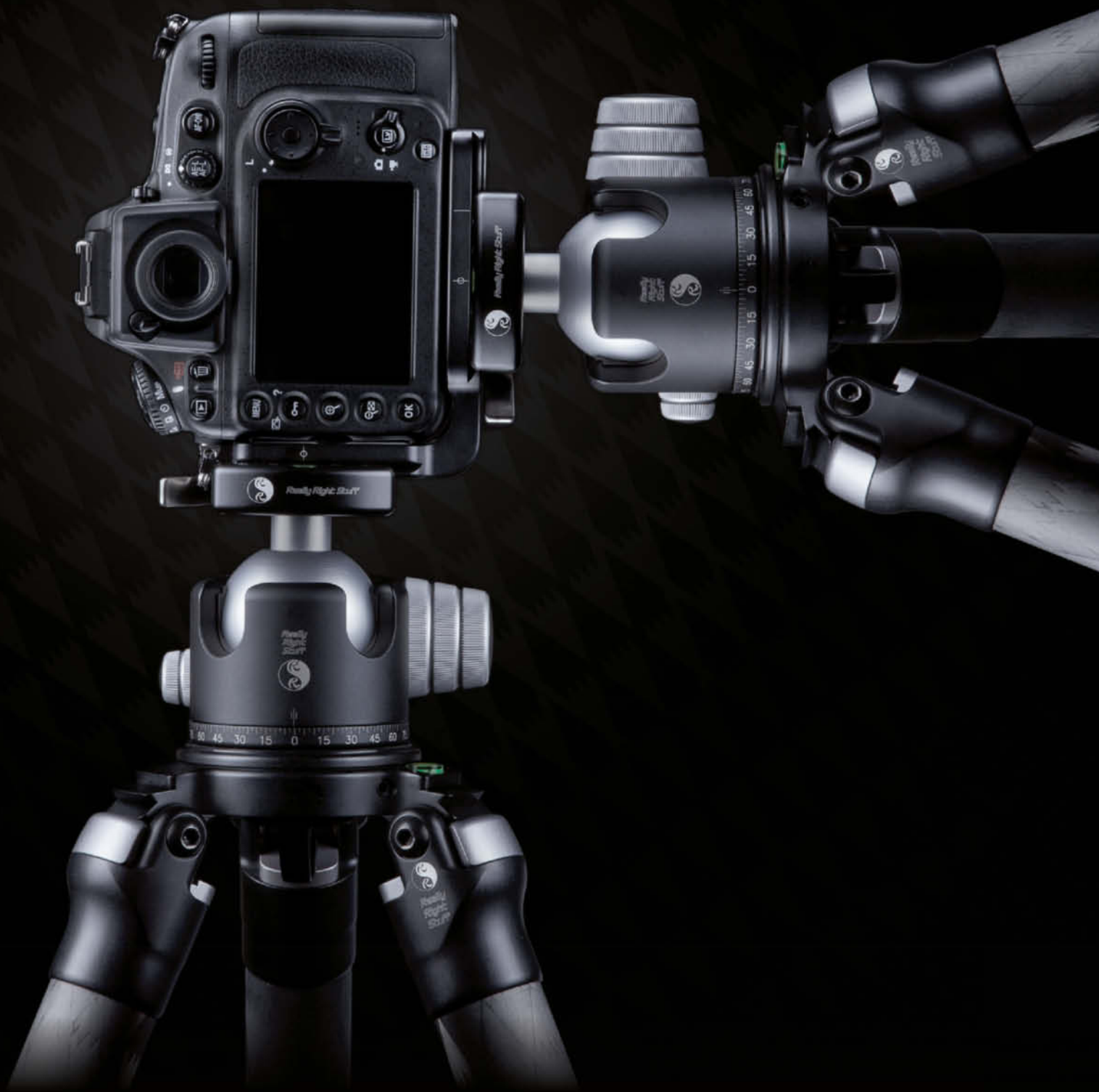
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