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Market Insights and Camera Test

Mirrorless and Happy

Sony A7 II vs. Canon, Fujifilm, Leica, Nikon, Olympus, Panasonic and Samsung



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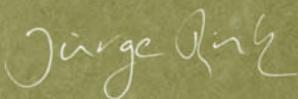
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Contributing editor Sophia Zimmermann hits the nail on the head when she says: "The reflex mirror has been a second-rate remedy since its invention, and was always a roundabout way of enabling photographers to see what they are capturing." And now, although the mirror has survived the transition into the digital age, its days are surely numbered, especially now that mirrorless camera manufacturers have started getting their act together with regard to autofocus speed and viewfinder clarity.

All photographers use light to illuminate the scenes they capture, but few see light itself as a potential subject, even though creating light sculptures in a studio environment is actually quite simple. See page 112 for an introduction to the fascinating world of light painting. And the Sun – the mother of all light – makes an attractive subject too, but please only point your camera in her direction once you have read our article on page 124.

Whether you decide to look out into space or close the door and shoot in the dark, have fun with all your digital photography experiments!



Juergen Rink





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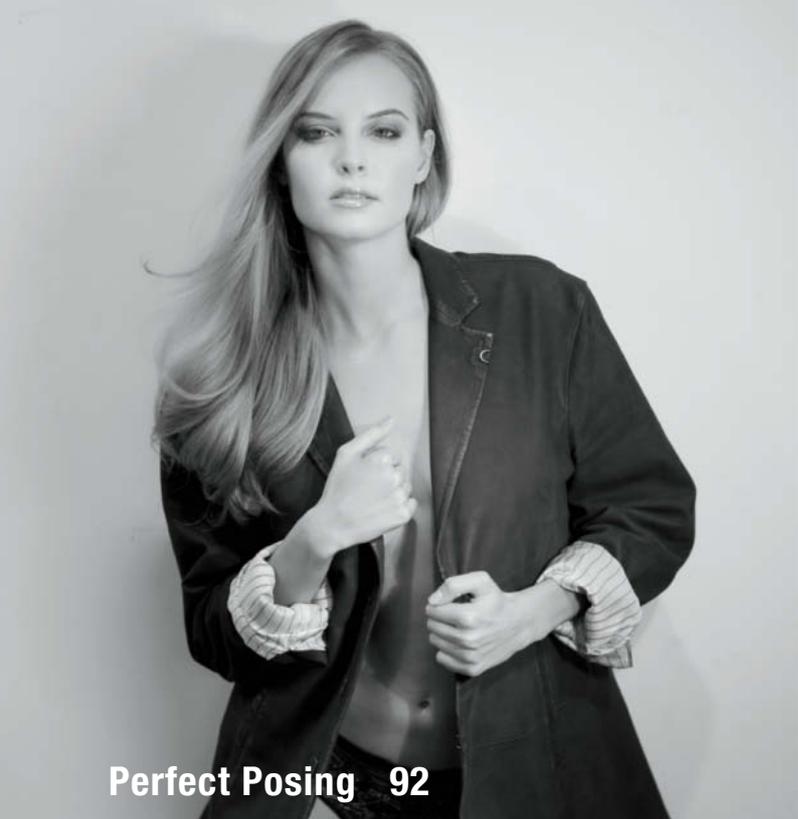
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Perfect Posing

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- Long-exposure Architectural Photos
- Improve Your Shooting Performance with Pro Photographer Mike Larson
- Between Rock and Jazz: The Works of Lisa Tanner

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Elements+ for Photoshop Elements 13

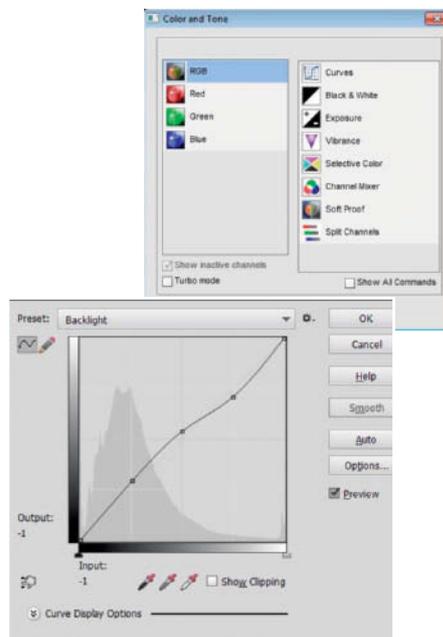
Special edition software: Elements+ unlocks a range of additional tools and functions that are normally hidden in Photoshop Elements.

Although Adobe sells *Photoshop Elements* as a cheaper beginners version of its image processing software, it still includes a number of hidden tools and functions that are normally only available in *Photoshop CC*. The Elements+ plug-in for Windows and Mac unlocks these and makes them available to everyone.

The official trial version of the plug-in has only limited functionality, but **ct Digital Photography** readers have access to a special pre-registered version that is much more powerful than the trial plug-in.

The special edition unlocks all color & tone, selection, layer styles and paths functions. These include the Curves tool, a Channel Mixer and the Selective Color adjustment. Quick Mask mode, alpha channels and the paths tools make

it simple to create complex selections. Additionally, Smart Filters and layers functionality are available in the full version of the plug-in. (sts)



Creative Nature Photography

Video tutorial: Using wide-angle lenses in macro situations



Hans-Peter Schaub is a nature photography expert who loves to take an unconventional and creative approach on his shoots. In this video, he demonstrates the effects of using various focal length lenses and extension tubes in close-up nature photos. Schaub rounds out the video with a selection of useful shooting tips and ideas on how to create unusual wide-angle macro images. (sea)

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Elements+ for PSE 13 special edition

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GIMP Portable
GREYC's Magic Image Converter (G'MIC)
Inkscape
Inkscape Portable
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Elements+ for PSE 13 special edition

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DCRaw
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Videos

Creative Nature Photography 4:
Using Wide-angle Lenses
Long-exposure Architectural Photos
Improve Your Shooting Performance
with Pro Photographer Mike Larson
Between Rock and Jazz – The Works of
Photographer Lisa Tanner

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WebSite X5 Home gives you all the tools you need to get your website up and running without first having to learn complex programming skills. The program provides more than 250 ready-made templates that you can fine-tune using the built-in graphics editor, and you can fill your pages by dragging and dropping text, images, videos, music, Flash animations and social network buttons. The program generates the corresponding HTML5 code automatically, ensuring compatibility with all popular search engines and mobile devices. See <http://www.websitex5.com/en/home.html> for more details.

c't Digital Photography readers can download and use the full version of WebSite X5 Home 11.0.6.27 for free – all you have to do is visit <https://answers.websitex5.com/> and register as a new user. During setup, the software installer then requests your e-mail address and the password you chose during registration. If you like what you see and wish to extend the program's capabilities, you also qualify for a 40% discount on an upgrade to the Evolution version 11 that you can purchase from within the program interface. The free registration offer and the upgrade discount are valid until October 15th, 2015. (sea)

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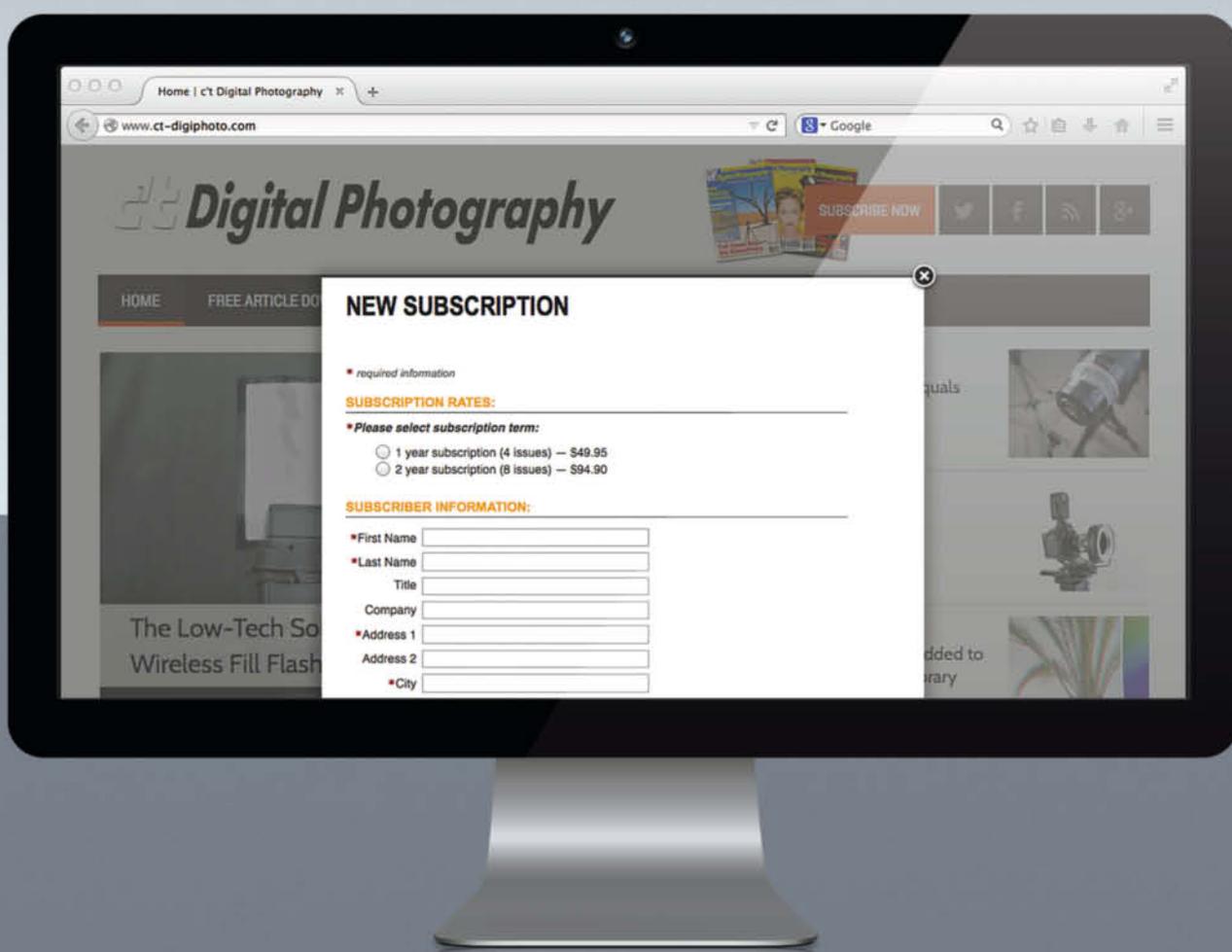
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Portfolio

Herbert Boettcher

Out on the ocean on a container ship for weeks on end, Herbert Boettcher has all the time in the world for photography. His images emanate stillness and calm that belie their subjects, for the logistics industry these ships are part of is a well-oiled machine that runs faster and faster with every passing day.





The colorful container ship in the foreground stands out crystal clear, while the clouds and the horizon disappear in a distant blur. There is not a soul in sight. The image exudes stillness and calm, despite the pressures of a transport system for which every minute counts and efficiency is the order of the day. Herbert Boettcher cleverly counters this hurriedness with his own unique take on things,

enabling viewers to take their time and enter into the stillness the images convey. The way Boettcher goes about his work is mirrored by the clinical orderliness and precision of his images. Snapshots are not his thing at all, and it is of utmost importance to him that his images turn out as he saw them in his mind's eye. Neither the limits of technology nor the vagaries of life at sea excuse work that is less than

perfect, and a voyage of several weeks may yield only a handful of photos.

Boettcher has been a freelance photographer for more than 20 years. His first two ocean-going sequences, *Seamotion 1* (2004) and *Seamotion 2* (2007), were captured using a home-made pinhole camera and a Hasselblad XPan analog panoramic camera, and he developed his films on board immediately after shooting. After years of dissatisfaction with the



From the 2007 *Seamotion 2* sequence. This photo was captured using an analog Hasselblad XPan camera. All the other images shown here were captured using a Phase One digital back on a voyage made in 2014.

way analog film reproduced colors, going digital in 2010 was a huge milestone that took him closer to the kind of image quality he was aiming for. Digital technology allows him to let a project lie fallow for a while and return to it when the opportunity arises. For Boettcher, there is no contradiction involved in working slowly using digital technology. He now takes a Hasselblad V, an Alpa body and a Phase One digital back with him on his container-ship travels.

The *SeaMotion* projects were commissioned by the Hamburg Süd arm of the Oetker Group – a client that values and seeks out his distinctive style. He also sells his images in calendar form or as single prints, combining commissioned work with artistic fulfillment.

The *Edition Panorama* gallery in Mannheim, Germany is exhibiting work created between 2004 and 2009 until the end of this year. (jr)

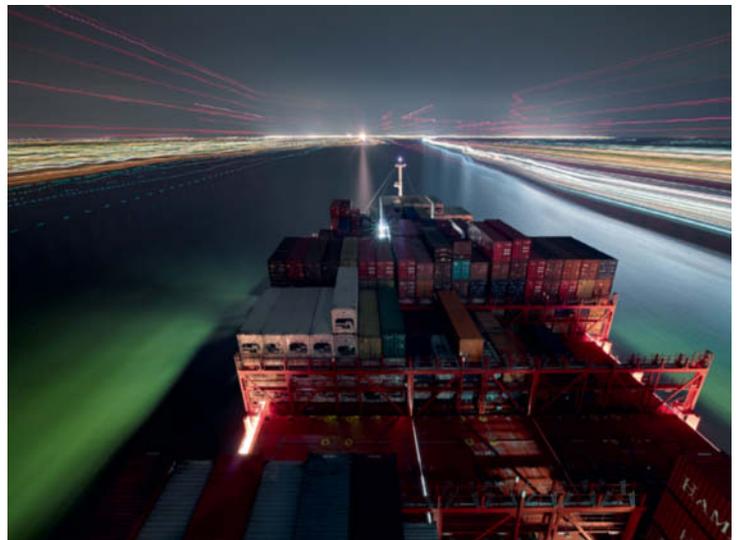
For more of Herbert Boettcher's work visit

www.HerbertBoettcher.de

or check out his gallery:

www.editionpanorama.com





Sophia Zimmermann

System Cameras Come of Age

The End of the Mirror?

With their compact bodies, sophisticated handling, excellent feature sets and high image quality, mirrorless system cameras continue to divert users' attention from traditional DSLRs. But are they really as good as the marketing would have us believe? We take a detailed look at the mirrorless market and test the top models currently on offer from the major manufacturers.



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Market Overview

2014 was the year in which mirrorless system cameras finally established themselves as real competition for traditional DSLRs, although they still come in a range of shapes and sizes that makes it difficult to precisely pinpoint their target market. We take a critical look at the market and where mirrorless technology still needs improvement, and we also make some predictions about what new users, established mirrorless photographers and pros can expect from this rapidly developing segment.

The reflex mirror has been a second-rate remedy since its invention, and was always a roundabout way of enabling photographers to see what they were capturing. This clumsy mechanical solution has survived into the digital age simply because its handling and reliability have yet to be surpassed, especially in the demanding pro sector. DSLRs today are still considered to represent the epitome of photographic quality.

But mirrorless system cameras, first introduced in 2008, have begun to present reflex cameras with serious competition. These cameras have no mirror that has to be mechanically moved out of the light path to allow the light entering the lens to reach the camera's sensor. Instead, the light hits the sensor unhindered and the viewfinder image is created electronically via a live view from the sensor. Because they have no bulky mirror box, mirrorless cameras are much more compact than their reflex-style cousins.

The last four or five years have seen rapid development in this new category of camera. The first mirrorless cameras to hit the market used the same contrast-based autofocus systems as their compact siblings, which is precise but often slow because the camera's firmware continually adjusts focus until it finds the maximum possible contrast between the pixels in the frame. Instead of contrast, DSLRs use phase-detection autofocus systems that evaluate focus using a single speedy measurement. The weak link in this case is once again the mirror, which has to steer the incoming light rays toward dedicated focus sensors that function independently of the image sensor. Today's contrast-based autofocus systems are a lot faster than their predecessors and many mirrorless camera manufacturers now use hybrid autofocus systems that combine the best of contrast-based and phase-detection technologies.

Electronic viewfinders have come a long way, and now offer zoom functionality to aid precise manual focusing. Handling has improved over the years as well, and you can read about the latest technical advances in the test section that starts on page 22.

2014 saw a swing in market share, with DSLR sales decreasing parallel to a marked increase in mirrorless sales. In Germany, for example, 30 percent of Sony and Panasonic monthly camera sales were in the mirrorless sector, while in Japan and South Korea, mirrorless sales hit more than 50 percent in some months.

Manufacturers offer a range of different mirrorless models. Some have small sensors and technology that meshes with smartphone functionality, and are obviously designed to win over compact camera users looking to trade up and who might otherwise be tempted to purchase a DSLR. Other models have large sensors, weatherproof bodies and high burst shooting rates that are aimed squarely at sophisticated amateur and even professional photographers.

Mirrorless for Beginners

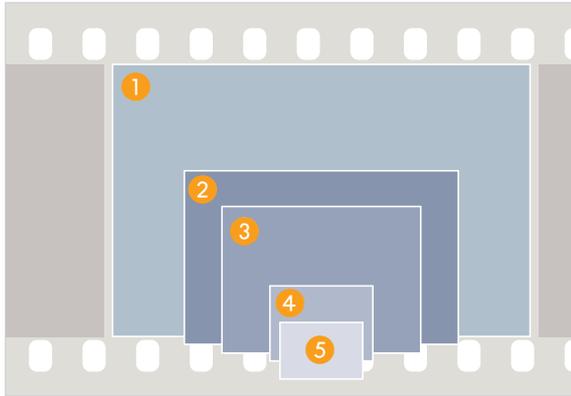
Entry-level mirrorless system cameras compete price-wise with mid-range

fixed-lens compacts and, with the exception of Leica, all the major manufacturers include at least one sub-\$600 mirrorless camera in their range.

The Samsung and Sony budget models are identified by the many zeros in the model names, while Nikon's budget 1-series model has an "S" suffix and the lower-end Olympus models are called "E-PL" or "E-PM". Most of today's common sensor sizes are available in entry-level cameras, ranging from the popular 1" sensors that are often found in high-end compacts through Four Thirds (and Micro Four Thirds) models all the way up to the APS-C sensors found in many DSLRs. Value mirrorless cameras look very much the same as compacts, with plastic rather than metal bodies, bright colors instead of weatherproofing, and low-res monitors instead of viewfinders. To keep prices down to a reasonable level, manufacturers often use outdated technology and leave out popular features. The only thing that distinguishes mirrorless cameras from the compact competition in this price segment is

Compact or mirrorless? The Samsung NX Mini has a 1" sensor and interchangeable lenses, and represents a new breed of camera that isn't easy to categorize





Today's mirrorless cameras are available with many different sizes of sensor. The smallest of these is the 1/1.7" Pentax Q-series sensor, which is the same size as those built into many mid-range compacts. The largest currently available sensor in a mirrorless camera is the full-frame model built into Sony's a7 cameras. Leica's M-series rangefinder cameras also offer full-frame sensors.

- ① 36 mm × 24 mm (full-frame; Sony a7)
- ② 23.6 mm × 15.8 mm (APS-C; Sony, Samsung, Fujifilm, Leica, Canon)
- ③ 17.3 mm × 13.0 mm (Four Thirds; Olympus, Panasonic)
- ④ 13.2 mm × 8.8 mm (1"; Nikon 1, Samsung NX Mini)
- ⑤ 7.6 mm × 5.6 mm (1/1.7"; Pentax Q)

their interchangeable lenses and, in some cases, their larger sensors.

DSLRs with APS-C sensors in the \$400-600 price range are more common, although here too, buyers have to put up with small viewfinders, plastic bodies and aging, low-resolution monitors. On this level, mirrorless cameras often have better specs for the same money, offering articulated

displays, Wi-Fi connectivity and high-end design as standard.

Mirrorless for Enthusiasts

This trend continues in the mid-range to high-end (\$600-\$2,000) segment, with some cameras offering features that are reserved for the pro end of the DSLR market or that are

unique to the mirrorless segment, such as the 4K video capture functionality built into the Panasonic Lumix GH4 and the Samsung NX1.

Olympus mirrorless cameras now have the unique 'Live Bulb' / 'Live Time' mode that enables you to watch long exposures take shape on the camera monitor while they are being captured; Sony's mirrorless a6000 has low shutter lag times in live view that some



The Olympus E-PL7 costs less than \$600 but nevertheless has a metal body and a high-end design. Its generous feature set includes Wi-Fi and an articulated touchscreen monitor.

Photo: Olympus



pro-grade DSLRs cannot compete with, even without live view; and the Samsung NX1's burst shooting rate of 15 fps is a new record in the APS-C arena.

Fujifilm has taken a different approach and, with its X-series cameras, is working hard to introduce brand new gear with an old-school analog feel, with separate dials for ISO, exposure time and exposure compensation settings, and an aperture ring built into the lens.

Mirrorless for the Pros

Sony is leading the way in the pro-grade mirrorless segment with its a7 cameras. These models have full-frame sensors and specifications that are tailored to quite specific shooting scenarios. The a7R's 36-megapixel sensor puts it on a level with Nikon's pro-grade D810 and the results we achieved with it are excellent (see Issue 16 for more details). Alongside its performance, the Sony's compact size and relatively cheap price point make it a tempting proposition. The same is also true of the a7S model which, with its maximum ISO setting of 409 600, finds itself in direct competition with the high-end Nikon D4s.

So Where's the Catch?

The camera alone isn't the key to great images and, just like their reflex cousins, high-quality mirrorless cameras are part of a system – and this is where you have to start making compromises.

There are simply not as many lenses available for mirrorless cameras as there are for DSLRs, and you can't use many popular low-price legacy lenses with them either. For

example, you can purchase a relatively bright 50mm f/1.8 standard lens for a mainstream DSLR for around \$120, or a brighter f/1.4 lens for around \$350. In the Canon and Nikon camps, such lenses can be used with full-frame and APS-C cameras too.

Lenses for mirrorless cameras paint a different picture. The 55mm f/1.8 for the Sony a7 cameras costs around \$1,000, while the 35mm f/1.4 for Fujifilm's APS-C X-series cameras will set you back about \$600 and a Micro Four Thirds 25mm f/1.8 costs \$400. With crop-sensor cameras, you also have to account for the crop factor, which in turn alters some aspects of the composition process. For example, a Micro Four Thirds lens with depth-of-field characteristics equivalent to those of a \$100 full-frame lens can cost \$1,000 or more.

Alongside high prices, another limiting factor is the small range of lenses that can be used without adapters on the new mirrorless bodies. Wide maximum apertures and super-telephoto focal lengths are a rarity, and the only way to address extreme situations is using adapters and lenses with other mounts or from third-party manufacturers. Before you commit to a purchase, it pays to take a closer look at the entire system that you are thinking of buying into.

The 'system' view also means taking a look into the future. Mirrorless is still a relatively new class of camera, and not all the major manufacturers have taken a long-term position with regard to market development. Canon's EOS M models still appear to be something of an afterthought rather than part of a long-term plan, and rumors continue to abound regarding a mirrorless full-frame camera from Nikon, although no-one knows which bayonet type this will have if it appears at all.

New mirrorless systems often suffer from a lack of dedicated lenses. Adapters make it possible to use lenses with other mounts, but this approach can be expensive and negates the advantages of using a compact mirrorless body. The image above shows a Sony a7R body fitted with an LA-EA4 adapter and the Sony 70-200mm f/2.8 G SSM II A-mount lens.

Mirrorless Camera Test

The following sections compare the image quality and handling of the current top-of-the-heap mirrorless models from a range of manufacturers.

The eight top-flight models we tested include the full-frame Sony a7 II, pro-grade APS-C models from Fujifilm and Samsung, and the Leica T with its high-end unibody design. We also checked out Micro Four Thirds models from

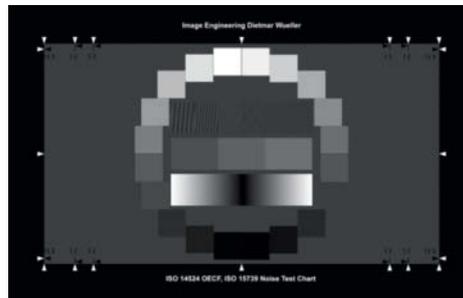
Olympus and Panasonic that aim to provide high-end image quality with just a quarter of the sensor area offered by the full-frame competition. Nikon's 1 V3, with its tiny CX-format sensor, completes our lineup. We

have already tested some of these cameras individually (see previous issues for details), but we couldn't resist lining them up together for a group test. Read on to find out how they fared in our detailed handling and image quality tests.

How We Tested

Noise Characteristics and Dynamic Range

We used an OECF chart to measure each camera's dynamic range, image range, white balance, signal-to-noise and visual noise characteristics. To do this, we captured frame-filling shots of the chart at various ISO levels using exposure parameters that consistently showed the upper left-hand white field as pure white.



An opto-electronic conversion function (OECF) is used to determine a digital camera's ability to convert brightness values into digital image data. We use a standardized OECF chart and an integrating sphere (also known as an Ulbricht sphere) to reliably determine each camera's noise behavior and dynamic range.

Resolution

To evaluate resolution, we took frame-filling test shots (at optimum aperture) of a chart made up of 25 Siemens stars with sine wave-shaped brightness gradients. Our testers focused manually on the center star and took five test shots at each aperture and focal length setting. They then used dedicated software to determine the maximum contrast between the darkest and brightest points at the fine ends of the points in the Siemens stars.

lens and released the shutter, which automatically started the LED sequence running at 100 Hz. The LED that was lit at the moment the shot was captured

enabled us to precisely determine the focus/shutter lag involved. We made 10 test shots for each focal length and used the average value in our table of results.

Sample Images

For our visual evaluation, we took test shots of the scene shown on the right under lab conditions at various ISO settings. The result of this subjective evaluation didn't form part of our empirical test results, but nevertheless allowed us to make a quick and simple judgment regarding the overall image quality produced by each camera.



Shutter Lag

To measure shutter lag, we used a board fitted with a 10x10 matrix of LEDs that light up in sequence. We defocused each



Handling

All the cameras we tested offer pro-grade handling, and the differences between them are largely to be found in the details. To keep the playing field level, we also included the exotic Leica T in our investigations.

First up is the **Sony a7 II**, the only full-frame camera in our lineup. The new version follows in the footsteps of the original introduced in late 2013, and offers more than just a cosmetic makeover. Sony has improved a lot of details in the body and the new version has a more robust, more professional feel. The bayonet, which showed visible play when used with large, heavy lenses in the original version, has been beefed up too. The grip is larger and provides a more secure feeling in everyday use, and now also provides a more natural-feeling home to the shutter release button. The new top plate is less cluttered and plays host to an additional (fourth) custom function button.

General handling sticks to a tried-and-trusted recipe, with a mode dial, a separate exposure compensation dial and two further dials that fulfill different functions depending on how the camera is set up. Most of the buttons and controls can be customized to suit your particular needs, turning the a7 II into a highly individual photographic tool.

The new camera's 5-axis SteadyShot image stabilizer can be switched to auto mode for use with compatible Sony lenses or can be manually set to between 8mm and 1000mm

to work with other lenses. We set up the system to compete with a tripod that can, of course, deliver printable images using just about any exposure time. We shot sequences of images at full-stop intervals and found that we could still shoot handheld at 1/5s using the 55mm f/1.8 lens and, with a manual setting of 400mm in the camera, at around 1/40s using a Canon 100-400mm zoom and a Metabones 3 adapter. In a crouched position supporting the camera on one knee, we even managed to keep still at slightly longer exposure times. Your own results will vary, depending on your experience, skill and fitness levels and, of course, on the steadiness of your hand.

Our test model was delivered with an in-camera charging cable but without a battery charger, which costs around \$60 extra in Europe. This may not apply in your territory, so please check what's in the box before making a purchase. The lack of a charger is a real bone of contention in a camera of this caliber, especially considering that Sony batteries are not known for their long life. Instead of the plastic covers used in the original version, the connectors on the side of the camera are now covered by a rubber cap, which provides better weatherproofing but might tear more easily under heavy use.

The **Samsung NX1** looks everything but retro and has a body designed very much along the lines of a modern DSLR, albeit one that is more petite than the Canon EOS 7D Mark II with which it competes. The large grip

Sony a7 II

The new version of the a7 is heavier and more robust than its predecessor



Samsung NX1

The NX1 has a DSLR-style design and is the only mirrorless camera in our test with a status display panel built into the top plate



is great to hold and, uniquely in this test, the NX1 has a status display built into its top panel that gives you a clear overview of all major settings. The NX1 sticks to its DSLR heritage with the rest of its controls too, and has a mode dial, a drive dial with buttons for ISO, white balance, AF mode and metering settings, and two command dials that can be used to adjust various exposure parameters depending on how the camera is set up.

The NX1's touchscreen display can, among other things, be used to adjust focus and activate the Tracking AF feature. The camera is generally quite practical to use, even if handling is not always intuitive. RAW capture, for example, is not possible in Auto mode. Like the Sony, the Samsung does not include a battery charger, so you have to charge the battery in the camera via USB. The optional ED-BC4NX03 charger costs \$30.

The **Fujifilm X-T1** includes a battery charger, so charging extra batteries is in this case a non-issue.

Compared with the other APS-C and full-frame models we tested, the X-T1 felt most solid. The camera feels cool to the touch, sits well in the user's hand and its overall build quality is excellent.

There is no dedicated mode dial, but instead separate ISO, exposure time and exposure compensation dials. The aperture is set in true old-school style using an aperture ring built into the lens. Overall, the X-T1 is designed from the ground up for manual use,

and it even has its own focus assist button. Unlike the Sony and the Samsung, the Fuji viewfinder doesn't switch on and off automatically, but it does offer a digital framing grid that you can show or hide as necessary.

With regard to handling, the **Leica T** is the complete antithesis of the X-T1. Its body is machined from a single block of aluminum and has very few visible buttons and controls. Its twin click wheels assume varying tasks depending on the mode the camera is switched to. All other adjustments are made via the camera's large touchscreen monitor. The tile-driven menu system is divided into relatively clear sections, although we found ourselves having to delve into the sub-menus to find some of the functions we were looking for. The 'My Camera' menu can be customized to contain the settings you use most often but, even though the touch-driven system is fairly intuitive, the Leica is quite difficult to use manually. We even had to resort to using the manual to find out how to review the images we shot. All in all, the Leica is aimed more at fans of great design rather than at dyed-in-the-wool photo enthusiasts.

The one-piece aluminum body is smooth and not as grippy as the other cameras we tested, and the lack of a viewfinder is a big drawback, especially when you consider that the optional Typ 020 model costs \$600 extra.



Fujifilm X-T1

The X-T1 has a chunky body with plenty of direct-access dials, and is aimed at photographers who prefer not to rely on automatic exposure modes



Leica T

The "T" is packed in a clean, smooth body machined from a single piece of aluminum and offers comprehensive touchscreen operation





Olympus OM-D E-M1

The E-M1 has a compact, retro-style body with a useful large grip. Its controls and handling are clearly designed for manual use.



Although the other cameras we tested have smaller bodies or sensors (or both), they still offer pro-grade features and handling.

The Olympus **OM-D E-M1** has a design that is not only nice to look at but also extremely practical. In spite of the large grip (which is much bigger than the one built into the earlier E-M5), the weatherproof E-M1 has very compact dimensions and has a less heavy-duty feel than, for example, the Sony a7II.

Olympus has geared the E-M1's handling toward photographers who like plenty of manual control, and the two main dials can be used to adjust either the aperture and the exposure time or the ISO and white balance settings. Used in conjunction with other buttons, these dials also control the focus mode, metering mode, HDR and burst shooting settings.

Like the larger a7II, the E-M1 is designed to enable you to make most major settings without taking your eye away from the viewfinder.

The 2.36-million dot viewfinder is similar to the ones found in other cameras in this class, and is just as easy to use as a conventional optical viewfinder. Once you become used to

using the zoom (focus assist) function or focus peaking to focus manually, you probably won't ever want to use anything else!

Like the a7II, the E-M1's 1.04-million dot touchscreen monitor can be tilted up and down, and its 720×480-pixel resolution puts it on a level with most of the competition – only Sony and Leica offer more. Also on par with the Sony is the built-in 5-axis stabilization.

The **Panasonic Lumix GH4** offers the same monitor and viewfinder resolution as the Olympus, although the monitor itself can be rotated and swiveled as well as tilted, providing even more shooting flexibility. The overall design has more in common with the modern DSLR aesthetics of the Samsung NX1 than the retro look of the Fujifilm X-T1 or the Olympus E-M1.

The Micro Four Thirds-based GH4 has more dedicated controls than the APS-C NX1, and its overall handling is better-thought-out and simpler. While Samsung forces its users to use both hands to set the ISO value, the Panasonic's ISO button and mode dial are located on the same side of the camera body, so users only need one hand to adjust both. The white balance and focus mode buttons are also conveniently located for one-handed control.

Panasonic Lumix GH4

The well-balanced DSLR-style body offers a broad range of direct-access controls and well-thought-out handling





Nikon 1 V3

The baby Nikon looks like a compact but works like a full-blooded system camera



Like the NX1, the GH-4's touchscreen monitor can be used to select the focus area, but its general touch-based controllability isn't as comprehensive as that offered by Leica and Nikon.

The touchscreen control built into the **Nikon 1 V3** is simple to use and reacts smoothly to user input. All you have to do is tap the parameter you wish to adjust and select your desired value in the list that pops up. You can focus and release the shutter via the touchscreen too.

In spite of its gesture-based simplicity, Nikon doesn't force you to do without a range of dedicated buttons and dials the way Leica and Canon do. If touch control isn't your thing, you can also control the "1" conventionally using its physical controls. The optional grip even includes an additional customizable function button and its own sub-command

dial. Handling is generally highly intuitive, although we did have to refer to the manual now and again.

The rubberized pads on the front and rear of the body are reminiscent of compact camera designs and make for a more secure grip than those offered by the Canon EOS M and the Leica T. Our only gripe with the tiltable display is that the ribbon cable connecting it to the camera is exposed, which could make it more vulnerable to damage than the Olympus or Sony cables, which are much better concealed.

The **Canon EOS M** doesn't have an articulated display, making it unique in this issue's test field. The EOS M is also the oldest camera we tested, although the new 24-megapixel MIII, designed to compete with the Sony a6000, had just hit the streets as we went to press. See Issue 21 for a review.

Like the Nikon 1 V3, the EOS M has a compact-style body and, although Canon has done away with most major controls in favor of the touchscreen, it still has a basic mode dial surrounding the shutter button and a four-way main dial, a menu button and a movie start/stop button on the camera back. There are no other settings dials.

All major settings are made via the touchscreen and the available buttons. For example, in aperture-priority (Av) mode, you can alter the aperture either by tapping the screen or using the main dial. Focus and shutter release are governed by the shutter button itself or via touchscreen gestures.

The EOS M is intuitive to use and its well-labeled buttons make it less of a puzzle to use than the Leica T. The only thing that holds it back at all is the sometimes sluggish response of the controls.



Canon EOS M

The EOS M packs an APS-C sensor into a compact-sized body and is controlled largely via its touchscreen monitor



ISO Comparison

Sony a7II

The sensor in the a7II hasn't been revised since the release of its predecessor and our test results turned out very much the same. Theoretically, the full-frame Sony should show much better noise characteristics than the competition, but this isn't always the case. The APS-C competition is strong and the results we measured are very similar for both categories of sensor. At ISO 100, the Sony produced a (subjectively judged) visual noise value of 0.8, which is, to all intents and purposes, noise-free. Values between 0.8 and 2.0 indicate low noise, values up to 3.0 some obvious noise, while values above 3.0 indicate obvious disruptive noise. Even at ISO 6400, the a7II scores below 2.0, and our sample images mirror our lab-based results. At low sensitivity settings, the camera delivers photos with a high level of detail contrast and reproduces fine textures in a sharp, natural-looking way that gives them a highly three-dimensional look. There is no detectable loss of detail all the way up to ISO 1600, but obvious (although non-critical) reduction in detail quality sets in above ISO 6400. At this level, the images are fine for full-screen viewing, and even shots captured at ISO 12800 look vibrant and lifelike when viewed on a monitor.

Samsung NX1

At low ISO levels, the Samsung NX1 offers the Sony a7II stiff competition and produces details that almost leap out at the viewer. Our lab-based test results speak volumes too, and the NX1 recorded 2016 line pairs of resolution when used with the 30mm f/2.0 lens, compared to the 1740 line pairs the Sony captured with the 55mm f/1.8. A visual noise value of 0.7 at ISO 100 beats the Sony too, but the Samsung loses detail faster than the Sony at higher ISO values, with obvious deterioration setting in at ISO 800 and above. The NX1 achieves great noise results by softening the entire frame, which in turn gives high-ISO results a slightly lifeless look. Bright colors and fine details take on an unnatural watercolor-style look, while some textures look oversharpened. Overall, the Samsung is less than ideal for shooting in low-light situations but nevertheless breaks a number of records with its extremely reliable autofocus and 15 fps burst shooting rate. AF shutter lag came in at just 0.2 seconds.

Sony a7II

Samsung NX1



Fujifilm X-T1



Leica T



Fujifilm X-T1

Of all this issue's test cameras, the APS-C Fujifilm X-T1 provides probably the stiffest competition for the full-frame Sony. We were very impressed with the results it produced with the XF 23mm f/1.4 lens, which makes the most of the relatively moderate 1623 line pairs of center resolution the camera recorded at ISO 100. The lens produces no visible errors and the resulting images have a clean, natural look. The X-T1 copes admirably at ISO values all the way up to 1600, with no visible loss of detail or texture. There is some visible grain at ISO 3200 and above, but this doesn't really spoil the overall quality of the images. Generally, the 16-megapixel X-T1 outruns the Samsung NX1 with its 28-megapixel sensor, producing clean, precise images with a high degree of natural texture. At high ISO values, the X-T1 is a match for the Sony a7II too, producing images with just as much detail and depth. The difference between the full-frame and APS-C image quality produced by these two cameras is extremely slight, and the X-T1 leads the pack in terms of dynamic range, recording just over 12 stops at ISO 400. At the end of the day, fans of highly detailed, natural-looking images are probably better off choosing the Fujifilm over the Sony.

Leica T

The Leica T produced excellent results in the lab, recording a visual noise value of just 0.7 at ISO 100 that increased only slightly further up the scale. At ISO 6400, the value suddenly hit 5.7, which is a sign of serious, disruptive noise. Our test images mirror these results nicely, with a precision almost on a level with that of the X-T1 at low ISO levels, although the Leica does tend to expose slightly more generously than the Fujifilm. Overall, the Leica images show a nice degree of depth and three-dimensionality. The Leica behaves a lot like the Fujifilm at higher ISO levels too, although edge details begin to lose definition a little earlier. Detail is very good all the way up to ISO 3200, although the grain the Leica produces is more obvious than that of the Fujifilm and gives images a slightly less vibrant look with a few color artifacts. The 23mm lens does a good job of utilizing the 16-megapixel sensor's resolution, recording 1570 of a potential maximum of 1623 line pairs. The most obvious weak point was the Leica's shutter lag, which came in at a relatively slow 0.7s using the Vario-Elmar-T 18-56mm f/3.5-5.6 ASPH lens.

Olympus OM-D E-M1

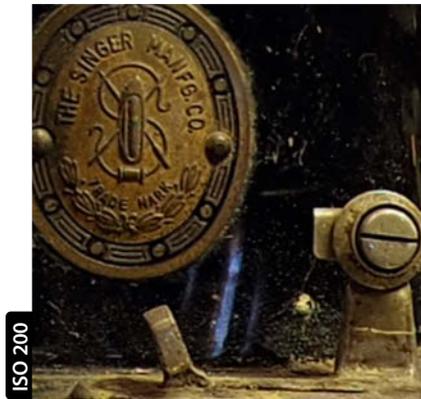
A Micro Four Thirds sensor has only one fourth of the surface area of a full-frame sensor and should, theoretically, be at a disadvantage when it comes to noise behavior and dynamic range. However, our lab test values didn't confirm the theory, recording visual noise values of 1.0 at ISO 100 and just 2.5 at ISO 6400 – values that are on a level with those of the APS-C Fujifilm X-T1. The test images we produced using the 25mm Leica lens show excellent detail and great depth at ISO 200 and utilize almost all of the potential 1728 line pairs of resolution offered by the lens. At higher ISO levels, the X-T1 begins to pull ahead and the images from the Olympus begin to show frayed edge details and poorly defined textures at ISO 1600. The Olympus firmware sharpens high-contrast edges more obviously than the Fujifilm, producing images that lack depth. At the end of the day, the high-ISO results produced by the Olympus are more comparable with those of the Samsung NX1, with its APS-C Csensor.

Panasonic Lumix GH4

The Panasonic Lumix GH4 and the Olympus OM-D E-M1 are technically very closely related, and our lab test values for the two cameras were very similar indeed. To keep the test comparable, we tested both cameras using a Leica DG Summilux 25mm f/1.4 ASPH lens, which resolved 100% of the GH4's potential resolution at its lowest ISO setting. There were virtually no visible differences between the images produced by the Olympus and the Panasonic, although the Olympus JPEG algorithm tends to produce higher contrast and therefore slightly 'harder' looking images, underscored by the Olympus' cooler overall white balance. The Olympus also tends to sharpen a little more than the Panasonic, which produces images that are generally slightly softer and more natural-looking. The Panasonic's sharpening and smoothing reticence at higher ISO levels is particularly obvious. In the shutter lag stakes, we measured 0.3s for the Panasonic and 0.26s for the Olympus, both using the 25mm Summilux.

Olympus OM-D E-M1

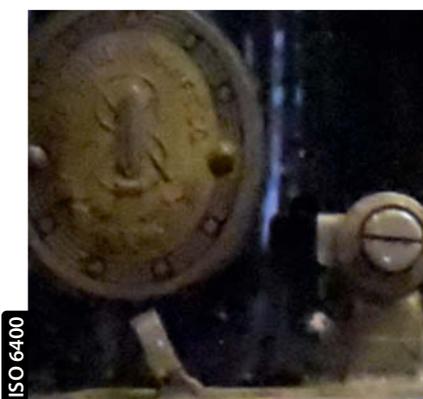
Panasonic Lumix GH4



Nikon 1 V3



Canon EOS M

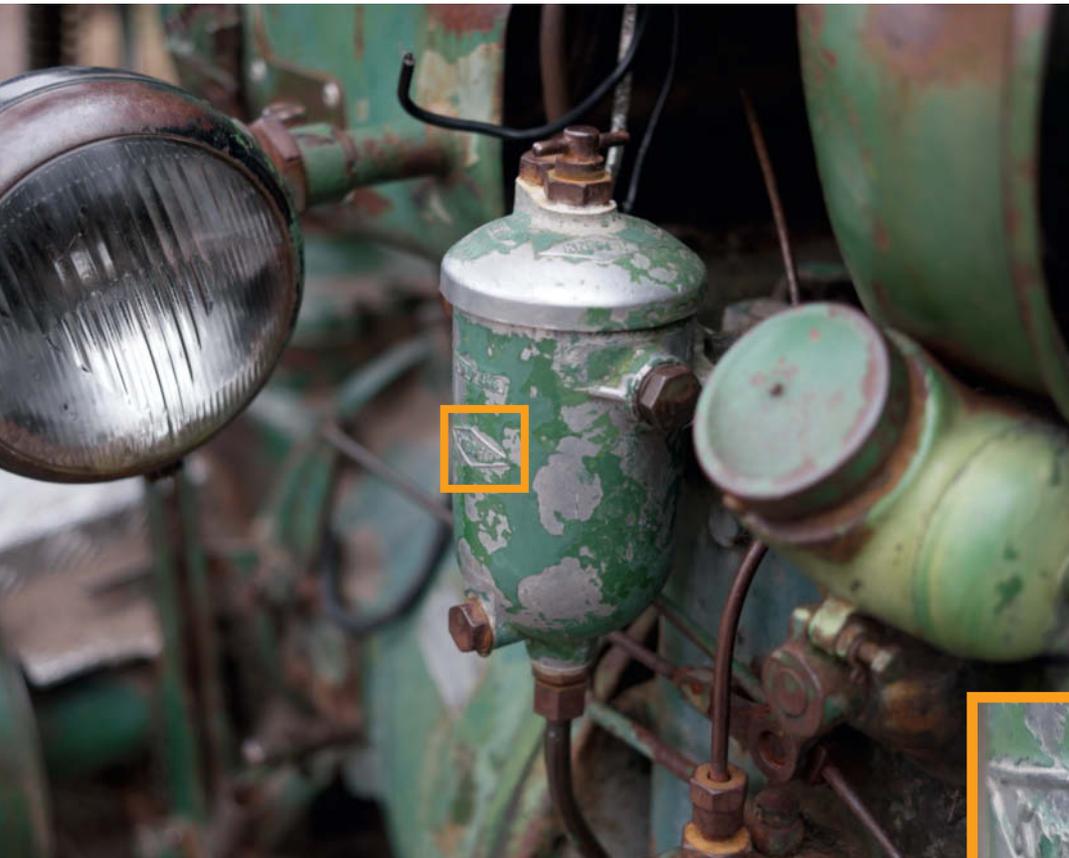


Nikon 1 V3

The Nikon 1 V3 adds a further class of sensor to our test. Measuring just 13.2×8.8mm, Nikon's 'CX' sensor format is a good deal smaller than Micro Four Thirds. Our lab tests showed no serious differences between the two sensors, but our real-world test shots tell a different story. The 1 V3 recorded a good visual noise value of 1.1 at the low end of the ISO scale and a moderate 2.7 at ISO 6400. Used with the 1 NIKKOR 32mm (85mm equivalent) lens, we measured almost 90 percent center resolution (1555/1744 line pairs). However, at ISO 6400 we measured a borderline value of just 1000 line pairs. In the real world, our test images began to show reduced detail at ISO values as low as 400 and begin to look quite soft at ISO 800. The Nikon's images also lack depth when compared with the shots produced by all the other cameras we tested. On the plus side, the V3's shutter lag value of 0.26s makes it one of the fastest cameras in this test.

Canon EOS M

The EF-M 22mm f/2.0 lens we used produced 94 percent center resolution (1627/1728 line pairs) at low ISO, although this value fell off more steeply than some of our other test candidates, measuring just 1430 line pairs at ISO 6400. The visual noise values we recorded are on a level with those of the other APS-C cameras we tested and came in at 1.0 at ISO 100, rising to just over 4 at ISO 6400. Our lab and real-world test images show good detail at low ISO values, although the depth and microcontrast on show is not as good as that produced by the Fujifilm X-T1. Like the Leica T, the EOS M tends to overexpose, and the images we captured at higher ISO values with these two cameras look very similar. At ISO 3200, the EOS M still shows good detail reproduction, although this is marred somewhat by obvious color noise artifacts that make the images look rather lifeless. The EOS M's shutter lag value of 0.9s makes it one of the slowest system cameras we have ever tested.



Samsung NX1
A 28-megapixel APS-C sensor that delivers full-frame image quality at ISO 100



Samsung NX1 with the 30 mm f/2.0 | ISO 100 | f2 | 1/160 s | 200%, captured at the Hannover Adventure Zoo



Olympus OM-D E-M1
The Micro Four Thirds sensor is a fair match for the APS-C competition, and the difference is hardly visible under good shooting conditions



OM-D E-M1 with the 40-150mm f/2.8 PRO | 150 mm | ISO 200 | f/5.6 | 2/3 s | 200%





Nikon 1 V3

Small sensor = Shallow depth of field? With the right lens, even the Nikon 1 V3 can produce lovely smooth bokeh.



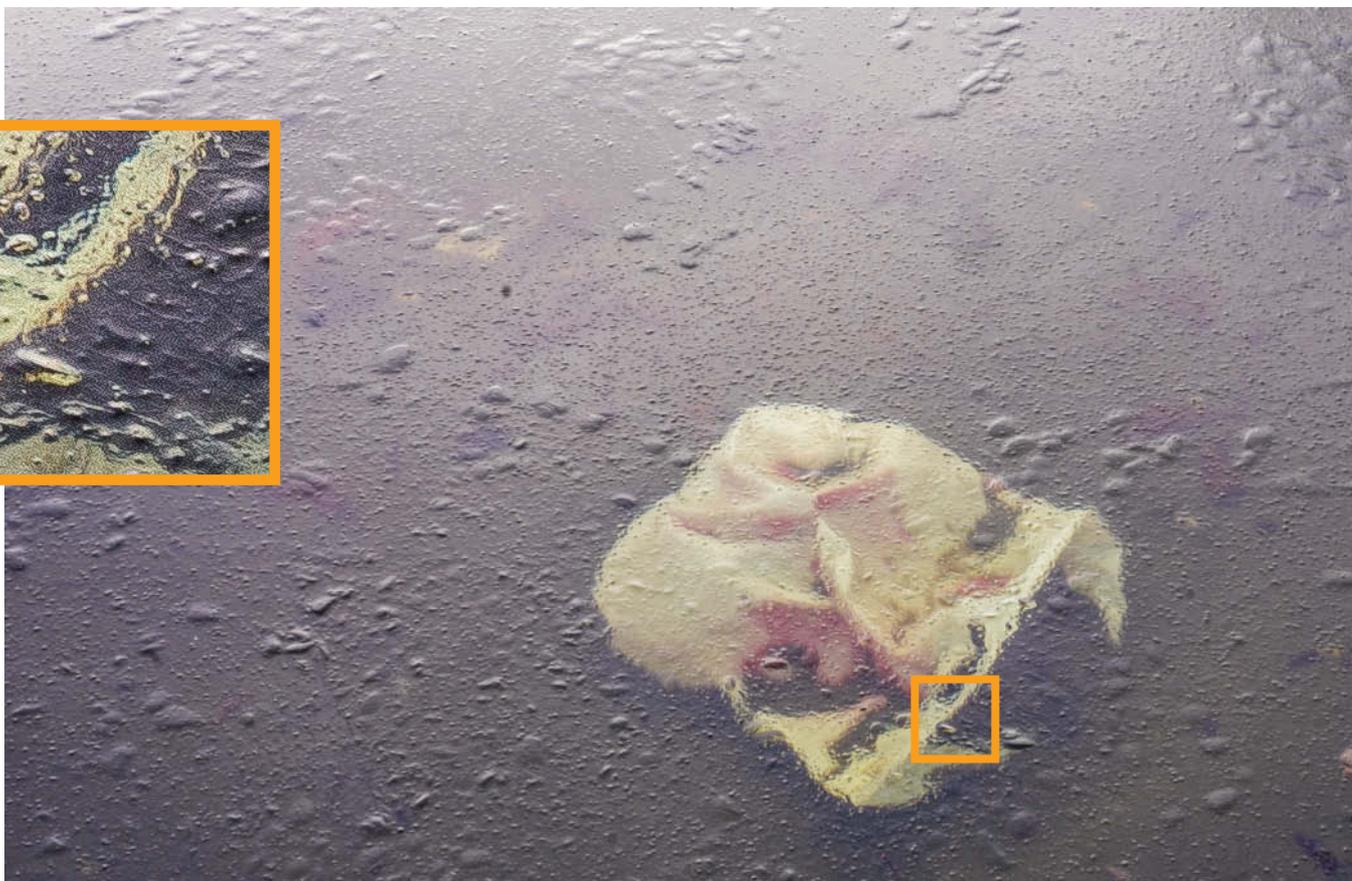
Nikon 1 V3 with the 1 NIKKOR 32mm f/1.2 | ISO 160 | f/1.8 | 1/1600s | 200%, captured at the Hannover Adventure Zoo

Sony a7II

Thanks to sophisticated stabilization, you can leave your tripod at home and shoot relatively long handheld exposures at small apertures



Sony a7II with the 55mm f/1.8 | ISO 100 | f/16 | 1/13s | 200%



Conclusions



Sony a7 II

- + A full-frame sensor in a compact body at a reasonable price. The a7II offers great design and excellent handling. The new version is a lot more robust than its predecessor, and is more reminiscent of a pro-grade DSLR. The 5-axis stabilizer is a huge bonus, and makes it possible to reliably shoot long exposures handheld.
- E-Mount lenses are more expensive than their DSLR system counterparts and the range of lenses available is relatively limited. Other lenses can be used with adapters, but involve compromises in handling and image quality. A battery charger should be included with a camera of this caliber.

Samsung NX1

- + The NX1 is Samsung's shot at entering the pro-grade camera league. The camera is extremely well built and handles like a true DSLR, with a status display panel on the top plate. The articulated touchscreen monitor, built-in Wi-Fi and NFC functionality round out the full feature set. The NX1 is faster than a lot of the APS-C competition.
- Samsung is new to the high-end camera market and has less experience than Canon, Nikon, Pentax and the like. This is evident in missing features such as RAW capture in Auto mode. Samsung, too, needs to expand its lens range if it is to remain competitive. A battery charger should be included with this class of camera.



Fujifilm X-T1

- + The X-T1 is the most ambitious newcomer in our test group, with excellent build quality and a high degree of manual control. Image quality is consistently high, producing natural-looking photos with plenty of depth and detail. Even at higher ISO values, the X-T1's APS-C sensor is often equal to the full-frame competition.
- Fujifilm has so far introduced only three weatherproof lenses to match the X-T1's robust body. The other primes available are of a very high quality but have high-end prices too.

Leica T

- + The Leica T is machined from a single block of aluminum and has an elegant, understated look that sets it apart from the rest of the black plastic competition. As expected, image quality is very good indeed.
- The minimalist design and touchscreen control is laborious, sometimes slow and tricky to master. This is not a camera for photographers who like to keep their shooting parameters under constant control. Autofocus is relatively slow and the optional viewfinder is expensive.



Olympus OM-D E-M1



- + Olympus' Micro Four Thirds strategy aims to put pressure on the APS-C mirrorless and DSLR competition, and the E-M1 succeeds on many fronts. Handling is practical and highly customizable. At low ISO values, results are as good as those of the APS-C competition, and the Micro Four Thirds system offers the widest range of lenses currently available for mirrorless cameras. This model also has a built-in 5-axis image stabilizer.
- High-end Micro Four Thirds lenses are expensive and quite large, which negates some of the advantages of a compact camera body. The firmware relies on heavy sharpening when processing JPEG images.

Panasonic Lumix GH4

- + The GH4's traditional DSLR-style body makes it a pleasure to handle, and its many controls and buttons can be customized for full manual control. The GH4 also has built-in 4K video capture functionality (see Issue 19 for more details on the pros and cons of 4K video capture for photographers).
- The GH4 is relatively small and doesn't feel as robust as the the Fujifilm X-T1 and the Sony a7II.



Nikon 1 V3



- + The baby in our test. With the "1" series, Nikon has introduced a new class of camera that takes the compromise between camera size and image quality to its extremes. Nonetheless, the V3 has a good range of manual controls and a well-thought-out system of buttons, dials and touchscreen gestures. The camera is very fast and the optional grip includes an additional custom function button.
- The tiny sensor simply cannot compete on all fronts with the larger competition. Only use the 1 V3 to shoot at high ISO levels in an emergency.

Canon EOS M

- + The EOS M is very compact for an APS-C camera. Image quality is very good and the original version of the camera can currently be purchased for around \$350, making it better value than many mid-range compacts.
- Canon has had to put up with heavy criticism for the EOS M's poor autofocus system. So far, Canon hasn't appeared too interested in developing the M system, although fans are hoping that the new version of the camera will change that. The current range of four medium-bright lenses is unlikely to convince enthusiasts to take the plunge.



TOP-OF-THE-RANGE MIRRORLESS CAMERA

Technical Data



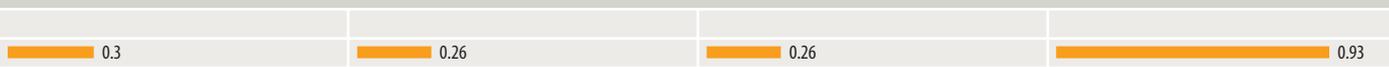
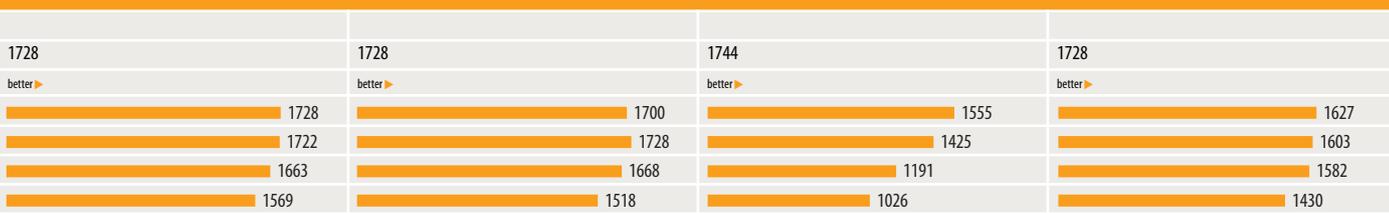
	Sony a7R II	Samsung NX1	Fujifilm X-T1	Leica T
URL	www.sony.com	www.samsung.com	www.fujifilm.com	us.leica-camera.com
Sensor type/size	Full-frame / 35.8 mm × 23.9 mm	APS-C/ 23.5 × 15.7 mm	APS-C/ 23.6 mm × 15.6 mm	APS-C/ 23.6 mm × 15.7 mm
Megapixel count	24	28	16	16
Sensor resolution	6000 × 4000	6480 × 4320	4896 × 3264	4928 × 3264
Crop factor	1	1.5	1.5	1.5
Sensitivity range	ISO 50-25 600	ISO 100-51 200	ISO 100-51 200	ISO 100-12 500
Autofocus	Hybrid	Hybrid	Hybrid	Contrast
Autofocus areas	117 phase-detection, 25 contrast	205 phase-detection, 209 contrast	49	n/a
Cross sensors	n/a	153	n/a	n/a
Shortest / Longest exposure time	1/8000 s / 30 s, Bulb	1/8000 s / 30 s, Bulb	1/4000 s / 30 s, Bulb	1/4000 s / 30 s
Max. burst rate (in fps)	up to 5	15	8	5
Video formats	AVCHD 2.0 / MP4 / XAVC S	MP4, AVI	MOV	MP4
Max. video resolution	1920 × 1080/60p; 50 Mbps	1920 × 1080/60p	1920 × 1080/60p	1920 × 1080/30p
Viewfinder	OLED	OLED	OLED	optional
Viewfinder resolution	2.36 million dots	2.36 million dots	2.36 million dots	–
Monitor	LCD, 3-inch	AMOLED, 3-inch	LCD, 3-inch	LCD, 3.7-inch
Monitor resolution	1.23 million dots (850 × 480 pixels)	1.04 million dots (720 × 480 pixels)	1.04 million dots (720 × 480 pixels)	1.3 million dots (854 × 480 pixels)
Monitor articulation	Yes (107 degrees up, 41 degrees down)	Yes	Yes	No
Lens mount	Sony E-Mount	Samsung NX	X-mount	T-mount
Dimensions	127 mm × 96 mm × 60 mm	139 mm × 102 mm × 66 mm	129 mm × 90 mm × 47 mm	134 mm × 70 mm × 33 mm
Weight (incl. batt. and mem. card)	600 g (21.2 oz)	550 g (19.4 oz)	440 g (15.4 oz)	384 g (13.5 oz)
Supported memory cards	SD, SDHX, SDXC; UHS-I; Memory Stick	SD, SDHC, SDXC; UHS-I, UHS-II	SD, SDHC, SDXC (UHS-II)	SD, SDHC, SDXC
Connectors	Wi-Fi, NFC, Micro USB, Micro HDMI	Wi-Fi, NFC, Micro USB 3.0, Micro HDMI, Bluetooth	Wi-Fi, Micro USB 2.0, Mini HDMI	Wi-Fi, Micro USB 2.0
Additional features	5-axis stabilizer	Status display panel, 4K video capture	No main mode dial	Aluminum unibody, 16 GB built-in memory
RSP (body only)	\$1,700	\$1,499	\$1,200	\$1,850

Test Results

Sensor resolution ¹	2000	2016	1632	1632
	better >	better >	better >	better >
Center resolution (lowest ISO)	1740	2016	1632	1570
Center resolution (ISO 400)	1754	1904	1632	1587
Center resolution (ISO 1600)	1700	1889	1630	1496
Center resolution (ISO 6400)	1642	1662	1506	1465
Dynamic range ² (lowest ISO)	11.4	9.33	9.56	10.46
Dynamic range (ISO 400)	10.13	9.9	12.4	10.31
Dynamic range (ISO 1600)	10.19	9.25	10.6	9.9
Dynamic range (ISO 6400)	9.9	9.27	10.4	7.75
Visual Noise (lowest ISO)	0.8	0.7	1	0.7
Visual Noise (ISO 400)	0.9	0.8	1.2	1.2
Visual Noise (ISO 1600)	1.1	1.2	1.5	2.3
Visual Noise (ISO 6400)	1.7	1.5	2.1	5.7
Shutter lag at 1000 lux	0.35	0.2	0.34	0.7
¹ In line pairs	² In f-stops	n/a = not applicable		



Panasonic Lumix GH4	Olympus OM-D E-M1	Nikon 1 V3	Canon EOS M
www.panasonic.com	www.olympus.com	www.nikon.com	www.canon.com
Micro Four Thirds/ 17.3 mm × 13 mm	Micro Four Thirds/ 17.3 mm × 13 mm	Nikon CX/ 13.2 mm × 8.8 mm	APS-C/ 22.3 mm × 14.9 mm
16	16	18	18
4608 × 3456	4608 × 3456	5232 × 3488	5184 × 3456
2	2	2.7	1.6
ISO 100-25 600	ISO 100-25 600	ISO 160-12 800	ISO 100-25 000
Contrast	Hybrid	Hybrid	Hybrid
49	37 phase-detection, 81 contrast	171 (105 phase-detection)	31
n/a	n/a	n/a	n/a
1/8000 s / 60 s, Bulb	1/8000 s / 60 s, Bulb	1/4000 s (mechanical), 1/16 000 s (electronic) / 30 s	1/4000 s / 30 s, Bulb
12	10	60	4
AVCHD, MP4, MOV	MOV, AVI	MPEG-4	MPEG-4
1920 × 1080/60p	1920 × 1080/30p/ 24 Mbps	1920 × 1080p/ 60fps	1920 × 1080p/25p
OLED	LCD	optional	optional
2.36 million dots	2.36 million dots	–	–
OLED, 3-inch	LCD, 3-inch	LCD, 3-inch	LCD, 3-inch
1.04 million dots (720 × 480 pixels)	1.04 million dots (720 × 480 pixels)	1.04 million dots (720 × 480 pixels)	1.04 million dots (720 × 480 pixels)
Tilt/swivel	Yes	Yes (87 degrees up)	No
Micro Four Thirds	Micro Four Thirds	Nikon 1	Canon EF-M
133 mm × 93 mm × 84 mm	130 mm × 94 mm × 63 mm	111 mm × 65 mm × 33 mm	110 mm × 67 mm × 32 mm
560 g (19.75 oz)	497 g (17.5 oz)	324 g (11.4 oz)	295 g (10.4 oz)
SD, SDHC, SDXC (UHS-II-compatible)	SD, SDHC, SDXC (UHS-I-compatible)	microSD, microSDHC, microSDXC	SD, SDHC, SDXC, UHS-I
Wi-Fi, Micro USB 2.0, Micro HDMI	Wi-Fi, Micro USB 2.0, Micro HDMI, Bluetooth	Wi-Fi, Micro USB 2.0, Micro HDMI, PictBridge	USB 2.0, Mini HDMI, PictBridge
4K video capture	Live Bulb, 5-axis image stabilizer	High burst shooting speeds	APS-C sensor in a compact body
\$1,300	\$1,300	\$1,200 (kit with 10-30mm lens, viewfinder and grip)	\$600 (original version w/ EF-M 22mm STM lens)





Sophia Zimmermann

High-End Compacts

Camera Test and Market Overview

DSLRs and system cameras are getting smaller and cheaper all the time, with entry-level models going for as little as \$500. In a market like this, who needs a camera with a fixed lens? The compact camera segment is shrinking rapidly, although many of these cameras are better than their reputation would have us believe. We take a look at the latest high-end offerings to hit the market and give the Sigma dp2 Quattro, Fujifilm X100T, Canon G7X and Panasonic Lumix LX100 the full *c't* test treatment.

Cool design, intuitive handling and high image quality are the cornerstones of most photographers' expectations when it comes to choosing a camera. System cameras (with or without a mirror) are most likely to fulfill these hopes, and the mirrorless segment in particular is brimming with innovative designs. However, all this progress has left the mid-range compact segment behind, while rapid improvements in smartphone technology have all but replaced the market for entry-level compact cameras.

But compact cameras are not dead yet! 2014 saw the introduction of a slew of new high-end compacts with large sensors and state-of-the-art features that are just as exciting as those built into the latest mirrorless system cameras.

Design

Design-wise, Sigma's dp Quattro cameras are particularly interesting, and look more like stretched smartphones with a grip than conventional compact cameras. Love it or hate it, it's a design that definitely gets people talking.

Fujifilm, Sony, Canon and Panasonic all prefer timeless understatement and have given their latest compacts a lot of retro-style design elements. The Sony RX100III has a particularly inconspicuous, no-frills body, while the Panasonic Lumix LX100 has a bulky body that conveys the impression of a powerful photographic tool, and the Fujifilm X100-series cameras wouldn't have looked out of place in a 1970s camera store.

What all these high-end compacts have in common is their complete lack of bright colors and cute, rounded corners – and they also all have plenty of buttons and dials to play with.

Sensors

None of the cameras tested here use the 1/2.3" sensors common in entry-level and mid-range compacts. These tiny (6×4.6mm) sensors are well-known for their relatively narrow dynamic range, poor detail reproduction under sub-optimum lighting and their excessive depth of field. This class of camera offers quality on a par with many smartphones and, as such, is not really suitable for serious photography.

True high-end compacts have 1" or larger sensors, and there is a wide range of options available in this segment. Sony uses 13.2×8.8mm sensors in its RX100 and RX10 cameras as well as in the QX100 smartphone camera module, and Panasonic uses the same sensor in its Lumix FZ1000 bridge

camera. Canon's PowerShot G7 X, introduced at last year's Photokina, also incorporates a 1" sensor.

Four Thirds sensors offer almost twice the surface area of their 1" counterparts and are still something of a rarity in the compact segment, mainly because Olympus and Panasonic prefer to build them into their higher-quality mirrorless system cameras.

The Lumix LX100 represents Panasonic's first foray into the Micro Four Thirds compact arena, while the Canon G1X Mark II has a similar-sized sensor that measures 18.7×14mm.

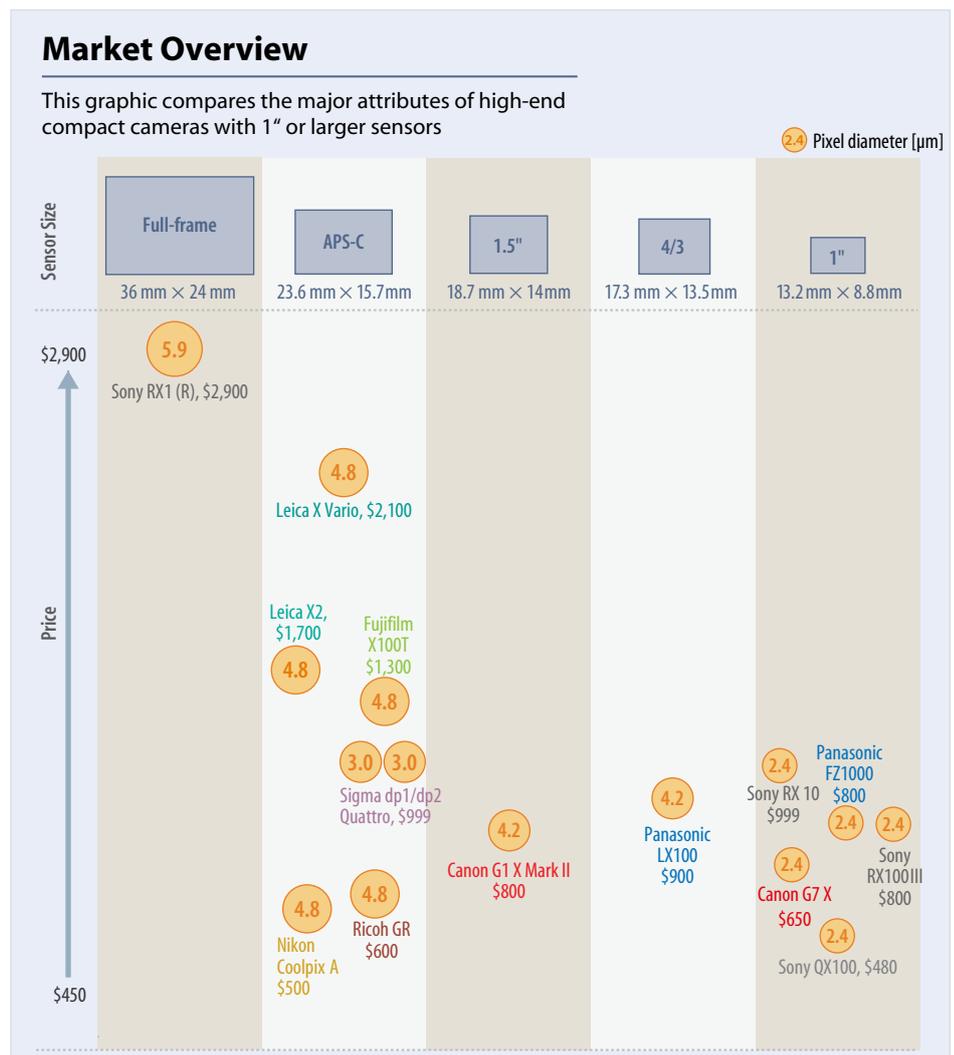
This size of a sensor makes it possible to switch formats without cropping and instead using optimized portions of the image circle projected by the lens for both 3:2 and 4:3 images. The LX100, for example, uses a 15.7×11.8mm section of the frame to shoot at 4:3, and a 16.3×10.9mm section for 3:2 shots. Both formats produce 12-megapixel images. Canon takes a similar approach, using

the full width of the sensor for 3:2 shots and its full height for 4:3.

APS-C, Full-frame, Foveon

Although they are often found in DSLR or mirrorless system cameras, APS-C sensors can also be found in compacts from Nikon, Ricoh, Leica and Fujifilm.

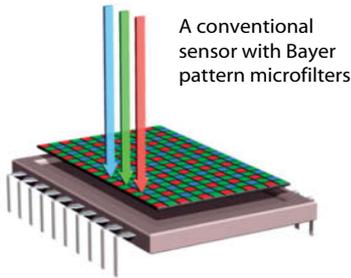
The most unusual sensor in this test is the Foveon type built into Sigma's dp2 Quattro. These sensors are the same size as APS-C models but, instead of using a Bayer pattern grid of color filters located in front of the sensor to interpolate color data from the incoming light, they use separate sensor layers to record data for each of the three primary colors red, green and blue. According to Sigma, the Foveon image capture process is similar to the way the separate layers of emulsion in an analog film capture images, and provides pure color data for each pixel. The manufacturer claims that this approach



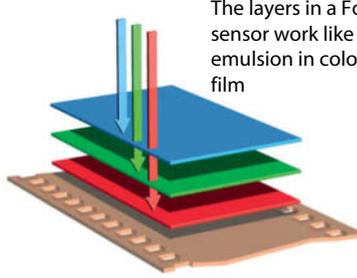
Foveon Sensors

Instead of a conventional sensor with RGB Bayer pattern microfilters, Sigma's dp Quattro cameras incorporate Foveon sensors that gather color data using three separate light-sensitive layers.

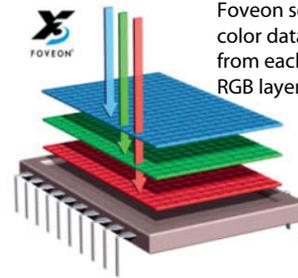
Illustration: Foveon Inc.



A conventional sensor with Bayer pattern microfilters



The layers in a Foveon sensor work like the emulsion in color analog film



Foveon sensors record color data for each pixel from each of the three RGB layers

produces images with more detail and fewer color errors and artifacts.

With its full-frame sensor, Sony's RX1(R) still occupies a unique pro-grade niche in the compact camera market.

Moderate Resolution

Even though camera manufacturers are still battling it out to see who can fit the most

pixels on a small sensor in the entry-level and mid-range compact segments, high-end compacts rarely have resolution of more than 12 megapixels and tend to stick to a less brash concept that produces well-balanced, high-quality images.

The fewer pixels a sensor contains, the larger each can be, and the larger it is, the better a pixel can perform the job of collecting

photons that generate the electronic signals that the camera's firmware transforms into image data.

Lenses

The lenses built into high-end compacts don't break any zoom-range records, and are designed to produce quality rather than

HIGH-END COMPACTS WITH 1" AND LARGER SENSORS

Manufacturer/Model	Canon G7 X	Panasonic FZ1000	Sony RX100 MIII	Sony RX10	Sony QX100	Canon G1 X Mark II	Panasonic LX100
Price	\$649	\$780	\$800	\$1,000	\$498	\$800	\$800
Digitization							
Sensor size / Crop factor	1", 13.2×8.8 mm/2.7	1", 13.2×8.8 mm/2.7	1", 13.2×8.8 mm/2.7	1", 13.2×8.8 mm/2.7	1", 13.2×8.8 mm/2.7	1.5", 18.7×12.5 mm/1.9	4/3", 17.3×13 mm/2
Sensor resolution	20 MP (3:2)	20 MP (3:2)	20 MP (3:2)	20 MP (3:2)	20 MP (3:2)	12 MP (3:2); 13 MP (4:3)	12 MP
Max. image size (pixels)	5472 × 3648	5472 × 3648	5472 × 3648	5472 × 3648	5472 × 3648	4352 × 2904 (3:2); 4160 × 3120 (4:3)	4112 × 3088 (4:3); 4272 × 2856 (3:2)
Image and video formats	JPEG, RAW, MP4/ H.264	JPEG, RAW, MP4, AVCHD	JPEG, RAW, XAVCS, AVCHD	JPEG, RAW, XAVCS, AVCHD	JPEG, RAW, MP4	JPEG, RAW, MP4	JPEG, RAW, MP4, AVCHD
Max. video resolution / fps	1920 × 1080/ 60 fps	3840 × 2160, 30 fps	1920 × 1080, 60 fps	1920 × 1080, 60 fps	1920 × 1080, 30 fps	1920 × 1080, 30 fps	3840 × 2160, 30 fps 1920 × 1080/ 60 fps
Memory card types / Internal memory	SD, SDHC, SDXC/ –	SD, SDHC, SDXC/ –	SD, SDHC, SDXC, / –	SD, SDHC, SDXC, / –	SD, SDHC, SDXC, / –	SD, SDHC, SDXC/ –	SD, SDHC, SDXC/ –
Features							
ISO sensitivity (extended)	ISO 125–12 800	ISO 125–12800 (ISO 80, 100, 25600)	ISO 125–12 800 (ISO 80, 100, 25600)	ISO 125–12 800 (ISO 80, 100, 25600)	ISO 125–12 800 (ISO 160–25 600)	ISO 100–12 800	ISO 200–25 600 (ISO 100)
Aperture range	f/1.8 – f/2.8	f/2.8 – f/4.0	f/1.8 – f/2.8	f/2.8	f/1.8 – f/4.9	f/2.0 – f/3.9	f/1.7 – f/2.8
Zoom range/ focal length(s)	4.2× / 24–100 mm	16× / 25–400 mm	3× / 24–70 mm	8× / 24–200 mm	3× / 28–100 mm	5× / 24–120 mm	3× / 24–75 mm
Close focus distance	5 cm (wa), 40 cm (t)	30 cm (wa), 100 cm (t)	5 cm (wa), 30 cm (t)	3 cm (wa), 30 cm (t)	5 cm (wa), 55 cm (t)	5 cm (wa), 40 cm (t)–	3 cm (wa), 30 cm (t)
Autofocus	Contrast (31-point)	Contrast (49-point)	Contrast (25-point)	Contrast (25-point)	Contrast (25-point)	Contrast (31-point)	Contrast (31-point)
Exposure times	1–1/2000 s (250 s long exposure)	60–1/4000 s (mech.), 1–1/16 000 s (electr.)	30–1/2000 s	30–1/3200 s	8–1/2000 s	60–1/4000 s	60–1/4000 s (mech.), 1–1/16 000 s (electr.)
Viewfinder type / Resolution	none	OLED / 2.36m dots	Pop-up OLED / 1.4m dots	OLED / 1.23m dots	none	optional	electronic / 2.8m dots
Monitor size / Resolution	Tilttable 3" LCD / 1.04m dots	Articulated 3" LCD / 921, 000 dots	Tilttable 3" LCD / 1.23m dots (4:3)	Tilttable 3" LCD / 1.23m dots	none	Tilttable 3" LCD / 1.04m dots	3" LCD / 921,000 dots
Connectors / Dimensions							
USB / AV out / HDMI	yes / yes / yes	yes (AV/USB multi) / yes / yes	yes (AV/USB multi) / yes	yes / yes (AV/USB multi) / yes	USB only	yes / yes / yes	yes (AV/USB multi) / yes / yes
Wi-Fi / NFC / GPS	yes / yes / via mobile device	yes / yes / via mobile device	yes / yes / via smartphone	yes / yes / via smartphone	yes / yes / via smartphone	yes / yes / via smartphone	yes / yes / via mobile device
W×H×D / Weight	103 × 60 × 40 mm / 304 g	137 × 99 × 131 mm / 831 g	102 × 58 × 41 mm / 290 g	129 × 88 × 102 mm / 813 g	63 × 63 × 53 mm / 180 g	116 × 74 × 66 mm / 553 g	115 × 66 × 55 mm / 393 g

quantity. You won't usually find more than 10x zoom capacity in a high-end compact.

The upside of this modest approach is that most high-quality compacts have fast lenses with wide maximum apertures. For example, the Canon PowerShot G7 X has a 24-100mm (equivalent) lens with an aperture range of f/1.8-2.8, while the Sony RX10 has a 24-200mm range at a constant maximum aperture of f/2.8.

Some compacts still rely on the wide-angle, fixed-focal-length lenses popular with photojournalists. Prime lenses are not subject to the quality compromises that variable focal lengths often involve, and provide sure-fire image quality.

Large maximum apertures make it easier to shoot in low light and also provide you with the opportunity to experiment with shallow depth of field at relatively short focal lengths.

Features and Prices

The photographic freedom that these models promise is mirrored in the wide range of buttons, dials and customizable controls they offer. Manual exposure control is the order of

the day, and unlike many conventional compacts, high-end models also have built-in (or optional) viewfinders to help you with your composition.

Viewfinder resolutions of 2.36-2.76 million dots provide almost HD clarity, compared with the rather old-school 921K dots (approximately 640x480 pixels) offered by most monitors. Articulated viewfinders, on the other hand, offer new opportunities for creative shooting. Most of these cameras also have built-in Wi-Fi functionality that enables you to control the camera remotely using a smartphone or tablet, although it has to be said, some manufacturers have taken more care than others in implementing this feature.

Many of the cameras tested here cost as much as a full-featured system camera. The Canon G7 X, for example will set you back \$650, while the Sony RX100 III currently costs around \$800, although if you are prepared to put up with the original RX100's teething troubles, it is still available and will cost you about half as much as the latest version. The Fujifilm X100T, with its APS-C Sensor, costs about \$1,300, and Sigma's Foveon-based dp Quattro cameras are slated to sell for \$999 each.

Conclusions

Compact cameras in this price range are generally aimed at enthusiast photographers without budget restrictions.

Many of these models make ideal point-and-shoot second cameras to complement a pro-grade DSLR outfit, and are sure to produce reliable, high-quality results that are better than any you can capture using a smartphone.

They are also ideal for photographers who demand high-quality images but who don't wish to deal with the complexity of a system-based camera or continually invest in new lenses.

Compacts with zoom lenses cover a useful range of focal lengths and offer maximum apertures that are otherwise only available in expensive system lenses.

Purists and reportage fans will love the Fujifilm X100T and Sigma dp2 Quattro with the fast, fixed-focal-length lenses that make these cameras great niche players, even if they are unlikely to gain a reputation as all-rounders. In fact, they are more like collector's items for lovers of slow-speed photography. (ssi)

Fujifilm X100T	Leica X2	Leica X Vario	Nikon Coolpix A	Ricoh GR	Sigma dp1 Quattro	Sigma dp2 Quattro	Sony RX1 (R)
							
\$1,300	\$1,700	\$2,100	\$600	\$600	\$999	\$999	\$2,800
APS-C-X-Trans, 23.6 x 15.6 mm / 1.5	APS-C, 23.6 x 15.8 mm / 1.5	APS-C, 23.6 x 15.8 mm / 1.5	APS-C, 23.6 x 15.6 mm / 1.5	APS-C, 23.7 x 15.7 mm / 1.5	APS-C, 23.5 x 15.7 mm / 1.5	APS-C, 23.5 mm x 15.7 mm / 1.5	Full-frame, 36 x 24 mm / 1
16 MP	29 MP	29 MP	24 MP				
4928 x 3264	4896 x 3264	4944 x 3274	4928 x 3264	4928 x 3264	7680 x 5120	7680 x 5120	6000 x 4000
JPEG, RAW, MOV (H.264)	JPEG, DNG	JPEG, DNG, MP4	JPEG, RAW, MOV (H.264)	JPEG, RAW, MPEG-4, H-264, AVI	JPEG, RAW	JPEG, RAW	JPEG, RAW, MP4, AVCHD
1920 x 1080, 60 fps	-	1920 x 1080, 30 fps	1920 x 1080, 30 fps	1920 x 1080, 30 fps	-	-	1920 x 1080, 50 fps
SD, SDHC, SDXC / 5.5 MB	SD, SDHC, SDXC / 110 MB	SD, SDHC, SDXC / -	SD, SDHC, SDXC / -	SD, SDHC, SDXC / 54 MB	SD, SDHC, SDXC / -	SD, SDHC, SDXC / -	SD, SDHC, SDXC / -
ISO 200-6400 (ISO 100-51 200)	ISO 100-12 500	ISO 100-12 500	ISO 100-6400 (ISO 25 600)	ISO 100-25 600	ISO 100-6400	ISO 100-6400	ISO 100-25 600 (ISO 50)
f/2	f/2.8	f/3.5-f/6.4	f/2.8	f/2.8	f/2.8	f/2.8	f/2.0
Fixed focal length / 35 mm	Fixed focal length / 35 mm	2.5x / 28-70 mm	Fixed focal length / 28 mm	Fixed focal length / 28 mm	Fixed focal length / 28 mm	Fixed focal length / 45 mm	Fixed focal length / 35 mm
50 cm, 10 cm (macro)	30 cm	30 cm	50 cm, 10 cm (macro)	30 cm, 10 cm (macro)	20 cm	28 cm	24 cm, 14 cm (macro)
Hybrid (Contrast + Phase)	Contrast (11-point)	Contrast (11-point)	Contrast	Contrast	Contrast (9 areas)	Contrast (9 areas)	Contrast
30 min - 1/4000 s (mech.), 1-1/32 000 s (electr.)	30-1/2000 s	30-1/2000 s	30-1/2000 s	300-1/4000 s	30-1/2000 s	30-1/2000 s	30-1/4000 s
Hybrid with LCD element	optional	optional	optional	optional	optional	optional	optional
3" LCD / 1.04m dots	2.7" LCD / 230,000 dots	3" LCD / 920,000 dots	3" LCD, 921,000 dots	3" LCD, 1.23m dots	3" LCD, 920,000 dots	3" LCD, 920,000 dots	3" LCD, 1.23m dots
yes (AV/USB multi) / yes / yes	yes / - / yes	yes / - / yes	yes / yes / yes	yes / yes / yes	yes / no / no	yes / no / no	yes (AV/USB multi) / yes / yes
yes / no / via mobile device	no / no / no	no / no / no	yes / no / no	no / no / no	no / no / no	no / no / no	no / no / no
127 x 74 x 52 mm / 440 g	124 x 69 x 52 mm / 345 g	133 x 73 x 95 mm / 680 g	111 x 64 x 40 mm / 300 g	117 x 61 x 35 mm / 245 g	163 x 66 x 81 mm / 425 g	163 x 66 x 81 mm / 425 g	113 x 65 x 70 mm / 482 g



Canon G7 X

In line with current trends, the G1 X Mark II's little sister has a 1" sensor, an articulated monitor and built-in Wi-Fi functionality.

Look and feel: The body is very robust and, in spite of its ability to flip through 180 degrees, the monitor is well built with no protruding cables. Its small size, smooth surface and closely-packed controls make the G7 X tricky to use for photographers with large hands.

Handling: The Canon system utilizes relatively few buttons and dials but nevertheless offers full manual control. Depending on the mode you set, the lens ring can be used to adjust focal length, aperture or exposure time. It has positive click stops that provide clear tactile and audible feedback, which is great for photographers but less useful if you are shooting video. There is no 'stepless' option. The camera has no accessory shoe and thus no optional viewfinder. There was also no USB cable included with our test camera.

Features such as star trail capture, simultaneous still and video capture and face-detection autofocus tread a fine line between usefulness and gimmickry, while Wi-Fi functionality is a genuinely useful tool. A touchscreen monitor would have been useful too, as the supplied app offers only rudimentary remote control options.

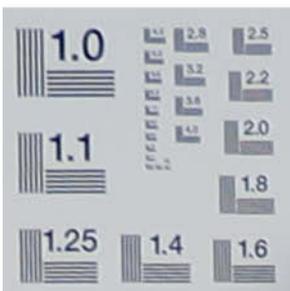
Test results and image quality: Our lab tests produced relatively balanced results throughout the zoom range, although the G7 X produced its best results (97% center resolution at f4) at the wide-angle end of the range. Edge resolution was much poorer, at just 71%/1350 line pairs. Our results were much the same at standard focal lengths, but dropped off slightly at the telephoto end. Center resolution was excellent at f1.8.

For such a small sensor, the Canon's signal-to-noise value of 69 at ISO 100 was very good indeed, and we also measured a good visual noise rating of 1.2. Both values increased continually – but not dramatically – with increasing ISO sensitivity.

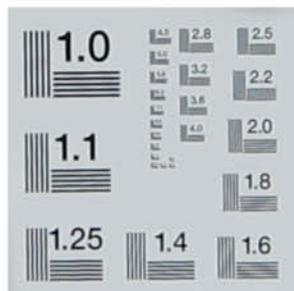
Our test images mirrored our lab test results, showing great center detail at ISO 100 and f/1.8 with the lens set to 24mm, although there was some obvious oversharpening and fringing at the edges of the frame. The images generally appeared a little softer at f4 and beyond. Fine textures began to lose sharpness at ISO 400, and serious softening became evident at ISO 800 and above.



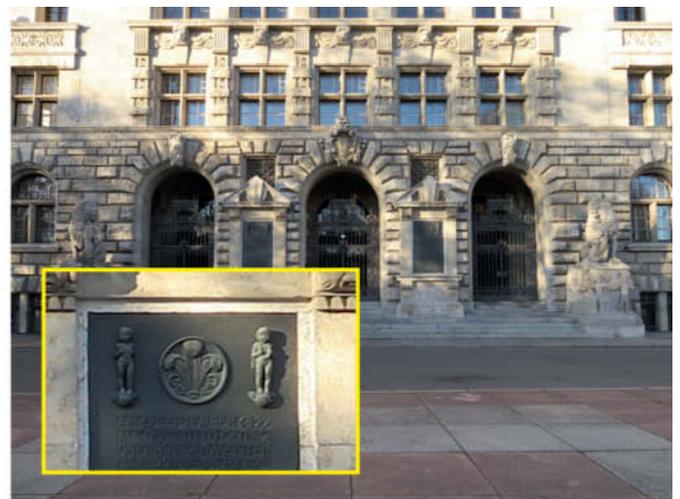
Detail from the c't lab test scene captured at ISO 125



Top left-hand corner



Center



ISO 125 | 24 mm | f2.8 | 1/400 s | 150%



ISO 125



ISO 400



ISO 1600



ISO 6400



Fujifilm X100T

The X100T has a large APS-C sensor, while its retro-style design and large dials give it a real analog feel. Its best feature is the hybrid electronic/optical viewfinder.

Look and feel: The X100T is the same size as many mirrorless system cameras and feels solid to hold. A grippier surface would, however, have made it easier to use.

Handling: The camera is obviously designed with manual use in mind and, instead of a mode dial, has an exposure time dial with a red "A" (for "Automatic") and a separate exposure compensation dial. The aperture is set using the dedicated ring on the lens, which also has a red "A" to denote the auto setting. The proximity of the aperture ring to the neighboring focus ring increases the risk of grabbing the wrong one if you are shooting with the camera raised to your eye.

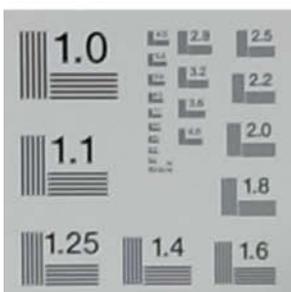
Handling is mostly intuitive, and the combination of electronic camera data and real-world visuals in the viewfinder helps to keep the shooting experience smooth. Built-in Wi-Fi functionality enables you to control the camera remotely, and the system worked very well with our Android 4.0.3 test device. The settings available in the app include ISO, film simulation, white balance and macro focus.

Test results and image quality: In the lab, the X100T produced highly satisfactory results, with an excellent signal-to-noise value of 63 at ISO 200. At just 0.8, the visual noise value is a sign of images that are, to all intents and purposes, noise-free. Noise increases continually but moderately with increasing ISO values, and our measurements were mirrored nicely in our test images. Overall, our images show a high degree of detail and a pleasantly three-dimensional look that is retained all the way up to ISO 800. Details and brilliance only begin to weaken obviously at ISO 3200 and beyond.

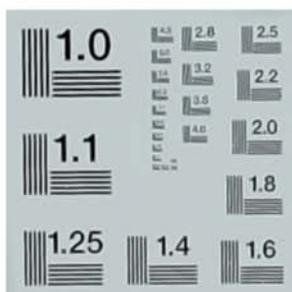
As expected, the lens makes the most of the sensor's resolution in the center of the frame at all apertures, although this great performance is marred by slight weakness at the edges of the frame, which is especially obvious in the images of our lab test scene. We expected better performance from a prime lens in this price range. On the upside, autofocus shutter lag came in at a very fast 0.2 seconds.



Detail from the c't lab test scene captured at ISO 200



Top left-hand corner



Center



ISO 200 | 35 mm | f2.8 | 1/220 s | 150%



ISO 200



ISO 400



ISO 1600



ISO 6400



Panasonic Lumix LX100

The LX100 marks a departure from Panasonic’s earlier Micro Four Thirds strategy and is the first Lumix compact to utilize this sensor format.

Look and feel: The LX100’s usefully-sized body is grippy and well balanced. The grip and the soft thumb rest on the camera back make it easy and pleasant to hold. The overall design is quite similar to that

of Fujifilm’s X-series models, and the lack of an articulated display makes it appear particularly robust.

Handling: Like the X-series cameras, instead of a mode dial, the LX100 has a separate exposure time dial and an aperture ring on the lens. Both have an “A” (Auto) setting that enables you to manually set P, A, S or M exposure modes. Full auto (iA) mode has its own dedicated button on the top plate, and activating it automatically selects the scene mode appropriate to the subject at hand. Use of the camera is generally intuitive, although we still found ourselves referring to the manual now and again. Manual focusing is simple thanks to the large, bright viewfinder and the built-in focus peaking functionality.

Test results and image quality: The LX100 showed excellent noise characteristics at low ISO values, recording a signal-to-noise ratio of 73 and a visual noise value of 0.7 at ISO 100. Our test values turned out markedly poorer at ISO 400 but deteriorated only moderately thereafter. Loss of detail and texture with color artifacts only really began to show up at ISO 1600.

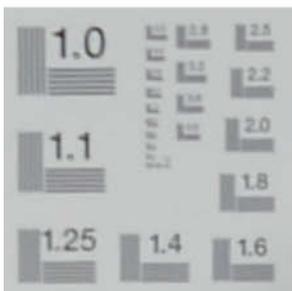
Center resolution came in at 100 percent between maximum aperture and f4, but edge definition was not as good. Using our test chart, we measured 1420 line pairs at 24mm and f4 in the center of the frame, but only 1140 at the edges. The telephoto end of the zoom range produced results that lagged behind our wide-angle results at all apertures.

The brilliance and depth of our test images weren’t up to the standards of the Fujifilm X100T, even at low ISO values.

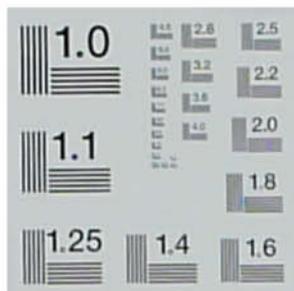
On the positive side, the LX100’s low shutter lag value of 0.2 seconds makes it a true snapshot camera, and its ability to capture 4K video is currently unique in the compact camera sector.



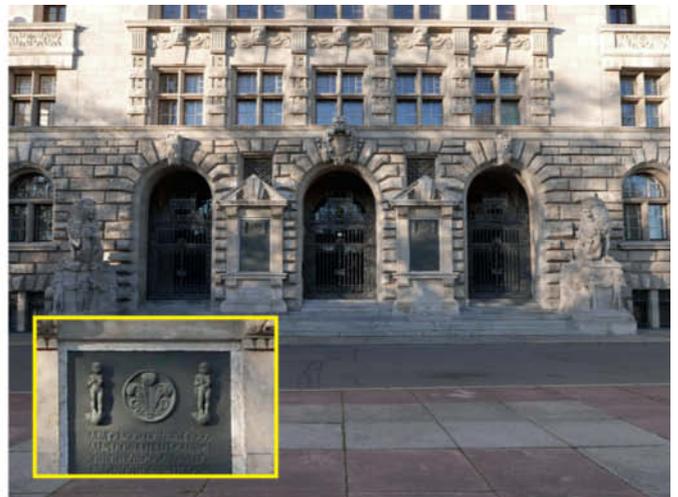
Detail from the c’t lab test scene captured at ISO 200



Top left-hand corner



Center



ISO 200 | 24 mm | f2.8 | 1/640 s | 150%



ISO 200



ISO 400



ISO 1600



ISO 6400



Sigma dp2 Quattro

Its unusual design and unique Foveon sensor make the dp2 Quattro one of the more exotic cameras we have tested.

Look and feel: This unusual camera has excellent build quality with a grippy, matte surface. Its angular, minimalist design creates a modern and rather spacy impression, although at a second glance, you might be forgiven for wondering whether it is actually practical. The camera is, in fact, not easy to hold, and the bulge in the grip at thumb level

actually makes it quite difficult to use. For most users, the greatest challenge involved in using the dp2 will be finding a comfortable shooting position.

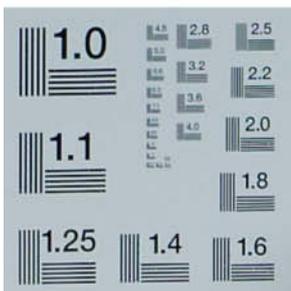
Handling: The controls are clearly laid out, and the two most important ones are the two dials on the top plate that are used to set aperture, exposure time and exposure compensation. There is a mode button for selecting one of the built-in modes or one of up to three custom shooting modes. The 'QS' button takes you directly to an overview screen of all major functions that you can customize without having to delve into the menu system. Focus mode is changed using the selector on the camera back and, in manual mode, you can zoom in on an image detail either by pressing the 'OK' button or by pressing the shutter button halfway. There is no focus peaking feature. Overall, the camera is easy to use but you will probably feel safest using it tripod-mounted, which is made easier by the side-loading SD card slot. Missing options that we would have liked to see are a viewfinder and *Lightroom* support.

Test results and image quality: Our lab test results showed that the dp2 Quattro is not really a snapshot camera and is better suited to use with a tripod. At low ISO settings, resolution is unparalleled, and the lens produces maximum resolution throughout the frame, even at its widest aperture. Even the Fujifilm X100T didn't produce detail contrast and image clarity to match that of the dp2. Sharpness and brilliance are almost supernatural and are more reminiscent of medium-format than compact camera quality.

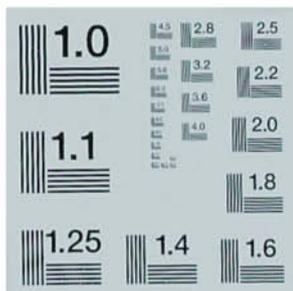
The downside of this unique device is its high-ISO performance. At ISO 1600, virtually all the fine details and texture we saw at low ISO settings disappear and the entire frame is marred by color artifacts that are even visible at normal full screen magnification. Shutter lag measured an average 0.5 seconds.



Detail from the c't lab test scene captured at ISO 200



Top left-hand corner



Center



ISO 100 | 45 mm | f2.8 | 1/200 s | 120%



ISO 200



ISO 400



ISO 1600



ISO 3200





Stefan Porteck, Peter Nonhoff-Arps

High-end Monitors

for Photographers

Compared to monitors with extended color spaces, conventional monitors literally pale in comparison. But bright colors alone aren't enough for high-end image processing applications – they have to be realistic too.

You can get fairly well saturated colors and a decent viewing angle in a \$250 monitor with an IPS panel, and that is usually good enough to manage and tweak your private photos. However, pro-grade photography requires pro-grade gear, and a wide-gamut monitor with an extended color space and high bit depth is an essential part of every high-end digital photo workflow.

For print applications, you have to be sure that the pre-press image you see on your monitor will turn out exactly the same in print, and this only works with monitors that can be precisely calibrated. Ideally, you should be able to save the required parameters directly in the monitor so that they are available to every application in exactly the same configuration, regardless of the settings you make in your computer's graphics driver.

We tested the 24" (16:10) Eizo ColorEdge CS240, the 27" (16:9) Eizo ColorEdge CG277, HP Z27X, LG 27MB85Z and NEC SpectraView II 272 models, and the 31" (17:9) LG 31MU97, the only 4K model in our lineup.

All About Monitor Calibration

Standard color spaces such as Adobe RGB and sRGB are pre-calibrated in all our test monitors and the corresponding logs are supplied. Our tests showed that they all comply fully with the predefined parameters. However, if you want to use the full gamut of a high-end monitor or run it at a custom color temperature, you have to set it up manually.

You can enter your own target values when calibrating the hardware and you can then use a simple colorimeter or a more expensive spectrophotometer to determine the corresponding gamma value or, as the case may be, the tonal values for a range of colors and grayscale values. The calibration



You can calibrate your monitor using a manufacturer's own colorimeter like those from HP and LG (center), a third-party model like the Spyder4 (left) or a spectrophotometer like the i1Pro 2 (right)

software then uses the differences between the target and actual values to fine-tune the colors displayed by the monitor.

Once color correction has taken place, the calibration software creates a corresponding ICC color profile that precisely describes the color values displayed by the monitor. This profile is then embedded in the computer's color management system. A profile-enabled graphics applications like *Photoshop* can only precisely display an image with a non-standard gamut once profiling has taken place. If you don't profile your system, colors will look different on every monitor you use. Calibration and profiling always go hand in hand and are often (incorrectly) considered to be the same thing.

For color-critical applications, monitor manufacturers recommend that you run your monitor for 15-30 minutes before you start work to avoid the color discrepancies that can occur while the backlight is warming up. However, this rule stems from the days

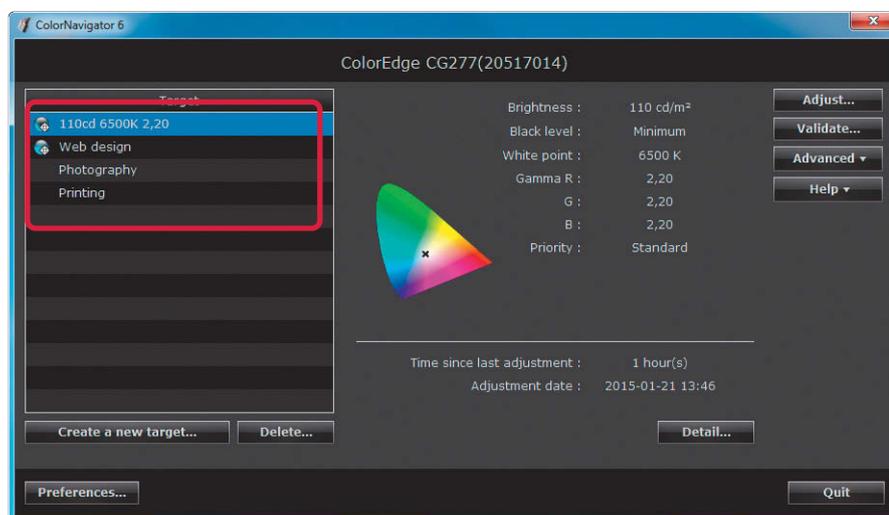
when monitors had cold cathode fluorescent (CCFL) backlights, which produce a spectrum when cold that varies distinctly from the one they show when warm. We were unable to detect any differences in the spectra produced by the LED backlights in our test monitors whether they had just been switched on or had been running for a while. If you are in any doubt as to whether this applies for your own monitor, it doesn't do any harm to wait ten minutes between turning it on and calibrating it.

The habit of re-calibrating a monitor at regular intervals also comes from the days of CCFL backlights. This is because ageing cold cathode lamps take on a distinct yellow cast and affect the colors in the images they display. LED backlights apparently do not suffer from this effect, although overall brightness does diminish by about 8% for every 10,000 hours of use. Our experience has shown that you only need to re-calibrate an LED monitor every three months to be sure of producing consistent results. If your regular measurements show no significant discrepancies, you can always increase the intervals between checks.

Two Bits More

The LCD panels built into most contemporary monitors are capable of displaying colors with 8-bit color depth, although some cheaper models with TN (Twisted Nematic) panels can

The Eizo *ColorNavigator 6* color management software has popular calibration targets as built-in presets that you can open at the click of a mouse





The Eizo CG277 has a built-in colorimeter that swings into place automatically when it is needed

only manage 6-bit color. An 8-bit panel can display red, green and blue tones at 256 different levels of brightness, resulting in a total of 16.7 million potential colors. In contrast, the 10-bit color support in the pro-grade monitors tested here provides 1,024 different levels for each RGB tone, resulting in a total of 1.07 billion reproducible hues with extremely fine color and shadow gradients.

Unfortunately, using 10-bit color is not a simple matter of connecting a monitor and increasing the color depth setting in the driver. The first hurdle is the path taken by the signals between the computer and the monitor. The DVI and HDMI 1.4 connectors built into our test candidates don't have sufficient bandwidth to handle 10-bit signals, so you need to install a DisplayPort graphics card in your computer before you proceed. Annoyingly, even though the chipsets built into many mid-range graphics cards support 10-bit color, their manufacturers artificially hinder this capability in their drivers. On the other hand, relatively cheap pro-grade cards like AMD's FirePro V4900 or the PNY Nvidia Quadro K620 (both around \$150) allow you to activate 10-bit color without any problems.

However, even if you have a powerful graphics card, you still won't necessarily have system-wide access to extended color depth. Your applications have to support 10-bit color too, and there aren't too many of these around. In *Photoshop*, you need to check the *Use Graphics Processor* option in the Preferences > Performance dialog and the *30 Bit Display* option in the Advanced Settings dialog.

Zoner Photo Studio is cheaper than *Photoshop* but supports 10-bit color too. The options for selecting it can be found in the Advanced section of the program's Preferences dialog.

In practice, the difference between 8-bit and 10-bit color support is easily visible in the much smoother grayscale gradients and color transitions (see the sample images included with this issue's online content). It is more difficult to identify such tiny nuances in real-world RAW images captured using 12-bit or 14-bit color depth, especially if you don't have a conventional display to compare them with. The differences involved are on a similar level to image noise and other individual artifacts.

Lightroom is capable of displaying 10-bit images but uses dithering techniques to smooth the fine grayscale gradients they contain.

Increased color depth also makes monitor calibration easier, and the 10-bit panels in our test models have much more headroom when it comes to adjusting and fine-tuning calibration parameters. Some of them even use internal 12- and 16-bit processes to enable them to distribute the remaining tonal values more evenly following adjustments like a reduction in contrast.

Extra Headroom

During calibration, high-end monitors store adjustments to parameters in their own

internal Lookup Tables (LUTs), whereas software-based calibration that can be applied to any monitor stores changes in the graphics driver. The 8-bit color depth supported by most graphics cards provides relatively little headroom for fine-tuning. For example, to remove a blue cast from a conventional monitor using software-based calibration, you have to reduce the strength of the blue channel, which leaves you with fewer than the original 256 brightness values for reproducing blue tones. This causes coarser color transitions that become particularly obvious in details such as blue sky or water. If the number of available tonal values is reduced by the graphics card, not even a 10-bit monitor or precise profile support can rescue the lost colors that result.

Doing What They Do Best

Pro-grade users rely on a monitor delivering consistent image quality regardless of the angle it is viewed from. In this respect, all our test monitors delivered the goods, producing either good or very good results in our lab tests. Please note, however, that when you view an IPS (In-Plane Switching) panel from the corner, some black tones appear either slightly orange or pink – a characteristic that applies for all six of our test models. This effect is especially obvious in darker surroundings.

All six monitors produced nicely saturated colors and cover virtually all of the Adobe RGB color space. They all have much less orange-looking reds and much deeper greens than conventional monitors. Secondary colors also all looked very good, and natural subjects and skin tones turned out looking highly realistic.

One issue that monitor manufacturers still don't seem to have mastered is inconsistent backlighting, which can lead to

Calibration in Practice

Calibration, profiling, color management and using a colorimeter all sound like complex processes that require a fair amount of learning before you can get your monitor to display a perfect image.

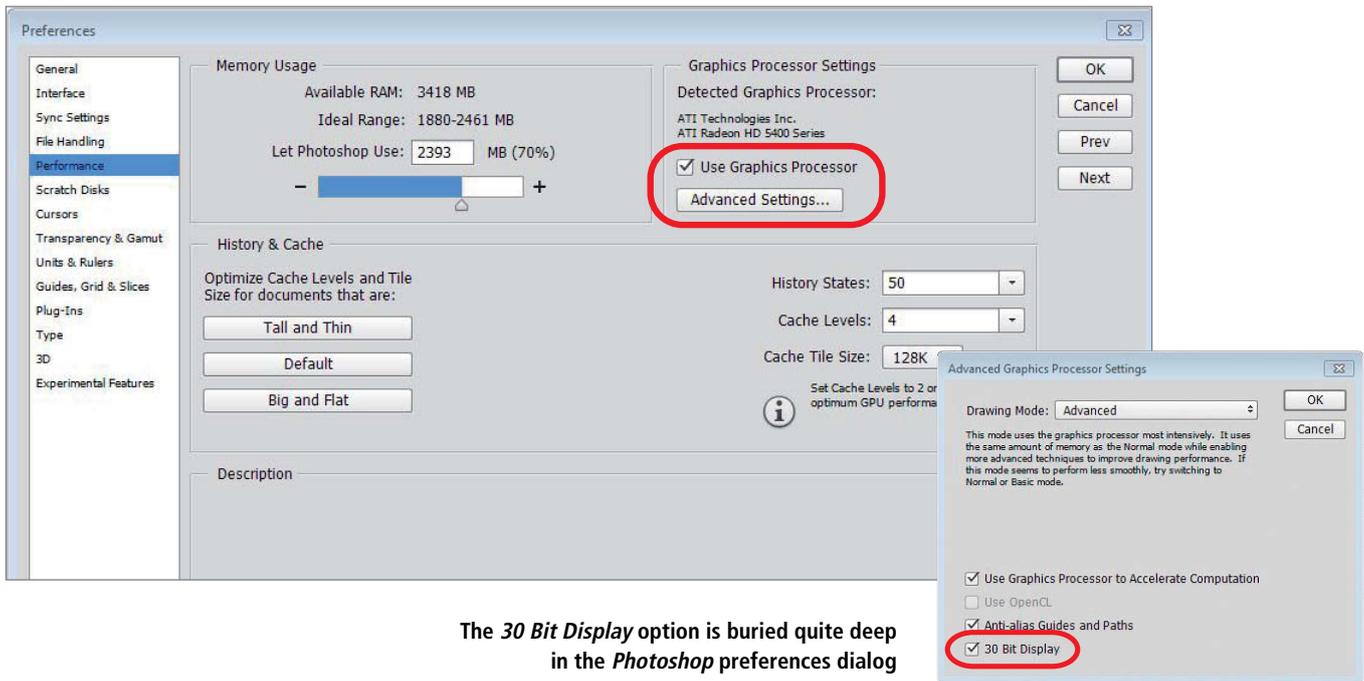
In practice, however, we were able to calibrate all of the monitors tested here within ten minutes using just a few mouse clicks. All you have to do to prepare for calibration is install the supplied software and plug the

colorimeter into a free USB port. If you want to use a third-party colorimeter or photospectromometer, the monitor manual usually lists the compatible alternatives.

Calibration is mouse-driven and automatically helps you select and set the appropriate parameters. If you are not familiar with the effects of using different color temperatures or color spaces, you can simply select

the default values. More important than the values you select is ensuring that the room lighting doesn't change during the calibration process.

The profiles the process creates are automatically embedded in the computer's color management system and, as long as you use profile-enabled software such as *Photoshop* or *Firefox*, you shouldn't have any further issues with color errors.

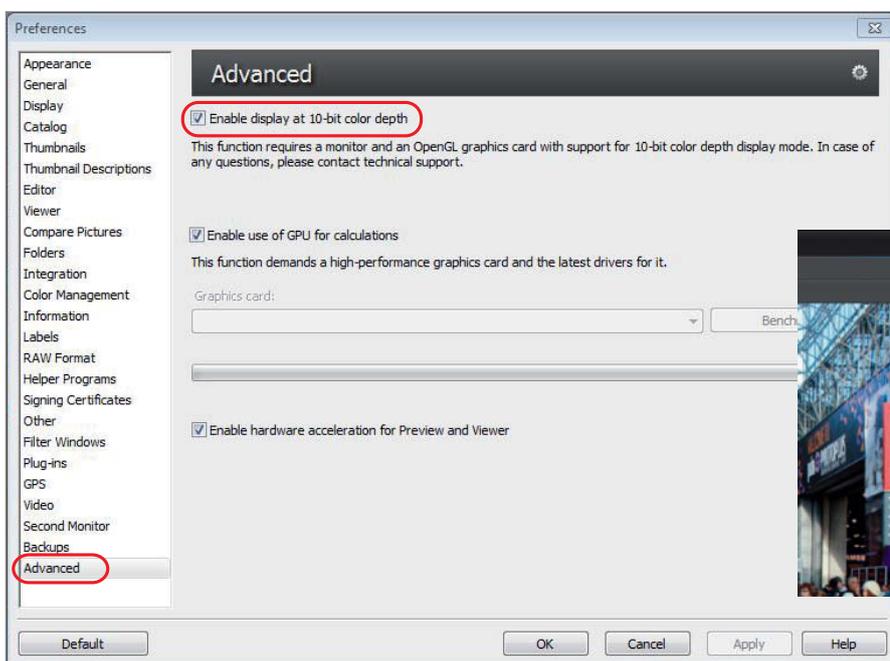


The 30 Bit Display option is buried quite deep in the Photoshop preferences dialog

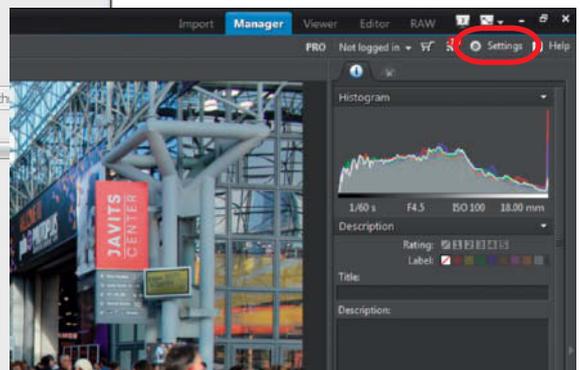
processing errors if you end up attempting to correct a highlight that is in fact a bright spot on the monitor. This was a non-issue for both Eizo monitors and the NEC SpectraView II 272, but the HP and LG models we tested showed some obvious inconsistency, even if it only amounted to a relatively minor variation of around 15% over the entire surface area. Because these panels have no

hard edge shadows and differences in backlighting are gradual, you need a well-trained eye and a single-color image to spot any differences at all, so they shouldn't cause any significant problems in everyday use. The LG 27MB85Z has a Digital Uniformity Equalizer (DUE) option for the sRGB and Adobe RGB presets that reduces variations in brightness to around 10%.

All of the monitors we tested have an 'overdrive' feature that is designed to boost response times by increasing the voltage used to make liquid crystals change state. Even with this kind of artificial assistance, IPS panels are not capable of reaching true gaming response times but, at an average of 7-10 milliseconds, (gray to gray), they are still speedy enough for video playback and editing.



Zoner Photo Studio is a cheaper alternative to Photoshop with built-in 10-bit color support



Our Test Monitors in Detail



The Eizo CG277 scores highly with its very even backlight and neutral grayscale tones

Eizo ColorEdge CG277

The 27" Eizo was the simplest to calibrate. Its built-in colorimeter is hidden behind a flap in the monitor housing and swings into place when it is needed. The supplied *ColorNavigator 6* calibration software includes presets specifically designed for use in Web design, pre-press and photographic situations. You can also create your own targets for minimum and maximum brightness, white point, color space and gamma values for the separate color channels. The ability to pre-program recalibration intervals from within the monitor's settings menu is a great additional feature. Calibration is then performed automatically without the computer having to be switched on.

With luminance set to 110 cd/m², center brightness varied by less than 5 cd/m², or 4%, which is extremely good indeed. Viewed with the naked eye, we were unable to find any of the edge shadows that are common in LCD monitors. One reason for this high performance is surely Eizo's policy of checking each panel in the factory and hard-wiring any necessary corrections into the monitor's circuitry.

Eizo ColorEdge CS240

The cheaper CS240 also includes the Digital Uniformity Equalizer (DUE) function that ensures very even lighting throughout the image. This model has no built-in colorimeter and is not supplied with an external calibration device. It is, however, supplied with the *ColorNavigator 6* calibration software that works very well with popular devices such as the Datacolor Spyder4 or the X-Rite i1 Display, DTP94, ColorMunki and i1Pro 2. In other words, you don't have to use Eizo's own EasyPIX2 colorimeter. The monitor's software includes the same range of tools and functions as those provided with the more expensive CG277, and here too, you can set your own calibration targets. The CS240 cannot calibrate itself automatically but you can program it to remind you to do so manually at preset intervals.



The 24" Eizo CS240 is sold without a matching colorimeter, although the supplied software works with most popular calibration devices



HP Z27X DreamColor

To calibrate the Z27X, you have to purchase the separate Calibration Solution package for \$250. The colorimeter itself appears to be a rebadged X-Rite i1Display Pro, but you still cannot work around purchasing the HP bundle, even if you download the software from HP. During our test, the software refused to work with the i1Pro 2 spectrophotometer and our Spyder4 colorimeter, and insisted that we use the HP branded device.

Along with the LG CG277 (see above), the HP had the best viewing angle in our test and also scored the best contrast of 1000:1. On the downside, its backlighting wasn't as even as that of the Eizo and NEC monitors.

Calibrating the HP Z27X requires use of HP's own DreamColor calibration device

LG 27MB85Z ColorPrime



The LG 27MB85Z is the only monitor we tested with a built-in Thunderbolt connector

LG gives you the choice of which device to use to calibrate the 27MB85Z, and the supplied *True Color Pro* software supports all popular devices. During our test with the X-Rite i1Pro, the LG software automatically advised us to calibrate the sensor using the standardized white panel built into its stand before we proceeded. Ironically, we couldn't get LG's own colorimeter to work properly, and our test calibration ended up producing a profile with an obvious pink cast. On inquiry, LG confirmed that this is a known issue that will be solved shortly by way of software and firmware updates.

Commonly used calibration targets such as sRGB and Adobe RGB and the monitor's native 6500K color space are available as presets that can be selected with a simple mouse click. In Custom mode, you can set your own gamut, brightness, color temperature and gamma values. *True Color Pro* offers a wide range of tools and functions in a clear interface that is easy for first-time users to understand.

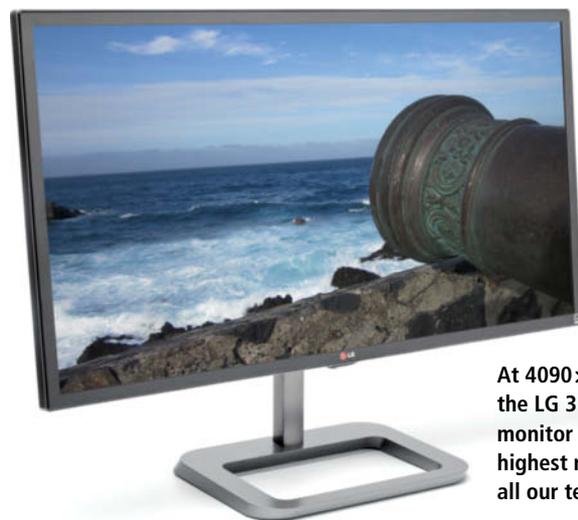
With its DVI, HDMI and DisplayPort connectors, the LG can be used with just about any graphics card, and its built-in Thunderbolt connector ensures compatibility with all the latest Macbooks.

LG 31MU97 Digital Cinema

The 31MU97 processes 60Hz UHD signals via its twin DisplayPort inputs but, due to insufficient bandwidth, can only process 4K signals at 30Hz via its HDMI 1.4 connectors. This is the only monitor we tested with built-in speakers, which are driven by sound data delivered via the HDMI or DisplayPort connectors.

Used with its default presets, the LG's grayscale reproduction wasn't as neutral as that of our other test monitors, but improved once we had calibrated it. The 31MU97 is supplied with the same software as its 27" cousin (see above) so here too, you can choose which calibration device you wish to use.

Its huge surface area and high resolution make this monitor great for use with office and CAD applications and, although our lab tests showed a less evenly lit panel than in some of the other test monitors, we didn't notice any brightness issues in real-world use.



At 4090×2160 pixels, the LG 31MU97 UHD monitor has the highest resolution of all our test candidates



The NEC SpectraView II 272 has an evenly lit panel with slightly less contrast than the competition

NEC SpectraView II 272

NEC's calibration software offers a broad range of options and supports most popular calibration devices. In fact, if you are not familiar with color management terminology, you might find the sheer range of options bewildering, although the manufacturer also provides a book on color management to help you get up to speed. The software didn't remind us to calibrate our spectrophotometer before calibrating the monitor and, although the calibration process functions without doing so, leaving this step out can cause inaccurate results.

The NEC produced a nice, evenly lit monitor image on a par with those of the HP Z27X and the Eizo CG277. The optional incident light protection hood helped to reduce the issues caused by the monitor's relatively low contrast and the brightening of diagonally-viewed dark areas that is typical of displays with IPS panels. The hood also makes it impossible to view the monitor from the side. Similar hoods are supplied as standard with the Eizo CG277 and the HP Z27X.

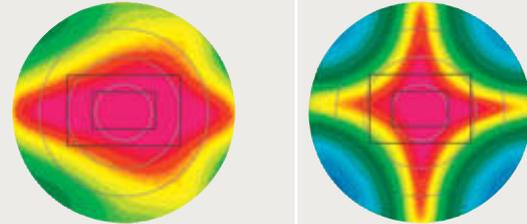
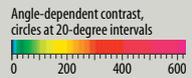
Conclusions

None of the monitors we tested showed significant weaknesses in image quality. They all have wide viewing angles with well saturated and finely graduated colors, and are all suitable for publishing and pro-grade photo work.

The Eizo CG277'S unique built-in automated colorimeter makes it extremely simple to calibrate but also the most expensive device we tested. If you already own a colorimeter or a spectrophotometer, the Eizo CS240 or the NEC SpectraView are definitely worth a look, as both are compatible with a wide range of third-party calibration devices. The HP Z27X can only be calibrated using HP's own calibration bundle so, if you want to work in a color-managed environment, you have to add \$250 to the retail price of the monitor. The LG 27MB85Z and Eizo CS240 are the cheapest models we tested, but neither comes with a calibration device or a hood.

All these 10-bit models showed very good grayscale reproduction and had plenty of calibration headroom, although setting up a complete 10-bit workflow is only really worth considering for imaging professionals. Considering the effort involved, we were disappointed by the results, and we could only really tell the difference between 8-bit and 10-bit images in our sample grayscale gradients. In RAW images captured using a high-end lens on a top-flight full-frame camera, we couldn't really tell the difference at all.

In the context of most people's private photo workflow, there is no real need for 10-bit processing or absolutely faithful color reproduction. At the end of the day, if you do without hardware calibration and 10-bit software, and instead use a conventional monitor with an IPS panel and a relatively large native color space, you are sure to achieve perfectly adequate results and save quite a lot of money in the bargain. (pen)

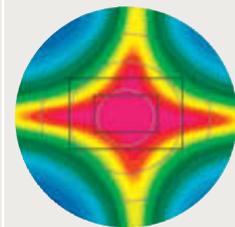
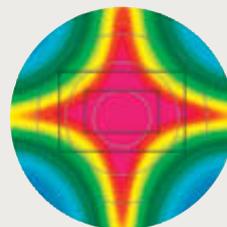
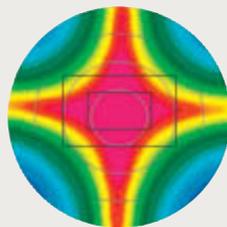
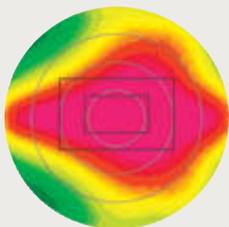
HIGH-END MONITORS		
Model	ColorEdge CG277	ColorEdge CS240
		
Manufacturer	Eizo	Eizo
Guarantee: LCD / Backlight (years)	5 / 5, incl. on-site pickup and exchange	5 / 5, incl. on-site pickup and exchange
Panel size / type	27" / IPS (matte)	24" / IPS (matte)
Pixel size	0.233 mm (109 dpi)	0.27 mm (94 dpi)
Resolution / Aspect ratio	2560 × 1440 / 16:9	1920 × 1200 / 16:10
Viewable image area / diagonal length	59.7 cm × 33.6 cm / 68.5 cm	52 cm × 32.5 cm / 61 cm
Video input	DVI-D, DisplayPort, HDMI	DVI-D, DisplayPort, HDMI
Color temperature presets / Custom	4000–10 000K in 100K increments / ✓	4000–10 000K in 100K increments / ✓
Display modes	Native, sRGB, Adobe RGB, EBU, REC709, REC1886, SMPTE-C, DCI	sRGB, Adobe RGB, Custom, Paper, CAL1-3
Gamma value: target / actual	2.2 / 2.22	2.2 / 2.2
Scaling: Off / True page / Full screen / Smoothing	✓ / ✓ / ✓ / –	✓ / ✓ / ✓ / –
Rotatable / Height adjustable / Portrait format	✓ / ✓ / ✓	✓ / ✓ / ✓
VESA mount (size) / Kensington lock	✓ (100mm) / ✓	✓ (100mm) / ✓
Bezel width	Sides, 2.4 cm, top 2.6 cm, bottom 3.8 cm	Sides and top 2.7 cm, bottom 4.3 cm
Other features	USB hub (2 × USB 2.0 ports), built-in colorimeter, ColorNavigator software, hood	USB hub (2 × USB 2.0 ports), ColorNavigator software
What's in the box	Cables: Mini DisplayPort, DVI, USB, power cord; Manual, QSG	Cables: Mini DisplayPort, DVI, USB, power cord; manual, QSG
Dimensions: W × H (variable) × D / Weight	65 cm × 43–58 cm × 28 cm / 12.7 kg	58 cm × 42–55 cm × 25 cm / 8.7 kg
Test marks	FCC Part 15, ISO 13406-2	FCC Part 15, ISO 13406-2
Special features	Built-in colorimeter, extremely even back-lighting, great contrast, lots of accessories	Very even backlighting
Test Results		
Minimal field of view ²	866:1 / 6.8 %	703:1 / 16.2 %
Extended field of view ²	724:1 / 22.7 %	490:1 / 46.1 %
These diagrams illustrate the dependence of contrast on the viewing angle. Blue represents low contrast, red represents high contrast. The circles denote the viewing angle in 20-degree increments. Ideally, the entire diagram should come out pink.		
Angle-dependent contrast, circles at 20-degree intervals		
Overall luminance	96.3 %	95.4 %
Power consumption (in use / standby / off)	40.1 W / 0.5 W / 0.5 W	26.4 W / 0.5 W / 0.4 W
Ratings		
Viewing angle	⊕⊕	⊕
Contrast	⊕⊕	⊕
Color reproduction	⊕⊕	⊕⊕
Grayscale resolution	⊕⊕	⊕⊕
Backlight	⊕⊕	⊕⊕
Build quality	⊕⊕	⊕⊕
Handling, on-screen menu	⊕⊕	⊕⊕
Price	\$2,400	\$825
¹ Class 2 pixel defects according to ISO 9421-307. Permitted are two full bright, two full dark pixels or 5-10 single or double bright or dark sub-pixels per million (i.e., depending on the number of each, no more than 5 bright, or "stuck on" subpixels are permitted). This also means that a maximum of 12 defective subpixels are permitted in a 1920 × 1200 widescreen LCD.		
⊕⊕ excellent ⊕ good ○ satisfactory ⊖ poor ⊖⊖ inadequate		

227X DreamColor	27MB85Z ColorPrime	31MU97 Digital Cinema	SpectraView II 272
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HP	LG	LG	NEC
3 / 3, incl. on-site pickup and exchange	3 / 3, incl. on-site pickup and exchange	3 / 3, incl. on-site pickup and exchange	3 / 3, incl. on-site pickup and exchange
27" / IPS (matte)	27" / IPS (matte)	31" / IPS (matte)	27" / IPS (matte)
0.233 mm (109 dpi)	0.233 mm (109 dpi)	0.167 mm (149 dpi)	0.233 mm (109 dpi)
2560 × 1440 / 16:9	2560 × 1440 / 16:9	4096 × 2160 / 17:9	2560 × 1440 / 16:9
59.7 cm × 33.6 cm / 68.5 cm	59.7 cm × 33.6 cm / 68.5 cm	68.6 cm × 38.6 cm / 78.7 cm	59.7 cm × 33.6 cm / 68.5 cm
2 × DisplayPort, HDMI	DVI-D, DisplayPort, HDMI, 2 × Thunderbolt	DisplayPort, 2 × HDMI, Mini-DisplayPort	DVI-D, DisplayPort, HDMI, Mini-DisplayPort
–	5000–10 000K in 500K increments / ✓	5000–10 000K in 500K increments / ✓	3000–15 000K in 500K increments / ✓
sRGB D65, sRGB D50, Adobe RGB, BT.709, BT.2022, DCI P3, Native	Custom, sRGB, Adobe RGB, DCM Simulation, Reader, Calibration	Custom, sRGB, Adobe RGB, DCM Simulation, DCI P3 Simulation, Reader, Calibration 1, Calibration 2	Adobe RGB, sRGB, DCI, Full, High, Bright
2.2 / 2.19	2.2 / 2.35	2.2 / 2.25	2.2 / 2.21
✓ / ✓ / ✓ / –	✓ / ✓ / ✓ / ✓ (10 increments)	✓ / ✓ / ✓ / ✓ (10 increments)	✓ / ✓ / ✓ / ✓ (30 increments)
✓ / ✓ / ✓	✓ / ✓ / ✓	✓ / ✓ / ✓	✓ / ✓ / ✓
✓ (100mm) / ✓	✓ (100mm) / ✓	✓ (100mm) / ✓	✓ (100mm) / ✓
2.1 cm on all sides	2.1 cm on all sides	1.6 cm on all sides	2.1 cm on all sides
USB hub (4 × USB 3.0 ports), hood	USB hub (3 × USB 3.0 ports), True Color software	Built-in speakers (2 × 5W), USB hub (3 × USB 3.0 ports)	SpectraView Profiler software, colorimeter
Cables: DisplayPort, Mini DisplayPort, HDMI, USB, power cord; CD manual, QSG	Cables: DisplayPort, DVI, USB, power cord; CD manual, QSG	Cables: HDMI, DisplayPort, Mini DisplayPort to DisplayPort, USB, power cord; CD manual, QSG	Cables: 2 × DVI, DisplayPort, power cord; CD manual, QSG
64.1 cm × 42–54 cm × 25 cm / 8.8 kg	64.3 cm × 41.7–54.7 cm × 26 cm / 7.5 kg	73.7 cm × 48.4–62.4 cm × 24 cm / 9.3 kg	64 cm × 39.6–54.6 cm × 23.5 cm / 12.9 kg
FCC Part 15, TCO '06, ISO 13406-2	TCO '03, ISO 13406-2	TCO '06, ISO 13406-2	FCC Part 15, ISO 13406-2
Very high contrast, can only be calibrated using HP's own colorimeter	High contrast, slightly small native color space, screen split, Thunderbolt 2 connectors	Very high resolution, built-in speakers, screen split	Very even backlighting, slightly low contrast, ambient light sensor, PIP (picture-in-picture)

1005:1 / 7.9 %	993:1 / 21.2 %	878:1 / 22.3 %	730:1 / 17.8 %
839:1 / 24.1 %	624:1 / 58.7 %	545:1 / 61.1 %	477:1 / 53 %



81.3 %
37.2 W / 0.5 W / 0.4 W

88.8 %
37.3 W / 0.5 W / 0.4 W

80.9 %
47.7 W / 0.7 W / 0.5 W

93.5 %
46.2 W / 0.2 W / 0.1 W

- ⊕⊕
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- \$1,130

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- ⊕
- ⊕
- ⊕⊕
- \$990

- ⊕
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- \$1,549

² These values represent the median and standard deviation for contrast. The minimal field of view includes all viewing angles that result when the monitor is viewed from a distance of 60cm (24") directly in front of its center. The corners are thus viewed from the steepest angle. The extended field of view involves the viewer moving his/her head parallel to the monitor surface as far its edge. In this case, the viewing angle for the opposite edge increases and center contrast is reduced.

✓ included – not included n/a not applicable





Felix Inden

Shooting with ND Filters

In this workshop, landscape photographer and filter expert Felix Inden explains how he captures his beautiful images and tells us all about the role neutral density filters play in their composition.

Filters were popular in analog times but play only a minor role in the digital image capture process. Even though many analog filter effects are easy to add during digital post-processing, neutral density (ND) filters are still a favorite tool of many digital image-makers. But are these dark slabs of glass that apparently cannot do anything except increase exposure times still necessary? This article explains the various filter systems available, investigates typical uses for ND filters – such as creating images of silky smooth waterfalls and architectural shots that include soft, cottony clouds – and also delves into some more exotic uses.

Filter Systems

The most popular filters are circular threaded ones that screw directly onto the lens and slot-in models with custom holders. Screw-in filters are only practical if you don't need to react quickly to changing lighting conditions or darken parts of the frame with a graduated filter. In practice, strong ND filters hinder autofocus systems and have to be continually mounted and removed. The Xume system makes this much less tedious by using magnets to attach filter holders to an adapter screwed onto the lens.

Square slot-in filters are easy to use and work with a range of adapters. ND filters are

available in many different grades for most slot-in systems, which are especially popular with landscape photographers and videographers, as they make it possible to increase the dynamic range that a camera can capture.

Screw-in ND filters are available from manufacturers such as Schneider Kreuznach B+W, Hoya, Rodenstock, Phottix and Cokin. Cheap online deals offering sets of up to seven filters for \$35 or less are only useful for testing effects, as they are usually of poor quality and reduce image sharpness and/or produce significant color casts. LEE, Formatt Hitech and Singh-Ray are the best-known manufacturers of slot-in filters (see the article



This shot was captured using an ND 1.8 and a 0.6 reverse graduated filter to accentuate the wavelets in the stream and adjust the brightness of the Sun

Nikon D810 | NIKKOR 14-24mm f/2.8 | Lucroit filter holder and glass filter | 24mm | ISO 64 | f11 | 5s



Screw-in filters (left) are great if you don't have to react quickly to changing conditions, whereas slot-in models (right) make it easier to switch filters in a hurry

on optical filters in Issue 3 of *c't Digital Photography* for more details). French company Cokin has been producing cheap, good-quality slot-in filters for decades, and the Fotodiox WonderPana system is a great value approach for use with wide-angle and ultra-wide-angle lenses. Newcomers to the fold of filter manufacturers include Haida and NiSi, as well as Lucroit from Spain, which specializes in producing filter holders and now also produces its own glass filters.

Screw-in ND filters are usually made of glass and have coatings that vary in quality depending on the manufacturer and the price range. Filter coatings influence the quality of your images just as lens coatings do, especially in backlit situations. Slot-in filters are usually made of synthetic resin, although the size of the filter often determines the material. Square models with sides measuring between 85 and 165 mm are most common, while graduated models are rectangular and measure between 85×165 mm and 165×200 mm. Haida, Lee, NiSi and Formatt Hitech all manufacture glass slot-in filters in sizes between 85 and 100 mm. Until recently, the large filters used for wide-angle applications were made exclusively of resin, but Haida and Lucroit now offer glass filters in these sizes, as does Formatt Hitech with its Firecrest series.

Protection and Color Casts

While glass filters are less susceptible to scratches, they are more fragile than plastic filters when it comes to transport wear and accidental knocks. On the other hand, resin

The Author's Kit

- Nikon D810
- NIKKOR 14-24mm f/2.8
- NIKKOR 24-70mm f/2.8
- NIKKOR 70-200mm f/2.8
- NIKKOR PC-E 24mm f/3.5
- NIKKOR 50mm f/1.4
- NIKKOR 85mm f/1.8
- Lucroit filter holder for the large front element on the 14-24mm NIKKOR
- Formatt Hitech holder with adapters for all other lenses
- Formatt Hitech ProStop resin IRND filters (3.0, 1.8, 1.2)
- Reverse graduated ND filters (0.9, 0.6, 0.3)
- Graduated ND filters (0.6, 0.9)
- Formatt Hitech Firecrest glass IRND 4.6
- Lucroit glass ND filters (3.0, 1.8, 0.9)
- Hähnel Giga T Pro II wireless shutter release
- Cable release for emergencies, with programmable long exposure mode (for use with the 'B' shutter setting).
- FEISOL CT-3472 tripod with Really Right Stuff BH-55 ball head. This is a very stable combo with a hook for hanging a weight on if the wind picks up.





This shot was captured using an ND 1.8 filter to soften the waves and increase contrast between the individual image elements

Nikon D700 | NIKKOR 14-24mm f/2.8 | Formatt Hitech resin filter in a Lucroit holder | 14mm | ISO 100 | f11 | 3s

EXPOSURE TIMES WITH ND FILTERS

Neutral density number	Filter factor	Reduction in light (f-stops)	Exposure time without filter	Exposure time with filter
0.3	2	-1	1/30s	1/15s
0.6	4	-2	1/30s	1/8s
0.9	8	-3	1/30s	1/4s
1.2	16	-4	1/30s	1/2s
1.5	32	-5	1/30s	1s
1.8	64	-6	1/30s	2s
2.1	128	-7	1/30s	4s
2.4	256	-8	1/30s	8s
2.7	512	-9	1/30s	15s
3.0	1000	-10	1/30s	30s

filters are much more prone to scratching, so it is worth investing in a high-quality case or bag if you decide to take this route. Even a single grain of sand in your filter bag can cause serious problems. Terrascope from

Portugal and movie camera manufacturer ARRI from Germany are the only companies we know of that offer high-end filter bags in a range of sizes. Resin filters don't break if you drop them and are now of such high quality that they can compete directly with their glass counterparts in the sharpness and color fidelity stakes.

Color casts go hand in hand with ND filters and often have to be corrected digitally during post-processing, depending on how pronounced they are. Filters with a cyan cast can completely ruin the mood of a warm, golden sunset and simply altering the white balance setting won't be enough to rescue it. If you are using ND filters, always shoot RAW if you can. This way, you have the maximum range of options when it comes to tweaking your images later on. In general, shooting with filters makes it impossible to produce images with completely realistic colors, and filter manufacturers offer a range of solutions for these types of issues. Formatt Hitech, for example, uses an innovative design with a filter foil sandwiched between two sheets of

glass, which is said to produce images with improved color neutrality.

Generally speaking, the larger the filter, the more expensive it is, so if you use Micro Four Thirds or some other kind of rangefinder style camera, you can save money by purchasing smaller filters. You can also build your own ND filter using the glass from a welder's goggles, which have the same light-reducing effect as a purpose-built ND filter. However, this is a makeshift solution best used for experimental projects in which you are prepared to consider imperfections in your images to be part of the composition. The ND filter function built into cameras like the Fujifilm X100T is also great for experimenting with increased exposure times. You switch the filter on via the camera's menu system but there is no way to vary its strength.

Filters for Unusual Lenses

There is a broad range of filters available for lenses with threads up to 77 mm in diameter. However, some wide-angle lenses, such as the



These shots of the banks of the Rhine in Cologne were captured (from left to right) without a filter, with an ND 0.6 filter and with an ND 0.9 filter. The effect is most obvious in the color of the sky.

Using an ND Filter to Photograph a Waterfall

Using conventional metering, the camera suggested that I shoot this scene using an exposure time of 1/30 second – a value that would neither capture the moving water in sharp detail nor give it a soft flowing look. An ND filter is the ideal tool for preserving the texture of the moving water while giving it a blurred effect that makes it more attractive. Many photographers use polarizers instead of

ND filters to shoot moving water, as these also reduce the intensity of the incoming light by around two stops. In this case, an ND 1.2 or 1.8 filter has the same effect. Using an ND 1.2 filter increases the exposure time to 1/2 second, which certainly makes things better, but an ND 1.8 extends it all the way to 2 seconds, giving the water a wonderful soft-focus look while retaining its texture.

The 30-second exposure time that would have resulted from using an ND 3.0 filter would have completely dissolved the patterns in the water and produced a dreamlike, almost textureless effect of a kind that is currently very popular on the landscape photography scene, even if some critics view it as cheap showmanship rather than true photographic artistry.



14-24mm f/2.8 NIKKOR and the Canon TS-E 17mm f/4, have such large, curved front elements that it is impossible to attach a conventional screw-in filter. Not long ago, only Fotodiox, Lucroit and LEE made filter holders for such exotic lenses, and the corresponding LEE filter measures 150×150mm (or 150×170mm for graduated versions). These lenses and filters are expensive and quite clumsy to use, but pro photographers and other devotees of high image quality use them because of their excellent reproduction characteristics and simply accept that using them is sometimes a complicated business. New filter systems for oversized lenses have been introduced in the last couple of years. For example, the Fotodiox WonderPana system even includes a polarizer filter designed for use with large front elements and NiSi now sells a new, improved filter holder. The advent of 3D printing technology has also seen more people trying out home-built filter holder projects, and a number of models available online are compatible with commercially available filters.

Typical ND Filter Scenarios

ND filters are the ideal tool for creating shallow depth of field in situations where the lighting conditions wouldn't otherwise allow

you to work at wide apertures. Placing an ND filter on the lens reduces the amount of incoming light and gives you the flexibility you need to select a wider aperture. In studio environments, ND gels placed in front of the light modifier on a flash head perform the same task. However, the increasing precision of output in studio flash gear means that regulating the light in this way is becoming increasingly obsolete. ND filters, often of the two-piece 'vario' type in which the intensity of the ND effect can be adjusted by rotating the front element, are an integral part of most video shoots too.

Landscape and architecture photographers especially favor ND filters, which can be used to make the people disappear from busy scenes. Moving people and objects appear blurred when captured using long exposures, and objects in constant motion disappear completely in shots captured at exposure times of 20 seconds or more, leaving only stationary objects in sharp focus. This approach can be used to direct the viewer's gaze within the frame. Clouds especially can be transformed into ethereal, soft-focus objects, while moving water changes its appearance constantly with increasing exposure times and, in really long exposures, often looks like a swathe of magical mist.

Speed of Movement and Exposure Times

The best approach to long exposures is to figure out how you want the image to look and use your camera's 'Bulb' mode to precisely control the exposure time yourself. The faster the objects within the frame move, the sooner you will produce an image with a soft, dreamlike look. You need to use much longer exposures to get a slow-flowing river looking blurred than you do to achieve a similar effect in breaking waves or fast-moving clouds.

Obviously, these factors will influence your choice of filter, and the softer the effect you are looking for, the longer your exposure will have to be. For example, to capture a major river like the Rhine in soft focus, you need to use a high-density ND filter and an exposure time of up to two minutes, whereas a seascape with moving waves can be captured with a similar effect using a weaker filter and an exposure time of around 30 seconds.

Graduated ND filters are used to darken selected areas within the frame. In landscape photography, they are typically used to balance the exposure between the foreground and the sky, reducing the dynamic range in the scene and giving the final image more detail. Unlike conventional



A 0.3 reverse graduated filter made it possible to preserve the details in the houses in the lower part of the frame that would otherwise have been overexposed

Nikon D800 | NIKKOR 14-24mm f/2.8 | Formatt Hitech filter | Lucroit filter holder |
Panorama made from six source images (14 mm | ISO 2000 | f2.8 | 15s)

graduated filters, which are darkest at the top and become lighter toward the middle, reverse graduated filters are darkest in the center of the frame, making them ideal for situations in which the horizon forms the brightest part of the subject (see the images on the previous page and opposite).

You can also use multi-shot techniques at the post-processing stage to artificially increase the dynamic range of an image, although such processes quickly reach the limits of their effectiveness, especially when the darkened part of the image contains moving objects. Trees, bushes, people and other mobile elements make it extremely difficult for multi-shot software to effectively combine multiple images and produce natural-looking results.

A graduated filter makes it easier to save additional image data in the original RAW image file. However, in extreme situations – for example, with the Sun shining directly into the lens – it is impossible to handle the enormous dynamic range that this produces, even using the strongest filters. The best way to produce authentic-looking results in extreme situations is to use ‘blending’ techniques to combine the effects of a graduated filter, multiple exposures and a manual increase in dynamic range.

Special Cases

Extreme long exposures are becoming increasingly popular and, at exposure times of three or four minutes or more, the results are guaranteed to have a surreal, almost textureless look, especially in moving objects. Because lighting conditions change during such long exposures, the effects produced by the light are just as evident in such images as the effects produced by moving objects.

Ultra-long exposures are a challenge for even the most sophisticated camera technology. Image noise increases, ‘hot pixel’ issues become more obvious and your battery runs out much faster when you shoot ultra-long exposures. If you are shooting a sunrise or a sunset, you’ll have to work out in advance which filter and exposure parameters will give you the result you want. If a four-minute exposure doesn’t turn out as planned, you can’t simply repeat it, as the lighting will have changed too much. Architecture and landscape photographers often prefer to shoot at times when the Sun is not too high in the sky, as this makes it easier to control contrast and there is less risk of stray light spoiling a shot.

Reverse graduated filters are also popular in nighttime situations and astrophotography, where they are used to darken the

About the Author

Architecture and landscape photographer Felix Inden lives in Cologne. He travelled a lot in his youth and “learned to love the ever-changing face of the natural world.” His approach to photography is highly emotional: “I want to take my viewers on a visual journey that puts them in touch with their feelings.”

Inden experimented with a variety of different styles in his early years and

discovered that wide-angle shots are his favorites. His recipe for success is simple: “I accent the differences between foreground, middle ground and background to add depth to my images and use the unique characteristics of each location to help me frame my subject and tell a story.”

www.felixinden.com



comparatively bright light from houses, street lamps and cities while leaving the sky unchanged. I use a 0.2 reverse graduated filter to reduce light pollution in my shots of the Northern Lights and the Milky Way.

Shooting Tips

If you are planning to use ND filters, a robust tripod is an essential part of your kit. In extreme weather conditions, you might need to weigh your tripod down, and many models have a purpose-built hook at the bottom end of the center column for you to hang your backpack or some other counterweight from. To prevent the mechanical jolts caused by the camera’s mirror from causing unwanted blur, always use mirror lockup and a remote shutter release if you can. This is, of course, a

non-issue for mirrorless cameras, and some DSLRs (the Nikon D810, for example) have a built-in electronic shutter that helps to reduce vibrations.

A remote release is essential when taking photos in Bulb mode. Many shutters have a maximum exposure time of 30 seconds – the kind of speed at which the long exposure fun often begins! Wireless remote releases are really useful and work at quite long range, but are more prone to technical defects than a good old-fashioned manual cable release. It is a good idea to have a cable release on hand at all times for use in emergencies. Increasing numbers of cameras are equipped with Wi-Fi functionality too (Sony’s Alpha series or the Olympus OM-D models, for example) and can be controlled remotely using smartphone or tablet-based apps. (sea) **ct**



In this shot, the ND filter softened the contours of the ice crystals and emphasized the patterns they made in the waves. The contrast between the hard ice of the glacier and the relative softness of the water is underscored, and a reverse graduated filter helped to keep the brightness of the rising sun to a level that made a balanced exposure possible.

Nikon D800, NIKKOR 14-24mm f/2.8 | Formatt Hitech resin ND1.8 and 0.6 reverse graduated filters in a Lucroit holder | 14 mm | ISO 100 | f11 | 2 s



Andreas Kesberger

Photo, Film and Print

Permanence

"Linger awhile, so fair thou art." Though the great German poet and playwright Johann Wolfgang von Goethe didn't invent photography, he certainly provided us with one of our favorite quotes when it comes to underscoring the most basic of every photographer's motivations. How long a wonderful moment can really linger is a question of equal importance to artists, collectors, galleries and museums all over the world, and this article investigates the best ways to ensure long life for all your photos and prints.

Der Biberpelz

Repro: Andreas Kesberger

Even if the subject on the left is rather damp, it isn't directly responsible for the mold on the print! Because mold thrives on gelatin, humidity of 65% and more is a real threat to all types of color and black-and-white prints.

Which of today's photos will still be intact in 100 years' time? Will we still keep analog images, which are becoming rare already, or will we produce generation after generation of copies from digitized originals? Or perhaps we will rely entirely on carefully managed, commercially viable image databases?

The world of photography has already collected 175 years of experience creating and archiving paper and chemical-based images. The Daguerreotypes produced during the first decade of popular photography were all unique but, at the time, the complexity of the process prevented it from gaining a more widespread foothold. However, with the advent of the wet-plate collodion-based negative process that is still occasionally used today, and albumen-based paper that the hens of the time had trouble laying enough eggs for, photography suddenly became a mass medium. The *carte de visite* was the 19th century equivalent of today's selfie, and photo studios sprang up everywhere. People liked to display images of kings, queens and popular actors at home. But the first complaints about mottled or faded photos soon began to surface, and the photo pioneers of yesteryear would surely not have shared the enthusiasm of today's hipsters for unique and deliberately imperfect instant photos.

The Fading Committee of 1855

What do you do if you aren't sure what to do next? Form a committee of course! And this is how the 'Fading Committee' came to be established in England in 1855. Its members began the search for reasons for the premature fading of photos and appropriate solutions to the problem. The committee quickly found that the worst enemies of permanent images were poor processing, humidity and a variety of environmental factors. Fortunately, air pollution is less of an issue than it was 150 years ago, although vehicle emissions have replaced coal dust as the most pervasive pollutant and significantly shorten the life of imaging media. At the end of the day, the image is dead and it makes no difference which poison did the deed.

The Fading Committee offered a prize for the creation of a durable photographic process, and the winner was the pigment printing process invented by Louis Poitevin. Although the process itself has long been superseded, pigment-based prints are an important part of today's printing repertoire. This process shared the fate of all later developments of the same type, namely: artists and consumers were quick to complain about visible imperfections but reluctant to make an effort or spend money to make the product last longer.

A developed image is generally quite robust, and little was done to research the permanence of images as long as visual media remained black and white. It was only in the 1970s that the question of photographic conservation gained a boost. Couples who moved in together once they were married often stored their (color) wedding photos in new furniture made of plywood. This was a deadly combination – not necessarily for the marriage but certainly for the photos. Six months or so in a plywood drawer was enough to give photos a strong magenta cast or even wipe them out altogether. It obviously wasn't clear at the time to Agfa, Fuji and Kodak how damaging vapors from plywood could be.

Photographic restoration was a popular hobby amongst inquisitive chemists, often with catastrophic results for the images themselves. Many Daguerreotypes never recovered from the restoration process. The first genuinely scientific attempts at restoration began when Hollywood studios came up with the idea of recycling old films and found that the reels had virtually self-desiccated, leaving only a pile of acetate and a strong smell of vinegar.

How Long do Today's Prints and Photos Last?

Movie industry research found the culprit in the acid that acetate film gives off over time, which simply destroys the film it was once part of. From then on, the movie world used exclusively polyester-based film stock, while the photo industry is still manufacturing film based on cellulose triacetate. Although Rollei and Adox produce roll film with a polyester base, only large-format sheet film has a polyester base as standard.

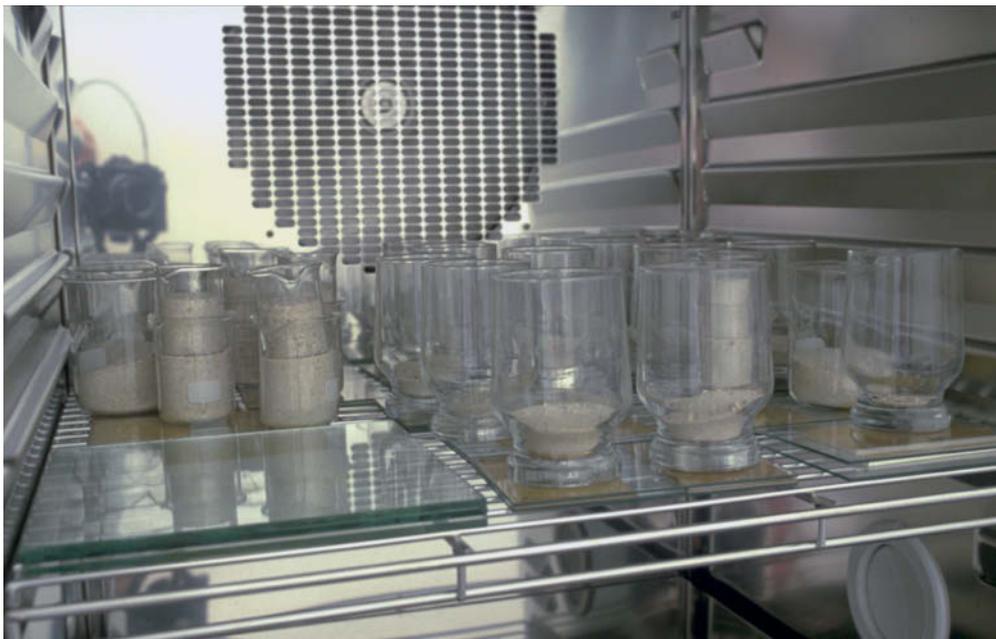
Because it contains less acetate material and is not always stored in an airtight environment, photo film tends to destroy itself more slowly than movies. This means that most public and private archives are full of ticking time bombs just waiting to go off, whether they consist of slides or negatives, in color or black-and-white. Now, after 40 or 50 years' storage, the day of reckoning is approaching fast.

Which brings us neatly to the question of our expectations with regard to the permanence of our images. If you haven't done so already, the first time you put a photo up for sale at an exhibition is the moment at which you have to consider the potential lifespan of your work. The question becomes even more relevant if the print proves to be less durable than you initially thought once it is in place above its new owner's sofa.

Collectors and artists of course prefer unequivocal numbers in cases like this, although these are quite hard to come by. A permanence figure is only valid for a scenario with specific lighting, climatic and pollution parameters. If the environment in your living room remains constant over a period of many



This 30x magnification shows the fissures common to albumen prints and identifies beyond doubt the material from which this 19th century print was made



A climate-controlled chamber is one of the more important (and expensive) tools for artificially aging test samples at high temperatures and predefined humidity levels. The Arrhenius equation is then used to analyze the results and provide an estimate of the lifespan of the tested material at room temperature.

years, there is a chance that an estimated number of years will hold fast. However, if it looks like test results are working against them, film manufacturers tend to reduce their threshold values accordingly. As if by magic, the expected lifespan of their products increases instantly.

All this makes it difficult to apply the lifespan quoted for a particular product to your own photos, although the numbers are usually fairly reliable under identical, or at least similar, conditions.

Wilhelm Imaging Research (www.wilhelm-research.com) recognized the power of numbers early on, and its founder, Henry Wilhelm, began publishing test results while Agfa and Fuji were still arguing about whose films faded faster. This gave his institute the head start it needed and made it possible to provide usable comparison values between legacy analog permanence values and those of today's digital media.

How to Test Permanence

The principle behind permanence tests is quite simple: all you have to do is expose a test sample to enormous amounts of light until a predefined change in density occurs. Developed black-and-white photos (whether old-school or digitally printed) are made of various colored dyes, and high-end inkjet prints are usually made using pigment-based inks. If a print loses density as it ages, it becomes paler – blacks lose their depth and, because they age at different speeds, the individual color layers develop casts of varying colors.

Once a test has been performed, the numbers it delivers have to be converted from those achieved by exposing the sample to a lot of light for a short time to equivalent numbers that represent exposing it to a little light for a long time. For storage in the dark,

most conservationists' use the 125-year-old Arrhenius equation, which describes the temperature dependence of equilibrium constants. This is used to plot bleaching values at various temperatures from which we can extrapolate the permanence of the tested material at room temperature or below, and is a reliable way to produce long-term longevity prognoses.

The ISO group led by Henry Wilhelm and Yoshihiko Shiahara from Fuji spent no less than 15 years in discussion before finally agreeing on the ISO 18937 standard for measuring indoor light stability for photographic prints. Unfortunately, anyone who spent money complying with the standard lost out. The standard defines how to conduct appropriate tests but, because it doesn't commit itself to a homogenous set of rules for interpreting the results, still doesn't provide a reliable basis for measuring the permanence of prints.

How much bleaching has to take place before a print is 'unstable' anyway? And how much light must it withstand on a daily basis? These are all vague quantities at best, and it will probably be quite some time before true standards for these types of values are established.

Henry Wilhelm's quasi-monopoly will probably live on too. German company Image Engineering has given up competing in this sphere because, according to its managing director, there is simply no money to be made performing independent permanence tests.

Just as supermarkets construct an ideal 'Joe Average' test person to see what he might purchase in the future, Henry Wilhelm



Failed!
The 'Photographic Activity Test' adds the material to be tested to a layer of a sensitive silver-based material on a polyester base, which is then artificially aged. If any of the test materials significantly accelerate the aging process, they are deemed unsuitable for archiving applications.

Fifty years on, negatives shot on Kodacolor film and prints made on Kodak paper between 1942 and 1953 have all but disappeared, whereas Kodachrome slides and black-and-white images from the same period have hardly aged at all. This example shows just how important it can be to pay close attention to the findings of image labs and archives.



Image: Photoindustrie-Verband/Kodak

has developed an ideal 'Jane Photographer', who exposes her photos to 450 lux of light for an average of 12 hours every day. This represents neither the dim light of a museum of 19th century photography nor the bright light entering the window in my living room. In Wilhelm's standard situation, a photo is framed behind normal, non-UV coated glass and slowly bleaches out at 24 degrees Celsius in 60 percent humidity. Just five degrees

cooler and 20 percent less humidity would quadruple the life expectancy of the photo. Remember too, that most people store their photos in the dark in a box of some kind.

Test Results

There are currently three major ways of getting your color photographic ideas down on paper:

- Dye sublimation printing, as found in most self-service kiosk systems.
- Wet chemical printing on photo paper, as practiced in mass-production and specialist photo labs (or its waterless counterpart, as found in most minilabs).
- Inkjet printing with dye or pigment-based inks.

Each process is supported by a range of manufacturers and the permanence of the



A critical factor in our considerations is the point beyond which we consider an image to have lost its appeal. Most tests show that people are prepared to accept a reduction in density of up to 20 percent, even if this means that the image already contains an obvious color cast. Our artificially bleached images (on the right) show the results of each color layer losing density. If these are too much for you, you need to adjust your own threshold values for the lifetime of your prints.



Repro: Andreas Kesberger

In practice, mechanical damage can be a lot more harmful to a photo than unintended bleaching, which can often be repaired digitally. The deadliest foes of any photograph, all caused by substandard archiving, are friction between surfaces, the remains of glue or tape on the back of the next image in a stack and aging gelatin that has come away from its paper base.

results vary considerably. In many cases, the lab you choose makes the decision for you. Mass-production labs and photo book makers don't always list the papers and machines they use, whereas specialist labs usually do. And advertising slogans like 'Lasts 75 years!' are only really comforting if you

don't take the trouble to find out which storage conditions are necessary for the product's promise to hold true.

Kiosk and waterless minilab systems come up with permanence values of 17-26 years when subjected to the Wilhelm tests. These values predict that the color density of prints

will be reduced by at least 20 percent once the specified period of time is over and that they will have color casts that make them look intolerably shabby. In paper tests, Fuji Crystal Archive scored 40-66 years, while Kodak doesn't let on that its 100-year permanence promise is based on one fourth of the amount of light that prints are subjected to in a 'normal' household. If you dial in the same base values, Kodak paper doesn't perform as well as Fuji – 100 years of daily exposure to 120 lux is equivalent to only 26 years at 450 lux. Furthermore, Kodak conducts its tests under UV protection glass at 50 rather than 60 percent humidity. In spite of these shortcomings, Kodak is the only option if you want to make really large prints, as Fuji Crystal Archive is only available in rolls up to 50 inches wide.

Fortunately, after a lot of haggling in the early days, the high-end inkjet print sector appears to have agreed on the use of pigment inks. The first Epson dye-based inkjet prints presented in 1994 lasted just six months. The only consolation in this case was that you could virtually watch your prints fade and thus check in real time whether the manufacturer's permanence claims were true! The next generation of printers with claims of 10-year print life were introduced about 15 years ago but were quickly withdrawn from the market when Epson discovered that prints made with them were extremely sensitive to ozone.

In a darkroom environment, the paper is the only link in the processing chain that is tested, whereas in inkjet workflows, each combination of printer, paper and ink has to be tested individually. The results of using different papers with manufacturers' own-brand pigment inks vary a lot less now than they used to with dye-based inks. Third-party ink manufacturers don't usually perform permanence tests anyway, as these are simply too expensive.

Most good-quality papers score permanence values of around 80 years when used with color pigment inks and a printer such as the Epson 3880, and black-and-white prints last around twice as long before they begin to show significant changes in density. But here, as in every market segment, there are exceptions. For example, the popular Hahnemühle Photo Rag fine art paper scores only 60 years, and Canson Baryta manages only 45 years (both with color inks). These values were significant enough to make both manufacturers improve their papers and have them retested, and we have been waiting more than two years to hear the results.

Because most printer manufacturers only test their own in-house papers, the results achieved by paper manufacturers with

different makes of printer are particularly interesting. Canon and HP printers tend to come up with better results than the current leader in the fine art market, Epson, which still has issues with the stability of its yellow pigments. However, HP only offers its high-end printers in large formats (24 inches and wider). Once again, if you are on the lookout for reliable longevity figures for your client or gallery owner, or for the most suitable paper for your printer, the best place to go is wilhelm-research.com.

Asked what he considers the ultimate in photographic print quality, Henry Wilhelm names black-and-white prints on baryta paper. Vintage prints by Ansel Adams, for example, were made on a paper with an extremely high silver content, and carefully processed examples that have been well protected from environmental influences show virtually no signs of aging. We are of the opinion that Adams' selenium toning helped make his prints last longer, too.

Even when the photographic mainstream wasn't particularly interested in the longevity of prints, there were people who took the trouble to develop high-end printing processes. Some of the luxury prints made in the late 19th and early 20th century and now housed in national collections in Hamburg and Berlin look as good today as they did the day they were developed. Before Fuji introduced its Crystal Archive paper in the late 1990s and everyday color enlargements finally became really durable, most photographic artists who worked in color used the Kodak dye transfer or Cibachrome processes. These produced extremely durable prints which, if properly stored in the dark, still look fresh today. Looking at normally developed vintage prints by William Eggleston or Joel Meyerowitz alongside older dye transfer prints is sure to open your eyes to reality and get you thinking seriously about the permanence of your own work, not least in terms of its potential market value.

Today's claims of a 200-year lifespan for prints made on Canson cotton paper using HP large-format printers, though sensational, are not that different from the benchmarks set by the Fresson family in France with the carbon prints they made in 1899. The same process, based on pigmented gelatin, has been applied to color prints since the 1950s. In those days, HP was still working on sound systems rather than printers and toner, and Epson simply didn't exist. Prints that take six hours to make are bound to change the way you think about time, and the subtle colors in a Fresson print reward the printer's patience with a lifespan of 225 years or more. Kodak's

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Most photographers want to show their works to others, although people are one of a photo's worst enemies. Wearing cotton gloves is the best way to avoid the salts that adhere to your skin from damaging prints.

discontinued dye transfer process is beginning to find imitators in digital circles, although reliable test methods that prove its permanence are not yet available.

Inkjet Jaundice

Every new process reveals new errors that were previously not an issue. Paper has

yellowed ever since it was invented, but cotton-based inkjet papers have elevated the yellowing process to a whole new level. It is probably only a matter of time before rag paper is given a new lease of life as a kind of automatic contaminant detector. In the presence of solvents and plasticizers – in frames or PVC sleeves, for example – the paper's coating turns yellow. The easiest

way to counteract this is to expose a yellowed print to sunlight, as the UV component of the light bleaches out the yellow effect. The difficult part of this simple fix is explaining to an angry collector that the solution to the problem is the exact opposite of all previous recipes for safe photographic storage.

The greatest advantage of inkjet printing processes over wet-chemical ones is that they virtually eliminate the human factor. Making an inkjet print is a simple matter of making some settings and pressing a button, whereas the quality of a darkroom-based print depends on constant vigilance by the lab technician at every stage of the process, from controlling the temperature of the chemicals to proper fixing, adequate rinsing and ensuring that wet baryta prints don't stick to each other. In machine-based darkrooms, the boss likes to see shorter rinse times, while photo conservationists prefer longer times that often exceed the machine manufacturer's stipulations.

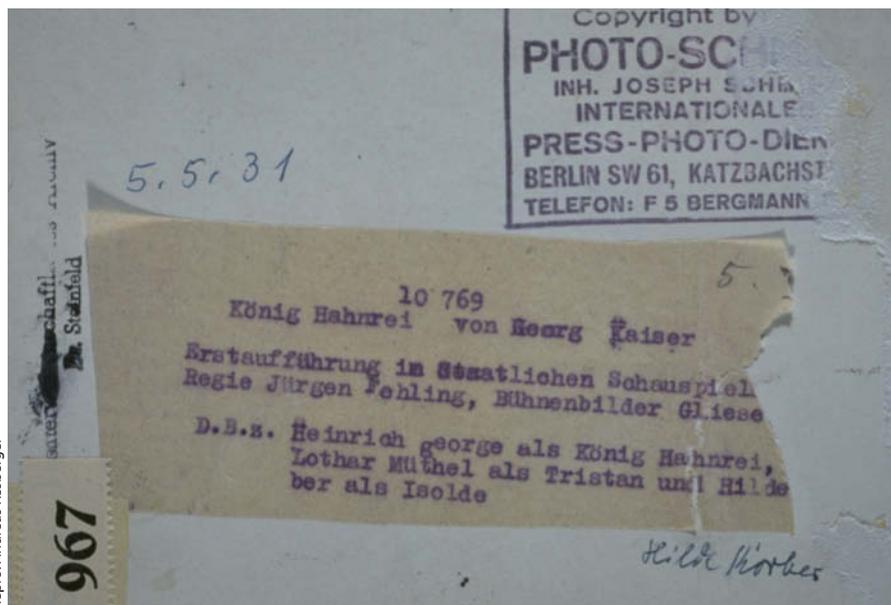
Black-and-White Longevity

Comparing the permanence of black-and-white images is even trickier, and because chemically fixed silver halides are relatively insensitive to light, applying conventional light-based aging tests doesn't really help. The main causes of damage to monochrome prints are environmental factors and the salts that adhere to the fingers of people who handle them. These can easily transform black silver halide crystals into a brown-stained silver/sulfur compound or an unwanted reflective silver layer. Unfortunately for art lawyers, it is usually impossible to tell whether damage to monochrome prints is due to substandard work on the part of the artist or simply because the gallery had the wrong carpet laid shortly before the exhibition opened.

A print taken from the rinsing tray or from a printer is, to all intents and purposes, finished. However, the length of its subsequent life depends not only on the care with which it was produced but also on the surroundings in which it is stored, which brings us to the differences between archiving and presenting photographic images.

The Risks of Presentation

Do you take photos only to pack them away in a drawer? Anyone who buys a work of art will usually want to live with it on a daily basis and show it to others too. Unfortunately, we



Repro: Andreas Keszberger

Inappropriate labeling on the reverse often causes damage to the image side of a photo. Foil-backed stickers with an extra layer of aluminum prevent the ink on a label from penetrating the paper.

It is a shame when the elemental silver particles in classic black-and-white images migrate from their intended positions to the surface of the print, forming an unwanted mirror in the process



are also surrounded by things like ozone, solvents and dust that are detrimental to photos. Even though health and safety commissions have had the amounts of ozone produced by laser printers reduced to a fraction of their earlier levels, and even though furniture manufacturers have reduced the levels of formaldehyde in their bookshelves in fear of the next public outcry, there are still significant numbers of substances just waiting to attack our images every day. The most obvious way to protect an image is to frame it and cover it with acrylic or glass. Cotton-based inkjet papers that are otherwise highly fade-resistant use a chalk layer to fix the pigments to the paper, and this makes them extremely vulnerable to mechanical damage.

The safest kind of frame is one with a mat-style mount and glass with a protective anti-UV coating. You also need to ensure that no potentially damaging substances are sealed inside the frame with the photo and, if you are using a wooden frame, that there is no contact between the paper and the wood, which contains lignin. Rear panels made of laminated board or MDF are cheap but, because they contain solvents, taboo. Mats should fulfill the same museum-grade criteria as archiving systems. Although it is generally accepted that you should use unbuffered card for any parts of an archiving system that have direct contact with photos, this is only really necessary if you are archiving prints made using one of a few historical processes. Direct contact between a gelatin-based print and glass is more dangerous, as gelatin can quickly bind the photo to the glass instead of the paper if the environment within the frame is too humid.

When mounting photos, use corners made of paper, polyester or polypropylene so that no glue comes into direct contact with the photo. If you are mounting baryta or rag papers, conservation-grade hinging tape is a good alternative, as it is easy to detach if necessary. Only very few types of tape or self-adhesive foil are suitable for long-term use with photographs, and most cannot be removed without damaging the material they are attached to.

Proper sealing is essential too, if you want to prevent tiny insects and mold from getting inside a frame. Framing experts recommend that you seal the complete photo/mat/backboard unit in a kind of airtight sandwich.

Diasec – Stylish or Harmful?

While inadvertently bringing a photo into contact with framing glass usually ends up destroying the image, deliberately fixing the entire surface of a photo to a transparent



Photo: Kristina Blaschke-Walther

Measure, measure and measure again. Here, a non-laminated reference color sample is scanned at the University of the Arts in Bern, Switzerland. The university conducted three large-scale tests to examine how Diasec face-mounting affects the lifespan of analog and digital prints.

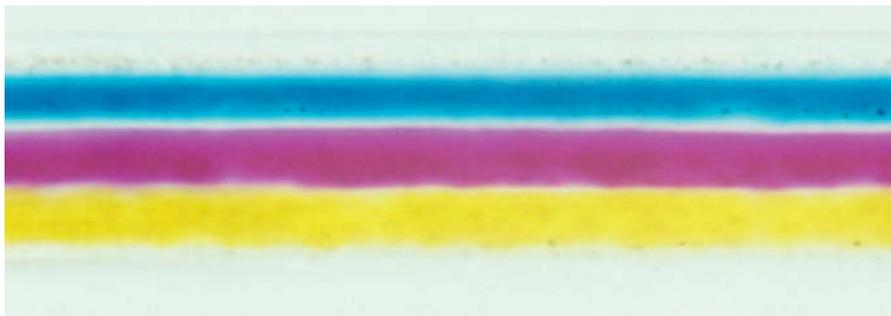
overlay is a technique that has found favor for many years. The patented Diasec process face-mounts and bonds the print to acrylic glass using a gel silicone sealant that acts as glue. This technique produces images with unprecedented depth and brilliance of color. Although the Diasec name can officially only be used under license from its Swiss inventor, it has come to be used by many labs as a generic term for this type of bonded mount. One prominent licensee is the Grieger lab in Düsseldorf, which mounts

work for many of the famous members of the Becher school of photography, including Andreas Gursky.

The downside of the Diasec process is the risk of the various materials involved expanding and contracting at different rates in response to environmental factors. This can cause bubbles, fractures and tears in the structure of an image, and applying glue to the carrier layer of a photo can also impair its permanence. Last but not least, acrylic glass is extremely vulnerable to scratching. Scratches



A dust-protected box and sleeves made of PAT (Photographic Activity Test) certified materials are a good basis for your home film archive. Unlike glassine, conservation-grade plastic sleeves don't acidify over time. However, if used to store film that already suffers from the 'vinegar syndrome', they only serve to accelerate the process.



Because the colors in analog film and photo paper age at different rates, both media develop various colored casts over time. The process can be slowed down, but not completely stopped, by storing affected material at low temperatures. This image shows a cross-section of a slide film viewed through a microscope.

can be removed by polishing, but makes the protective layer covering the photo thinner and can only be performed a certain number of times before there is nothing left. Matte acrylic glass cannot be polished at all. As an alternative, some labs offer glass bonding, but the influence of the silicone glue on the photo remains a problem.

Because of its importance for the art market, the Diasec process has been thoroughly researched, most notably as part of the ‘Materiality in Art and Culture’ program at the University of the Arts in Bern in Switzerland, and the results are anything but conclusive. In her 2004 dissertation, Sabine Zorn proved that silicone bonding of chromogenic colors reduces their permanence – a finding that directly affects the Fuji and Kodak papers most often used with the process and includes works that often sell for \$2 million or more at auction. On the other hand, work led by Professor Sebastian Dobrusskin on black-and-white prints, Ilfochrome direct-positive enlargements and inkjet pigment prints shows that face-mounting can actually make them more stable, even if they are less susceptible to premature aging anyway.

Pack it Away

My chemistry professor, who used to work for Agfa, once said that if you want a photo to last forever, you should put it in a cardboard box and never look at it again! There is a lot of truth in this, as one of the major factors influencing photographic longevity is the choice between presentation and storage in daylight or in the dark. Assuming that no-one really keeps their negatives in framed mat mounts hung on a wall, storage in the dark is the most likely practice.

The surrounding environment and the packaging materials are the two crucial factors

when transforming permanence test figures into reality. ‘Acid-free’ is the buzzword in this context. It sounds good and is easy to understand but, unfortunately, things aren’t quite that simple in the world of photography, even if we disregard some of the more exotic image creation processes that actually thrive in acidic packaging. Archive-grade paper used for graphics applications is treated with an alkaline buffer, but this doesn’t work for albumen or dye transfer prints.

Many photo enthusiasts know that the term ‘acid-free’ alone doesn’t cover enough bases when it comes to certifying photographic materials. The PAT (Photographic Activity Test) procedures popularized by the Image Permanence Institute in Rochester, New York, which are based on accelerated aging, investigate whether sensitive image carrier layers age when they come into direct contact with the test material, be it paper, card, plastic, glue, or whatever. It sounds a little crazy to store inkjet prints in boxes that have been tested for their effects on silver halide prints, but the last two decades have seen precisely these factors gain acceptance as general risk detectors for all popular photographic image creation processes.

Although many paper dealers don’t immediately know what the acronym PAT stands for, some do keep stocks of PAT tested papers specifically for photographers. PAT certification makes paper, storage boxes, sleeves and mats more expensive, but it is definitely worth paying for.

A Cool, Dry Climate

The immediate environment is possibly even more important than the packaging when it comes to preserving photos, although the two factors are inextricably entwined. The more densely a photo is packed, the less it will be affected by changes in its immediate

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environment. Put simply, keeping temperature and humidity low and fluctuations in both to a minimum is the best way to maximize the lifespan of your photos. It is said that humidity of less than 25 percent can cause photographic gelatin to develop cracks, but most photographers' home environments are rarely that dry.

'The cooler the better' is only valid if you keep an eye on the other two factors too. Keeping your negatives and important photos in the fridge (or even in the freezer) only makes sense if you keep humidity down to a suitable level and don't look at them often enough to subject them to regular climatic variations. Fotomuseum Winterthur in Switzerland is a great example of ideal photo storage in practice. There, monochrome prints are stored at 19 degrees Celsius and 45 percent humidity, and color archives are stored at 13 degrees and 35 percent humidity, proving that it is possible to prolong the life of important archive material without forcing staff to wear cold weather gear to work.

These kinds of conditions are not realistic for most domestic situations and contradict most people's energy-saving ideals anyway, but you can apply similar measures to preserve even the smallest private archive. A damp cellar or an uninsulated roof space is not a good place to store photos, and perspiration issues makes storing them under the bed less than ideal. If, however, you go for a stove-enameled steel cupboard located away from windows and sources of heat, you can sit back and relax while your images gently age.

Film as a Data Medium

Colored dyes disintegrate in the dark too. Even though Kodak slide films had a shelf life of 220 years by the time production ceased, film as a medium is disappearing fast, and there are very few test results to be found for the few film types still being sold. By the way, Kodachrome slides last longer if you don't project them, as they react badly to the heat and radiation from the projector lamp.

Among currently available films, independent test results are only available for Fuji Velvia. It takes 150 years for the color density in a Velvia slide to decrease by 20 percent, but the slide will still contain enough color data to be scanned and digitally restored should scanners still be around in 2165.

If you prefer to think in terms of centuries, Ilford Micrographic Film, which is much too insensitive for conventional photography, makes a great archiving material for analog and digital data. Unfortunately, Ilford's Swiss inkjet arm became insolvent and production

PERMANENCE IN THE DARK	
Under archive conditions	
Cuneiform script (in clay)	Several thousand years
GlassMasterDisc ⁸	> 1000 years
Monochrome film with polyester base (color prints) ³	> 500 years
Ilford Micrographic Film ²	500 years
Kodachrome ^{1,2}	206 years
Fujichrome Velvia slide film ^{1,2}	150 years
UDO disk / MO disk ⁴	71–86 years
Color neg. film (Kodak Vericolor III S) ^{1,2}	70 years
JVC Archive-grade DVD ⁵	30 years
CDs ⁶	3–20 years
Hard disk ⁷	6 years

¹ Possibly shorter if carrier layer damaged
² Test results from Wilhelm Imaging Research
³ Test results from Image Permanence Institute
⁴ ISO standard test results from manufacturer
⁵ Tested by ADTC
⁶ Data from University of Cologne
⁷ Average value calculated by Blackblaze following analysis of 27,000 hard disks in continuous operation
⁸ Unchanged after 1,000-hour test at 90°C and 85% humidity (test performed by LNE)

of the micrographic material disappeared with it. This gap in the market triggered the renaissance of the color separation process, which is already more than 100 years old. A deceptively simple idea, it involves creating a monochrome negative for each of the red, green and blue color layers that can be archived long-term and reunited using color filters at a later date. Toned monochrome negatives made on a polyester base are sure to be intact in 500 years or more.

But why would we want to store digital data on film? Maybe because purely digital copies have to be renewed regularly to ensure that they last, even if they can be copied losslessly. The appearance of the first CD burners was quickly followed by the first permanence test, which estimated a lifespan of 3-20 years for the new medium – and economic reality (helped by some thorough **ct** testing) has caught up with those who promised otherwise.

Nowadays, the strictest standards that exist for writable CD media cover the storage of medical data on JVC archive-grade disks with a lifespan of up to 30 years. This is negligible, however, compared to the capabilities of the GlassMasterDisc technology, which uses indentations sandwiched between two glass discs to store data that can be read by conventional DVD and Blu-ray players. This new format shows no signs of aging whatsoever in an accelerated aging test and is the best ultra-long-term memory solution we know of. Storing 5GB of data on a GlassMasterDisc currently costs around \$220.

If this is too expensive, or you don't think Blu-ray players will make it into the coming centuries, the best solution is probably to

migrate your data to a variety of media and keep copying and/or migrating them on into the future. Using a single backup disc or medium is a big risk. Cloud service providers, for example, have discovered that the average life of an industrial-grade hard disk in continuous use is six years. Disks used in backup mode last longer, but statistics show that five percent of these simply break down within a year anyway.

What Now?

In view of the enormous numbers of photos that are taken every day, it is probably a good thing that many of them won't survive into the future. However, if you want to give your offspring the opportunity to decide for themselves which pictures of you they want to keep, now is the time to get to grips with the subject of image permanence.

Our test results shows that, if you want your work to last into the 22nd century, all you actually need is an inkjet printer with pigment inks and an archive-grade box or, alternatively, some black-and-white film with a polyester base.

Last but not least: the photos your archive contains should be good enough to prevent your descendants from disposing of them before they disintegrate of their own accord. (jr)

DAYLIGHT PERMANENCE	
Under gallery conditions	
Frescon color pigment print	225 years
Color inkjet pigment print on Canson Rag Photographique using an HP Z3100	219 years
Black-and-white baryta print with gold or selenium toning ²	> 200 years
Monochrome inkjet pigment print on Epson Traditional Photo Paper using an Epson 3880	200 years
A1A art print (pigment ink embedded in acrylic) ³	200 years
Color inkjet pigment print on Epson Photo Glossy Paper using an Epson 3880	85 years
Monochrome PE paper without toning ²	50 years
Color inkjet pigment print on Canson Baryta using an Epson 9880	45 years
Fuji Crystal Archive (RA-4 photographic paper)	40-66 years
IRIS print	32 years
Kodak Dye Transfer	32 years
HP Indigo 6-color digital print	31 years
Ilfochrome direct-positive	28 years
Kodak Endura (RA-4 photographic paper) ⁴	26 years
Kodak Picture Kiosk system	26 years
Polaroid SX 70	10 years
Inkjet dye print (e.g., Epson 1270 from 2001)	4-27 years
Sony DPP-FP30 thermal sublimation printer	6 years

¹ 12 hours daily at 450 lux, 60% humidity and 24° Celsius, framed under glass. Test results from Wilhelm Imaging Research
² Estimated
³ Test results from the Institut of Polymer Technology
⁴ Converted Kodak and Wilhelm values





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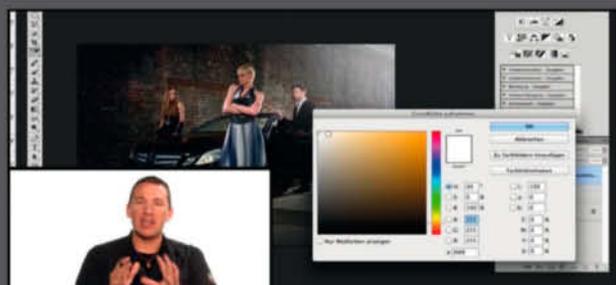


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Ralph Altmann

Open Source Raw Converter Test

Most of the free raw converters around are open source. There are many advantages, but also some disadvantages, to using free software for image processing. The greatest drawback is that, unlike projects like the Firefox Web browser, which has been sponsored by Google and Yahoo!, the programmers behind most open source projects are unpaid and do all the necessary work in their free time. This of course means that it is unrealistic to expect free software to work as smoothly as programs developed on a large budget. On the other hand, developers of free software can make their own decisions and are not subject to the market-oriented tactics that often govern the development of commercial products, so many free raw converters offer features that are not available in their more expensive counterparts. For this article, we put some of the more popular free packages through their paces to find out how the image quality they offer compares to that of the commercial competition.

Corrections Without Asking

Manufacturers of commercial software usually try to make handling as simple as possible. Although this approach makes software easier to use, it often means that the software takes decisions for you, hides away complex procedures or simply leaves out complicated features altogether. While software-makers try to make the path to the 'perfect' image as short as possible without the need for specialized know-how, the perceived quality of the results is more important to most users than the simplicity

of achieving them. Commercial programs often apply hidden curves in order to produce increased contrast or color saturation. The last version of *Capture One* we tested even applied noise to every image, supposedly to improve perceived sharpness and therefore overall image quality too. But not every photographer wants software to perform such adjustments unasked, and an option to switch automatic corrections on or off would be a useful addition to many programs. In practice, most commercial converters still perform hidden adjustments to raw image data, and the only way to find out what's going on behind the scenes is to perform complex reverse engineering.

Transparency robs software manufacturers of commercial advantages, although the algorithms they use are seldom genuinely secret and cannot be easily patented. Countless specialists all over the world are constantly working on improved image processing software and the results they publish find their way into commercial and free software in equal measures. This is why commercial image processing software and the free programs tested here have very similar basic functionality.

The Advantages of Free Software

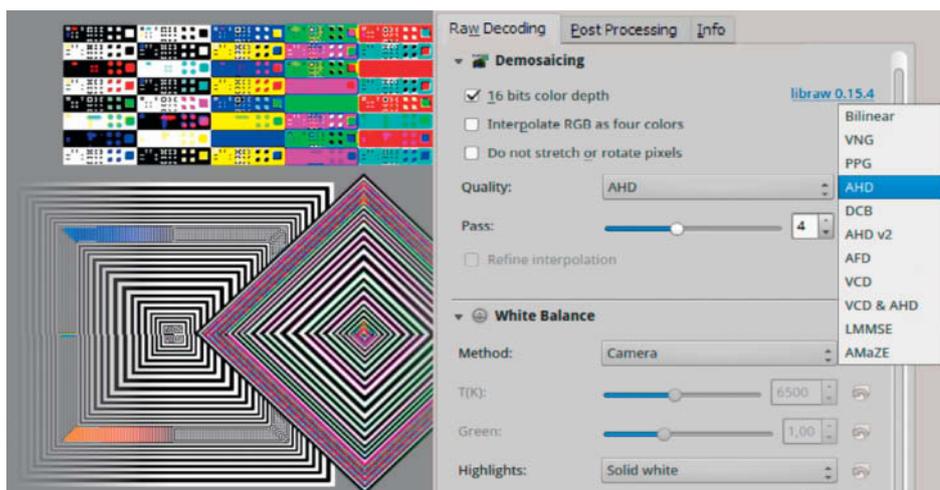
The best thing about open source software is that you can open it up and check it out, all the way down to the code level. If you have some coding experience, it is easy enough to add your own improvements and tweaks. If you are not a coder, openness is only a theoretical advantage. However, open source software is often programmed

There are many free alternatives to raw converters like *Lightroom* and *Capture One*, and some offer tools and functions that are as good as, or better than, those of the commercial competition. In this article, we test the best of the current crop and compare the image quality and ease of handling they provide.

Online Content

- Sample demosaicing, highlight recovery and denoising images
- Converted raw files
- DCRaw batch files
- Raw converter software

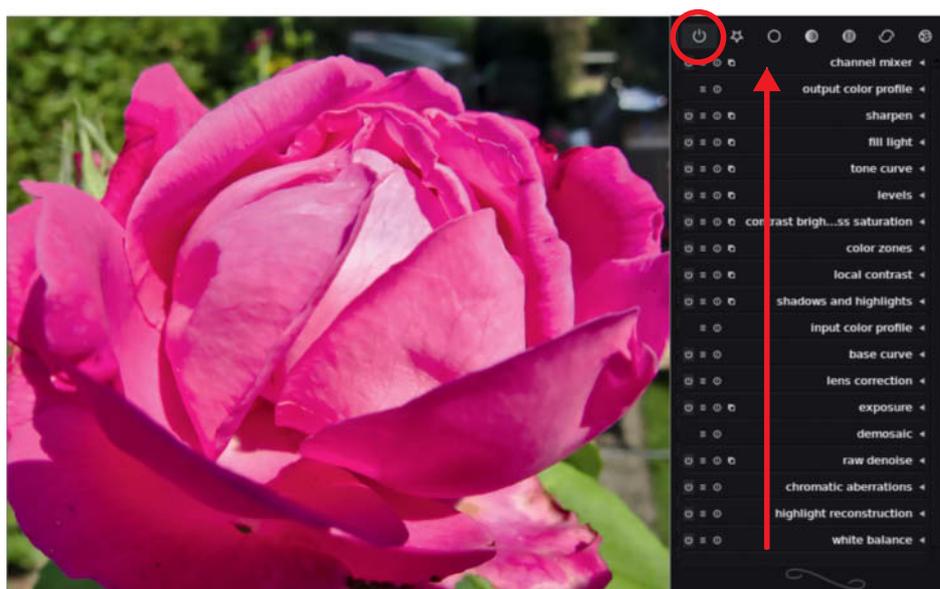
www.ct-digipho.com/downloads202015



Some programs, like the Linux version of *digiKam* shown here, offer a range of different demosaicing methods. The best method to use depends on the textures contained in your image, and our test pattern offers some useful indicators.

to work closely with the algorithms it contains, so a working knowledge of raw development processes is a bonus, even if you don't delve into the inner workings of the software and stick instead to the user interface provided. The programs we will be discussing on the following pages leave many of the processing decisions to the user. While most commercial programs offer only a single sharpening, denoising or color

correction tool and don't divulge which demosaicing method they use, many open source programs offer a variety of options with results that are beneficial to many different types of image. This is one of the reasons open source software is popular with niche users such as astrophotographers, panorama specialists and HDR image-makers, who want to squeeze the very last drop of detail out of



All raw converters have their own specific internal workflows, which are seldom disclosed to the user. *darktable* is a great example of software transparency, as it details all the modules it uses and the order it applies them in (indicated by the red arrow).

their image files. For such specialized applications, an image processing program counts as 'good' if, instead of just making an average-quality snap colorful enough for printing, it can transform imperfect source images into usable image data.

Multi-platform Support

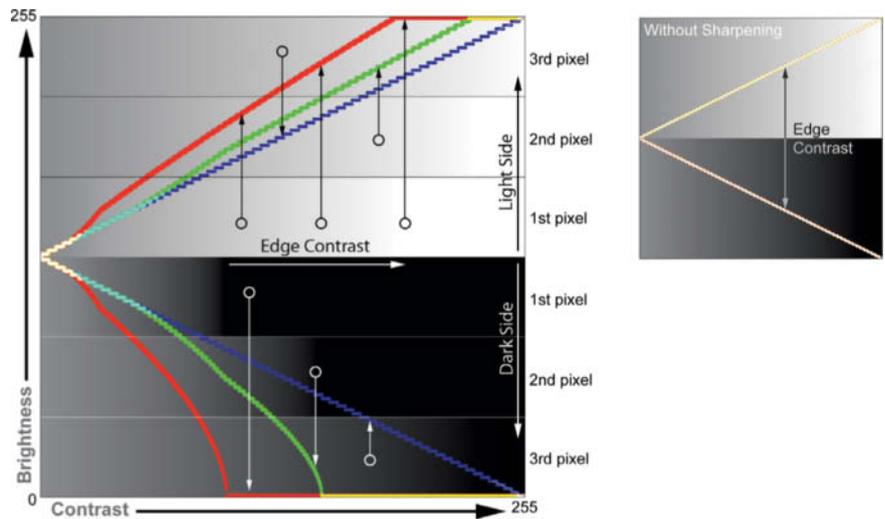
Before we began testing, we looked at the open source *darktable*, *digiKam*, *GTRawGallery* and *RawTherapee* packages, and *Raw Photo Processor* for Mac, which requires a donation if you want to use some of its more advanced features. We also checked out Hasselblad's free *Phocus* software, although this only works with Hasselblad's proprietary file formats. Most of the programs we tested support multiple operating systems, but they don't all support the same features or offer the same degree of stability from system to system. The widely held opinion that open source software runs better on Linux-based computers than on Windows or OSX systems is largely a myth. We used a Linux system for the raw tool test in Issue 11 of *c't Digital Photography*, but we didn't notice any striking performance or stability metrics, even using tried-and-trusted standard hardware, so for this issue's test, we used the operating systems most often chosen by each program's users. Windows was the most popular system, and we used a Mac to test *darktable* and *Raw Photo Processor*, as neither is available for Windows. In cases where the versions we tested displayed unusual behavior, we installed and tested the Linux version of the software as a comparison.

Hasselblad Fails the Test

In its Windows version, *Phocus* only supports Hasselblad file formats and, although the Mac version can open hundreds of RAW formats, the range of tools available for processing non-Hasselblad files is extremely limited. Essential features such as highlight recovery, denoising and lens corrections remain grayed out. This means that *Phocus* is only of interest to Hasselblad users. Because Hasselblad cameras use the same Sony sensors as Pentax cameras and those from other manufacturers, this move is an obvious attempt to set the brand apart from its competitors – in other words, if you want to create a different look, you have to use someone else's software. In spite of its clean, easy-to-use interface, these limitations made it impossible to include *Phocus* in our broad-based test.

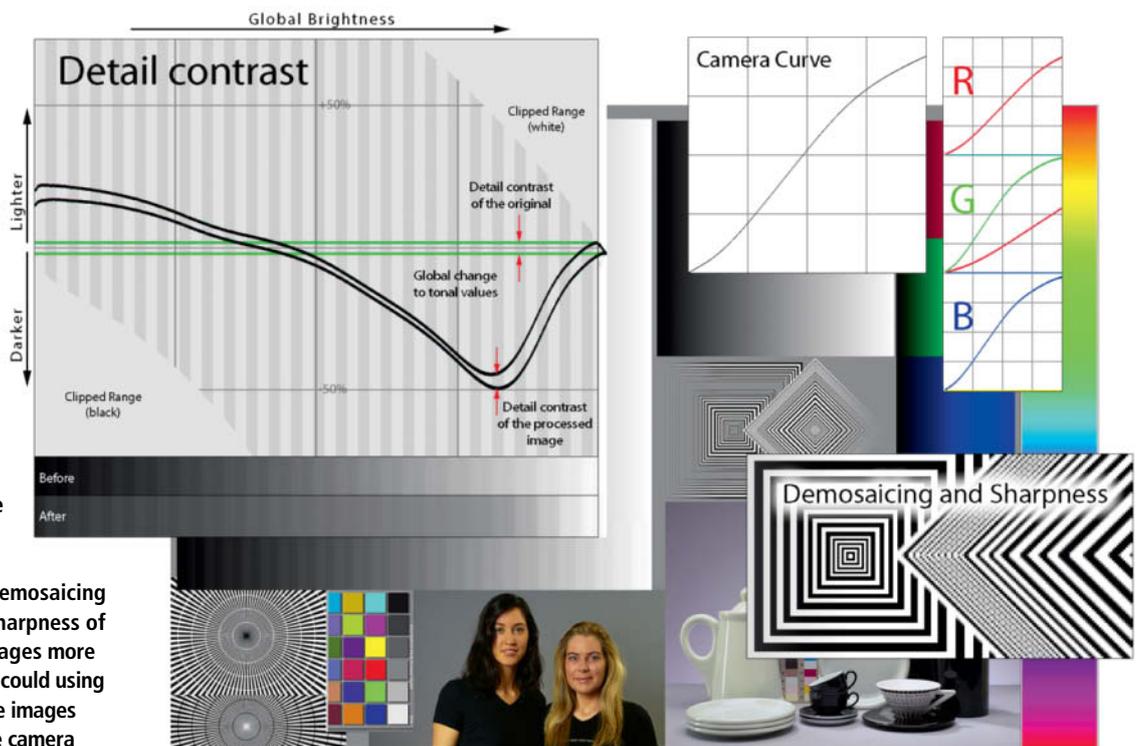
How We Tested

For our last raw converter test, we hacked three popular raw formats and inserted our own test pattern into the files to help us analyze the performance of the software. We used the same synthetic NEF, NRW and DNG images to perform most of the tests for this article. Our raw test pattern consists of various tonal gradients that we used to ascertain the transfer curves each converter uses. The pattern includes a camera curve, color fields, a rainbow gradient and two details from *c't* test photos to help us judge overall visual quality. The 'demaicing and sharpening' square and its rotated counterpart are made up of fine lines of varying widths and helped us to evaluate the quality of the demosaicing (i.e., the process that transforms raw image data into an RGB image). The finest lines are one pixel wide in the original image, but we doubled the dimensions of our sample images using 'nearest neighbor' interpolation to avoid applying an additional interpolation that would counteract the one that takes place during demosaicing. In some cases, we used TIFF files to test functions that don't take place on a raw level. Finally, we fed our test converters with a range of raw files captured using various cameras to check how they handle overexposure, underexposure and noise issues.



The sharpening curves show how markedly the contrast in the first three rows of pixels on either side of an edge is increased. The red curve is the closest to the edge and is altered the most. The green curve represents the second row and the blue curve the third, which in this case remains unchanged. Curves that meet and follow the top and bottom horizontal axes indicate oversharping, which becomes visible in real-world images in the form of light or dark sharpening artifacts.

We compared the results produced by the open source programs with each other and with results produced by leading commercial raw conversion packages.



Our hacked raw test images make it possible to evaluate detail contrast, demosaicing quality and the sharpness of the converted images more precisely than we could using normal raw source images straight out of the camera

darktable X

darktable 1.6 has been extensively reworked and is now said to be fully Mac-compatible. However, we came across an unusual issue during the installation process, in that the software searched for display and output profiles in a hidden folder called `<User>/.<config>/darktable/color/out` which didn't exist. This meant that our favorite output profiles were missing and that the monitor colors were all wrong. To view and create hidden folders in the Mac Finder, you have to enter the following command line in the Terminal window:

```
defaults write com.apple.finder AppleShowAllFiles TRUE
```

You can then create the `.config` folder and all its subfolders in the usual way and copy all your profiles there. The current display profile is usually found in:

```
<User>/Library/ColorSync/Profiles/
```

Once you are done, you can switch the Finder view back to normal by entering the same command as before, this time with the word `FALSE` at the end instead of `TRUE`.

Images are imported and viewed using the *lighttable* view, which has a basic metadata editor, various management tools and an export function. Images can be grouped and

filtered according to various criteria, and the results saved as collections. The steps you apply to an image can be viewed in the *history stack* and saved as a *style*, which can then be applied to other images. The program doesn't register changes you make to your collections from outside its interface so you have to re-import your entire collection to cover any changes you make. *Lightroom's* Sync tool is simpler to use. *darktable* supports processing for 32-bit TIFF and EXR files, and HDR creation and tone mapping functionality is built-in too.

The *darkroom* view offers a broad range of tool modules sorted into five groups, and two further groups display the currently active modules and your favorites. The selected modules (the 'pixelpipe') are applied from bottom to top and, although you cannot change the sequence, many modules allow you to apply multiple instances. The *Blending* option, available in nearly all modules, allows you to reprocess an image using the current input to check its effect before handing it on to the next step in the sequence, much like the *Photoshop* Fade tool. The system also supports preset and custom-drawn masks.

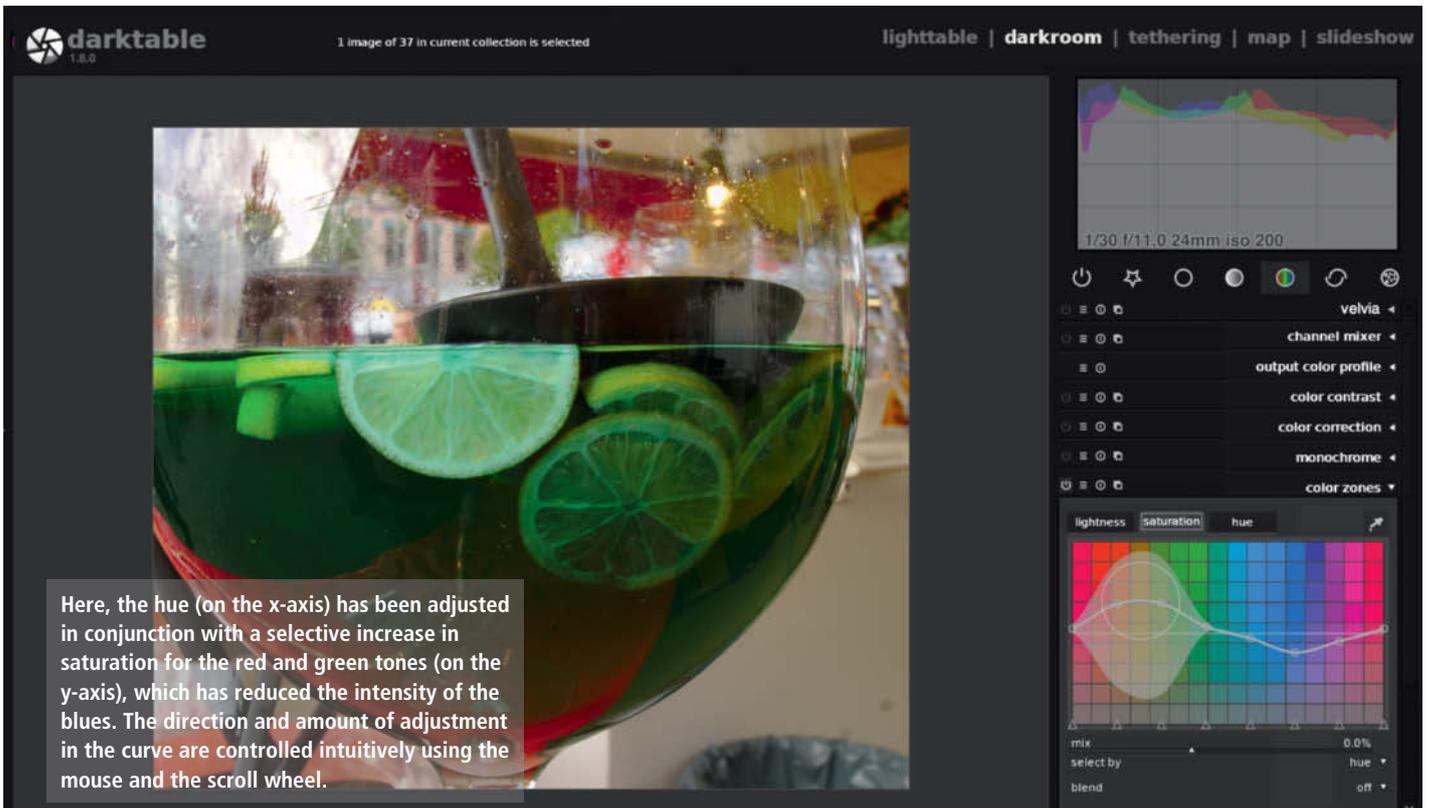
All processing steps are recorded in an XMP sidecar file. Lens corrections are performed based on the open source Lensfun

database (http://wilson.bronger.org/lensfun_coverage.html), to which anyone can add new lens profiles.

The *tethering* view is designed for controlling your camera remotely, the *map* view supports geotagging, and the *slideshow* view is self-explanatory. A comprehensive online manual is available at darktable.org/usermanual.

The Tone Group

The *exposure* module enables you to enter values between +3 and -3 EV and to adjust the black point. Both adjustments can be made directly in the histogram using the mouse, and the *auto* option enables you to apply your settings to a selected image area. The *brightness* function protects highlight and shadow detail, which can be adjusted selectively using the *shadows and highlights* module. The Tone group also includes a Lab-based *tone curve* module, a *levels* module similar to the one found in *Photoshop*, and a module for adjusting local contrast. Unlike the *shadows and highlights* module, the *fill light* and *zone system* modules don't retain detail contrast. Apart from the *clip highlights* option, the *highlight reconstruction* module offers



The screenshot shows the darktable interface in the 'darkroom' view. The main image is a photograph of a drink with lime slices. The right-hand panel displays various adjustment modules, including 'velvia', 'channel mixer', 'output color profile', 'color contrast', 'color correction', 'monochrome', and 'color zones'. The 'color zones' module is active, showing a color correction curve. A text box in the bottom left corner explains the adjustments:

Here, the hue (on the x-axis) has been adjusted in conjunction with a selective increase in saturation for the red and green tones (on the y-axis), which has reduced the intensity of the blues. The direction and amount of adjustment in the curve are controlled intuitively using the mouse and the scroll wheel.

reconstruct in LCh and *reconstruct color* methods, which are designed for rescuing grayscale data and color data from neighboring pixels. Used in conjunction with the *color reconstruction* module (with its bilateral grid functionality), the *reconstruct color* method produced the best result for our overexposed sample image.

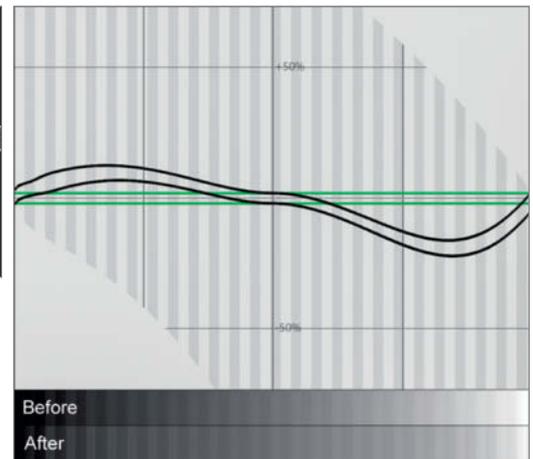
Unlike many other raw converters, *darktable* doesn't allow you to enter preset gamma values, but sets them as part of each of the available output profiles instead. However, you can select and adjust a base curve equivalent to the manufacturer's camera curve, which is used for improving contrast either in-camera or following raw conversion.

The Color Group

Some of the functions included in the color group are extremely well implemented. The *color zones* module is in fact a powerful HSL (Hue/Saturation/Lightness) tool with which you can quickly and intuitively use your mouse to select the tonal range and tolerances for your adjustments. The *color correction* module only influences highlights and shadows, while *color contrast* increases or decreases contrast in the green/red (a) and blue/yellow (b) Lab channels, although you



Retaining microcontrast while brightening shadows and darkening highlights is a complex task that *darktable* mastered with *bravado*. Compare the detail contrast curve on the right with the one produced by *digikam* (see page 81) for proof.



can adjust these more precisely using the *tone curve* module in the tone group. There are no RGB curves adjustments available, but the sliders in the *color balance* module do a similar job. The *color transfer* module offers an interesting way to transfer the mood of one image to another.

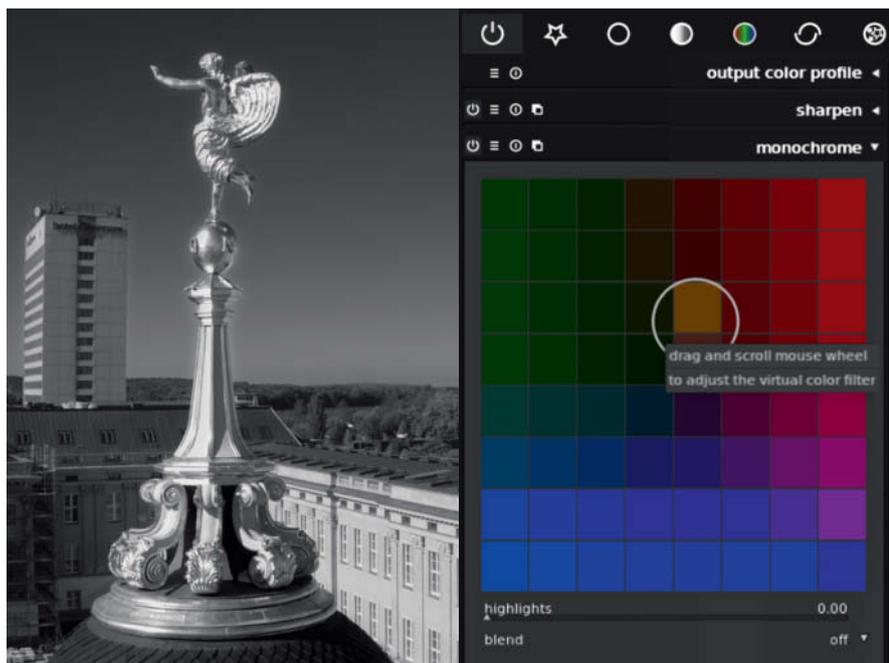
Denoising and Sharpening

darktable has no less than five different modules dedicated to noise reduction. The

raw denoise module taken from *DCRaw* was too weak to make much of an impression on our test image, as was the *non-local denoise* module, which works by averaging the structures in neighboring pixels. The *bilateral denoise* module works in all three RGB channels, comparing neighboring pixels and tonal values, and has a more pronounced effect. The *profiled denoise* module was the easiest to use and produced the best results with the fewest test runs. This module is based on user-created profiles for more than 100 cameras used at various ISO settings. Combining parametric masks with blending modes is a great way to selectively denoise a specific image area.

Finally, the *equalizer* is a powerful module but is quite tricky to use. It is based on wavelet analysis and can be used to reduce noise and increase local contrast. The effect can be applied steplessly over a broad spectrum rather than in the preset increments common to similar tools in other programs.

The *sharpen* module is a conventional unsharp masking tool that only affects the L channel. The tool doesn't limit oversharpening, but you can control its effect by reducing its opacity or by using a blend mode such as *soft edges*.



The *monochrome* module in *darktable* uses an adjustable virtual color filter that takes a little learning but produces great results once you have mastered the technique

- ➕ Easy-to use interface
- ➕ High-quality color adjustments
- ➕ All steps reversible
- ➖ Complicated installation (on Mac)

digikam

digikam is based on the KDE Platform 4 that was developed for use with Linux-based operating systems but also runs under Windows. The *Showfoto* raw converter and editor is built in and uses *LibRaw* (an enhanced version of *DCRaw*) to convert image files. With regard to its toolset and versatility, *digikam* is just as good as some of the commercial competition and also offers comprehensive image search, sorting and filter functionality that includes face recognition and similarity search features. It can also be used to manage albums and edit metadata. Even though the list of features is impressive, not all of them are good enough for real-world use, and the program's Wiki isn't always completely up to date.

Before you start using *digikam*, you have to manually enter the path to your image folders in the program's preferences. Once you have done so, the program automatically generates albums and you can add your

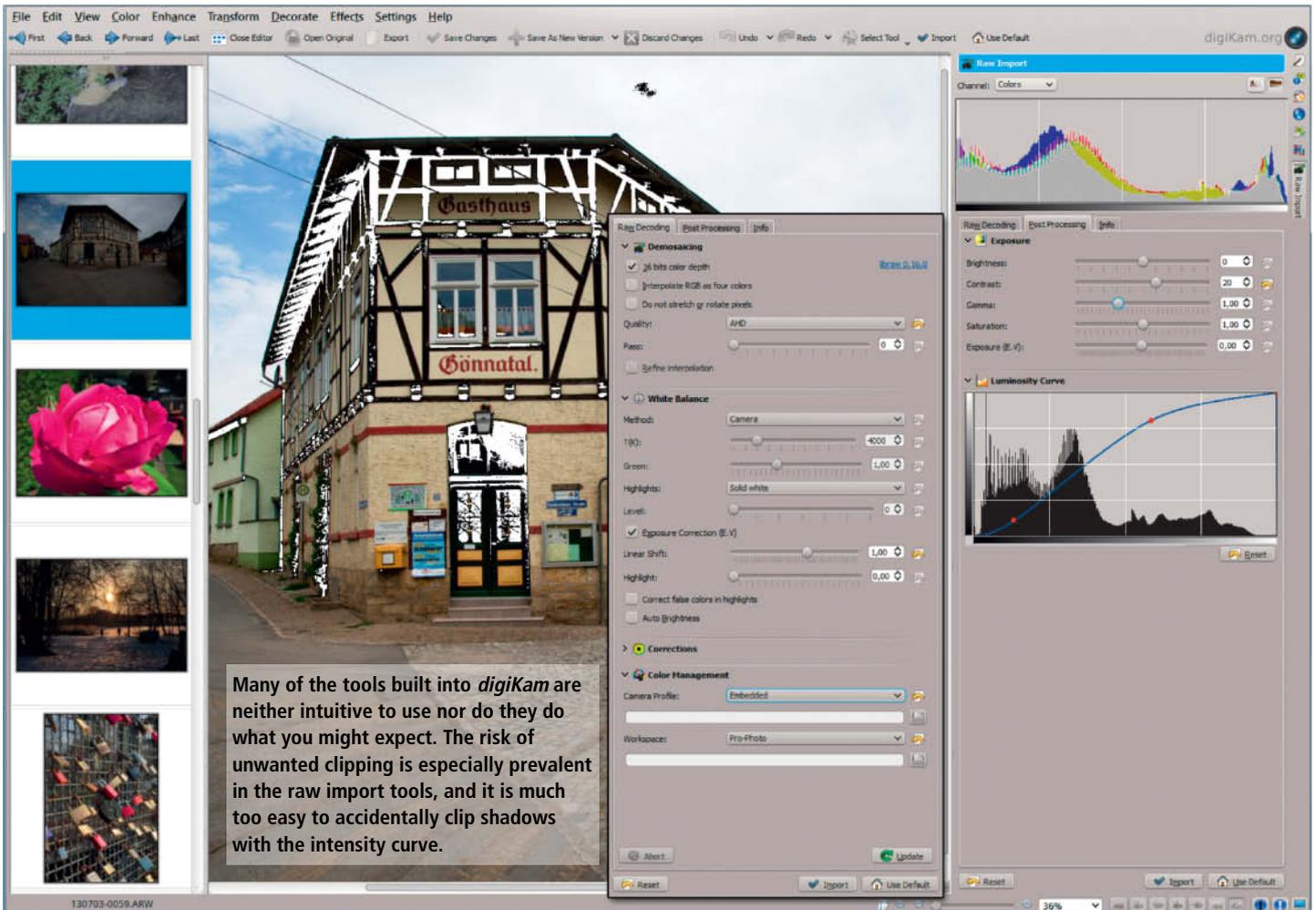
own later. For our test, we selected the dark 'Obsidian' color scheme, as this is much easier to read and use than the default light gray version.

The main program window is aimed at image management, but you can use the additional Light Table view to help you sort and compare your images. Editing in the Image Editor view is quite complicated. The tool you select opens temporarily in the right-hand sidebar but doesn't allow you to switch between settings or experiment with different combinations of effects the way you can in *darktable*. Additionally, you usually have to click the 'Apply' button to get the selected effect to show up in the preview window. This all makes a smooth workflow extremely difficult to achieve.

Raw image files are imported using a tool that works like the *Adobe Camera Raw* module in *Photoshop*, and only converted images that have been handed over to the main program

can be freely edited. The Raw Decoder performs all the functions built into the *DCRaw* module it is based on, including demosaicing, white balance, highlight recovery and denoising, and also offers a Post Processing tab with brightness, contrast and saturation sliders and a curves tool. You cannot save your settings and the only settings option available is the default for automatic raw development.

Used with Windows, *digikam* offers a limited selection of demosaicing algorithms. *AMaZE*, the best (but also slowest) open source algorithm, is only available with the Linux version of the program. The Windows version also had issues handling common raw formats such as those captured by the Canon Rebel T3i/EOS 600D and Sony NEX cameras. By the end of our test, the program failed to recognize half of the raw files it detected at the start, even following a fresh installation. Image export also produced some unreadable



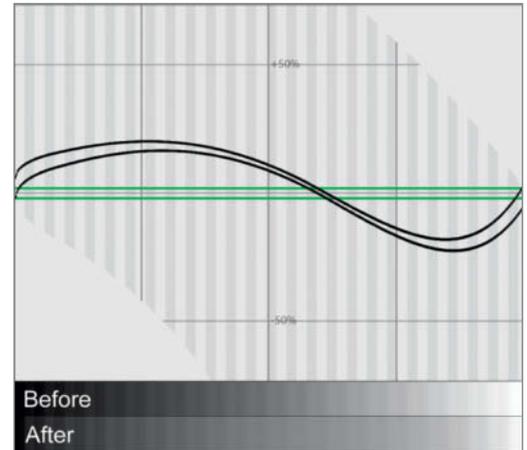
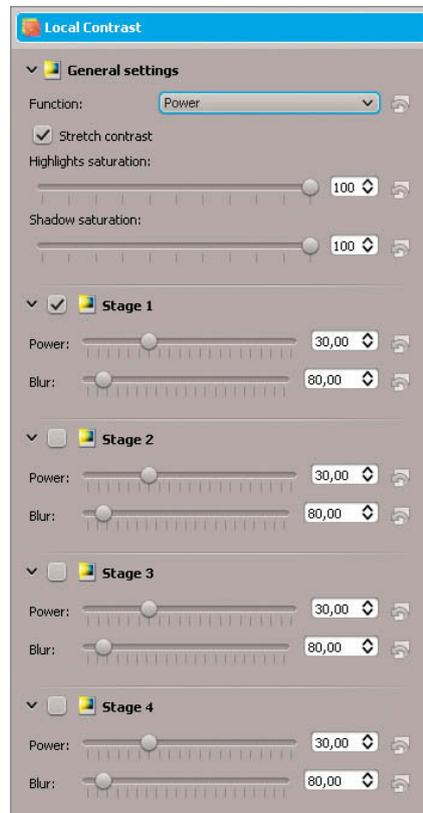
files and saved some images in formats different from those we selected. The Windows and Linux versions also converted some RAW files to TIFFs that *Photoshop* was unable to read, although we were able to open and convert them using *PhotoLine*.

Tonal Corrections

The most important raw development setting is hidden in the *Highlights* drop-down menu, and the option you choose determines whether highlights are clipped or recovered. The default setting is *Solid White*, which increases the tonal values of the as yet non-demosaiced image proportionally so that the brightest pixels are pure white. In most cases, this produces pleasing, well exposed results, but it can also spoil unusual lighting moods and create some burned-out highlights. The *Unclip* option leaves the values in the individual channels unchanged, which leaves underexposure and highlight color casts uncorrected and causes overexposure as well as some magenta color casts. The *Blend* option combines both approaches and recovers highlights as grayscale values, while *Rebuild* (available on seven levels from 0-6) is a copy of the original *DCRaw* function that attempts to guess the original color of highlights by looking at correctly exposed neighboring pixels. Because this module is widely implemented, the same settings can also be found in some of the other programs we tested. *Rebuild* applied at level 0 produced the best result with our test image, although it was still paler and obviously more magenta-toned than the results we produced using *darktable*, making additional post-processing essential.

Strange Reactions

Reducing the exposure value usually helps to restore highlight detail, but care is required when doing so with *digiKam*. Simply activating the Exposure Correction tool increases exposure by 2EV, even though the *Linear Shift* slider is set to zero by default. Generally, selected values have little to do with the results they produce, and the same is true for the *Exposure* slider in the Post Processing tab, which increases exposure by about 2EV for every 1EV increase in the setting. The *Luminance* slider shifts tonal values in an extremely primitive, linear fashion and, unlike the *darktable* 'brightness' slider, clips highlights and shadows in the process.



Local contrast can be adjusted in four stages, each of which applies a global adjustment that brightens shadows and darkens highlights. This and the default increase in saturation often produce better-looking images, even though microcontrast in the midtones is reduced (see the graph above). *darktable* does a better job of retaining midtone contrast.

The tools available following raw import are conventional and fairly old-school too. You are probably better off leaving the *Brightness* and *Contrast* sliders in the Brightness Contrast Gamma tool well alone; the Adjust Levels or Curves tool will produce better results instead. The Local Contrast tool produced no genuinely noticeable results.

The White Balance tool is the most noteworthy and, alongside the usual slider for adjusting color temperature, offers sliders for brightening shadows, adjusting the gamma setting, altering saturation and setting the intensity of green tones. The adjustments produced by the tool's *Exposure Compensation* sliders are twice as strong as the indicated values. The fact that all these corrections can only be applied to developed, gamma-coded images limits their usefulness. In contrast, all corrections performed in *Lightroom* are applied in a linear color space and produce much higher-quality results.

Color Corrections

Other than using the *Saturation* slider in the raw import dialog, you can only adjust colors

once raw import has taken place. The available tools, such as Color Balance and Hue/Saturation/Brightness, are similar to those found in other programs, while *Wavelets*, *FBDD*, *CFA Line* and *Impulse* denoising options are available in the raw decoding module. For the first three of these, only the threshold value can be adjusted, but the *Impulse* option differentiates between luminance and color noise. The Noise Reduction tool available following raw development works in the YCbCr color space, which is more popular among video-makers than photographers.

- ➡ Rich feature set
- ➡ No real-time preview
- ➡ Inflexible, non-reversible workflow
- ➡ Raw development settings cannot be saved

GTKRawGallery

GTKRawGallery combines three powerful open source photo tools in a single GUI. These are *DCRaw* for raw development, *ImageMagick* for processing converted RAW files (and other raster-based formats) and *Exiftool* for displaying and editing metadata. The program also has a built-in image browser and you can create albums too. There are four separate layouts available for viewing and sorting your images, two of which show thumbnails only, while the other two display thumbnail filmstrips with a larger preview image. Unfortunately, the fonts and icons in the interface are too small for many modern monitors, and using the program proved to be quite laborious on our 27-inch, 2560×1440-pixel model. Additionally, some buttons have no obvious function.

There is no online help and no tool tips available for the individual tools, so you need to know your way around raw development processes if you want to get the most out of the software. The main reason we decided to test it here is the GUI it provides for the normally command line-based *DCRaw* module, which gives a clear overview of nearly all the *DCRaw* functions, although not in the same order as they are applied internally. Some of these – including output in a linear

(i.e., non-gamma-corrected) color space, the *Subtract dark frame* noise reduction feature and *Document mode*, which outputs grayscale images without demosaicing them (enabling you to create black-and-white images with very fine resolution) – are not available at all in other raw converters. You can save your development settings as presets and, unlike in *digikam*, the preview image is automatically updated to include your current adjustments. Using the *Disconnect* option switches the auto update feature off and enables you to apply multiple adjustments without being slowed down by the image updating.

Cumulative Corrections

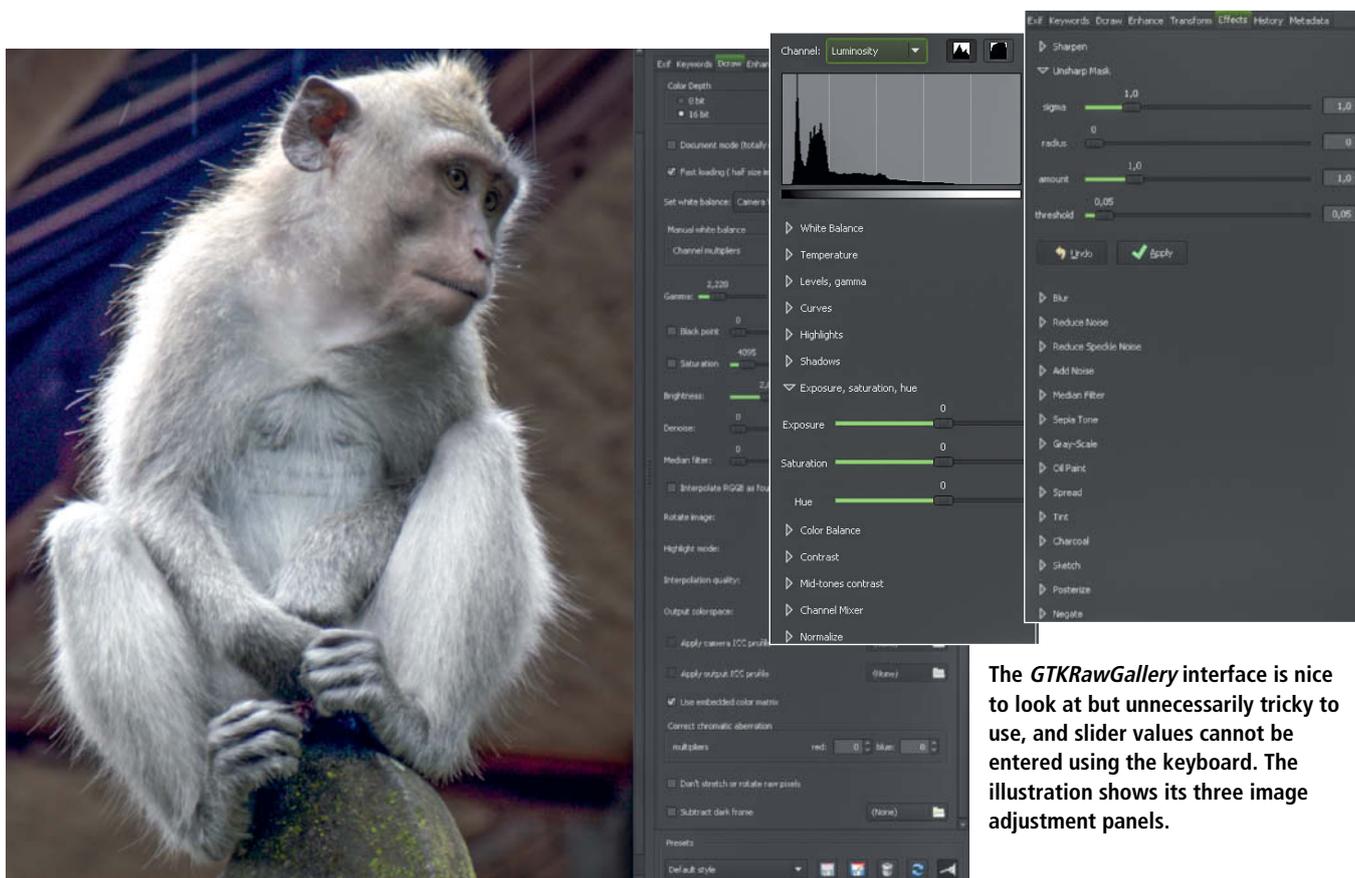
Other processing options can be found in the *Enhance* panel (including a histogram that is missing in the equivalent *DCRaw* panel), the *Transform* panel (rotation, scaling, lens corrections etc.) and the *Effects* panel (sharpening, blur effects etc.). Unlike in *Lightroom*, the corrections you make in *GTKRawGallery* are cumulative (i.e., destructive). This means that opening a tool causes the program to irreversibly alter the current image according to the adjustments you have made, and all the sliders

automatically reset themselves to their default values. However, the original raw file is not altered and all steps are recorded in the History panel and can be undone one by one. The cumulative effect of all the steps you apply can be saved as a Style and can be applied to other images the same way as a *DCRaw* Preset.

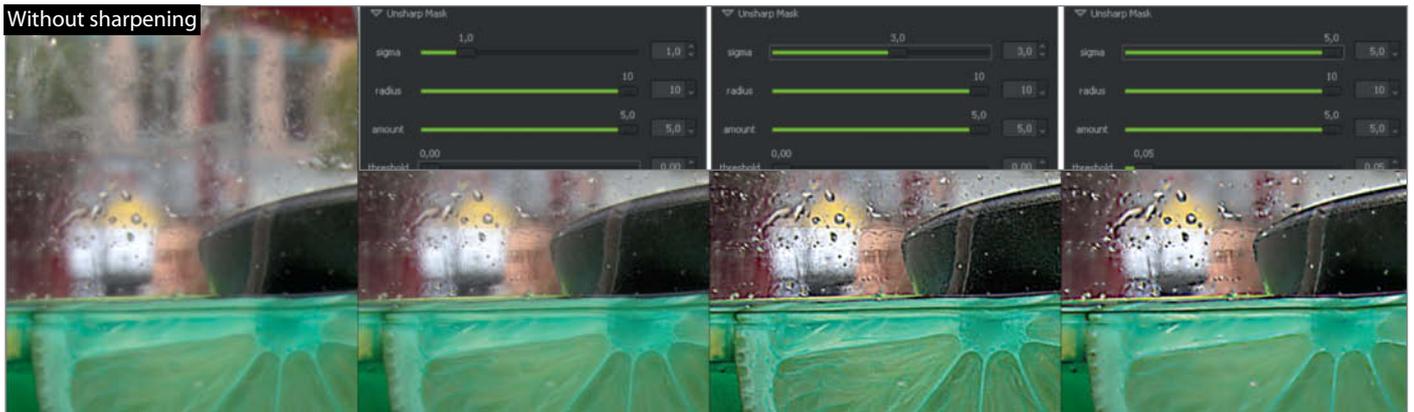
Used with Windows, the 0.9.9 version of the program opened raw images from the Sony a7R and NEX-7 as well as those from two of our Canon cameras with strong red casts, and turned Nikon NRW files into pixel mush. However, these issues weren't repeated with the Linux version and did not occur with the latest 9.22 version of *DCRaw* either (see the box on page 84).

Adjusting Tonal Values

The *Highlight mode* section near the bottom of the *DCRaw* panel is the program's highlight recovery function. The default setting is *clip*, which is equivalent to *digikam*'s *Solid White* option, and all the other options have the same names and effects as their *DCRaw* equivalents. One feature of *GTKRawGallery* that neither *digikam* nor *darktable* offers is a user-adjustable gamma curve that consists of



The *GTKRawGallery* interface is nice to look at but unnecessarily tricky to use, and slider values cannot be entered using the keyboard. The illustration shows its three image adjustment panels.



The Unsharp Mask tool is gentle and produces very few artifacts. Its *sigma* and *radius* settings can be used to sharpen details to differing degrees.

a non-linear exponential gamma portion and a linear 'toe slope' (Ts) portion at the dark end, both of which can be adjusted using sliders in the *DCRaw* panel. Default is the BT.709 curve, an sRGB variant that is often used for HDTV applications, with a gamma value of 2.22 and a Ts of 4.5. A standard sRGB curve has a gamma value of 2.4 and a Ts of 12.92, which is much steeper at the shadow end. ProPhoto RGB has a gamma value of 1.8 and no linear toe slope (i.e., Ts = 0). *GTKRawGallery* doesn't automatically adjust the gamma curve to suit the output color space, so you may have to enter appropriate values manually. Once entered, values can be saved as a preset, and experimenting with different values (especially in the Ts area) can help to improve shadow detail.

If you don't want to use the *DCRaw* default values, which are in fact highly appropriate, the *Black Point* and *Saturation* sliders can be used to determine the black and white points during raw development. In this case, *Saturation* doesn't refer to color saturation but rather the brightness value at which clipping begins. Shadow clipping begins below the selected black point value. In the Windows version of the program, both sliders continually jumped back to their starting positions but the selected values were still applied.

The exposure slider is called *Brightness*. The channel values of the linear RGB image (i.e., the demosaiced but not yet gamma-corrected version) are multiplied by the value you select (from 0.0-10.0). This approach has also been lifted directly from *DCRaw* and is not particularly easy to use – other programs add this factor in the background to provide more practical EV steps. A *Brightness* value of 4.0 is equivalent to adjusting exposure by +2EV, a value of 8.0 is equivalent to +3EV, 0.5 to -1EV

and so on. The *Exposure* slider in the *Enhance* panel doesn't directly affect exposure and is only applied after gamma correction, in a process more like conventional brightness adjustment. The indicated values are percentages. *Highlights* and *Shadows* adjust brightness selectively in the shadow and highlight areas, and you can adjust their limits manually. There is no dedicated function for preserving or otherwise adjusting microcontrast.

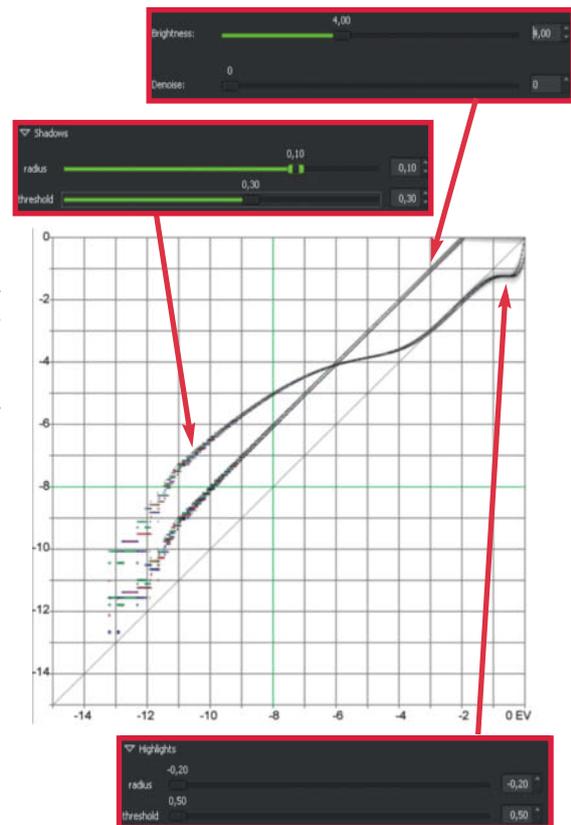
Color Adjustments

The only parameter that can be adjusted during raw development is white balance, allowing you to neutralize potential color casts. Applying similar adjustments manually is complex and requires you to enter the appropriate factors separately in each RGB channel. Eyedropper tools and a color temperature slider are only available in the *Enhance* panel, where you will also find conventional saturation, color correction and channel mixer tools.

Denoising and Sharpening

DCRaw's denoise slider controls a wavelet-based denoising tool that is applied before demosaicing. Two further denoising tools from *ImageMagick* can be found in the *Effects* panel. All three tools have fairly limited effects. The *Effects* panel also includes two sharpening tools with additional *sigma* sliders. Leaving these set to the default value of 1 ensures gentle sharpening without halo effects, even if *radius* and *amount* are set to their maximum values of 10 and 5 respectively. Greater *sigma* values produce stronger sharpening and can cause oversharping if not used carefully.

- ➡ GUI for DCRaw
- ➡ Clunky handling
- ➡ Cumulative corrections
- ➡ Poor raw format support in Windows



The EV curve shows the linear exposure shift caused by adjusting *Brightness* and the effects of the *Highlights* and *Shadows* sliders. Because the adjustment doesn't preserve microcontrast, the strong flattening of the curve produces areas of pale colors.

Hands-on Raw Development with DCRaw

DCRaw (named after the initials of its programmer, David Coffin) is a free, open source raw developer that is used in a wide range of free and commercial image processing software packages, either as an embedded library or as part of the application code. The program can also be controlled via the command line, which gives you access to all of its tools and functions, including ones that are not always available in applications that include the *DCRaw* module. Embedded versions are also subject to update delays when new versions of the base module are introduced.

The program has a fairly limited range of command line parameters, although it is not always clear what they mean. A complete list is available from www.cybercom.net/~dcoffin/dcrow/dcrow.1.html, and examples of usage are available at www.camera-hacker.com/Digital/DCRaw_by_example.shtml.

This issue's online content includes batch files with a number of useful *DCRaw* system calls that you can open using the Windows Explorer 'Send to' command. Once you have copied the batch file to `C:\Users\<User>\AppData\Roaming\Microsoft\Windows\SendTo`, the commands appear in the Explorer context menu. To apply a command, select one or more raw files, right-click them and select a command from the 'Send to' menu. A separate window then appears and displays progress for the development steps involved. The converted images are saved as TIFF files in the same folder and are automatically renamed to include the applied parameters, making it simple to compare the results of applying various effects. The renaming process ensures that previously adjusted image files are not overwritten when you apply subsequent commands.

The 'Dcrow' tab in *GTKRawGallery* provides a GUI for many of *DCRaw*'s most important commands and parameters

1 GTKRawGallery DCRaw menu	2 DCRaw parameter
Color Depth: 16 bit linear	-6 -4
Document mode (totally raw)	-D
Fast loading (half size image)	-h
Set white balance: Camera WB	-w, -W, -a
Manual white balance	-r
Channel multipliers: 1,000, 0,578, 0,817	-g
Gamma: 2,222, 2,222, 4,5, 4,5	-k
Black point: 0	-S
Saturation: 4095	-b
Brightness: 1,00	-n
Denoise: 0	-m
Median filters: 0	-f
Interpolate RGB as four colors	-t
Rotate image: AUTO	-H
Highlight mode: clip	-q
Interpolation quality: AUTO	-o
Output color space: ProPhoto	-p <filename>
Apply camera ICC profile	-o <filename>
Apply output ICC profile	-M
Use embedded color matrix	-C
Correct chromatic aberration	-j
Multipliers: red: 0, blue: 0	-K <filename>
Don't stretch or rotate raw pixels	
Subtract dark frame	

As an example, the following command converts the file `Raw.cr2` to a 16-bit TIFF file with the Prophoto color space (gamma value 1.8) and gentle highlight recovery:

```
C:\DCRaw\DCRaw -v -w -q 3 -H 2 -T -6 -o 4 -g 1.8 0 Raw.cr2
```

For the command to work, `dcraw.exe` has to be located in `C:\DCRaw`.

The parameters we applied work as follows:

-v	Print verbose messages
-w	Use the white balance specified by the camera. If not found, print a warning and use another method.
-q 3	Use AHD demosaicing
-H 2	Blend clipped and unclipped values for a gradual fade to white
-T	Write to TIFF with metadata
-6	Output with 16-bit color depth
-o 4	Output to Kodak Prophoto RGB D65
-g 1.8 0	Gamma curve set to 1.8 with no toe slope (to suit the Prophoto color profile)

Image Dimensions Produced by Various Raw Converters (width x height in pixels)

Camera	RAW format	Sensor size (according to Exif)	Lightroom	darktable	digikam, GTKRawGallery, Raw Photo Processor, DCRaw	RawTherapee	Maximum increase in pixels (compared with Lightroom)
Canon EOS 6D	CR2	5568 x 3708	5472 x 3648	5494 x 3666	5496 x 3670	5488 x 3662	208,464
Nikon D5000	NEF	no data	4288 x 2848	4310 x 2868	4310 x 2868	4302 x 2860	148,856
Olympus E-PL1	ORF	no data	4032 x 3024	4094 x 3082	4096 x 3084	4088 x 3076	439,296
Panasonic DMC-GH2	RW2	5208 x 2816	4976 x 2800	4992 x 2816	4992 x 2816	4984 x 2808	124,672
Sony a7R	ARW	no data	7360 x 4912	7366 x 4920	7392 x 4920	7354 x 4912	216,320

Because they include edge pixels that are normally hidden, the files produced by the open source converters we tested are often larger than those produced by the commercial competition

Raw Photo Processor X

Raw Photo Processor (RPP) is the most spartan of the raw converters we tested, offering only basic raw development functionality and *Sharpness* and *Local Contrast* filters. There is no lens correction tool and there are no color or effect filters. The user interface is minimalist too, offering just a single dialog window without any additional panels, sliders or buttons. This window has a number of fields for entering parameters and appears at the right-hand edge of the monitor when you open an image for processing. However, this apparent simplicity conceals a surprisingly versatile program that is relatively simple to operate using keyboard shortcuts and tooltips, although it is anything but intuitive to use and is squarely aimed at keyboard fanatics. To get the most out of it, you need to use it regularly – otherwise, you will spend too much time referring to the manual.

Once you are familiar with the way it works, you can quickly alter your input using the numerical keys, the arrow keys or the scroll wheel in your mouse. There is, however, no real-time preview function, so you have to

click the 'Apply' button to see the results of your adjustments.

In addition to the standard L* scale, the histogram has EV and Ansel Adams-style zone system scales. Ctrl-clicking a pixel displays its RGB and Lab values and their relative intensity and also marks their positions on the histogram. This is a really useful indicator that is only otherwise available in *RawTherapee*. Brightness values displayed in the histogram can be dragged to the exposure correction boxes too. Every step you apply is recorded in the background (click the 'History' button to see them all). They can also be saved as an XMP file, making it simple to undo individual steps or apply your adjustments to other images.

Exposure can be adjusted precisely by up to +/-20EV, which is the broadest range we found in any of the programs we tested. The Compressed Exposure feature helps prevent clipping by compressing highlights into a user-selectable EV range. This feature works very well when combined with highlight recovery, although the Highlight Recovery tool itself is difficult to apply without

producing unwanted artifacts. In our overexposed test image, it produced obvious banding.

Unlike our other test candidates, which are all open source, *RPP* works on the donationware principle. The free version includes all of the donation version's tools but the 'Next' button (for opening the next image), *Lightroom* integration, camera profiling and multi-processor support are only available to those who make a donation. The author sends out unlock codes as soon as a donation is received.

- ➕ Extremely lean package
- ➕ Settings reversible and transferrable
- ➖ No real-time preview
- ➖ Poor highlight recovery



RawTherapee

As far as actual raw development is concerned, *RawTherapee* probably has the richest feature set of any software we tested. Its interface is arranged in customizable modules and panels similar to those in *Lightroom*. Processing steps can be applied in any order and altered at any time before an image is saved or exported. All settings are saved either in its own database or in PP3 sidecar files. The program uses *DCRaw* to read files and its own algorithms to process them. You can choose between 10 different demosaicing methods (or none), and the program processes image data internally in 32-bit floating-point format. It also supports 32-bit HDR files, but only in TIFF format.

RawTherapee organizes your images according to their native folder structure and doesn't allow you to create new albums. Its keywording and metadata editing functionality are fine, but difficult to apply to multiple files, as user-specified data fields are

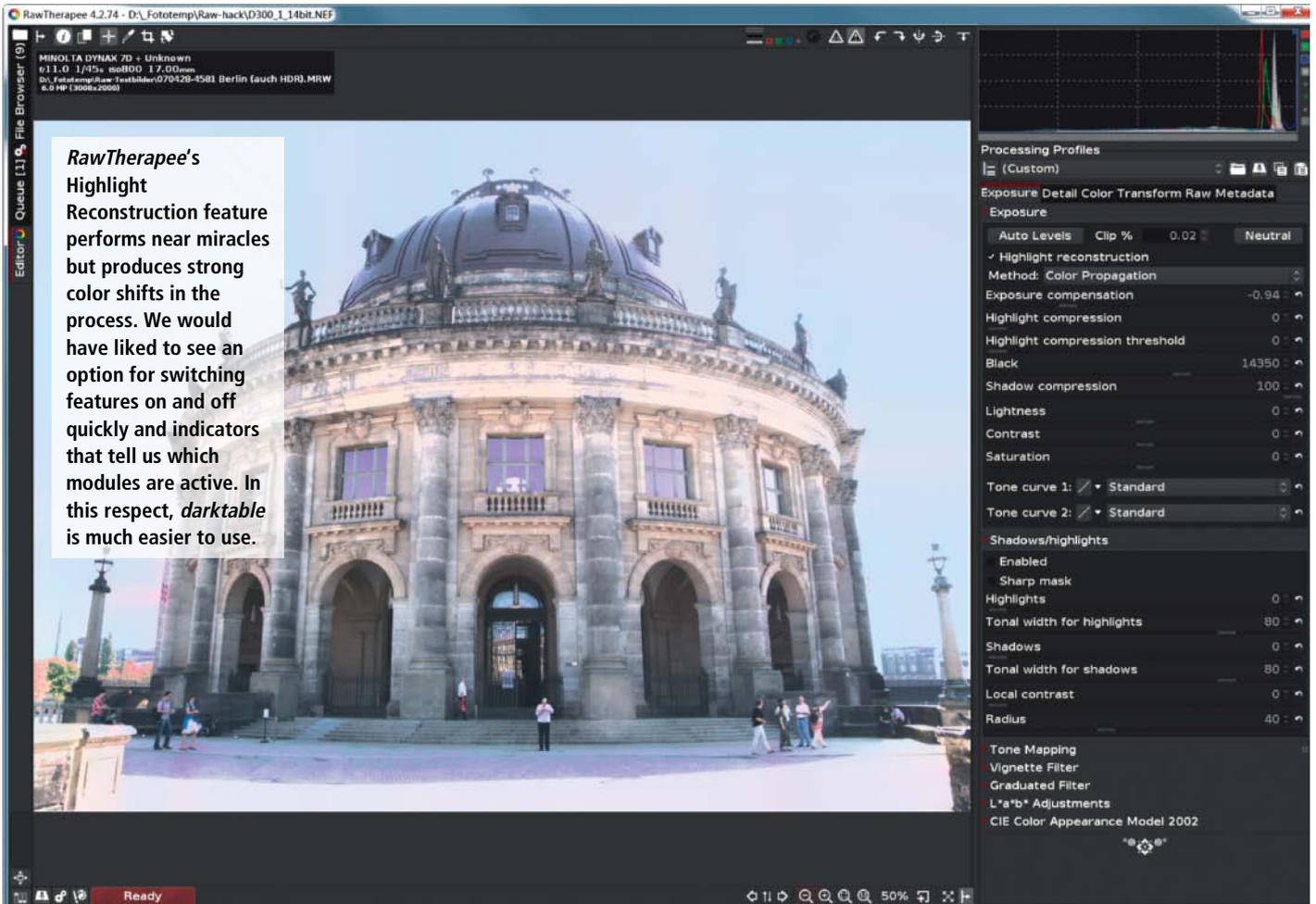
not part of the metadata search function. In contrast, raw development and image adjustment steps are displayed in the File Browser tab, making them simple to apply to multiple images. The Editor tab adds a large preview image and a histogram window to the mix. There are no advanced selective editing features like *Lightroom's* Clone Brush, but there is a built-in graduated filter.

Adjusting Tonal Values

The Raw tab is tucked away in fifth position in the Toolbox panel and its inner workings are somewhat hidden too. As well as selecting the demosaicing method, you can choose denoising and chromatic aberration correction settings, while the Dark Frame tool enables you to subtract a dark frame from your image to reduce noise and eliminate hot pixels. The Flat Field tool uses a white frame to combat imbalances in the distribution of

brightness levels. You can adjust the black point for each individual RGB channel but the white point can only be adjusted globally. The Linear Correction Factor white point setting has the same effect as the Brightness slider in *GTKRawGallery*, and the resulting EV shift is the binary logarithm of the value you select – in other words, the maximum value of 16 is equivalent to 4EV and the minimum value of 0.1 represents an exposure shift of about -3.3EV. To ensure that highlights don't burn out, you can use the *Highlight Preserving Correction (EV)* option to define a range within which highlights are brightened only slightly or not at all (like the *Compressed Exposure* feature in *Raw Photo Processor*, but with a slightly harsher curve that tends to make rescued highlights look pale).

The *Exposure* tab provides more flexible options. The Exposure Compensation slider works just like the linear correction factor setting, except that it is denoted in terms of



The screenshot shows the RawTherapee 4.2.74 interface. The main window displays a raw image of a large, ornate domed building. The interface includes a top menu bar, a toolbar, and a central preview area. On the right side, there is a processing panel with various settings. A text box is overlaid on the image, providing a critique of the software's highlight reconstruction feature.

RawTherapee's Highlight Reconstruction feature performs near miracles but produces strong color shifts in the process. We would have liked to see an option for switching features on and off quickly and indicators that tell us which modules are active. In this respect, *darktable* is much easier to use.

The processing panel on the right shows the following settings:

- Processing Profiles: (Custom)
- Exposure Detail Color Transform Raw Metadata
- Exposure: Auto Levels, Clip %: 0.02, Neutral
- Highlight reconstruction: Method: Color Propagation, Exposure compensation: -0.94, Highlight compression: 0, Highlight compression threshold: 0
- Black: 14350
- Shadow compression: 100
- Lightness: 0, Contrast: 0, Saturation: 0
- Tone curve 1: Standard, Tone curve 2: Standard
- Shadows/highlights: Enabled, Sharp mask, Highlights: 0, Tonal width for highlights: 80, Shadows: 0, Tonal width for shadows: 80, Local contrast: 0, Radius: 40
- Tone Mapping: Vignette Filter, Graduated Filter, L*a*b* Adjustments, CIE Color: Appearance Model 2002

EV increments in a broad range from -5 to +12. The twin Highlight Recovery sliders can be used to rescue image areas that are overexposed in only one or two channels without running the risk of producing the color casts inherent in exposure compensation adjustments. The blacks level can be adjusted either channel by channel in the Raw tab (before demosaicing) or globally in the Exposure tab (with an additional Shadow Recovery setting). Combined with highlight recovery in *Color Propagation* mode, this method worked well with our overexposed test image, and it even managed to recover the colors, albeit with a slightly bleached overall look. The result produced by *Lightroom* for the same test image was only slightly better.

Global Lightness, Contrast and Saturation sliders and a Tone Curves tool round out the first section of the fully featured Exposure tab. Other sections include Shadows/Highlights, Tone Mapping, Lab Adjustments, and graduated and vignette filters.

The *CIE Color Appearance Model 2002* option, which is unique to *RawTherapee*, serves to adjust images to suit various different presentation scenarios, including the color of the lighting, background colors, or light and dark surroundings. The feature is, however, only useful if you know the conditions under which the image is to be presented.

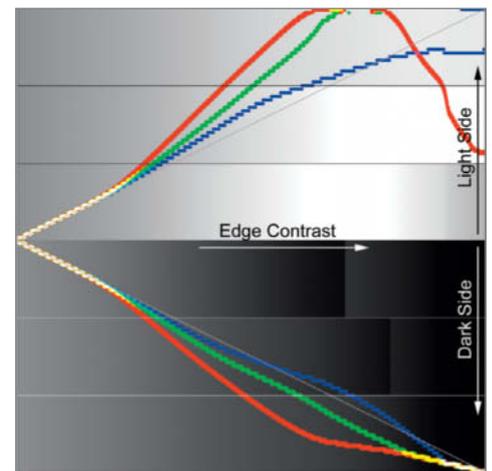
Color Corrections

RawTherapee has a wide range of color correction tools too. The Vibrance section of the Color tab can be used to separately adjust the saturation of more or less saturated colors (i.e., bright and pastel tones), and the threshold values between the two types can be individually selected too. There is a special $H=f(H)$ (Hue according to Hue) curve tool for fine-tuning the yellows and reds that make up skin tones. The HSV Equalizer is designed for making general color adjustments, i.e., curves in which the color you wish to adjust is represented by the x-axis and the hue (H), saturation (S) or value (V) scale follows the y-axis. *Minima/Maxima Control Points* can then be added directly to the curve or placed within the image using a Ctrl-click, and you can adjust the corresponding colors to taste. The Color tab also includes tools for color toning and monochrome conversion, an RGB Curves tool, a Channel Mixer and a tool for simulating film types based on reference images.

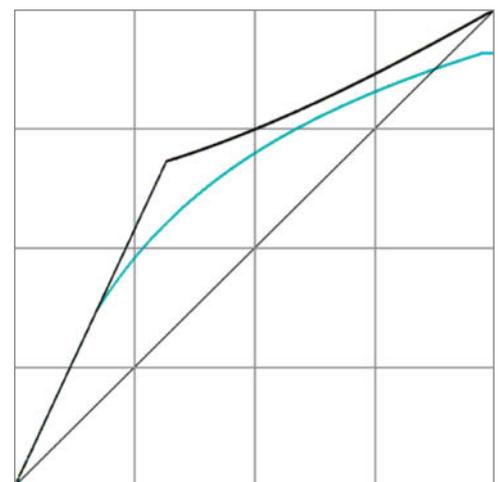
Denosing and Sharpening

While the Impulse Noise Reduction section in the Detail tab has just a single slider for reducing 'salt and pepper' (i.e., black-and-white) noise, the features included in the Noise Reduction section enable you to reduce noise according to the needs of a particular image or image area, optionally with the help of control point curves for luminance and chrominance noise. You will have to decide for yourself whether this is a case of filter overkill. We managed to produce pretty good results using a combination of impulse noise reduction, L-channel noise reduction and the Chrominance (Master) filter.

Sharpening is controlled by a customized USM filter with adjustable upper and lower threshold values, halo control, an edges only option and a Richardson/Lucy Deconvolution filter designed to combat Gaussian blur more effectively than other USM tools. There is also a dedicated edge sharpening tool. The Microcontrast and Contrast by Detail Levels tools help to adjust and preserve microcontrast, and the latter can be set up to exclude fine details (such as noise) from sharpening and protect skin tones while other areas are sharpened. If you need to adjust local contrast in shadows or highlights, use the Local Contrast slider in the Shadows/Highlights tool located in the Exposure tab.



RawTherapee's USM filter includes individual settings for upper and lower threshold values, as well as for the softness of the transition to unsharpened areas. However, high-contrast details sometimes produce an opposite, blurred effect, shown here by the turnaround in the red curve.



The *Highlight Preserving Correction* option in the Raw tab produces a sharp bend in the EV curve, while *Highlight Reconstruction* produces a gentle curve (shown here in green). These differences were quite obvious in the real-world photos we processed.

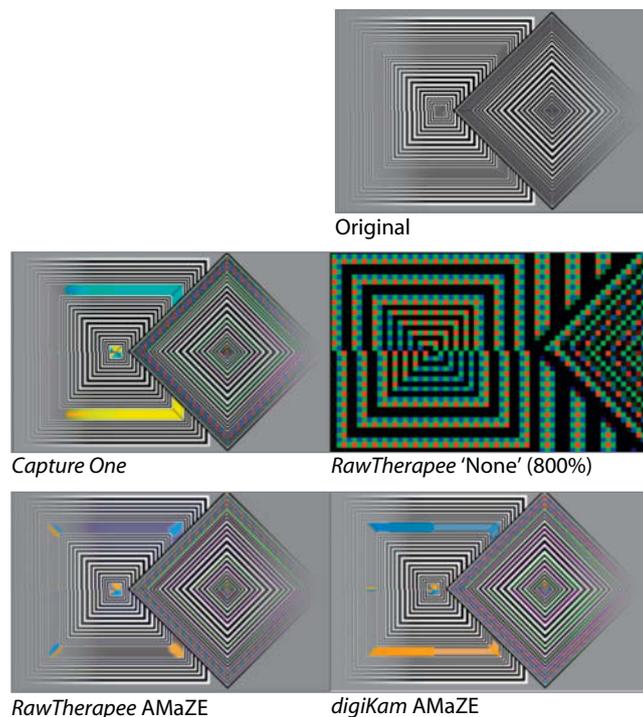
- ⬆️ Good demosaicing
- ⬆️ Precise filter settings
- ⬆️ Great range of tools
- ⬇️ Rudimentary image management

Raw Converter Comparison

This section compares the performance of the open source programs tested on the previous pages with that of the commercial competition.

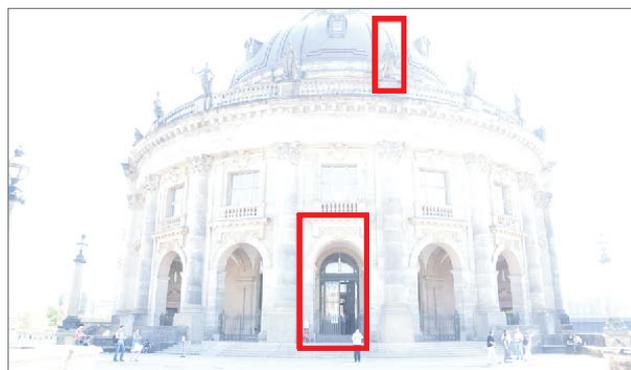
Demosaicing

The open source demosaicing algorithms we tested are at least as good as, if not better than, the one built into *Capture One*, which is the best commercial raw converter we have tested recently. Because the differences are difficult to see, we doubled the resolution of our test pattern, making the finest lines half as wide as a single RGB Bayer pattern cell. This is well illustrated by the image we saved in *RawTherapee*'s 'None' mode (i.e., without applying demosaicing). Demosaicing errors are unavoidable in such fine textures, although the AMaZE algorithm handled them very well. We were surprised to see how different the results produced by the various programs were, especially considering that they often use the same algorithms. *RawTherapee* and *DigiKam* both use the AMaZE algorithm, but *RawTherapee* produced much higher-quality demosaicing results. This is probably because *digiKam* is based on LibRaw and computes its results at 16-bit color depth, whereas *RawTherapee* uses its own algorithms and 32-bit floating-point processes. In this discipline, *RawTherapee* beat both *Capture One* and *digiKam*.



Highlight Recovery

Lightroom's highlight recovery functionality came out on top in our last commercial raw converter test, so we used it as our yardstick here. *Lightroom*'s 'Lights' adjustment is highly intuitive to use, and the contrast and color in the final image are very realistic. The open source competition was able to produce a similar level of detail but the images were all pale and obviously magenta-toned. *darktable* and *RawTherapee* were the best of the bunch, while *Raw Photo Processor* produced astonishingly poor results.



Denoising

Denoising digital images is a complex procedure and you need plenty of experience if you want to get the best out of the countless open source denoising tools on offer. Highly automated tools like DxO's PRIME denoiser are often a welcome alternative. Our denoising test image was captured at ISO 6400 using a Sony A580, and our test detail was taken from a shadow area that had to be brightened first, producing additional noise. All the open source tools we tested had trouble getting to grips with this level of noise, and we weren't able to produce results comparable to those produced by DxO PRIME, even by combining multiple denoising filters. Overall, *RawTherapee* produced the best results. We admit that in such a noisy image, it is worth considering leaving most (or even all) of the noise in place for the sake of detail retention – as ever, such decisions are a matter of personal taste.



Original (detail magnified to 150%)



DxO Optics Pro
(PRIME)

darktable
(profiled denoise)

darktable
(equalizer)

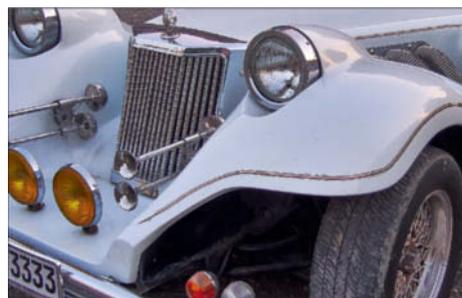
digiKam (Noise
Reduction, estimated
noise amount)

GTK Raw Gallery
(Raw Denoise and
Median filter)

RawTherapee
(Impulse +
Lab denoising)

Brilliance

In the high-gloss stakes, both *darktable* and *RawTherapee* produced results almost on a level with our commercial champion, *Capture One*. Our reference image was simple to create using just two of *Capture One's* sliders, whereas creating similar results using open source software is a matter of experimenting with combinations of tools and feeling your way slowly toward an acceptable result. It is always a good idea to save settings you like as a preset to save yourself the trouble of having to find them again later. We weren't able to brighten the shadows effectively enough in *digiKam*, and most of the detail within the wheel arch remained dark. The differences in color temperature illustrate how tricky it can be to achieve similar results using sliders with varying scales that react to our adjustments in completely different ways.



Capture One



darktable



digiKam



RawTherapee

Conclusions

The handful of programs we tested gave plenty of insights into the pros and cons of open source software. The interfaces and handling provided by *digiKam*, and especially those in *GTKRawGallery* are clunky and tricky to use, with long pauses in which nothing appears to happen and strange reactions to user input. Additionally, open source documentation is often out of date, incomplete or simply missing. *digiKam* was unstable when run in Windows and wouldn't open many raw formats once it had been running for a while, although the same issues were not in evidence in the Linux version. We also found that some exported *digiKam* and *darktable* files were incompatible with *Photoshop*, regardless of which platform they were generated on. This might be due to oversensitivity on *Photoshop's* part, as we didn't experience the same issues using *PhotoLine*. Regular updates are also a problem – *GTKRawGallery*, for example, hasn't been updated for more than a year, and the formats it supports reflect this. *digiKam* has an amazing range of functions but ties them to an inflexible workflow that makes it impossible to switch between tools while you work. Like real-time previews, this should be a standard feature, but it is lacking in *digiKam* and *Raw Photo Processor*. On the upside, we really liked *Raw Photo Processor's* concentration on the basics of raw development and its simple but comprehensive interface.

darktable Sets Standards

The highlights in this test were *darktable* and *RawTherapee*, both of which offer plenty of useful features, a contemporary workflow style, support for a wide range of cameras and good stability. With its clear and intuitive handling, *darktable* was our favorite for Linux and Mac, and *RawTherapee* – whose makers could learn a thing or two from *darktable* – is our tip for Windows users. The other programs all score with specialties such as dark frame subtraction and customizable gamma curves. Both these functions are available on a command-line level in *DCRaw*, which you can control from the Windows interface using the custom batch files that we have included with this issue's online content.

Open Source Raw Converters			
Program	darktable 1.6.0	digiKam 4.5.0 / 4.6.0 (Linux)	
Manufacturer/Author	darktable Team	digiKam	
URL	darktable.org	digiKam.org	
Operating systems	– / Mac / Linux	Win / Mac / Linux	
Internal processing	32-bit floating-point	no data	
Plug-ins	Lua scripting	Kipi	
Other features	Tethering, geotagging, slideshow	Geotagging, slideshow	
File Management			
Image browser	–	✓	
Album support	–	✓	
Bitmap formats	JPG, TIFF, PNG	PNG, TIFF	
32-bit support / Lab	✓ (TIFF, EXR) / –	–	
Sort / Filter	✓ / ✓	✓ / ✓	
Grouping	✓	In albums or according to file format	
Metadata editing	✓ (keywords, author)	✓	
Raw Development			
Converter	Proprietary algorithms	LibRaw	
Bayer demosaicing	PPG, AMaZE, VNG4	Bilinear, VNG, PPD, AHD, DCB, AHDv2, AFD, VCD, VCD&AHD, LMMSE, AMaZE ¹	
X-trans demosaicing	VNG, Markesteijn	–	
Unrecognized raw formats	Foveon	Foveon, 3FR, Leica DNG, A7R, NEX 7	
Histogram / Tonal value display	✓ / ✓ (eyedropper)	✓ / –	
White balance	Camera, manual (color temperature)	Auto, presets, manual	
Raw black points	–	–	
Raw white points	–	–	
Highlight recovery	✓	✓	
Exposure correction	✓	✓ (with optional compression)	
Chromatic aberration	✓	✓	
Denoising	Raw denoising	Impulse, CFA, FBDD, wavelet	
Dark frame subtraction	–	–	
Raw settings save to	XMP	Cannot be saved	
Post-processing			
Tonal values	Base curve, exposure, brightness, contrast, zone system and others	Auto, brightness, contrast, gamma and others	
Color corrections	Color range, color correction, color balance, channel mixer and others	Saturation, channel mixer, compare colors	
Curves	Lab curves	✓	
Black-and-white	Via virtual color filters	✓	
Selective adjustments	Masks, Spot removal	✓	
Sharpening	USM	USM, refocus	
Microcontrast	Local contrast	✓	
Denoising	Three noise filters (also with camera profiles), detail equalizer	Hot pixels, L-channel denoising	
Other	HDR, Blend option, low and high pass	HDR and panorama creation (via plug-ins)	
Lens Corrections			
Geometry	✓ (preset projections)	✓ (preset projections)	
Vignetting	✓	✓	
Profile support	✓ (Lensfun)	✓ (Lensfun)	
Output			
Formats	JPG, TIFF, PNG, EXR and others	JPG, TIFF, PNG and others	
Bit depth	8, 16, 32	8, 16	
Profiles	Any	Any	
Custom gamma curve	–	–	
Workflow			
Save settings	✓	✓ (as presets)	
Batch processing	✓	✓	
Virtual copies (versions)	–	✓	
Snapshots	✓	–	
Presets	✓ (Styles)	✓	
Before/After view	✓ (by switching modules on and off)	✓ (except during raw development)	
History	✓	✓ (except during raw import)	

¹ Italics = not in Windows ² Only with unlock code purchased via donation

	GTKRawGallery 0.9.9	Raw Photo Processor 4.8.0	RawTherapee 4.2
	GTKRawGallery Team	Andrey Tverdokhlebo	RawTherapee
	gtkr_gallery.sourceforge.net	raw-photo-processor.com	rawtherapee.com
	Win / - / Linux	- / Mac / -	Win / Mac / Linux
	16-bit	32-bit floating-point	32-bit floating-point
	-	-	✓
	-	-	-
	✓	-	✓
	✓	-	-
	JPG, TIFF, PNG	-	JPG, TIFF(8- and 16-bit), PNG, no PSD
	-	-	✓ (TIFF) / -
	-	-	✓ / ✓
	-	-	-
	✓	✓ (copy and paste)	✓
	DCRaw	Proprietary algorithms	DCRaw and proprietary algorithms
	Bilinear, VNG, PPG, AHG	VCDMF, AHDMF, half	None, mono, fast, AHD, DCB, VNG4, HPHD, EAHD, LMMSE, IGV, AMaZE
	-	VNG, 2/3, half	None, mono, fast, 1-pass, 3-pass
	Foveon, NRW, A7R, NEX 7	Foveon	Lumix RAW, Adobe DNG (lossy)
	✓ (only in Enhance panel) / -	✓ / ✓ (RGB, Lab, EV)	R,G,B,L, Ch / ✓ (RGB, HSV, Lab)
	Auto, camera, manual	Auto, presets, manual	Auto, camera, manual, presets
	Global	Global	RGB
	Global	-	Global (with compression)
	✓	✓	✓
	✓	✓ (with optional compression)	✓
	✓	-	✓
	Denoise, Median	Dot noise	Line noise filter, hot pixels
	✓	-	✓
	Application database, presets (optional)	RPPS file	PP3 file
	Levels, gamma, contrast and others	Film curves, brightness, exposure, contrast	Brightness, contrast, shadows/highlights and others
	Saturation, channel mixer, color balance	Saturation	Vibrance, channel mixer, HSV equalizer and others
	✓	-	Tonal curves, RGB curves
	✓	✓	✓
	-	-	-
	Sharpen, USM	✓	USM, R-L Deconvolution, edge sharpening
	-	✓	✓
	Two conventional and Median noise filters	✓	Lab/RGB and Impulse noise reduction
	Red eye removal	Gamut diagram	
	Manual	-	✓
	✓	-	✓
	-	-	✓ (uses Adobe lens profiles)
	JPG BMP, PNG, TIFF	JPG, TIFF	JPG, PNG, TIFF
	8, 16	8, 16, 32	8, 16
	sRGB, AdobeRGB, Prophoto, Wide, XYZ, RAW	Lab, Beta RGB, eciRGB, sRGB, BT.709, RAW	Any
	✓	✓ (only exponential portion)	✓
	✓ (as Style)	✓ ² (via History)	✓
	✓	✓	✓
	-	-	-
	-	-	-
	✓	✓	✓
	✓ (side-by-side or vertical)	✓ (only as a final step)	✓ (side-by-side)
	✓	✓	-

The Best Demosaicing

With regard to demosaicing, which is the single most important step in the Raw development process, all of our test candidates were able to keep up with their commercial counterparts. However, the quality of the results depends on which algorithm you select. We used AMaZE wherever possible, even though it can be quite slow and is only available for Windows in *RawTherapee*. The Windows version of *digikam* offers four demosaicing algorithms, of which AHD is the best. The Linux version of the program offers seven additional algorithms, including AMaZE. Although AMaZE produced better results than AHD, AHD was still just as good as the proprietary algorithms utilized by commercial software makers. When it came to correcting technical shortcomings such as burned-out highlights and noise artifacts, the open source programs had trouble keeping up with their commercial cousins, and most required a lot of experimentation and tweaking of settings to achieve acceptable results. The same is true in the color quality and brilliance stakes too – because they lack automated tools, open source software packages are often much more fiddly to operate.

Rescued Edge Pixels

The upside of using open source software is the feeling that you are somehow closer to the action and more in touch with the individual pixels that make up your images. It is also easier to make manual adjustments in situations where commercial programs keep the workings of their automated tools shut away from prying eyes. Again, the degree of transparency varies from program to program, and sophisticated features like dark frame subtraction and customizable gamma curves are only available in *DCRaw* and its offshoots *GTKRawGallery* and *RawTherapee*. The most obvious advantage of open source raw converters is that they squeeze more pixels out of your image files. Most raw images include edge pixels that are automatically cropped by the camera firmware but can be rescued and processed by open source software. See the table on page 84 for some numbers on how many additional pixels you can gain. (sts) **ct**



Roberto Valenzuela

How to Achieve **Natural-Looking Poses** with Anyone, Anytime

You know how it is – the pose is great but the image still looks somehow forced and unnatural. In this workshop, Roberto Valenzuela, inventor of the “Picture Perfect Posing System”, shows you how to get your model to pose expressively with energy and real feeling. The techniques involved are simple, and all you have to do is learn how to apply them.

Photographs in which the photographer intervened to pose the subjects tend to fall into three main categories:

- Portraits in which the subjects are looking straight at the camera
- Portraits in which the photographer attempts to create a “photojournalistic” moment but fails to create a natural look, so the subjects appear as if they simply followed the photographer’s directions
- Portraits in which the photographer creates an image that appears so natural that you totally connect with the moment without seeing a hint of the photographer’s influence

Most photographs fall into the first and second categories. Why is that? It’s because inexperienced portrait photographers generally find it much easier to have their subjects look straight at the camera all of the time. It is, after all, what we have been trained to do since we were children. When someone points a camera at us, we subconsciously look into the lens and put on our “camera smile.”

Let me be clear: there’s nothing wrong with the first category of photo. Having our subjects look at the camera creates a clean portrait, but getting them to do so with a natural smile is another matter. Capturing a natural expression requires people skills, a savvy sense of humor and a great sense of timing. Without these qualities, asking people to smile will yield a fake look in all your photographs.

As a photographer, you’ll encounter the second category when you venture beyond the “look at the camera” stage but fail in your attempts to create a “photojournalistic” feeling in your photographs. I put quotes around photojournalistic because the term is usually reserved for photos in which the photographer captured a moment without altering the scene, expression, or any other part of the events being captured. In its purest form, most people in a true photojournalistic image weren’t even aware they were being photographed. This style strives to capture the purest of human

expressions and a wide range of emotions. Many true photojournalists risk their lives to capture such photographs.

Naturally, as portrait photographers, our clients are well aware of our presence, but we can still respectfully borrow the feeling of a photojournalistic photograph and apply it to our posed portraits to achieve candid expressions. This is, however, easier said than done. To do it well, photographers must work on their people skills to break through the defensive barriers people naturally put up. Our subjects need to feel completely at ease if they are to project their true selves when being photographed. For these reasons, and many more besides, once photographers leave the comfort zone of having subjects always look at the camera, they often gravitate toward taking photographs that belong in the second category. I hope this article can shorten your learning curve and boost your photography from category 2 to category 3, which I call “posed photojournalism”.

Posed Photojournalism

The term “posed photojournalism” is obviously an oxymoron. As I mentioned before, true photojournalism means that the photographer does not alter anything about the scene being photographed. I love the movement and real expressions of photojournalism, but I cannot wait for my clients to fall into a perfect pose with the most beautiful expressions on their faces at the exact moment I happen to click my shutter button. When great moments happen naturally, I am perfectly capable of capturing them in their purest form but, when time is not on my side, I pose everything. If you do it right, you can combine the best of both worlds: a candid photojournalistic expression with movement and a beautifully crafted pose photographed in great light.

To begin, let’s look at a familiar scenario. During a photo shoot, as soon as we have our subjects in front of the lens we are ready to start directing the pose. We say things like “Shift your body weight”, “Put your arms here” or “Turn your chin a little to the left.” Once we have finished issuing countless directions, the pose looks completely rigid and our subjects can barely hold on to all the pieces they were told to think about. There’s no flow to the pose, and just looking at the photo makes you feel tense. I know that feeling of frustration when you work hard to pose someone correctly but the photos all look completely unnatural when you download them to your computer. The recommendations discussed in this workshop have worked well for me and have given me the candid “photojournalistic” feel I crave so much in my posed photographs. Try putting them into practice on your next shoot.

The key is to have a general pose in mind, show your subjects what you envision, and have them naturally move into that pose. By using movement, you will automatically give the pose a sense of fluidity. This technique might be effective to break the rigidity of a pose, but it comes with its own set of challenges. Because you are allowing your subjects to move themselves into a pose, you will find that parts of the body settle into the wrong place and others fall into place just fine.

You have to learn to anticipate which parts of the body are most likely to wreck the pose, and I call these troublesome parts of the body high-risk areas. I call the other important parts of the body that produce naturally more forgiving poses low-risk areas. Let’s look at two typical scenarios: one in which I am photographing a female subject for her

modeling portfolio, and the other where I am photographing a bride.

Example 1: Posing a Model with Movement

During a workshop, I was photographing model Monique Victoria from “America’s Next Top Model.” I wanted to pose her with glamor and finesse, but the challenge was that we had to pose Monique sitting down. I began by analyzing the basic pose for high- and low-risk areas. I know that when a person sits down, the risk of slouching is much higher than if the person were standing, making the spine a high-risk area.

In Figure 1, the red dots represent high-risk areas and the blue dots low-risk areas. The red dot on the model’s torso marks a high-risk area because her spine appears to be slouched.

The second biggest concern is the height of her left elbow, which is causing a major distraction and doesn’t look very elegant. The other two red dots are on the hands because I need to make sure that her fingers are always soft and relaxed. Since misplaced hands can be highly destructive to a pose, I always consider them high-risk areas.

Let’s move on to the blue dots. The blue dot on her legs signifies a low-risk area and, by using a higher shooting angle, I know I can shift the emphasis back to her face and away from her legs. It doesn’t make much difference in this portrait if her left leg rests on her right leg or vice versa, making this a low-risk area too. The blue dot on her arm symbolizes low risk because, although it looks larger than it should, I know that this can be fixed by simply straightening her back. As she brings her chest closer to the camera to straighten her spine, it will automatically put more emphasis on her torso, and her arm will be less visible. The blue dot on her face is there because a window on the right side of the photo provides beautiful light, while a reflector placed on the other side of her face evens out the light. The dot means that the window light will not wreck the photo if she accidentally turns her chin left or right, since both sides of her face are evenly lit.

Once all the risks are determined, you can give more precise instructions that move your subject into the pose you envisioned. This allows the model to address the high-risk areas and make sure that she is posed perfectly. You can see the results in the large photo opposite.

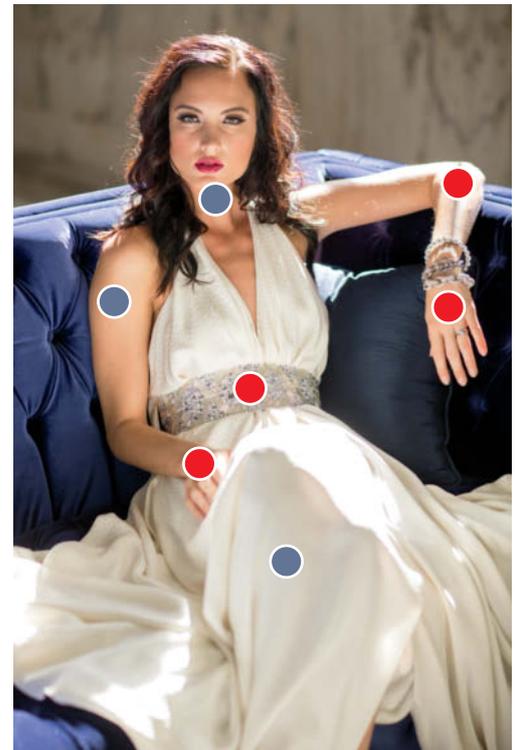


Figure 1: Ask your model to sit, analyze the high-risk (red) areas and the low-risk (blue) ones, and then start to give directions. The result of taking this approach is shown on the right.



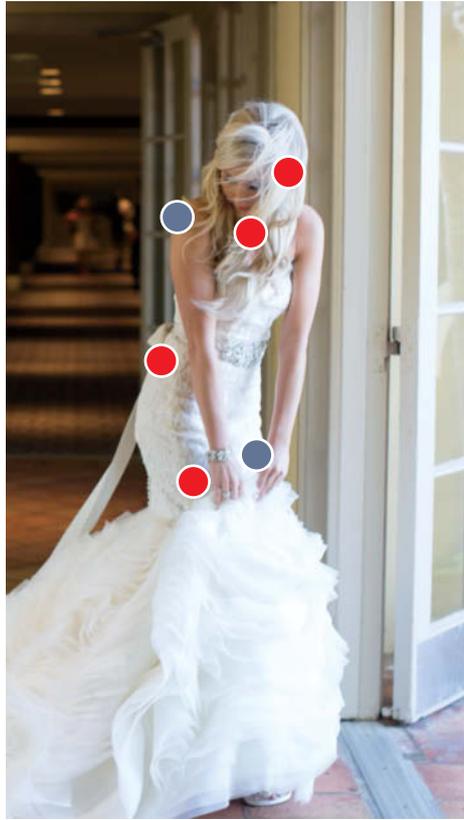
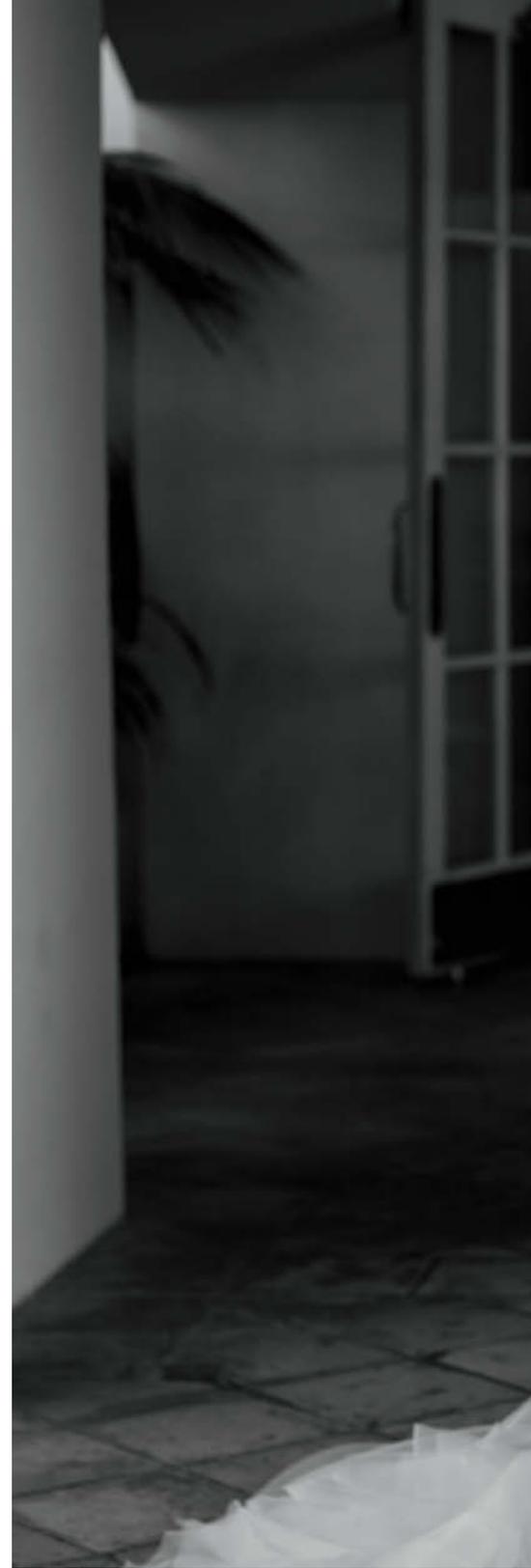


Figure 2: Adding movement to a thoroughly orchestrated pose. Starting with the situation shown on the left, I asked the bride to make as if she wanted to walk through the door on the right. Once again, the high-risk areas are marked with red dots.

Figure 3: Following the analysis of Figure 2, the high-risk issues were corrected. Sometimes, instructions you give can result in errors like those marked in Figure 2 and you need to correct these before you can achieve the perfect pose as shown here.



By listening to my precise instructions based on the low- and high-risk areas, Monique was more easily able to move into a beautiful and elegant pose. Take a minute to study how we addressed all the potential issues we discussed.

I know you are wondering how it is possible to think about all this during a shoot. If you try to learn all of this at once, it will certainly be difficult, so the secret is to do it little by little. You cannot expect to master all

of these aspects at once but with experience and solid practice, you will soon be able to determine the high- and low-risk areas of a pose without much effort.

Example 2: Posing a Bride with Movement

Now let's explore how to introduce movement to create a pose that appears to be photojournalistic, even though it was posed

from head to toe. Although this example uses a bride, the principles apply equally to anyone.

Let's begin by harnessing the opportunity presented to us in Figure 2. There is a long, dark hallway with a door on the right leading to a patio at the Ritz Carlton in Laguna Niguel. Here, we have a few choices to make. We could take advantage of the beautiful light created by the doorway and simply pose the bride in



front of it but, as you can see, the pose looks static and dull. The light is great, but we need more than good light to create an amazing image. This is where posing with movement comes into play. It makes sense to pose the bride as if she were preparing to walk through the doorway to the patio. The act of walking toward the door is the perfect excuse to create the movement we need to counteract the lifelessness of the original pose.

Next, we have to pose the hands. Since she is going to be walking out the door, it would make sense to use her hands to hold up her dress. The results of these changes are reflected in Figure 3.

Figure 2 shows the problem areas I noticed on my first attempt to create this pose. The red dot on her right leg is crucial, because I needed to make sure that this leg leads the step. When you are photographing women, it's advisable to bend the leg closest to the

camera. There's a red dot on her back because when she reached down to hold up her dress, she accidentally curved her thoracic spine, creating an unacceptable hunch in her upper back. As for the red dot by her neck, I realized I had forgotten to ask her to elongate her neck to create a more glamorous pose. The result is that she appears to be ducking. The red dot on her hair is there because I cannot have a beautiful portrait of a bride if her hair is covering 80 percent of her face. The blue dot

Flash Card

Having your subjects hold a pose for more than three seconds will most likely result in a fake expression. For the most part, a genuine expression lasts only a couple of seconds.

by her right shoulder is a low-risk area because as soon as she straightens her back and raises her head to elongate the neck, her shoulder will automatically drop. In this image, her shoulder is far too high. The blue dot by her hands is there to make sure she doesn't make a fist when she holds onto the dress. If she does, however, it will not wreck the photo – unlike the sections marked with red dots. Having assessed the situation, I asked her to return and start walking toward the door again. This time, I adjusted my instructions based on the high- and low-risk areas we have just identified. The final result is shown in Figure 3. Sometimes I have to make mistakes creating a pose

before I can correct them. These photos are genuine examples of my thought processes and demonstrate how I turn an ordinary photo with no wow factor into an iconic image.

When Posed Photojournalism Fails

In the previous section, you learned how to create a photo that appears candid or photojournalistic. However, not every attempt is a success. For example, the photo in Figure 4 did not turn out as planned. As soon as you look at this image, you realize that it looks staged. Sira's expression is slightly overdramatic, and the male model's energy doesn't seem to match hers. It is just as important for your growth as a photographer to recognize when and why a photo fails as it is to be able to create natural-looking images. This photo failed for several reasons. First, both stances are too stiff because the models distributed their weight equally between both feet. The pose would have appeared more relaxed had I asked them to shift their weight to one foot. Next, no part of either body is in motion. It looks as if they placed themselves in the pose

and held it until the photo was taken. This photo was taken during a workshop I was teaching in Switzerland and, if I remember correctly, the models were standing in this pose for more than five seconds because they were waiting for me to manually focus my Hasselblad camera. Had I prefocused before I had them pose, the issue of holding a pose for too long would have been fixed.

Last but not least, their expressions are completely off because their eyes were not posed correctly, and it is the eyes that dominate any expression. If I had asked her to lower her chin and look at a spot on the floor near his feet, it would have placed her head and eyes in a better position to make the expression more believable. The male model should have been facing her with his forehead pointed toward the side of her head. If the groom's head had been turned, it would have crossed their nose directions. It is essential to avoid having noses run parallel to each other, and that's precisely what's happening in this example, which is why the photo seems a bit cheesy.

There are so many lessons to be learned from our mistakes. If you analyze a few photos from every shoot the way we have here, you will learn and retain the lessons better than you can imagine.



Figure 4: This photo shows that not every attempt produces a great image. It is immediately obvious that the image is posed – the woman's expression is too dramatic and the man's attention is not on his partner.

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important discussions about this quickly changing photo industry, and offer artistic support and knowledge for those seeking it.



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Why Posing the Eyes Is So Important

There is nothing more important than the eyes when it comes to capturing a great expression. If a subject is looking in the wrong direction, it will derail the pose faster than anything else, so it is essential to take time to study how to pose a model's eyes. When I ask photographers from around the world what

they do about their subject's eyes, most of them respond that they have never really paid much attention to them or thought about posing them separately. Considering that your subject's eyes can make or break a photograph, this always surprises me. To prove the point, let's compare two photos of

Flash Card

To better control the eyes, tell your subjects exactly where to look and make sure their eyes stay fixed on that spot, regardless of expression or any spontaneous reaction.



Figure 5: In this image, the pose isn't bad, but the eyes are positioned all wrong, giving the shot an off-kilter feel



Figure 6: This is the result of correcting the pose shown in Figure 5. The subjects have swapped positions and I gave instructions on how to position their eyes. The secret of this image is that I got them both to smile.

my sister-in-law Sarah and her fiancé Neal. Figure 5: this photo had great potential as a keeper because everything is posed fairly well. However, both pairs of eyes are posed completely wrong, which makes this photo almost painful to look at. It's not a bad thing that Neal is connecting with the camera, but Sarah being so close to his face with her eyes wide open is just awkward. I deliberately posed them this way to leave no doubt in your mind as to how important posing the eyes can be.

Figure 6: now for the real photograph. After taking the silly photo, I switched them around and this time, I posed their eyes. I asked Neal to smile with his eyes closed and Sarah to look at a specific spot on the ground. The crucial next step was to make sure they locked their eyes on the spot I mentioned. No matter what I said or how hard they laughed, their eyes stayed fixed! The resulting photograph is a testament to this technique. As a matter of fact, I did make them laugh, which makes their expressions real while their eyes remain under control. If Neal had opened his eyes wide as Sarah did in Figure 5, the photo would have been ruined.

The Three Parts of the Eye

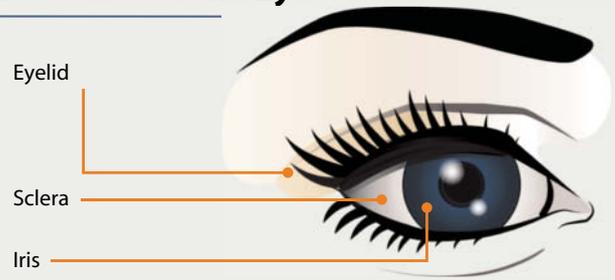
For photographic purposes, we need to pay special attention to three parts of the eye. These are always on my mind during a shoot, and by using them in different combinations, our subjects can appear happy, seductive, surprised, thoughtful, angry, sexy or charming. Before I click that shutter button, I ask myself if all three parts of the eyes are in the right place for the expression I'm seeking (see Figure 7).

The Eyelid

What you need to keep in mind with the eyelid is how open or closed it is. Wide open eyes indicate that a person is exceedingly focused, almost like a hunter about to claim prey. If the eyelids are half-closed, the feel changes to a more seductive, glamorous or romantic expression, while a completely closed eyelid can symbolize a soft and thoughtful expression. If a person laughs but feels shy or vulnerable doing so, they usually look down with their eyelids almost closed (see Figure 8).

Figure 7: The Three Parts of the Eye

The eyelid, the iris and the sclera (the white of the eye) are the three parts of a subject's eye that you have to consider when composing a photo.



The Sclera

The sclera is the white part of the eye. It plays an important role in a photograph because if too much white and too little iris shows, the person can look a bit like a ghost. It's simply not attractive to see 90 percent of someone's sclera unless you are doing a Halloween shoot. I have lost count of how many potentially great photos I have ruined because I did not pay attention to how much sclera was showing from my camera angle. Choose a camera angle that shows more iris than sclera (see Figure 8).

The Iris

The iris is the colored part of the eye, as shown in Figure 7. When the iris moves up or down, the eyelid will move with it, but the iris can move independently of the eyelid when it moves left or right. This means that you can choose to have the iris look in different horizontal directions without altering the eyelid. When posing the eyes, I usually position the eyelids before I address the irises. Being aware and deliberate about good iris positioning will pay off tenfold when you create the exact look and feel that you want.

Figure 8: The Effects Eyes Have

Wide open eyes appear highly focused, while half-closed eyes are more romantic and beguiling. Closed eyelids convey a softer, more thoughtful impression.

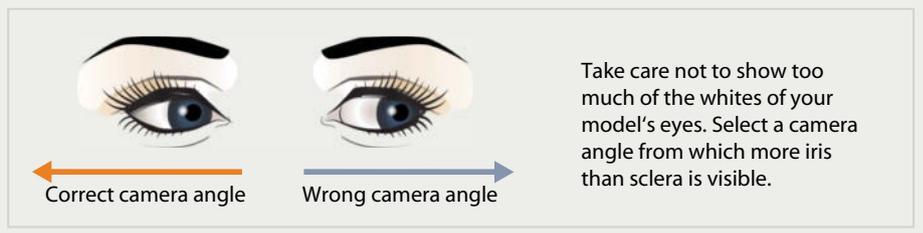
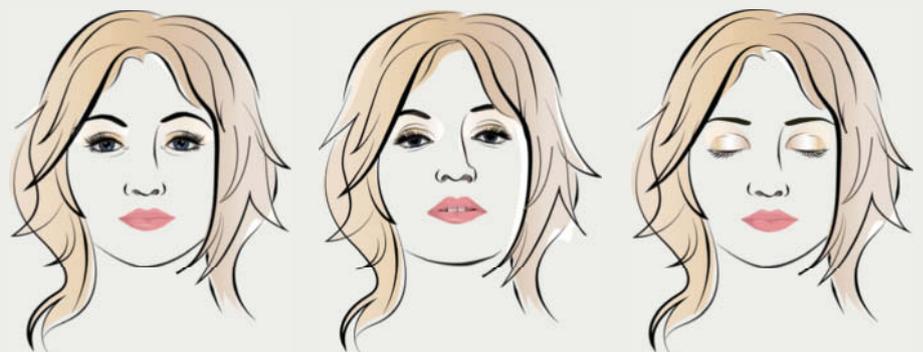




Figure 9: The bride's distant gaze is what makes this image so effective. I achieved this look by diverting her attention away from the shoot at just the right moment.

Techniques for Posing the Eyes

This section explores some powerful techniques I use to achieve a beautiful expression based on the look and feel of the subject's eyes.

Give the Brain a Task

One of the most iconic images of my career is a photo I took during Brittany's wedding, which became the cover of my first book *Picture Perfect Practice*. This photo was a success based purely on the posing of the eyes (see Figure 9).

To get that incredibly captivating, infinite gaze, I first positioned Brittany's head a couple of inches below my camera angle. This forced her to raise her irises to look into my lens, which in turn opened up her eyelids exactly right. Once in position, if I had simply asked her to look at the camera, the look on her face would have been less than desirable. I needed her to ignore the camera and large macro lens pointed straight at her, and the technique I used to accomplish this was to occupy her mind with an unrelated task. I asked her to look through the lens instead of directly at it, and to tell me as quickly as possible when she saw the shutter open and close. I told her it was going to be lightning fast, so she really had to focus 100 percent on the task or she would miss it with a single blink of her eye.

As I slowly pointed my large 100mm macro lens at her face, concentration completely took over her expression. Her brain wasn't thinking, "I'm having a photo taken!" and instead focused on the task of watching the shutter. That shutter was opening and closing at a very high speed, so it required her full attention, and the results were glorious! It is one of my all-time favorite images.

The task you give your client has to be simple but nevertheless require their complete attention. During the shoot in Tallinn, Estonia for the photo on the right, I positioned my lens well below the model's face to control the degree to which she closed her eyes. I know that if the eyelids are half-closed, the model's expression will be soft and glamorous, rather than the aggressive look that can occur if the eyelids are wide open. I covered one of her eyes with her own hair to add a sense of mystery and romance to the photo. Finally, to keep her brain busy for a second so she would forget about the shoot, I asked her to stare down the barrel of my lens and watch the movement going on inside as the lens attempted to focus. That was enough to switch the expression in her eyes from "What am I looking at?" to the dazzling gaze shown in Figure 10.

Flash Card

By having your subjects close and reopen their eyes, you can take photos of them facing bright sunlight and also reset their expressions. Note that you have only a little more than one second to take the photo before the retina and pupil react to the bright light or the surroundings.

Something to Count

By giving the brain a quantifiable task, such as something to count, a part of the brain called the parietal lobe is called into action. The look in people's eyes when they are busy counting cannot be easily replicated, and you can feel how the whole world is ignored in order for them to fully concentrate. The way the brain handles counting is photographic magic!

Let's examine why. We will compare two posed images taken seconds apart at the same location. In one photo, the model was asked to simply look at the camera, while in the other she was given a counting task. In the left-hand image in Figure 11, I posed model Monique Victoria on a blue sofa. Once her hands, arms, neck and head had been posed,

I asked her to look at the camera. Looking at this image, you can tell that she is engaged at a low level and that the task of merely looking at the camera is not challenging enough for her brain. The result is a photo in which the viewer is only superficially intrigued by her physical beauty, the same way that we see what a mannequin in a store is wearing but don't give the mannequin itself a second thought.

Now let's see what happens to this model/viewer relationship when the model is asked to count something. In the right-hand image, Monique was sitting on the same blue sofa as before, except this time her arms were resting on her legs instead of framing her face. I then asked her to count how many iron bars she saw in a fence outside. The fence was to her right, which is why she turned her head that way. The gaze in her eyes makes you wonder what she can see that is so intriguing and the photo has a soulful feel.

Because she is obviously thinking but you don't know what about, you can see more than just her beauty and relate to her as a human being. This is the magic of the brain's parietal lobe at work.

The same counting technique was used for Figure 12. I wanted this photograph to be intriguing on several levels, and the dress, the flower arrangement and the headpiece were all demanding visual attention. But I wanted her expression to have meaning as well. The result is much more interesting than it would have been if she had just been looking at the camera and smiling.

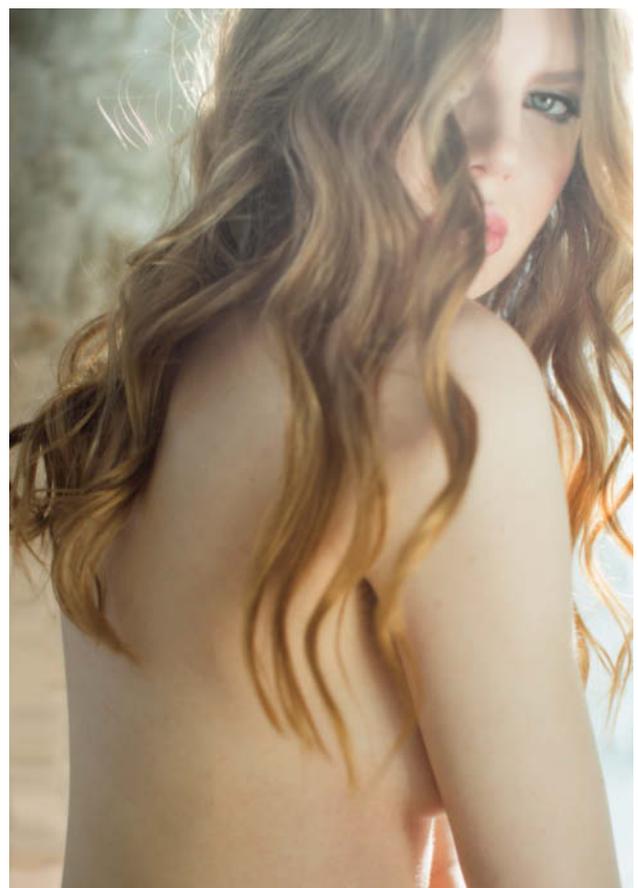


Figure 10: Here, the camera is positioned beneath face level to help determine just how far the model closes her eyes. In this case, the half-closed eyes give the image a soft, glamorous look.



Figure 11: In the image on the left, I positioned the model's arms and asked her to look into the camera. This doesn't work because she is obviously not involved in the situation. On the right, I got her to count some objects to my left, which distracted her and produced a thoughtful expression that conveys real emotion in the finished image.

Have Your Subjects Close Their Eyes

Closing your eyes is almost like pushing the reset button for your expression. It is a brand new start and gives you a new way of looking at your surroundings. When the eyes are closed for a second, they seem to immediately rest and, when your subjects open their eyes again, their look is fresher and more aware. Why does this happen?

The human eye can adjust to changes in luminance levels by a factor of 100,000,000 using the hypersensitive rod and cone cells in the retina. It takes these cells only a second or so to determine the amount of light and make the proper adjustments. The good news is that this tiny window of opportunity gives photographers just enough time to take a photograph of someone in bright light with their eyes wide open but not squinting. The size of a subject's pupil is affected not only by how much light enters the eye but also by his/her mood.

If you become scared, angry, happy, frustrated or surprised, your pupil size will change. Eyes react physically to what they see and how an individual feels. Most importantly, to get your subject's eyes completely relaxed and cleared of any expression or reaction, you must take advantage of the short time it takes the eye to physically react to the environment and to the prevailing mood.

One great example of this technique at work is the photo in Figure 13. I relied on my knowledge of the eye's behavior to clear all expression from Kristen's eyes, which was critical to the success of the photo. I did not want her eyes to convey anything about her mood and I needed to eliminate any chance that viewers would relate to her in any way and instead see her almost as a statue or a character in a video game. To achieve this, I

had to make sure every muscle in her face was completely relaxed with no telltale signs of human expression. This way, her lack of expression would completely captivate viewers as they try to figure out what draws them into the photo.

Once the pose was set and her hands were positioned, I asked her to elongate her neck as much as possible without tilting her head. This was a tough position to hold, so there was natural tension in her body language. To release this tension, I asked her to slowly breathe in and out as she focused on relaxing all of her facial muscles.

Then, to eliminate all residual expression from her face, I asked her to close her eyes, open them slowly and stare straight through the barrel of the lens. It took a few attempts to get the perfect face, but when it finally happened I couldn't have been happier.



Figure 12: Here too, the model had to count, and the results is much more interesting than if she had simply looked into the camera

Figure 13: One way to get a model's eyes looking totally relaxed is to have her close and reopen them before you shoot



Bringing Feeling, Movement and Expression Together

It is a bit of a dance bringing feeling, movement and expression together in a single photograph. Sometimes, two of these elements are perfect but the expression is not all there. To help you with this process, first think of the overall feeling you want to capture in a photograph. Do you want the photo to feel candid, charming, sexy, seductive, innocent? If you don't have a general idea of the feel you wish to create in your head, how are you supposed to direct your subjects?

After you have decided which feeling you are striving for, you will be better equipped to introduce the second, movement-based stage. Two questions should come to mind before directing your clients. First, does the whole body need to move to achieve the desired pose, or should the subject walk into the pose? And second, could I move just a

portion of the body? The answers to these questions will strongly influence the final result. For example, in the left-hand image in Figure 14, it proved much easier to use motion to create that strong 'S' curve between the subject's head and her waist.

I asked her to move one leg forward as if she was about to take a step, and arch her back and tilt her head forward as if she was looking at the design on the floor. Try doing all of this while standing still and you will see how difficult it is make it appear effortless. But do it while moving and it all flows together, even if it takes you three or four attempts. The same principle was applied to capture the right-hand photo in Figure 14.

Even though the model is standing on the spot, there appears to be fluid movement in her pose. I first told her where and how to pose her legs, how to hold onto the jacket,

how to place one hand higher than the other and then how to bring her chin up. Finally, I asked her to do so with her eyes closed and then open them and look at the camera at the very last second. Remember that it takes a few attempts to get a shot like this right. The resulting photo of Sydney Bakich is very fashion-oriented, but it also has movement, grace and fluidity and, best of all, it looks glamorous and effortless. The beautiful expression in her eyes is the result of her opening them at the last second before the photo was taken.

When moving only part of the body, such as the torso, do not neglect posing the feet, even if they don't appear in the photo. The way the feet are posed will always influence a person's upper body. The way body weight is distributed between the feet determines whether a pose looks effortless or rigid.



Figure 14: In the photo on the left (which is also our title image on page 92), the strong 'S' curve between the model's head and waist was created by getting her to take a step forward, and the movement gives the image an effortless feel. A similar technique was used to create the photo above.



Figure 15: Although this photo shows only the model's upper body, the position of her feet was crucial to the overall look

Figure 15 was posed thinking of the feet first. The greatest challenges here were posing Sarah's hands and getting her facial expression right. After I demonstrated how to pose her hands and fingers, I asked her to close her eyes and, on a count of three, look at the camera. Sarah's feet and legs were posed but not in motion, so only her upper body, hands and head were moving into the pose.

For Figure 16, the goal was to showcase the beautiful headpiece designed by Celadon & Celery Events and the elaborate detail on the dress designed by R-Mine Bespoke. This meant there was no need to use the arms to frame the face. Hands draw attention to themselves but all the attention in this photo needs to be on the headpiece and the dress. To create a pose that best met the goal, I asked Dylan Quigg to stand with her left foot over her right and shift her body weight to her back foot. This allowed her to arch her lumbar, bring her shoulders as far back as she could, and balance her upper body by bringing her



Figure 16: This pose was created by getting the model to place her left foot over her right and shifting her weight to her back foot



Figure 17: This photo, shot in Switzerland, took quite a lot of effort to set up. The overriding theme is vulnerability in the woods, which explains the protective position of the model's arms. Her bent right leg and raised chin complete the mood of the pose, which was created by having her walk into position.



head forward. Moving her shoulders back emphasized the dress, while tilting her head forward elongated her neck and isolated the headpiece beautifully.

During a photo shoot in Switzerland, I was having a hard time achieving the feeling I wanted for the photo shown in Figure 17. The Swiss forest reminded me of a scene in which a startled deer spots a potential hunter in the woods. Such a deer would naturally feel exposed and vulnerable and, to bring this theme into a photo, I had to stop for a minute and think about how a woman would react if she found herself in a similar predicament. Her instinctive reaction would be to shield her body. I decided that her arms and hands should be used to cover herself, but the pose had to be done with her arms as straight as possible, as you would if you were trying to protect yourself. I also wanted the leg closest to the camera to be bent but, even after several attempts, something was still wrong.

The issue turned out to be the position of her chin. With her chin pointed down, she did not appear to be in 'high alert' mode, but with it raised she looked perfect! To bring it all together, I asked her to walk a few feet into the pose with her chin down and eyes closed and to raise her eyes with a sexy but nevertheless cautious expression the moment before she reached the spot marked for the pose. As usual, the effort paid off and, by not rushing the photo, I was able to craft it impeccably. This photo of Miriam in Switzerland has become one of my all-time favorite fine-art photographs.

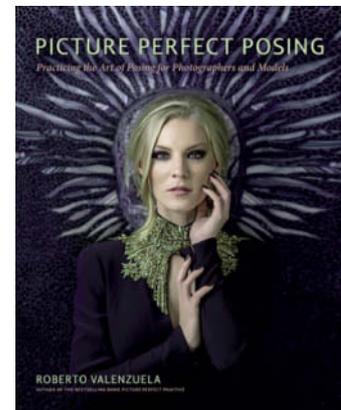
Posing Case Study

To really increase your awareness of posing issues and how to correct them during a shoot, you have to take the time and effort to analyze your photos subjectively. Try to ignore whether you actually like a photo or not and instead concentrate on finding which issues exist, why they exist and the actions you need to take to remedy them. Performing this process regularly will help you fine-tune your posing skills under the pressure of a real shoot. Let's begin by taking a close look at an example from an engagement shoot.

Problem #1: The subjects in the photo are a couple but the pose doesn't communicate this. The only sign is her hand gently covering his. The body language therefore has to be significantly improved to emphasize that they are in love.

Picture Perfect Posing

Roberto Valenzuela's hit book introduces his posing system and uses his own images to explain how it works. The "Picture Perfect Posing" system consists of 15 basic rules that anyone can master. Once you have learned the system, you can get the best out of every situation without having to remember individual poses.



Picture Perfect Posing

Roberto Valenzuela
Published by New Riders
336 pages
8 × 10 inches
Hardcover
\$39.95
ISBN: 978-0-321-96646-9

Problem #2: The second problem I see here are the facial expressions. I strive to achieve expressions that look natural and compatible, but here, their focus is on me instead of each other. Furthermore, the vibes of the individual expressions don't match – he is smiling at me while she appears to be waiting for me to take the photo. This has to be changed to create a feeling of deeper understanding between the two of them.

Problem #3: The third posing problem here is her left arm, which is closer to the camera but not engaged in the pose. This makes her

appear uninterested. To fix this, we must find a reason to get her arm doing something.

Problem #4: The final major problem I identified is the position of her legs. They are virtually straight, which makes them appear static. In order to achieve a sense of elegance and relaxation, we must introduce diagonal lines in the joints as much as possible.

The simplest way to correct this is to ask her to shift her body weight to the foot furthest from the camera so that the leg closest to the camera appears elegantly bent and relaxed. Next, the column in the balustrade is blocking her leg and Valentino shoes. This is a big no no! People go to a lot of trouble to choose an outfit and shoes are sacred to a woman, so they have to be visible in the final pose. It is essential to identify issues like these during the shoot, but you have to be well trained to do so under pressure. This is why I recommend that you thoroughly analyze a few images from every shoot.

Now that we have recognized the major issues affecting this photo, we can address them individually. We let our models continue holding hands, as this helps the viewer to recognize them as a couple. The body language issue has been solved by having them lean their heads toward each other. This indicates the positive, loving energy that they are giving to each other. Now we can work on her left arm and the column that is blocking the view of her legs. I asked the groom to kiss the top of her head because this increases the romantic energy of the pose while keeping his back straight. Had I asked him to kiss her lips, he would have had to hunch his back or bend his upper body, which would not look good. Kissing the top of her head works perfectly.

Although the pose is now looking a lot better than it did at first, I still felt I could do better with the authenticity of the expressions. I wanted it to feel more like a true candid moment rather than a pose, and the photo in Figure 20 shows the final result. I got the groom to give me a real laugh (not a "fake camera smile") by talking at him energetically the whole time.

A photographer has to bring plenty of energy to a shoot so that the subjects can feed off it. This way, you get real expressions out of your subjects because they are reacting to your energy. To give her arm a natural excuse to bend and become engaged in the overall pose, I had her hold a piece of fabric from her dress to make it appear as if she was protecting it from the hard stone. I also asked them both to move a few inches so that her legs were visible between the columns of the balustrade, thus showing off her legs and revealing more of her shoes. The final image is the result of



Figure 18: This photo from an engagement shoot has several issues: the subjects don't appear to be a loving couple, their expressions don't match, her left arm has nothing to do, and the pose of her legs is all wrong



Figure 19: This version is much better. The couple's heads are leaned toward each other and the way he is kissing his fiancé gently on the head keeps his back straight.

Figure 20: The result of solving the four listed issues and getting both subjects to laugh by interacting directly with them while I was shooting

addressing all the issues we discovered in the initial shot. Unfortunately, it is far easier to identify these types of issues after the shoot when you are viewing your photos on a computer screen, but by then it is too late. As a photographer, you have to train hard to recognize posing issues as they arise. After all, you can't fix a posing problem if you don't know it is there.

To sum up, you have to know in advance which potential problems might arise and you also have to be able to recognize them under

pressure during a shoot so you can remedy them while you work.

A Few Last Words

It requires constant awareness of the three major posing elements and plenty of practice to fine-tune your skills and bring all you have learned together on every shoot. Trial and error will be your constant companion, but when all three concepts come together in a single photograph, it will not only bring a



huge smile to your face but will also give you a new sense of appreciation for the art of photographing people. Remember that when it comes to masterful posing, it is the subtlest details that make the biggest difference!

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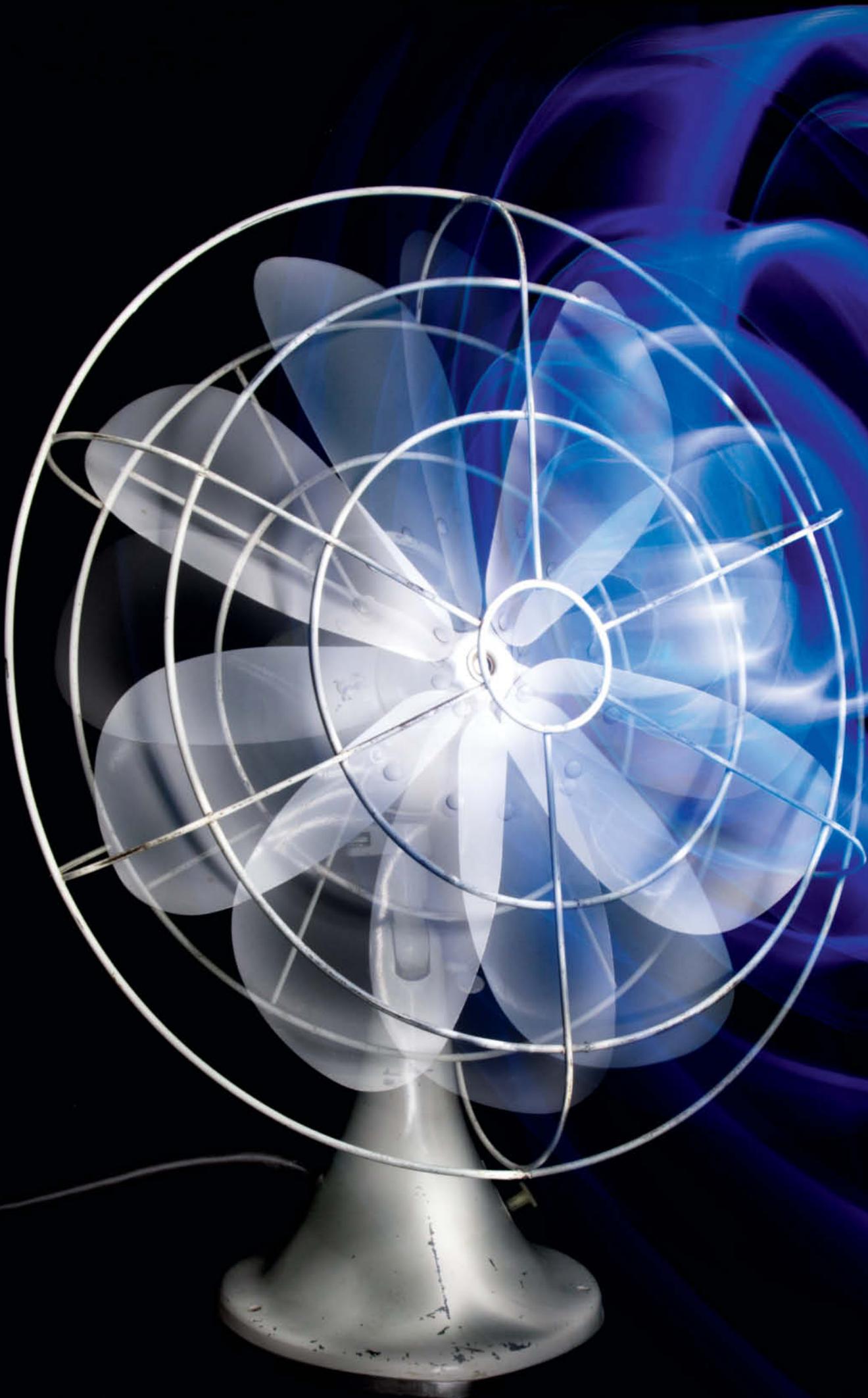
About Roberto Valenzuela

Roberto Valenzuela is based in Beverly Hills, California. He developed his unique teaching style by practicing just as intensely as he does for his role as a classical guitarist. He believes passionately that alongside talent, conscientious practice is the key to success. Valenzuela gives private workshops, seminars and lectures at the world's biggest photo shows.

He is a three times winner of international awards and has been recognized by his peers as one of the ten most influential photographers and photo educators in the world. *Picture Perfect Practice* is the top selling wedding photography training book at amazon.com.

www.robertovalenzuela.com







Cyrill Harnischmacher

Light Painting

and Light Brush techniques

This workshop introduces a fascinating and endlessly variable form of visual expression that enables you to create abstract hovering drawings, ethereal messages, delicate translucent ornaments and impressive 'light sculptures' that often look as if they have floated in from another planet.

Over the years, countless artists have created a huge variety of work using light as a medium. Perhaps this is because light itself has a magical quality, and because combining space, time and movement creates images that are visible, yet intangible. Or maybe the appeal of painting with light lies in the creation of a form that is captured at a unique, unrepeatable moment.

Unlike working in the open, when you paint with light in a studio environment, you are free of the constraints of weather, time of day and prevailing lighting conditions. This situation offers plenty of opportunities, but it also creates some restrictions that we will deal with later on.

First however, we need to clarify the difference between capturing images of moving objects that radiate their own light and ones of objects that we illuminate – either completely or partially – using a movable light source that does not appear in the finished image. This article refers to the former technique as 'light painting' and the latter as using a 'light brush'. Both are based on extremely long exposures, and the light that makes up the final image is 'collected' during the entire time the shutter is open. This means that the artist does not capture an existing situation or lighting setup but instead manipulates the light in real time while the work is being created. Producing this type of image therefore requires careful planning and plenty of imagination, especially when you consider that it is impossible to use a modeling light to check your effects in advance or take an accurate test shot! If you are just starting out, you need to spend some time feeling your way into the techniques involved. Spontaneous

shoots can produce extremely pleasing results, but you will need some experience before you can produce images with an underlying concept.

Planning and General Requirements

The main prerequisite for both light painting and light brush techniques is a room that can be effectively darkened. You also need a stable tripod and a camera with a built-in 'bulb' (B) mode that allows you to make exposures that last as long as several minutes. Plenty of free space surrounding your subject or stage is essential and, as you will be working in complete darkness, you need to make sure that there is nothing lying around that you might stumble over, and that your tools are carefully arranged where you can reach them easily. To ensure that you don't accidentally touch or jog the camera, it is a good idea to set it up a little distance from the subject and use a medium telephoto lens.

Wear black to prevent yourself from appearing in the final image, and cover your hands too, ideally with thin black cotton gloves that allow you to reliably control the buttons and switches on your lamps and your camera.

To keep noise in long exposures to a minimum, it is best to shoot using a full-frame DSLR rather than a compact or bridge camera. Manual focusing is an integral part of the process too.

Shoot in RAW format if you can, as this gives you much more control over shadow and highlight detail at the post-processing stage. If your camera has a noise reduction feature, activate it before you begin shooting.

Using a Light Brush

Still lifes captured using light brush techniques often have an atmospheric, almost surreal feel. Such images are often reminiscent of paintings by the old masters and are characterized by soft but precisely targeted light.

In a studio, the light brush technique is based on the principle of lighting the subject gradually, bit by bit. The beam is moved to cover the subject and leaves traces wherever it goes, and the more slowly (or more often) the light brush covers a particular detail, the more intense the lighting effect there will be. This is an ideal way to accent selected details and, because the light brush never illuminates precisely the same place twice, it produces a wonderfully soft lighting effect, in spite of the fact that the brush itself is a fairly hard, almost point-shaped light source. The simplest tool to use for light brush effects is a focusable pocket flashlight. Still lifes are the most obvious candidates for light brush treatment, although it is also very effective for adding accents to all sorts of product shots, and can even be used for macro photos. Portraits and nudes, too, can be set in soft, flattering light using light brush techniques, although it can be difficult for a model to remain perfectly still during such long exposures.

Before you actually open the shutter, it is a good idea to perform a dry run of all the movements you plan to make during your

shot. This will help you to estimate the length of the required exposure and to find appropriate places to position the various tools and implements you will be using. If you are using flashlights with different colored filters, you can give each a different tactile label, such as a rubber band for yellow, a piece of tape for blue, etc. If you do find yourself getting confused as to which light you are holding, you can always move away from the subject, shade the lamp with your hand and switch it quickly on and off to see which color it is.

Shooting

Once your subject is set up, take a test shot under normal room lighting to make sure that all the relevant details are properly framed and in focus. At this point, you can still adjust the aperture and focus if they aren't quite right. The next step involves making a test

long exposure with the lights off to make sure that there aren't any stray light sources that have gone unnoticed and only show up when the shutter is open for a long time.

Now all that's missing are appropriate camera settings. A low ISO value and a small aperture (f22, for example) will provide plenty of depth of field and won't produce too much noise. The exposure time itself will depend on the complexity of your subject and the power of the lamps you use, although I have often found that 20-30 seconds is about right for smaller subjects, while as much as several minutes may be required for more intricate work. The best way to make such exposures is using a cable release with a physical lock that enables you to make exposures longer than those allowed by the camera's built-in electronics.

To avoid producing obvious bright spots or light trails that lead into or out of the frame, only switch your lamp on once it is

Keep the light beam as narrow as possible when capturing large subjects, especially if you are accenting specific details. In addition to my LED lamp, I also used a flashlight with a conventional bulb to paint the light in this shot.

38 mm | ISO 400 for the fog | All images captured at f25 |
Four separate images with exposure times of 121, 173, 44 and 20 seconds



moving and keep it moving the whole time it is switched on. Repeated movements or long pauses in one place produce bright spots; a more effective way to avoid overexposure is to repeat a quick movement several times.

Light Brush Close-ups

Many commercially available LED flashlights cannot be focused accurately enough to effectively illuminate fine details in small subjects. However, if you attach a small piece of optical fiber to the lens of your lamp, you will be able to direct the light extremely precisely. Plants and flowers are great subjects for this type of treatment and can be presented in completely new and artistic ways (see the example below). If you don't have access to optical fiber, a piece of narrow aluminum tubing makes a great directional attachment too.



I lit the torso of this mannequin using an LED flashlight fitted with two parallel optical fibers and used a second exposure to add the 'wings' using three LED lamps with Plexiglas caps attached to a pole (see page 123 for more details)

60 mm | ISO 100 | f16 | 40 s



You need modified lamps to effectively light the details of subjects like this dried rose. An optical fiber attached to the lamp makes the light beam tight enough to illuminate even the smallest details.

60 mm | ISO 100 | f25 | 15 s



I used a piece of optical fiber attached to the lens of my lamp to give these fist-sized stones their mysterious markings

54 mm | ISO 100 | f22 | 111 s

Objects Made of Pure Light



Light spaghetti! I made the 'pasta' using an LED lamp fitted with a double optical fiber and used a normal flashlight to give the cutlery additional golden highlights during a second exposure. I finished up making two more exposures, during which I lit the edge of the plate and the background with an LED lamp set at a shallow angle. I glued the fork to the dish to make sure it remained in place while I twirled the spaghetti around its prongs.

52 mm | ISO 320 | f20 | Image constructed from four source image exposed for 98, 9, 40 and 9 seconds

This completely abstract image is made of light trails 'painted' in space. Your imagination is the only limit when it comes to making images like this. For this shot, I used blue and yellow acrylic rods that I rotated while I painted. I created the bright spots by briefly stopping the movement.

60 mm | ISO 100 | f16 | 40 s



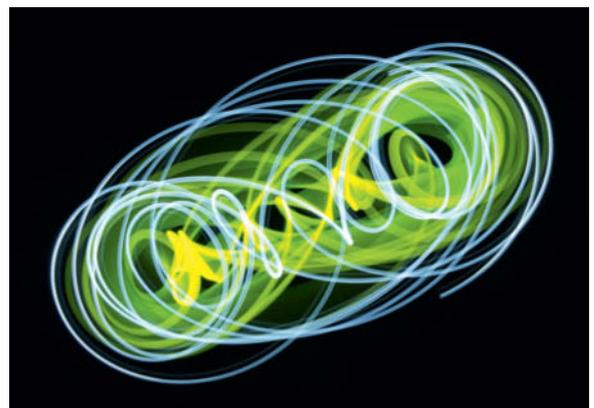


Even if it looks as if it was made in several stages, this shot was actually captured during a single exposure. I began by painting the yellow stripe on the glass background and then added the outline of the model car using an LED lamp with an optical fiber attachment.

60 mm | ISO 100 | f29 | 116 s

Here, I attached two lamps to the ceiling with string and set them in motion. In addition to the side-to-side movement, I gave them a little spin to add depth to the light trails. Loosely tied together, the lamps produced patterns that are similar, but by no means identical.

48 mm | ISO 250 | f22 | 16 s



Unlike the light brush technique, which uses various light sources to illuminate a selected subject, this approach creates images from the trails left on the camera sensor by the lights themselves. The idea is simple – all you have to do is move your light in front of the camera and watch as the image is created bit by bit.

The results range from completely abstract to concrete and representational. If you want to paint with light in space without including any 'real' reference objects, you'll need to make some additional preparations. To avoid painting outside of the plane of focus or your intended frame, pre-focus and visually mark the boundaries of your 'canvas'. An old picture frame hung from the ceiling or pieces of string stretched across the room are two ways to help you stick to a predefined space. Sometimes, a couple of pieces of sticky tape on your table will do, and you can also use stencils to guide you. Apart from that, you need to mount your camera on a tripod and

darken the room as you would for a light brush exposure.

Unlike in outdoor situations, indoor light painting is subject to quite a few restrictions. Because of the space restrictions, it is extremely difficult to achieve effects that rely on centrifugal force (i.e., light sources that rotate around a point), and light sources that involve fire or sparks are of course taboo!

If you use multiple light sources, you can adjust their intensity by varying the speed of the movements you make. This makes it possible to combine weak light such as that from a glow stick with powerful LED light in a single image.

The light sources available range from simple pocket flashlights through sparklers, color-changing LED lamps and glow sticks to laser pointers and much more. In principle, anything that generates its own light can be used for light painting. As well as online shops, toy stores, furniture stores and dollar stores are great sources for all sorts of lighting gear.

A Pendulum of Light

A fascinating way to unleash the potential of a lamp is to hang it from the ceiling and set it swinging like a pendulum. To capture the results, you have to position your camera on the floor with the lens pointing upward. This makes it impossible to focus using the viewfinder, so you have to measure the distance to your lamp by hand and set focus accordingly. The movements of a pendulum create symmetrical patterns that are impossible to draw freehand, and you can vary the effect by altering the length of the string, changing the hanging point or setting the lamp spinning while it swings.

Merging Multiple Images

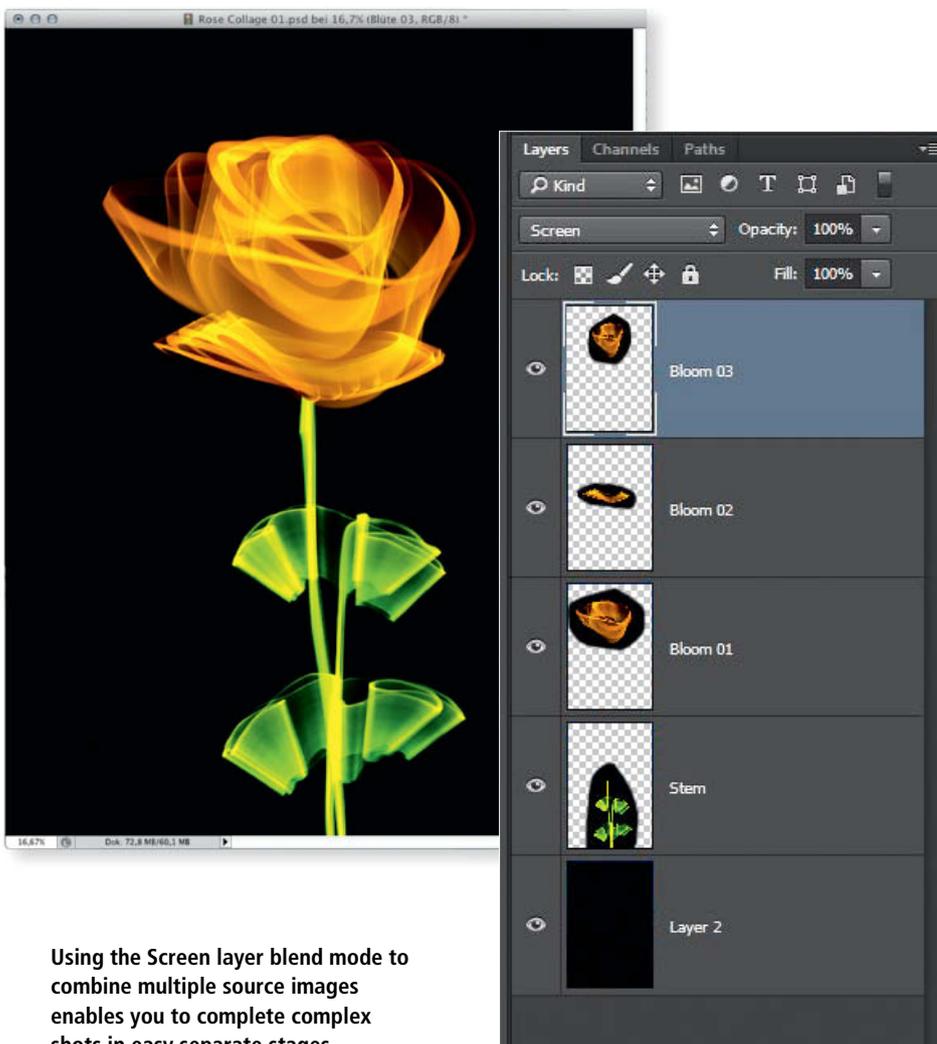
If you are creating large, complex images, a single long exposure is not usually enough to capture all of your planned effects. The best way to work around this kind of restriction is to shoot multiple images and merge them into one later on. If you switch light sources between shots, you can work in individual different-colored 'layers' that you can repeat if they don't immediately work as you intended. To combine layers in Photoshop, use the Screen layer blend mode.

Another way to achieve a similar effect is to use your camera's multiple exposure function. The advantage of this approach is that you can then view the result of each step on the camera monitor before you proceed, and you can repaint individual details or intensify the effect of accents as necessary during subsequent exposures. The downside of making multiple exposures is that you run the risk of joggling the camera every time you release the shutter, which can cause unwanted offset between the individual source images.

Screen blend mode is also great for merging photos of objects captured in front of black backgrounds with objects captured in daylight. This makes it possible to combine light painted images with images of situations in which light painting simply isn't possible.

Combined Techniques

It is easy to combine light painting and light brush techniques and there is nothing simpler than adding flash to a light painting shot. A flash fired during the main exposure can be used to add a basis for your light painted accents or to add its own detail accents. The different colors of flash and the light from a lamp can be used to create interesting effects like the one shown page 120.



Using the Screen layer blend mode to combine multiple source images enables you to complete complex shots in easy separate stages

Combining light painting with flash. I used a 4" light stick to trace the outline of the guitar and give it a glowing 'aura'. To make the guitar itself visible in the final image, I lit it from the side using a strip-shaped flash that I fired during the main exposure.

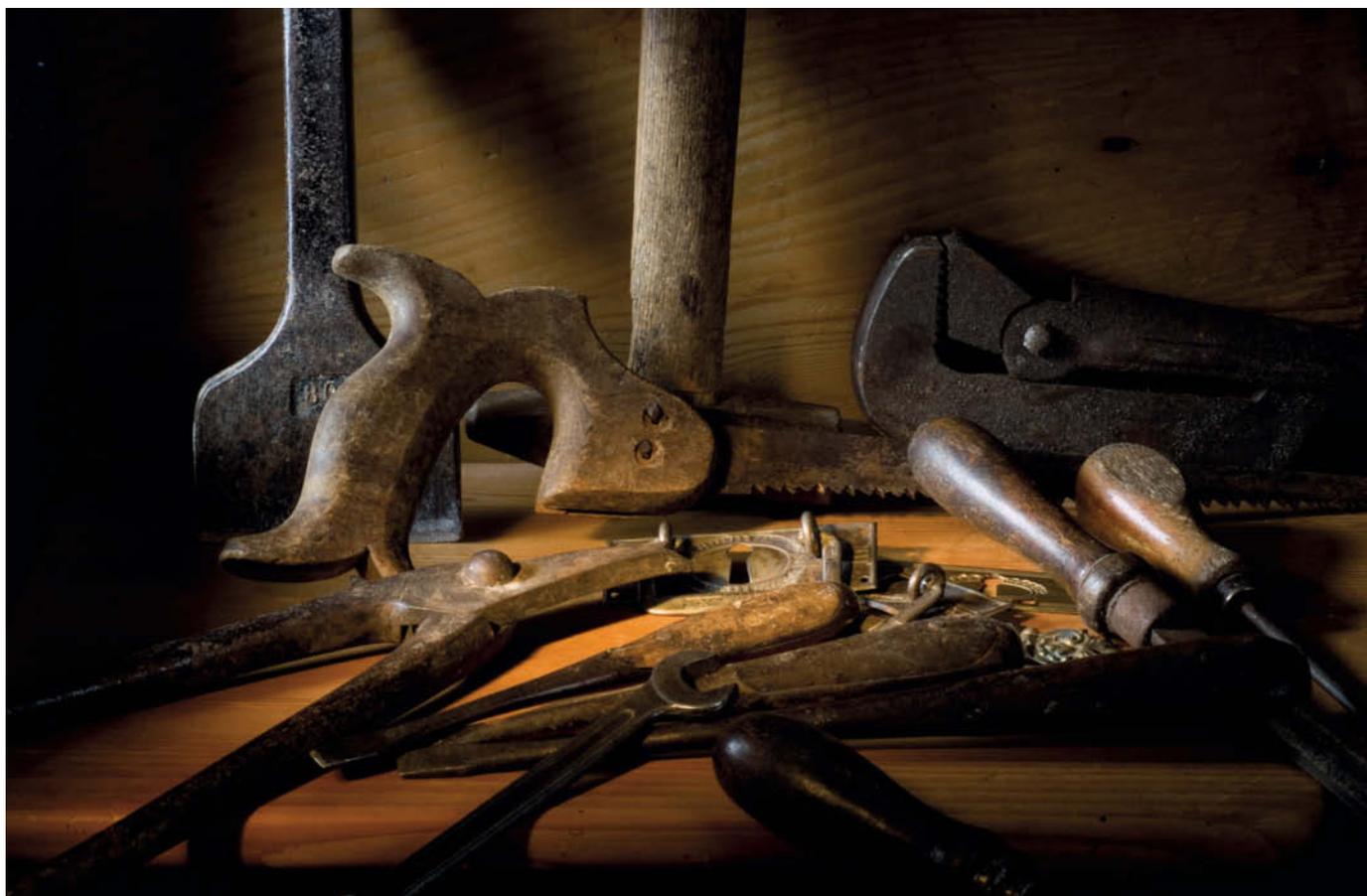
28 mm | ISO 100 | f9.0 | 25 s





Creating artificial accents: a conventional flashlight simulated the sun shining through an imaginary workshop window and the main scene was lit using a flash fitted with a softbox. The mixed LED and flash light give the effect of golden evening sunlight.

60 mm | ISO 100 | f22 | 15 s



Light Painting on Paper, Canvas and Other Surfaces

Light painting on canvas involves lighting the canvas itself and capturing its texture along with the trails left by lamps on its surface.

Conventional white primed canvas is ideal because the light brush nicely accentuates its texture, but you can, of course, use paper, plastic or anything else you fancy.

A copy stand makes a perfect 'easel' for this type of work. It enables you to mount the camera vertically above the canvas and gives you space to paint as you would on a conventional drawing board. It pays to tape your canvas in place to prevent it from moving while you work, especially if you are using techniques that involve contact between the canvas and the light brush.

Acrylic rods or offcuts from an acrylic sheet lit from one end can be used like marker pens, and optical fibers can be used to draw fine lines. The closer your brush to the canvas, the more precisely defined the edges of your strokes will be. The speed at which you move your brush also determines the 'thickness' of the color you apply and thus the intensity and brilliance of the resulting patterns.

You can use a flashlight almost as you would an airbrush or an aerosol spray, but this creates problems that you wouldn't normally face when using conventional painting techniques. For example, pausing for too long in one place can easily cause a saturated color to overexpose to white or simply produce a burned-out highlight.

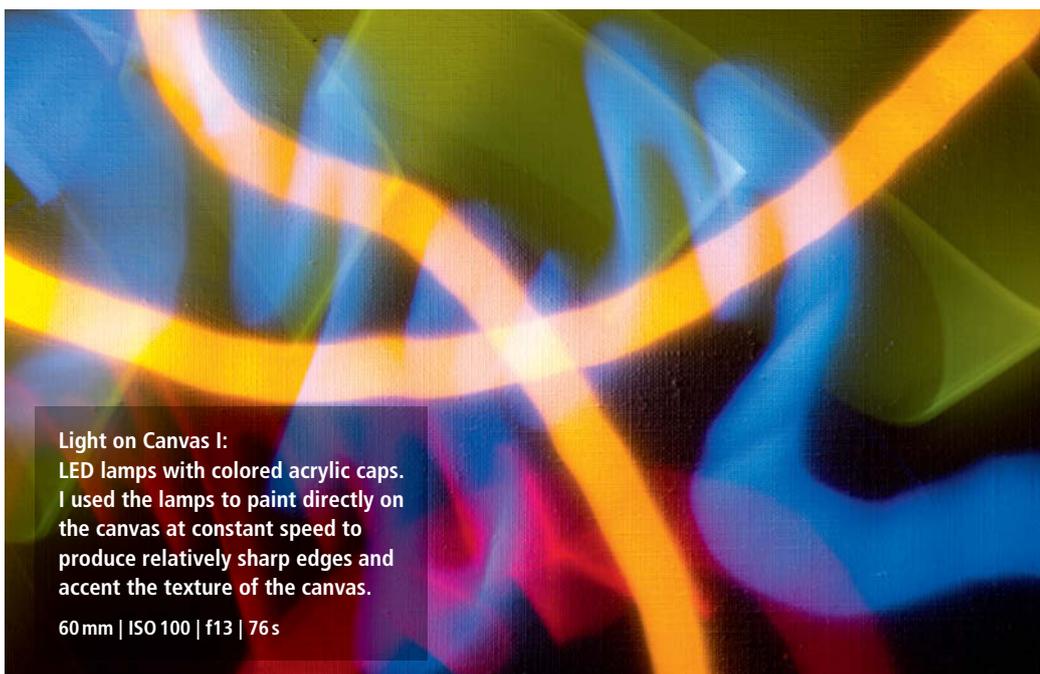
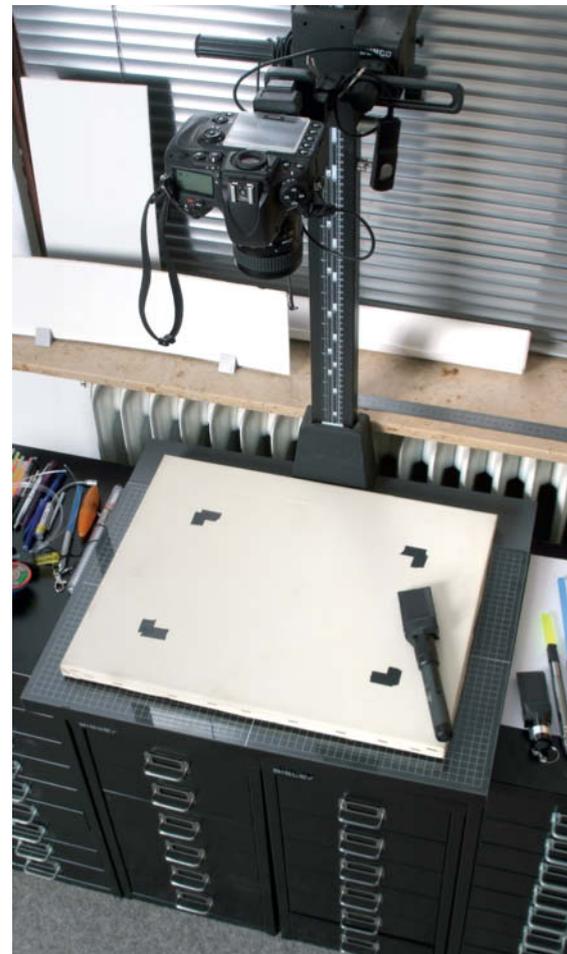
If you are creating a light painted representation of a real object, you have to apply light to a dark background to produce a visible shape. Conversely, if you want to create shadows, you have to prevent any light from reaching the corresponding areas.

Because you cannot actually follow what you are doing and check where you have applied which color while you work, you have to rely on your intuition and 'fly blind'. Additionally, because you have no object as a reference, you need to mark the limits of the area the camera can see.

If you make a sketch to help you paint, this too will be visible in the finished image, although you can, of course, deliberately combine conventional painting and light painting techniques if you wish. How about using pre-cut stencils to help you paint a particular shape? Once you start experimenting, you will quickly discover that there are no limits to the techniques and effects you can apply.

Last but not least, the great thing about painting with light is that the canvas remains white and can be used time and time again.

A copy stand is a great tool for light painting on canvas. Always mark the area the camera sees before you begin.



Light on Canvas I:
LED lamps with colored acrylic caps. I used the lamps to paint directly on the canvas at constant speed to produce relatively sharp edges and accent the texture of the canvas.

60 mm | ISO 100 | f13 | 76 s



Light on Canvas II:
LED lamps with colored acrylic caps and a blue acrylic light stick. To soften or harden the effects, speed up or slow down the movement or change the distance between the lamp and the canvas during the exposure.

60 mm | ISO 100 | f13 | 61 s

DIY Light Brush Gear

The moment you begin to realize your own light painting ideas, you are sure to find that the specific piece of gear that you need doesn't actually exist. In fact, building your own gear is an integral part of the light painting process and offers a myriad of ways to get truly creative. It is actually quite easy to make your own tools and every household has things lying around that can easily be turned into great light brushes.

Custom Flashlight Attachments

Light painting effects depend on the shape of the light source, so it is a logical step to see what happens when you hold various translucent colored objects in front of a flashlight. Screwdriver handles, the caps from toothpaste tubes and a thousand other things are just waiting to be used to create interesting patterns. Anything translucent will do and you can always use colored gels and foil to create the hue you are looking for. Search for "LEE Swatch Book" or "Rosco E-Colour+" on the Web to find sample books

of ready-cut filter gels. Mixing filters enables you to create new colors or vary the intensity of existing ones.

Light Brushes, Light Pens and Light Markers

Acrylic sheets and rods are great for creating blocky and angled brush tips. Acrylic sheets can be cut to any size you want with a fretsaw and produce an effect similar to that of a broad marker pen. Optical fibers attached to a flashlight with tape are perfect for producing fine lines.

Various sizes of optical fibers (usually white) and acrylic sheets (in many colors) are available quite cheaply online. Plexiglas® LED is purpose built to produce bright, shining edges when illuminated, and you can make your own light sticks using offcuts from acrylic rods. Rubbing the ends of the rods with fine sandpaper produces a more intense effect.

The best way to fix an acrylic rod or an optical fiber to a flashlight is to use a small piece of foam rubber and some black tape. Just cut the foam rubber to the size of the reflector in your lamp and then make a hole in it with a nail or a drill. You can then insert one or more lengths of optical fiber into the hole.

To fix a piece of acrylic sheet to a flashlight, simply cut an appropriately sized piece of foam rubber in two and wind tape around the pieces with the acrylic sheet in the center before fixing the complete unit to your flashlight with tape. Once they are fixed to your lamp, wind tape around the optical fiber or the acrylic sheet to prevent stray light from escaping from the sides.

If you want to use your new tool as a light brush, wind the tape so that it protrudes a

little at the end. This will prevent the opening from appearing as a well-defined shape in the finished image. For light painting purposes, you need to leave one or two millimeters of your brush tip free of tape.

To make a soft brush from an old glass-fiber lamp, just cut off some of the fibers, tape them into a bundle and attach them to your lamp as described above for an acrylic 'marker'. The lamp will now produce soft, lightly textured brush strokes.

Makeshift Tools

It is not always possible to paint precise circles, straight lines or repeated patterns freehand, but there are various makeshift tools you can use to help you work accurately.

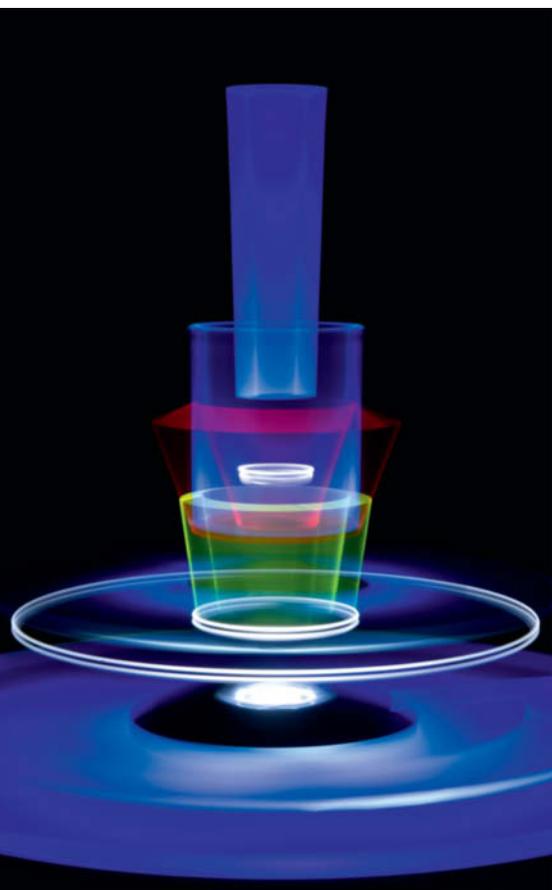
Attach a lamp to a coat hanger and rotate it around its hook, or attach lights to a bicycle wheel to create perfect circles. Using stencils made of black card, you can build up complex patterns step by step. If you shine your lamp through the hole in a stencil, you will end up with a colored version of the shape you have cut out. If, on the other hand, you shine your lamp on the cutout, you will create an outline of the shape or a black shape against a bright background. Use a matte black painted wooden batten as an invisible guide to help you 'draw' straight lines in the air.

Many light painting projects require the help of other people, if only to release the shutter while you perform your rehearsed moves in front of the lens.

Using a Smartphone

Your smartphone can double as a light brush. The simplest approach is to set the monitor to display a single color and then use it as a broad light brush, although a striped screen can produce interesting results too. You can alter the color and brightness using the smartphone's own controls. As ever, the best thing to do is experiment and see what ideas you come up with.

Light Writer for iPhone and *Dr. Light* for Android are cool apps that enable you to generate luminous text that you can then add to light painted images captured with another camera (see opposite). It takes a bit of practice to get usable results, but it is well worth the effort. The app starts to display text the moment you move your device, so it is a good idea to start it by giving your phone a quick shake before you begin the movement you want to record in your photo. (tho)



This image is constructed from multiple shots of various acrylic objects placed on building blocks on a turntable. To prevent unwanted trails from spoiling the effect, I covered the camera with a black cloth every time I swapped out the subject.

72mm | ISO 250 | f29 | 258s

Basic Equipment



LED flashlights (bottom) and conventional flashlight bulbs (second from bottom) have very different color temperatures. Adding single or combined colored gels enables you to create just about any color you like.



Optical fibers, available in various widths, are ideal for creating fine lines and patterns. You can combine several to create interesting visual effects. A piece of thin aluminum tubing is another way to focus the light from a lamp.



Translucent plastic objects make perfect light brush tips. From left to right, these are: a screwdriver grip, a glue gun stick covered in colored foil, the lid from a tube of cream and the cover of a pencil sharpener.



Your local toy store is a great place for discovering new light sources like luminous spinning tops, light-changing flashlights, light sticks and glowing keychains. Bendy glow sticks are perfect for creating light rings around other objects.



Large shapes are best created using acrylic rods and sheets. Rubbing up the surface of acrylic with fine sandpaper accentuates the glow effect in its surface. Acrylic rod offcuts are ideal for light painting on canvas.



The *Light Writer* app for iPhone and *Dr. Light* for Android enable you to add text to your light painted images. You can use your smartphone's screen as a broad light brush too.



A glass fiber brush not only looks like a conventional paint brush but also produces softly textured light trails that are very similar to brush strokes



Illuminating stencils and cutouts made from black card forms either luminous shapes or glowing outlines

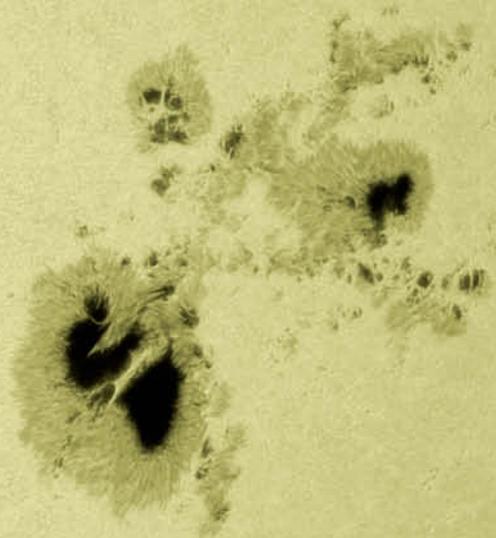


Try attaching a lamp to a black plastic coat hanger and rotating it around the hook to create circular shapes

Rolf Hempel

Photographing The Sun

Although the solar eclipse on March 20th was the last to be visible from Earth for some time to come, the safety measures and special techniques that many photographers used to capture it can be applied to solar photography at other times too. The Sun is a fascinating and ever-changing subject that offers a wealth of unusual photo opportunities. Read on to find out more.



Solar panorama, captured on March 26, 2014

Canon EOS 5D Mark II | ISO 100 | 4,500mm | f35 | 1/400s | Solar filter | 114 source photos

The Sun is perhaps the most widely used and certainly the most important photographic light source, but is not particularly popular as a subject in its own right because daytime sunlight is simply too bright to be captured safely using conventional camera shutters and sensors. If you shoot directly into the sun, you may find that your camera no longer works afterwards, and looking at the Sun through the viewfinder usually causes serious damage to your eyes or even blindness. So take great care whenever you point your camera skywards. If you follow the tips and instructions detailed on the following pages, you will be able to get to grips photographically with the enormous amounts of energy the Sun releases.

The Sun as a Photographic Subject

The Sun lies at the center of our planetary system and dominates its surroundings. It has three hundred thousand times the mass of Earth and its core is an enormous fusion reactor that provides our solar system with light and warmth and makes life on Earth possible. Within our galaxy (the Milky Way), the Sun is just one of billions of stars, but it is the only one that is close enough for us to make out details on its surface.

And there is plenty to see. The hot gases that make up the Sun's surface are in constant motion, channeled by powerful magnetic fields. There are massive localized temperature differences, with cooler areas appearing dark and hotter ones bright. Viewed at high magnifications, the complex lines traced by the magnetic fields can be identified in large sunspots. If you magnify your view still further, the apparently homogenous surface of the Sun is transformed into a dense network of smaller cells, or 'granules', with dark areas between

them. This structure enables you to observe the thermal currents in the Sun's photosphere in action. Just like in a pot of boiling water, hot material rises through the center of a granule, cools and sinks back down in the space between the cells – an extremely turbulent process. A typical granule has a diameter in the order of 1,500 km and lasts 8 to 20 minutes before dissipating.

The Sun is constantly changing, and even large groups of sunspots change their appearance every few hours. If you observe sunspots over a period of several days, you will see that, due to the Sun's rotation, they appear to migrate from West to East. The Sun completes one rotation every 27 Earth days.

The US satellite Solar Dynamics Observatory offers a continuous stream of visual data, and the images provided by the project's website (see sdo.gsfc.nasa.gov/assets/img/latest/latest_1024_HMI.jpg) show the current distribution of sunspots.

The activity above the Sun's surface is even more spectacular. Streams of ionized material called plasma are transformed by the Sun's magnetic field into enormous arcs that can be as much as several thousand kilometers high. These arcs can often be seen together with groups of sunspots in active regions and appear relatively static for several months at a time. These 'protuberances' can also produce sudden eruptions that catapult material out into the universe at hundreds of miles per hour. If they reach the Earth, these gas masses cause spectacular polar light shows but can

also cause havoc with electricity and telecommunications networks.

Every few years, the moon's orbit moves it between the Sun and the Earth, creating a partial or total eclipse. The most recent total eclipse was visible from a narrow band in the northern Atlantic on March 20th, 2015.

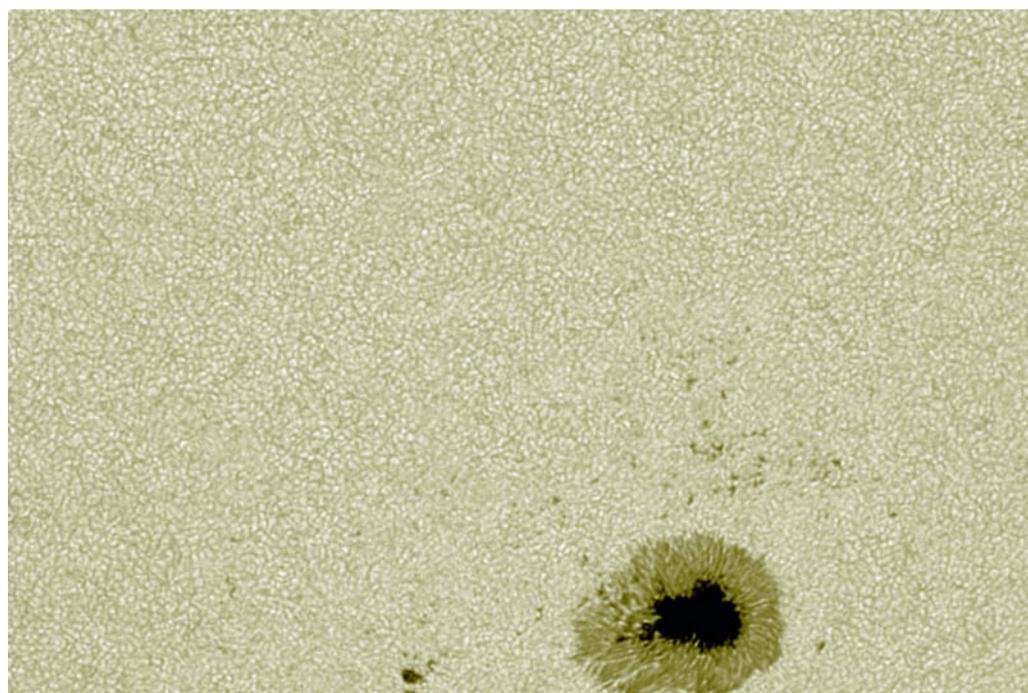
Stay Safe!

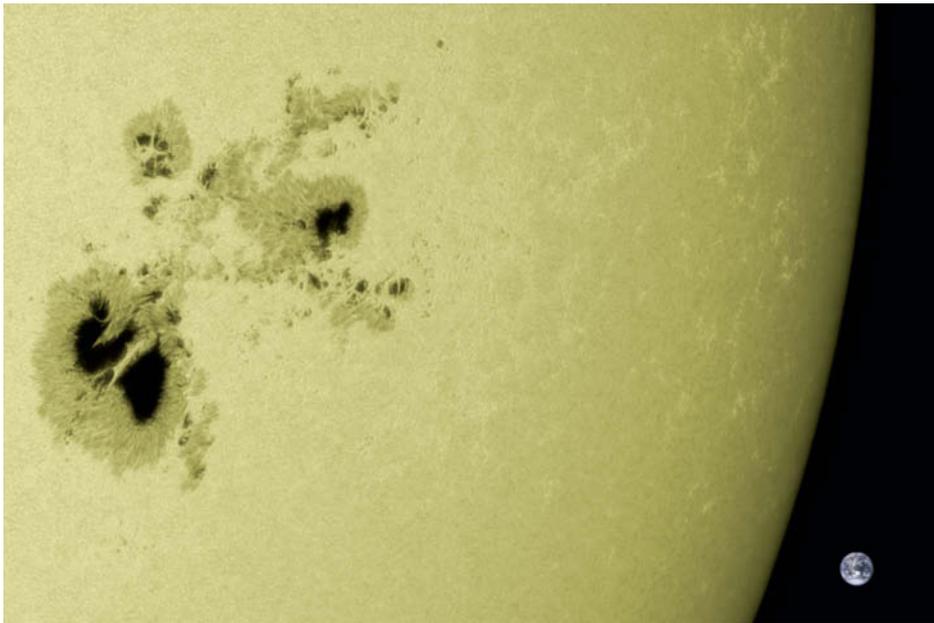
Always attach a solar filter to your camera or telescope BEFORE you point it at the Sun to reduce the incoming brightness to a manageable level. As a comparison, high-quality sunglasses reduce the Sun's brightness to around a sixth of its original strength, while a solar filter only allows one ten-thousandth of the original brightness through. A filter that reduces the strength of the incoming light by absorbing it gets very hot and can easily break as a result. If this happens, you can be suddenly faced with the full strength of the Sun's rays, which will certainly kill your camera's sensor and will also damage your eyes if you happen to be looking through the viewfinder at the crucial moment. The poor quality solar filters are often supplied with cheap telescopes should NEVER be used for solar photography.

The best way to filter the Sun's rays is to use a beam splitter that diverts and renders harmless at least 99% of the incoming radiation – for example, using a purpose-built wire mesh. Then reduce the strength of the remaining light still further using

The seething convection cells on the Sun's surface can measure as much as 1,500 km (930 miles) across, and they appear and dissipate within minutes (August 1st, 2012)

Canon EOS 5D Mark II | ISO 100 | 5,000mm | f38 | 1/400s | Solar filter | 178 source images





A detail from a solar panorama captured on March 26th, 2014, showing Active Region 12192, which is the largest group of sunspots seen for more than 25 years. The scale image of the Earth shows just how large sunspots can be.

I used an apochromatic lens with a diameter of 130 mm and a Baader FFC (Fluorite Flatfield Converter) to extend the focal length from 1,200 to 4,500 mm. I filtered the sun's rays using a Herschel wedge with an additional ND filter, and the final image was constructed from 114 source images captured by a Canon EOS 5D Mark II and merged using the 'lucky imaging' technique.

conventional gray or color filters. The most common type of beam splitter, called a Herschel wedge, was named after its inventor, astronomer John Herschel. These start at around \$300 and are not used directly on a camera, but rather in conjunction with a telescope with a medium-sized aperture.

The cheapest way to get started photographing the Sun is to put aluminized film in front of the lens. The film reflects rather than absorbs most of the incident radiation and therefore prevents heat damage to the lens. The same technique can also be used for large-aperture telescopes. In both cases, you need to make doubly sure that the film is firmly attached so that it doesn't tear or get dislodged by the wind.

Do not experiment with other types of foil that are not purpose-made for solar observation applications. Substandard foil not only reduces the optical quality of the results, it also increases the risk of filtering too little ultraviolet and infrared radiation. Because our

eyes don't have receptors for these types of radiation, using an inappropriate filter foil poses the risk of serious damage to your eyes because there is no dazzle to warn you of the danger.

Foil sold under the Baader AstroSolar brand is of sufficient quality and comes in various sizes, starting at around \$25 for a letter-sized sheet. See the next page for a step-by-step guide to making your own lens-mounted filter. The foil is available in ND5.0 and ND3.8 strengths, where ND stands for neutral density. The number denotes the number of powers of 10 by which the strength of the incident radiation is reduced. ND5.0 foil is usually sufficient to reduce brightness to a level (one one-hundred-thousandth) that is



This illustration shows a solar photographic setup comprising a Herschel wedge, an ND Filter, a Baader FFC, T2 extension rings and a Canon EOS 5D Mark II. The beam splitter in the Herschel wedge only allows 1% of the incoming light through and the rest is refracted downward. Glass filters inserted into the already filtered light path don't get too hot and present no additional risk. This is the best – but also the most expensive – way to filter sunlight. The Baader FFC increases the effective focal length of the telescope.

Build Your Own Solar Filter

Solar filter foil is available in various sizes, starting at around \$25 for a letter-sized sheet, which should give you enough material to build a filter for your camera lens, a telescope and possibly even an additional telephoto lens if you have one.

As well as the foil, you need double-sided tape, card, glue and a selection of suitable modeling knives – all things that you probably have at home anyway.

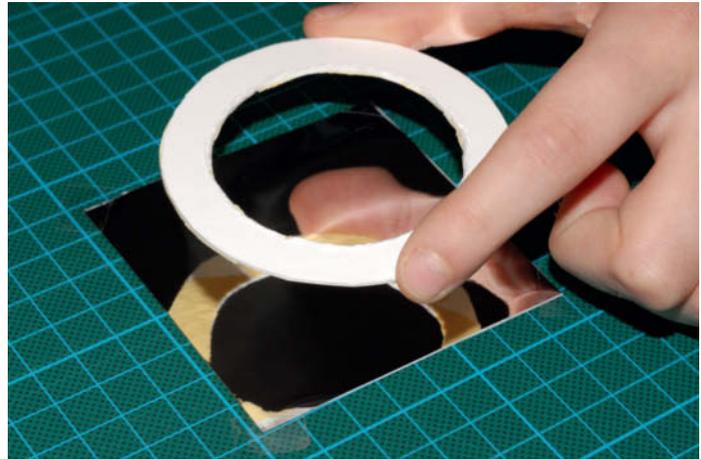
Before you begin, please note:

- Solar filter foil is available in ND5.0 and ND3.8 densities. ND3.8 is designed for use with extremely short exposure times and must not be used for solar observation unless you use additional filters. Always use ND5.0 foil if you can.
- Avoid touching the parts of the foil that are directly exposed to incoming light with your fingers. The foil is quite robust, but fingerprints reduce the optical contrast and the quality of your results. Only ever handle your filter by its edges.

1 Cut rings from the card that match the size of the front element of your telescope or lens and use double-sided tape to affix two rings to either side of a piece of foil. Make sure that the foil is not overstretched, and also that it doesn't have any wrinkles, which reduce the sharpness of the resulting images. Slight 'waves' in the surface are less critical. The best way to ensure an even surface is to tape the foil to the table before you attach the first card ring.

2 Wrap strips of card around the front element of your telescope or lens and tape them together to form a tube. Make sure the tube is stiff enough and that it fits snugly enough to resist jolts and the effects of wind.

3 Glue the filter to the ring, making sure that no stray light can escape along the join, as this reduces image contrast. Use tape to cover the join if you are in any doubt. The finished filter in use on a Canon compact is shown in the illustration on the next page.



Taping the filter foil to a cardboard ring



Making the tube for the telescope or lens



Fixing the filter to the tube



A Canon compact fitted with a home-made solar filter. The camera's 20x optical zoom is powerful enough to make large sunspots visible.

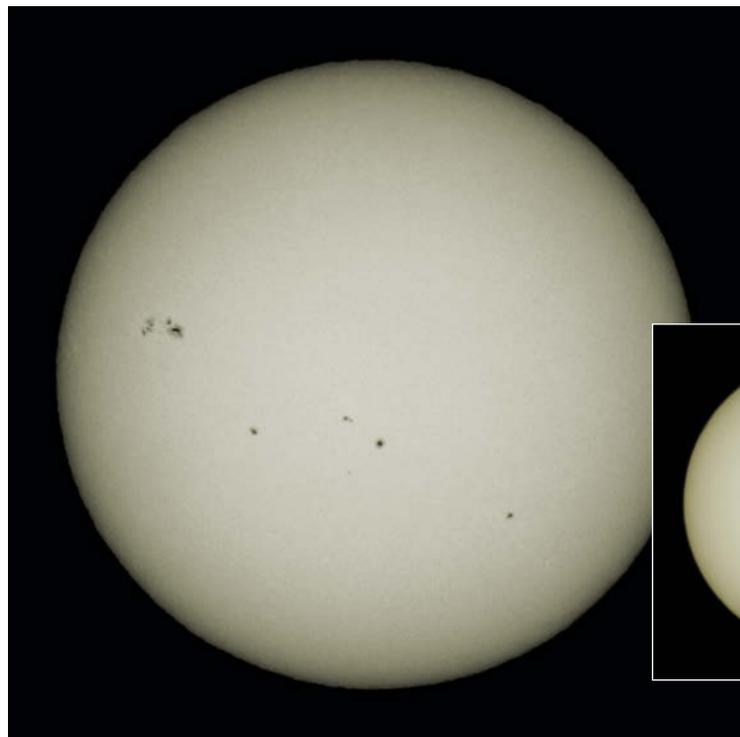
tolerable for human observation without the use of additional filters. ND3.8 foil delivers an image that is more than ten times brighter than ND5.0 and is only suitable for shooting at extremely short exposure times. Great care is required at all times when using ND3.8 foil, and looking through a DSLR viewfinder while using it is not safe.

How to Shoot Photos of the Sun Without a Telescope

The Sun's angle of coverage is so narrow that you can cover it up completely with an outstretched little finger. This means you need to use extremely long telephoto focal lengths to produce frame-filling images of the Sun. Even a 1,000mm equivalent focal length lens produces an image of the Sun on the sensor that is just 9mm in diameter, and longer lenses are prohibitively expensive. The best way to produce sharp images of small details on the Sun's surface is therefore to use a specially equipped telescope.

Nevertheless, you can capture adequate overview images that show large sunspots using a bridge camera with a long zoom, such as the Panasonic Lumix DMC-FZ200, even if you cannot fill the frame with the subject.

If you have access to one, a DSLR with a 400mm (or longer) lens is a better alternative. Mirror telephoto lenses offer long focal lengths (usually 500 or 1000mm) in affordable, relatively compact units. The



A DSLR fitted with an EF 100-400mm telephoto zoom and a 1.4x teleconverter shows a lot more detail than an image shot with a compact – for example, these relatively small sunspots from January 1st, 2015

Canon EOS 5D Mark II | ISO 100 | 532mm | f8 | 1/250s | Solar filter

Russian Maksutov MTO-11CA lens enjoys an almost legendary reputation among astrophotographers, with its 1,000mm focal length and fixed aperture of f10. This particular model is a standard part of many eclipse photographers' setups. The lens itself has an M42 screw mount, but adapters are available for most popular cameras. You can usually find used examples in online auctions for around \$200-300. The MC Rubinar 500mm f/5.6 is a good alternative capable of capturing most of the corona produced by an eclipse.

Capturing Eclipses

You can use a camera equipped with a mirror lens to capture all the phases of a partial eclipse. The small portion of the frame covered by the bright Sun will probably cause your camera's automatic exposure circuitry to fail, so, if it has a manual exposure mode, taking test shots at low ISO values is the best way to approach such a shoot. Once you have

This huge sunspot was captured handheld on October 23rd, 2014 using a Panasonic Lumix FZ48 bridge camera fitted with a foil filter and set to an equivalent full-frame focal length of 735mm. Merging seven source images helped to reduce image noise.

Panasonic Lumix FZ48 | ISO 200 | 108mm | f5.2 | 1/200s | Solar filter | 7 source images

Image:
Daniel Fischer,
Königswinter, Germany



Photo: Klaus-Dieter Fischer, Mühldhausen, Germany

This relatively compact Rubinar 500mm f/5.6 lens is a favorite among solar and eclipse photographers

found appropriate parameters, you can keep using them until significant changes in the clouds or the position of the Sun make an adjustment necessary.

Begin shooting when the Moon begins to cover the Sun and try to capture images at consistent intervals of five or ten minutes. If you are using a tripod and you want to fill the frame with the subject, you will, of course, have to continually adjust your framing to follow the Sun's path across the sky. The sequence is over when the Moon no longer covers any part of the Sun.

Even though most photographers consider a cloudless sky ideal for photographing an eclipse, clouds can add drama to your images. However, it is better to leave adjustments in exposure to the camera's automatic exposure meter if moving clouds make your scene significantly darker or brighter.

The Sun will have a color cast in your images that depends on the type of filter foil you use, but this is simple to correct during post-processing. Although the Sun's light is actually white, many photographers find a slightly yellow tone more aesthetically pleasing and adjust their images accordingly.

The only time you can ever photograph the Sun without using a solar filter is during a total eclipse, when the full beauty of the Sun's

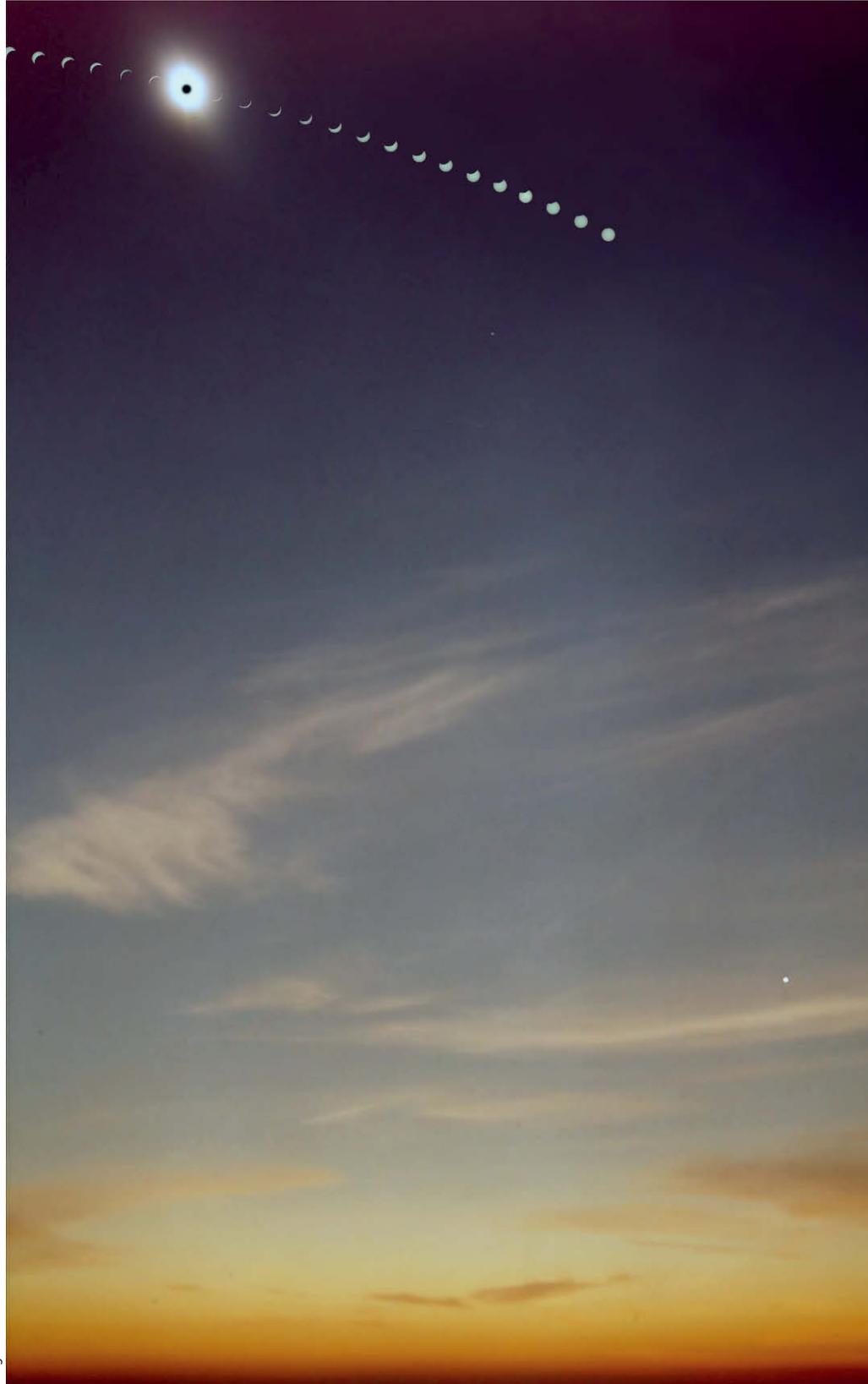


Image: Klaus-Dieter Fischer

A sequential image of the total eclipse that occurred on March 26th, 2006. The moment of totality and the clouds in the foreground were captured without a filter, and the other, filtered images were captured at intervals of five minutes during the rest of the eclipse and merged with the main image during post-processing. The bright point at bottom right is the planet Venus.

Image: Claus-Dieter Jahn, Leipzig, Germany



Clouds can add drama to images of partial eclipses. This photo was captured on October 3rd, 2005 using a 500mm f/5.6 Rubinar lens.

Canon 300D | ISO 100 | 500 mm | f5.6 | 1/4000 s

required exposure times range from 1/100 to several seconds, so the best way to capture the corona is to use a bracketing sequence that you can merge into a single image later on. Remember to re-attach your filters to all of your lenses and telescopes before the totality ends – otherwise, you are sure to end up damaging your camera's sensor. Anyone who has experienced the end of a total eclipse will confirm how suddenly the Sun reappears. And remember too, to stop looking through the viewfinder before the eclipse is over.

atmosphere, or 'corona', becomes visible for a few short minutes. At the moment of totality, the corona is several times wider than the Sun itself, so you can use a shorter lens than usual to photograph it. Using an equivalent focal length of 400 mm or more can crop the edges of the corona.

Your camera has to deal with an enormous dynamic range if it is to successfully capture all of the Sun's corona. At ISO 100 and f11, the



Image: Erich Meyer, Linz, Austria

A single shot of the moment of totality on March 29th, 2006 captured in Turkey. The photographer was lying on the ground and captured the shot handheld.

Canon EOS 5D | ISO 160 | 260 mm | f5.6 | 1/200 s | March 29th, 2006



Image: Klaus-Dieter Fischer

The enormous dynamic range of the Sun's corona can be captured using a sequence of differently exposed images. This image was produced using source images captured using a Larson-Sekanina filter on a 500mm f/5.6 Rubinar lens at exposure times from 1/8-1/1000 second. The final image was merged using the *Fitswork* astrophotographic image processing software (available for free from fitswork.de).

An interesting way to document an eclipse is to merge images of each of its phases into a single sequential image. Back in analog times, the best way to do this was to use a relatively short lens that enabled all phases of the eclipse to take place within a single frame and then make multiple filtered exposures at regular intervals. The result was an image with the phases of the eclipse arranged like the pearls in a necklace. It takes the Sun about two minutes to shift by the equivalent of its own diameter, so intervals of 5-10 minutes ensure that the individual exposures don't overlap. This type of image can also be enhanced by an additional exposure of the foreground made without a solar filter.

Digital technology has made shots like this a lot easier; all you have to do nowadays is shoot a sequence of individual source images and merge them digitally later on.

Using a Telescope

If your initial experiments have whetted your appetite for solar photography, you might want to take things further and begin capturing detailed images of the Sun's surface. The best way to do this is using an astronomer's telescope. The Sun is bright enough to capture usable images using a telescope with an objective with a diameter of as little as 100 mm or a small reflecting telescope. Most telescopes allow you to attach a DSLR using a simple T2 adapter, thus transforming them into super-telephoto camera lenses. The size of the telescope objective determines the equivalent focal length. This is often in the region of 1,000 mm, which is sufficient to produce a frame-filling overview of the Sun on an APS-C sensor.

Avoid using cheap department-store telescopes if you can. For beginners, I recommend the Vixen 80M refracting telescope and the Skywatcher NEQ-3 mount. This set costs about \$600 with all the various bits and pieces you need to get up and running.

To produce detailed images of sunspots or the Sun's granulation, you will need a focal length closer to 2,000 mm. The easiest way to achieve this is by adding a projection lens element to the light path between the telescope and the camera to magnify the image produced by the telescope and project the enlarged version onto the camera sensor. You can then use extension tubes fitted between the projection lens and the camera to fine-tune the degree of magnification. The best projection lenses to use are either long-focal-length eyepieces or the 'Barlow' lenses often provided with telescopes. Try as



A Vixen 80M refracting telescope with a Nikon D80 and a solar filter attached. A small astronomical telescope like this can be used with most DSLRs and is much cheaper than a super-telephoto lens.

many options as you can before making a purchase.

It helps if the projection lens you use has a T2 mount, although many field telescopes and Barlow lenses don't. The Baader Hyperion Zoom is a popular Barlow lens with a T2 mount that costs around \$130. The Baader Fluorite Flatfield Converter, the Rolls-Royce of Barlow lenses, costs around \$800. This was the model used to capture the image reproduced on page 124.

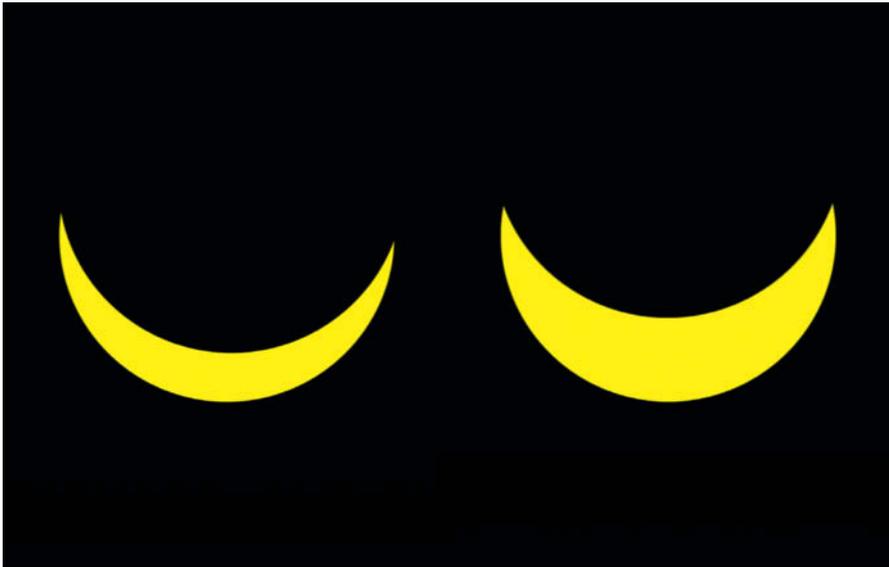
At focal lengths of several meters even the tiniest jolts, such as those caused by the movements of the camera's mirror or shutter, are sufficient to spoil the resulting images, so it is best to use live view mode, which keeps the mirror raised. Use exposure times of no more than 1/100 second to reduce the effects of shutter movements and wind. If all else fails, you can always increase the ISO value to help keep your exposures short. The ND3.8 filter foil mentioned earlier also makes it possible to use shorter exposure times, but remember that you can't use the viewfinder if you are using an ND3.8 filter because the magnified image will be too bright and will damage your eye. Only use live view with an ND3.8 filter and then only if you are experienced and know how to protect your eyes.

Due to atmospheric turbulence, the same flicker effect that occurs above asphalted streets in the midday sun means that even extremely short exposure times don't

guarantee sharp images. Turbulence is always an issue at the high magnifications involved in solar photography and can be reduced but never eliminated. Selecting a viewpoint near



A Zeiss Abbe Barlow lens attached to a Nikon D80 using a T2 adapter. You can use a lens like this and extension tubes to extend focal length as far as you like.



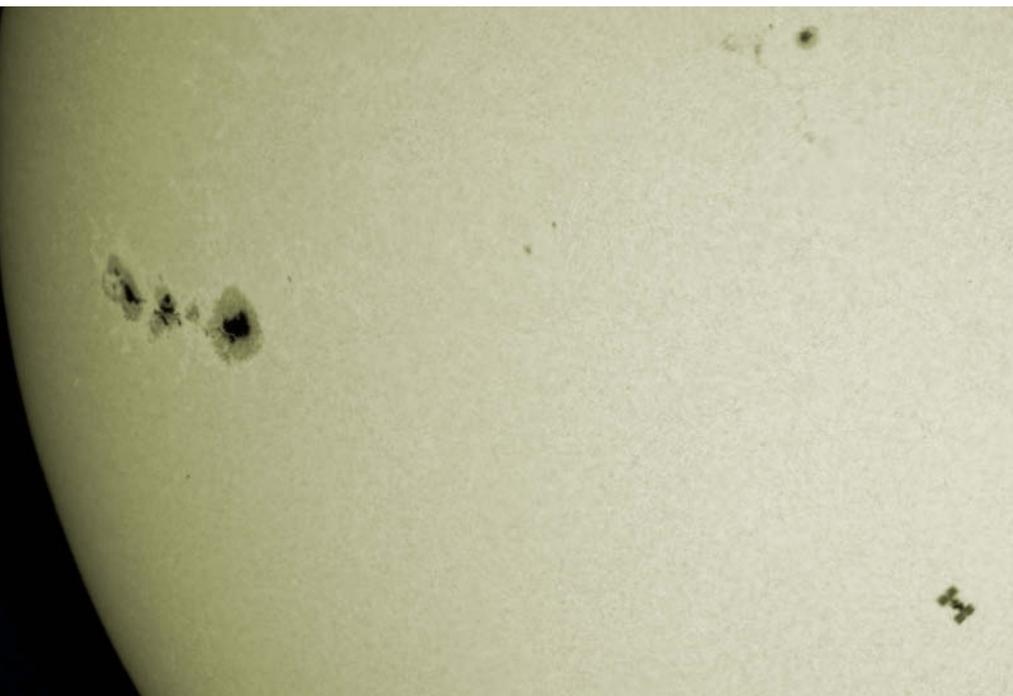
The degree of occlusion during the eclipse on March 20th, 2015 was clearly greater when viewed from Flensburg in northern Germany (on the left) than in Konstanz in the south (on the right).

a cooling body of water or in a meadow helps to keep it to a minimum.

The appearance and timing of turbulence is highly variable, and you will notice that some parts of some of the shots in a sequence are always much sharper than the rest. You will only be able to capture a completely clear shot with perseverance and a little luck.

The 'lucky imaging' technique, originally developed for use with video streams,

searches sequences of identically framed shots for sharp areas and combines the ones it finds in a single image. Because the appearance of the Sun's surface changes rapidly, you have to shoot lucky imaging source photos within the space of a few minutes so that they don't vary too much. The image on page 124 shows what lucky imaging is capable of. This particular image was made from 114 separate source photos shot in four



minutes using a full-frame DSLR. None of the source images comes anywhere near the quality of the merged version.

The images were merged using Michael Theusner's free *AviStack2* software (see www.avistack.de for details). Once you have set the software up, you can sit back and let your computer to do the donkey work. On a quad-core computer, the program can take several hours to process a sequence of 20-megapixel images, and you'll need to apply a sharpening filter to the final image to get the best out of all the detail it contains. *AviStack2* includes a wavelet-based sharpening method, although I prefer the results produced by the *Mexican Hat* filter built into Georg Dittié's free *Giotto* (www.giotto-software.de). To finish up, use your favorite image processing program to perform any color corrections, toning or other fine-tuning steps.

ISS Flyby

If you plan carefully or strike it lucky, you should be able to capture images of the International Space Station (ISS) silhouetted against the Sun. The higher in the sky the orbit of the ISS, the closer it is to Earth and the larger it appears in photos. The problem here is that the closer it is, the faster it zooms past. Even when it crosses the Sun at its widest point you will only have about a second to capture it. The lower it flies by, the quicker the window of opportunity closes.

This means you have to use a short exposure time of 1/1000 second or less (the ISS travels its own length in about 1/100 second) to keep it looking even slightly sharp. Most importantly, you have to release the shutter at precisely the right moment. Simply waiting for the ISS to appear in the viewfinder is not a good idea, and you are more likely to score a hit if you take a sequence of images around the moment when the space station is due to appear. However, even if you use burst shooting mode, good timing is still essential. As soon as your camera's write cache is full, its burst rate is drastically reduced, so the ISS should be out of the frame by the time this happens.

A lucky hit! This shot of the ISS is part of a sequence shot on September 24th, 2009. The ISS was moving too fast to capture it sharply using an exposure time of 1/500 second.

Canon EOS 5D MKII | ISO 200 | 4500 mm | f35 | 1/500 s | Solar filter

Waiting for the ISS to turn up in one of your Sun shots by accident is a bit like waiting to win the lottery, although it did happen to me once. However, because I was shooting the Sun rather than the ISS, I was using a slow exposure time of 1/500 second and the ISS looked pretty blurred in the resulting shot (see the image opposite).

The website at <http://iss.astroviewer.net> offers an interactive interface for calculating visible passes at your choice of location and, if you are prepared to drive a few miles, you will usually find an opportunity to capture photos of the ISS within a month or two from just about anywhere. Try to avoid shooting at a time of year when the Sun is low in the sky, as the ISS is then furthest away and appears too small in the resulting photos.

Capturing Gas Eruptions

All of the techniques discussed so far are dedicated to capturing images of the Sun's surface or 'photosphere' and are not intended to capture images of the enormous protuberances and gas eruptions that occur regularly in the corona region above its surface. This is mainly because the light produced by these phenomena is much weaker than that of the photosphere and is usually simply not visible.

However, with some technical know-how and a couple of simple tricks, you can capture photos of all sorts of sunquakes, solar flares, eruptions and protuberances.

The Sun's surface radiates a continuous spectrum that includes colors of all wavelengths from ultraviolet to infrared, whereas the relatively weak light of a protuberance is limited to one of a few discrete wavelengths that belong to the 'H α ' (hydrogen-alpha) group. To capture these, you have to use a special filter that allows mainly H α wavelengths to pass. This doesn't weaken the light coming from any protuberances too much but almost completely blocks out the light coming from the photosphere. In turn, this massively increases the contrast between the Sun and its coronal activity and makes it possible to observe and photograph these phenomena at leisure.

A planned shot of the ISS, captured on September 11th, 2010. The fast 1/4000s exposure time kept both the ISS and the details of the Sun's surface sharp.

Canon EOS 5D MKII | ISO 400 | 3000mm | f23 | 1/4000 s | Solar filter

Constructing effective H α filters is a complex process, and the larger models designed for use with telescopes can cost as much as several thousand dollars (i.e., more than the telescope itself). You also have to take care when using one if you want to

avoid observing damaging infrared light. For amateur use, a good alternative is a purpose-built H α telescope, such as the Lunt LS35THa or the Coronado Personal Solar Telescope (PST), both for around \$1,000. These models have relatively small apertures



(35mm and 40mm respectively), but are fine for observing a range of solar activities.

These telescopes are designed for observation only, although it is possible to attach a DSLR to one if you are prepared to tinker a little. If you replace the telescope's eyepiece with a DSLR and a T2 adapter, the resulting range isn't sufficient to capture the Sun in sharp focus. However, a quick Web search for "Coronado PST adapter" turns up various home-build projects, and German company Teleskop Service (teleskop-express.de, also in English) sells a custom PST-to-T2 adapter.

Viewed laterally, coronal gas phenomena appear in $H\alpha$ light either in the form of bright luminous arcs or single prongs or 'spicules'

The Coronado Personal Solar Telescope (PST) is designed for observing phenomena that take place above the surface of the Sun. It works by transmitting the $H\alpha$ wavelengths at which gas events shine brightly, making it particularly easy to observe protuberances and filaments. The DSLR is attached using a custom eyepiece and a T2 adapter.



Image: courtesy of Teleskop Service



Image: Peter M. Oden, Bonn, Germany

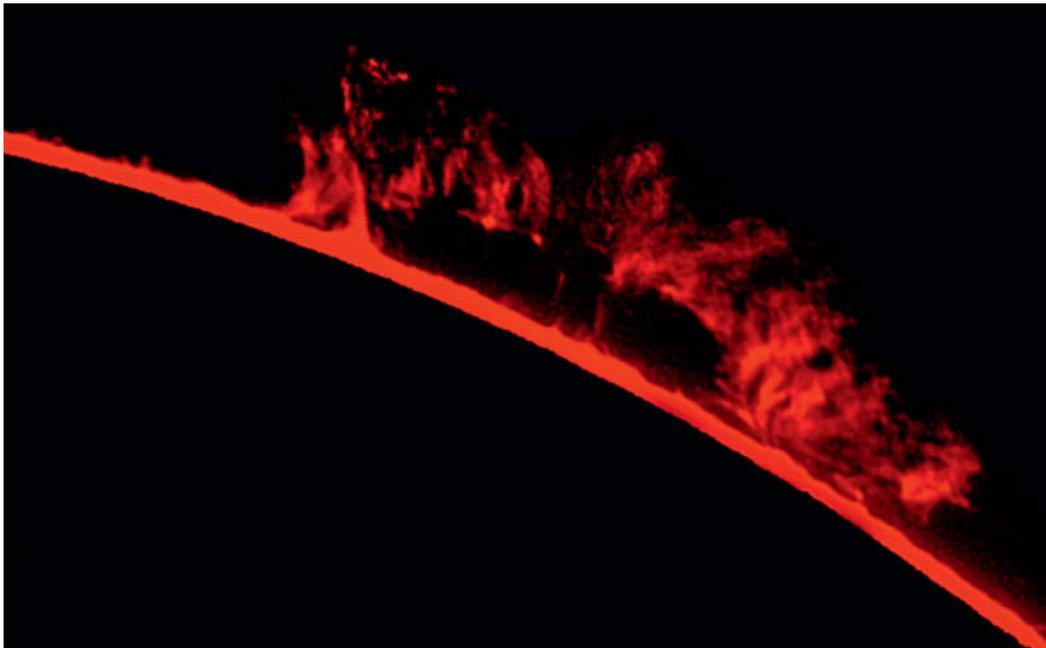


Image: Reinhard Pankrath

An H α shot of a solar protuberance. To increase resolution, the photographer replaced the lens of his Coronado PST with a 1000mm model with a 102mm objective.

that show up well against the darkness of space. Viewed from above, the gas masses involved show up as dark filaments. Capturing photos of solar protuberances requires much longer exposure times than shots of the Sun itself, so you need to take a long exposure to capture the protuberance and a shorter one to record the disc of the Sun and then merge them on a computer.

Because an H α filter only allows a narrow band of wavelengths to pass, the resulting images are monochrome. Although many photographers present their photos in black and white, digitally adding a deep red tone adds appropriate drama and depth to images of solar activity.

The Fascination of the Sun

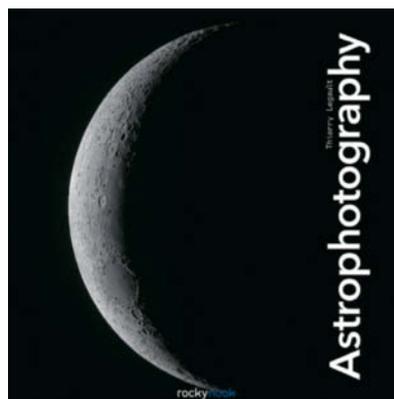
The Sun is a multi-faceted photographic subject that offers a broad range of technical and aesthetic challenges and rewards photographers with fascinating insights into our planetary system's central source of

energy. The Sun deserves to be seen as more than just a source of light for earthbound photos.

Perhaps photographing the Sun will get you interested in other aspects of astrophotography, and digital technology makes it possible for anyone to capture

photos of planets, galaxies, supernovas and much more besides. If this article has whetted your appetite, we recommend that you read Thierry Legault's fantastic book *Astrophotography*, currently available to readers of *c't Digital Photography* at a special price (see the box below). (jr)

Book Tip: Astrophotography



This book has deservedly become a standard reference on astrophotography. Thierry Legault's clear, no-frills approach makes it a joy to read and opens the wonderful world of astrophotography to everyone.

The book contains a wealth of background knowledge on digital photography as well as practical tips on

complex subjects such as how to reduce background and thermal noise in your images. The text is highly detailed and will help you understand exactly why your photos turn out the way they do and how to continually improve your technique. Legault also goes into plenty of detail on the gear involved and even provides formulae for calculating image size and resolution. He also discusses images of Mars, Jupiter and Saturn – all planets whose surfaces can be observed and captured in detail. There are chapters on the Sun, the Moon, comets, asteroids and galactic photography outside of our own solar system. This book makes fascinating reading and is full of spectacular images. Visit www.rockynook.com/shop/photography/astrophotography and enter the coupon code *astroct29015* to get a **35% discount** off the cover price of the eBook version. This offer gives you access to PDF, EPUB and MOBI formats and is valid until November 15th, 2015.



This image is the result of merging two H α images captured on September 24th, 2011. The dimmer surface activity was exposed for much longer than the main body of the Sun.

Coronado PST | 40mm | f10 | DMK 21 USB camera | 1,000 superimposed frames

Book Review



50 Years of Wildlife Photographer of the Year: How Wildlife Photography Became Art

Rosamund Kidman Cox
 Published by Knesebeck
 256 pages, 190 color illustrations
 11.3 x 11.3 inches, Hardcover
 \$49.95
 ISBN: 978-0-56509-351-8

50 Years of Wildlife Photographer of the Year

How Wildlife Photography Became Art

Both terrifying and beautiful: German publisher Knesebeck has come up with a stunning coffee table book to mark the 50th anniversary of the "Wildlife Photographer of the Year" award. These 200 photos reveal the dazzling beauty of the plants and animals around us, but at the same time confront us with the vulnerability of our threatened ecosystem.

We lurch from the pinnacle of delight and fascination to the depths of shame and anger, longing to lose ourselves in the red, blue and green magnificence of a bird of paradise, only to be sickened at the sight of the severed head of a monkey that urges us to turn the page as quickly as possible.

But it is this juxtaposition that makes the book and the photo competition exceptional. The book's strategy is not to lull us into complacency with photos that are nice to look at. Instead, it consistently brings us crashing back to reality, reminding us in an instant of the

harsh world that we have created out of what was once paradise.

50 Years of Wildlife Photographer of the Year also manages to chart the history of wildlife photography, from a means of documenting botanical information to its status as an art form in its own right. It goes right back to the beginning, with William Henry Fox Talbot's photogenic image of a fern in 1839, and explains how he placed the fern frond on a piece of paper treated with silver nitrate and a salt solution, covered it with a plate of glass and let the sun finish the job.

It was many years before the first images of animals in the wild were captured, and even longer until the competition was established and aesthetics began to dominate the field of wildlife photography.

The book covers all these phases by way of interesting and engaging anecdotes, as well as with fascinating images that thoroughly deserve our attention. (ssi)



Image: Daniel Beltrá/Knesebeck



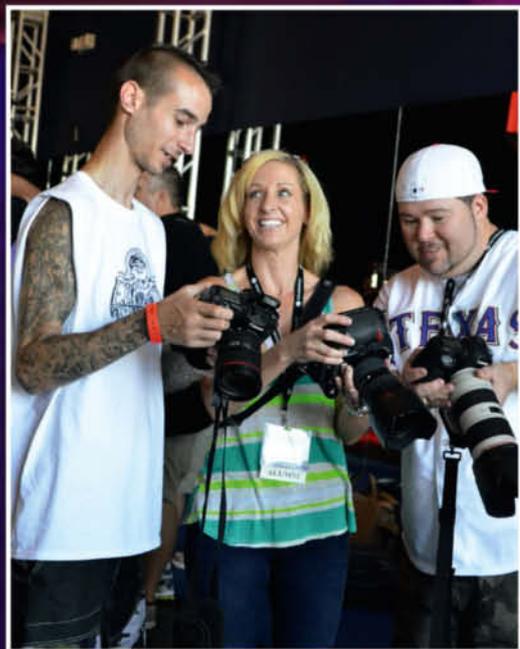
Image: Tim Laman/Knesebeck

This book shows us fascinating and wonderful impressions of nature, and contrasts these with photos that document the vulnerability of our planet and the threat posed to it by mankind

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Coming up in Issue 21

● ● ● ● ● available from September 24

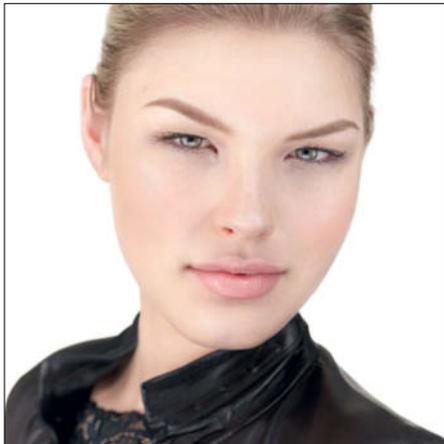


Photo: Head Quarters Studio

70-200mm Telephoto Zoom Test

Telephoto zooms cover a really useful range of focal lengths that give you plenty of scope for bringing distant subjects closer and producing beautiful background blur. Many are great all-rounders that are ideal for sports, nature and portrait use. We test fast, high-end models from the major camera manufacturers and compare them with cheaper alternatives from third-party suppliers.



Image: Canon



Photos: Martin Vieten

The Art of Headshots

Peter Hurley is one of New York's premier portrait photographers and came to prominence with his unique headshot shooting style. This article gives you the low-down on what headshots are, why you need one and the role they play in creating digital identities. The accompanying workshop explains how to use simple setups to shoot your own great-looking headshots.

Sharpening with Photoshop

Sharpening is an essential part of the digital image creation process and without it, most digital photos would look dull and lifeless. Images are sharpened either in the camera immediately after shooting or later using dedicated computer software. *Photoshop's* Smart Filter technology is one of most versatile sharpening methods around, and this article tells you all about how to apply it.

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