Free DVD inside

Urban Photography • Hardware Tests • Drones • Free Software

c't Digital Photography

The in-depth quarterly for the photo enthusiast

Camera Mega-Test

Ruggedized, Super Zoom and High-end Compacts

High Speed Imaging

With graphics acceleration

Photo Drones

Fun with multicopters

Tripod Test

Stability under pressure

A3 Printers
Print Retouching

Big City Photography

Capture the Urban Spirit

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The Girl in the Picture, Kim Phuc, Napalm bombing in Trang Bang, South Vietnam, June 8, 1972 (©Nick Ut, Corbis, AP)

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Nick Ut and Kim Phuc

Mekong Delta

A generation of people will never forget the 1972 Life Magazine cover image. Historians credit it with helping end the Vietnam War – symbolizing what words cannot convey, the iconic image of the 'Napalm Girl' still instructs us about the impact of photojournalism, social change and healing from conflict.

Join Kim Phuc and Nick Ut on their first-and-only historic return to Vietnam. Insider's access to key people and places give travelers an unprecedented experience of Vietnam.

We invite you and your family to experience a life-changing immersive holiday. Understanding history's lessons first-hand, we are better equipped to participate as ethical citizens of a global community.

Highlights Include

Experience Saigon's legendary buzz
Savor French colonial charm
Photograph rare scenery with Pulitzer Prize-winner Nick Ut
Boat the mighty Mekong Delta
Witness Kim Phuc's historic return to Trang Bang
Crawl the infamous Cu Chi Tunnels
Honor U.S. veterans on China Beach
Relax in Hoi An's tropical seaside luxury
Shop modern and traditional markets

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This issue's article on big city photography takes you to the pulsating life, social contrasts and architectural surprises that make cities such fantastic photographic subjects. As well as getting inspired by the wealth of scenes on offer, our author, pro photographer Torsten Andreas Hoffmann, delves deeper and explains why he sees photography as a creative act. Before you even unpack your camera, simply asking yourself what you want your photos to convey will help to get your creative juices flowing. What feelings do you want to capture and what is special about the mood you wish to communicate? Our in-depth workshop shows you how to use this approach to build up your own visual language and will help you to develop your photography and create true photographic art instead of just capturing snapshots.
To help you on your way, our tripod test tells you all you need to know about the best of the current crop of light and mid-weight camera supports, while our camera mega-test reviews the latest travel zooms, super zooms, ruggedized models and fast-lens compacts, and reveals which are the best to take with you on your next trip to the city.

Have fun honing your skills and see you again next time ...

Juergen Rink

P.S. Don't miss our exclusive ***c't*** *Digital Photography* nature photography seminar in Santa Monica on October 19th. Book now to take your place among some of today's top pro nature and landscape photographers. Check page 36 for more details.

Portfolio

Sterile aesthetics are the hallmark of Lauren Marsolier's images. Do they symbolize the the disorientation that is rife in the modern world, or are they simply fascinating pictures of a slightly skewed look at life?

Photo Drones

Attaching your camera to a remote-controlled drone gives you access to previously unthinkable vantage points for as little as a few hundred dollars. We take a look at how drones work and give you all the info you need to take off on your own.

Compact Camera Mega-Test

We test 17 compact and super zoom cameras, from cheap and cheerful to high-end and waterproof models. Today's cameras are more highly specified than ever, but does technical progress add up to better images in the real world?

Big City Photography

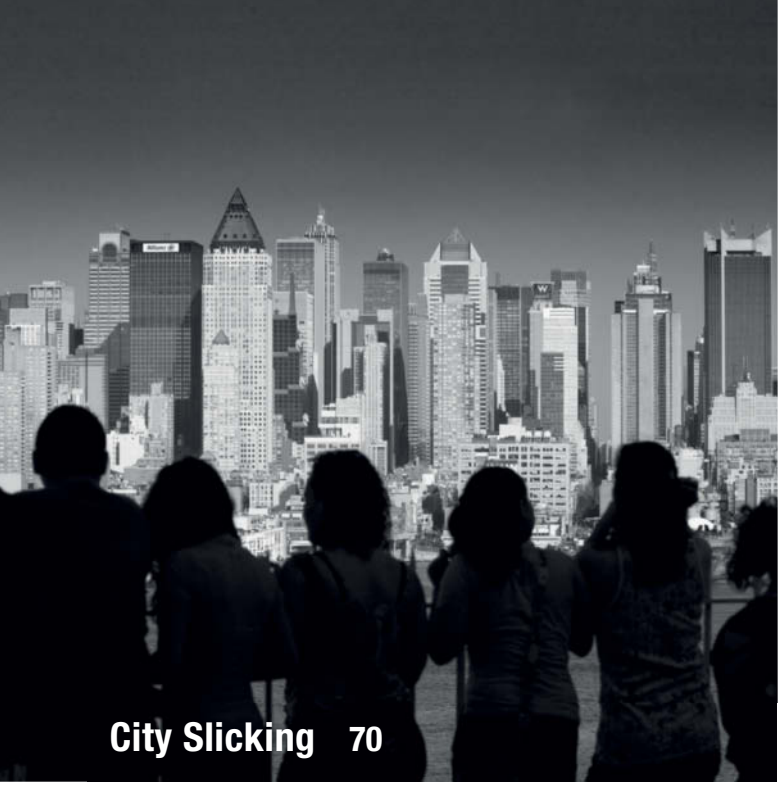
Cities offer life in all its colorful diversity, architectural surprises and an unbeatable selection of subjects. This article will help you develop your own visual language when shooting off the beaten track.

Tripod Test

Carbon fiber or aluminum? Pan/tilt or ball head? Lightweight and portable or big and heavy? We put a selection of tripods through their paces and give you the low-down on what they are really capable of.

Home Printing Workshop

We test a range of large-format printers with a selection of different papers to help you decide when high-end home printing is worth the effort. We also give you valuable tips on retouching your own prints.



Web Publishing with Koken

Koken is a simple Web publishing solution aimed specifically at photographers and designers. This article explains how to use it to get your own photo website up and running.

Accelerated Imaging

Graphics acceleration techniques can be used to get the most out of a computer's processing power. We test a range of onboard and discrete graphics processors and come up with some surprising results.

About Us

DVD Download

If your copy of the magazine contains no DVD, navigate to www.ct-digiphoto.com/dvd132013 to download the DVD content for free.

Free DVD

Free Full Version Software: PhotoAcute Studio

PhotoAcute Studio processes sets of images taken in continuous mode to produce high-resolution, low-noise images. It also corrects image geometry and chromatic aberrations, and expands dynamic range.

Free Full Version Software: Zoner Photo Studio 15

A comprehensive image processing, management, archiving, presentation and sharing tool.

Videos

- Car Shoot with pro René Staud
- On Location with star photographer Steve Thornton
- Robert Leslie's Road Trip through the USA
- Composition Using the Golden Ratio

Readers' Letters

Popular Tree in the Namib Desert

First off, let me say thanks for such a terrific magazine – incredibly exhaustive content, intelligently presented with hardly any adverts. As the Brits are fond of saying, Well done you! I did notice one curious thing though. The cover of your Summer 2013 issue is nearly identical to the sample image used in my Snapseed app on the iPad! That oddity aside – and it's a small world we live in to be sure – please keep up the good and great work!

Steve Soper (not the race car driver, the one in Rhode Island, USA)

Tell us what you think:

We are always happy to receive your comments and suggestions in a letter, an e-mail to editor@ct-digiphoto.com or at www.facebook.com/ct-digiphoto. We reserve the right to abbreviate your input for publication. Our comments are printed in italics.

How About Andreas Gursky?

You probably know Andreas Gursky, right? If you were to publish a technical (not biographical) article about him with a cover picture too, I am sure it would give the magazine a big boost. Just a dream!

Maxim Dupliy

Superior Print Publication

I grew up reading ***c't*** bought at kiosks in Germany and now live in the USA. Today, I came across a copy of ***c't*** *Digital Photography,* so I just wanted to say 'Hi' and congratulate you on producing a superior, informative photo magazine in print form. In view of the poor competition here, I was really happy to find your magazine!

Florian Boehm

Pentax K5 Test

Issue 12 has just arrived in Australia, and along with issue 1, has to be my favourite. The best thing in this issue was the mention of the Pentax K5 II s, which I am thinking of buying as I have been a Pentax user for over 35 years. Keep up the great magazine.

Bob Broadhead

Choice of Test Lenses

This concerns the article *Full Frame and System Camera Test* in issue 12. Specifically, I have a question about the test methodology used for the test results. Other than the Sony RX1, why did you choose lens/camera combinations for most of the tests resulting in widely varying 35mm equivalent focal lengths? For instance, the EOS 6D was tested with a 50mm equivalent lens, but the Nikon D600 was tested with a 105mm equivalent lens. How did you make these choices?

Gary Androphy

The tests were carried out by independent photo engineers at a lab in Cologne who are often some of the first to get test samples directly from the industry, often even before the press. Their methodology involves using proven high-quality fixed focal length lenses to obtain the best possible results while keeping an eye on the affordability of the lenses in question. For the AF speed tests, they use what they believe to be AF-optimized lenses or kit zooms, depending on availability. I have often argued that readers would prefer us to use the standard kit lenses for our tests but, especially in the upper price range, such camera/lens bundles are not always available. ***c't*** *is currently investing in its own testing facilites but, until we have full control over the test procedures, we will advise the lab staff to vary the test lenses they use as little as possible and use kit lenses whenever they are available. (Dr. Klaus Peeck)*







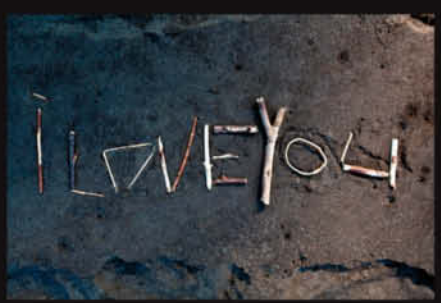
















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DVD Highlights & Contents

This issue's free DVD includes a wide range of image processing and photo tools, including free full versions of PhotoAcute Studio and Zoner Photo Studio. To get your creative juices flowing we have also included videos of top-flight photographers at work on location and in the studio. Sample images from our comprehensive lens test and a video tutorial on composition using the Golden Ratio round out this issue's offerings.

Car Shoot with René Staud

Video tutorial: This video gives you a privileged look over the shoulder of pro photographer René Staud as he prepares and photographs the famous Porsche 911.

Capturing impressive auto shots is an art in itself, and pro photographer René Staud is a master in his field. His specialty is the virtuoso use of light, and this video lets you in on some of his best-kept secrets.

We take you behind the scenes of an exclusive shoot of the Porsche 911 S Turbo he Staged for his project *The Porsche 911 Book*, published by teNeues. The world-famous 911 is a success story that began 50 years ago with the introduction of the first production model at the 1963 Frankfurt Auto Fair.

René takes us through all the steps involved in capturing top-notch images of this exciting vehicle, from polishing the metalwork before the shoot to choosing the right background and setting up the bombastic lighting. Have you ever seen a 30-foot softbox in action? His attention to the tiniest details – like the exact position of each wheel in this shot – is what makes René's work really stand out. The aim of all this effort is to portray the car's wonderful design in perfect harmony with its surroundings.

This video takes you all the way from the first test shots, taken using a Leica S2 DSLR, right up to the final sophisticated image. (sea)

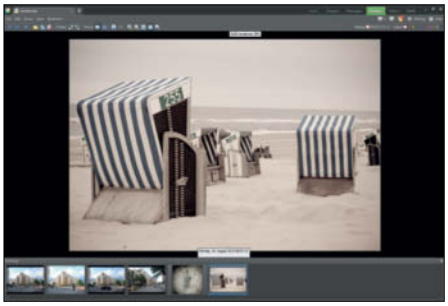
PhotoAcute Studio 2.96

Full version software: PhotoAcute is the perfect tool for improving the quality of images captured using smartphones, compact cameras and less powerful DSLRs.

Excessive noise or unwanted details can ruin an otherwise perfectly good image. *PhotoAcute Studio* uses sequences of images shot in continuous mode to work its magic, and uses the minimal shift between source images to generate a range of useful effects and optimization steps.

The program uses its unique approach to increase resolution, reduce noise levels and increase depth of field. It is also capable of correcting distortion and reducing fringing effects. Its ability to remove moving objects from image sequences is particularly useful in candid situations and built-in HDR functionality rounds out the comprehensive range of tools on offer. It supports the DNG RAW format and can output results to DNG for further optimization in *Lightroom* or other image processing programs.

Use of the full version requires free registration. ***c't*** *Digital Photography* readers will receive an additional 40% discount on purchases of version 3 of the program (includes updates for one year), and the serial number this includes is also valid for full versions of the HDR software *HDRAW* (hdraw.net). This offer expires on January 31, 2014. (tho)



Zoner Photo Studio Pro 15

Full version software: A comprehensive image processing, management, archiving, presentation and sharing tool for all your photo workflow needs.

Zoner Photo Studio 15 is all you need to take complete control of your digital photo workflow. The program's broad-based functionality starts making life easier with its simple import tool and offers many ways to systematically sort and organize your images, including batch renaming and automatic backups to keep your photographic treasures safe.

Alongside its management tools, *Zoner Photo Studio* is packed with manual and automatic editing tools, and commonly used effects such as exposure, contrast, tonal range and sharpness correction form the central element of the user interface. A range of selection and retouching tools and red-eye correction are also part of the package, and the manually adjustable tilt/shift effect is a real bonus for those who like to experiment with visual effects. For new users, there is a step-by-step launch guide and built-in tutorials that demonstrate creative photo edits

Automatic upload to popular social networks (Facebook, flickr, Picasa Web Albums) complete the range of functionality on offer. This issue's free DVD includes a free full version of *Zoner Photo Studio Pro 15*. (sea)

Image Processing Tools

Windows

Fotomatic 1.4
GIMP 2.8.6
GIMP Portable 2.8.6
GREYCs Magic Image Converter (GMIC) 1.5.6.1
Image Analyzer 1.35
Inkscape 0.48.4
Inkscape Portable 0.48.4
Pencil 0.4.4b
PhotoAcute Studio 2.96 **full version**
PSPI 1.0.7
Zoner Photo Studio 15 Pro **full version**

Mac OS

GIMP 2.8.6
GREYCs Magic Image Converter (GMIC) 1.5.6.1
Inkscape 0.48.2
Pencil 0.4.4b
PhotoAcute Studio 2.96 **full version**

Linux

Pencil 0.4.4b
PSPI 1.0.7

Photo Tools

Windows

ExifTool 9.34
FastStone Image Viewer 4.8
FastStone Image Viewer Portable 4.8
GTKRawGallery 0.9.8
jAlbum 11.4
Piwigo 2.5.2
WordPress 3.6
XAMPP 1.8.3
XAMPP Portable Light 1.8.3
XnView 2.04
XnView Portable 2.0.4

Mac OS

ExifTool 9.34
jAlbum 11.4
MacPorts 2.2.0
Piwigo 2.5.2
WordPress 3.6
XAMPP 1.8.3

Linux

ExifTool 9.34
Gallery 3.0.9
GTKRawGallery 0.9.8
jAlbum 11.4
Piwigo 2.5.2
WordPress 3.6
XAMPP 1.8.3

Sample Images

Camera Test Sample Images

Videos

From East to West, Parts 1 and 2
Robert Leslie's Road Trip Through the USA

Image Composition using the Golden Ratio

On Location with Steve Thornton

René Staud and the Porsche 911

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Learning to Edit Your Photographs

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Portfolio

Lauren Marsolier

The sterile aesthetics of Lauren Marsolier's images immediately grab the viewer's attention and are one of the main reasons for the French photographer's success. But there's more to these desolate views than meets the eye.

Landscapes and buildings are the dominant themes in these people-free images, which appear inert and have an overridingly bleak, minimalist look. The longer we look at them, the clearer it becomes that something is 'not quite right' in these slightly confusing scenes. The reason is probably that they don't actually exist. Lauren Marsolier creates her images by merging multiple source photos and leaving out the details she considers to be irrelevant to the overall effect.

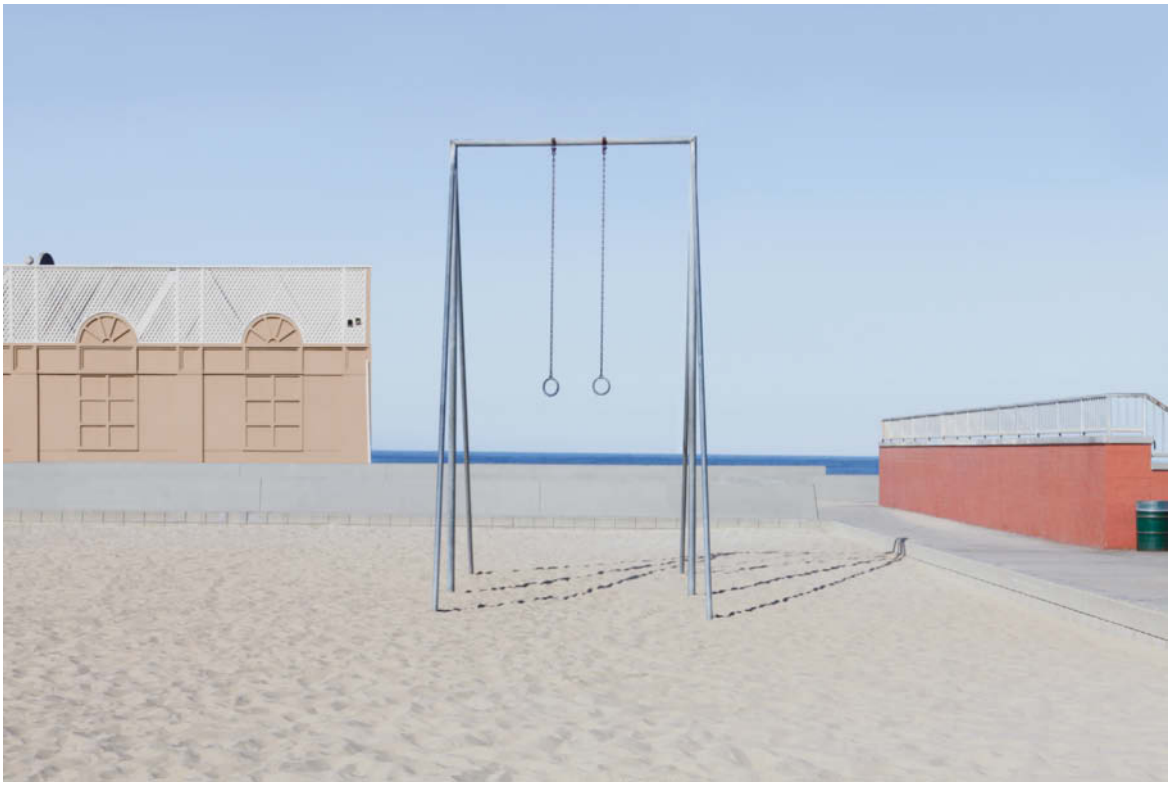
Marsolier has shot countless photos in Europe and the USA, where she has lived for the past three years. The *Transition* series portrayed here consists of about 60 individual works and took eight years to produce. Personal upheavals were the main motivation for the project, and Marsolier says the artificial landscapes have helped her to investigate her own psyche. But there's more to these images than just introspection. What began as an intuitive and personal journey ended up as a wide-ranging interpretation of the position of the individual within society as a whole.

The world that surrounds us has been shaped by human beings and reflects the inner workings of our mind. This juxtaposition of psychology and reality is the key to Marsolier's work.

Her landscapes radiate emptiness and have no fixed points around which we can orient ourselves. This lack of orientation reflects the state of the human race in today's world – a world that is changing faster than ever before. Many people complain about being left behind and feel that they cannot catch up. This feeling of being part of a rat

Landscape with Covered Car (2012)

Playground 3 (2011)



race is not the fault of the individual, but is due rather to the massive acceleration that grips our all-encompassing society. The confusion this causes is the subject of these images. Not surprisingly, Marsolier cites the cultural theorist Paul Virilio, one of the leading voices in the current technological debate, as one her influences.

To achieve maximum effect, Lauren Marsolier eliminates all unnecessary detail and compares the results with her own selective memory. This game of mixing memory and reality is also a major aspect of the work of Lukas Roth, who we introduced in issue 3 of ***c't*** *Digital Photography*. Like Lauren Marsolier's work, Roth's images show recognizable places in a non-real form constructed from memory using multiple source images. Lauren Marsolier also mentions Andreas Gursky and Thomas Demand among her influences – both photographers who work with simulated reality.

Lauren Marsolier's large-format images can measure as much as 44 inches square and are currently on show at the Robert Berman Gallery in Los Angeles. Her first book is due to appear soon. (jr)

Lauren Marsolier
www.laurenmarsolier.com

Robert Berman Gallery
www.robertbermangallery.com

Freeway (2010)

Bus Stop (2008)

Urban Scape (2010)

House 2 (2011)

Landscape with Lawn (2012)

Ralph Altmann

Unidentified Flying Cameras

Extend your visual world and expand your perspectives! Attaching your camera to a remote-controlled drone gives you access to previously unthinkable vantage points. A working photo drone can cost as little as a few hundred dollars at the local toy store, but multicopters with eight or more rotors that can carry full-spec DSLRs are the tool of choice for photographers with pro ambitions. In this article, we take a look at how drones work and how they can be used to capture unusual photos. We also discuss some of the pitfalls and technical challenges you are likely to face before you take off for the first time.

In this article


OLYMPUS
F1.8

Most photos are taken at eye level, giving cityscapes and landscapes the same rather predictable vertical perspective, shot after shot after shot. Simply shifting your standpoint by a meter or two can radically change an image, as ground-level worm's-eye view shots prove. Try it yourself and crouch down for your next shot of a building. Farther up, the length of your arms provides a natural limit to how far you can alter your shooting position, making a stepladder a standard piece of kit for anyone shooting at outdoor events. Specialized camera stands can provide shooting heights of 10 meters or more. After that, you need a viewing tower, although there isn't always one handy when you need it.

Get Detached

With a drone, or unmanned aerial vehicle (UAV), you are no longer tied down. The flexibility it provides frees you to realize any number of creative or crazy ideas at relatively little expense. Your next set of photos of a mountain trek is guaranteed to get a viewer's heart beating faster if it seems like you were floating over the abyss. A photo drone makes it quick and easy to produce aerial shots that previously required the use of a helicopter. Drones are agile too, giving you almost limitless access to narrow canyons, glacial crevasses, mountain streams, narrow streets and small indoor spaces that not even a helicopter can reach. Shooting altitudes just above roof height are a drone's natural habitat, and you can even use them to look into birds' nests (making sure, of course, that you don't disturb the residents while doing so).

Drones also come into their own nearer the ground, for shooting footage or stills that normally require the use of a crane or dolly. What's more, drones can simply hover in one place or follow a predetermined route made up of GPS waypoints. GPS also utilizes 'follow me' technology to precisely frame or follow moving subjects such as wakeboarders, snowboarders, sailboats or surfers. Commercial film-makers have been using drones for years now, although it has to be said that commercial, industrial and agricultural users have easier access to an appropriate budget and may be in a better position than most private users to save money, thanks to economies of scale. Drones are used increasingly often by real estate agents, for thermal imaging and a wide range of inspection work. Unlike for stills applications, propeller noise is often a problem when shooting video, and dubbing is required, just as it is for footage shot from a conventional helicopter.

Stills photographers often use cameras that are too heavy for cheap drones, but you can still produce effective high-resolution images by merging multiple shots from a compact camera. The trend in hobby-grade drones is moving toward the use of ready-to-fly drones equipped with the type of camera usually found in a smartphone. These tiny cameras often produce images that are just as good as those produced by compact cameras.

If you are exploring the idea of acquiring a drone of your own, the following pages will give you all the technical, commercial and practical information you need to get off the ground as soon as possible!

Please note: it is not always possible or legal to use a drone to capture footage of anything you happen to fly over or around. Always check with the local authorities or the owners of property you wish to photograph and always make sure you have appropriate permission before you begin a shoot. Privacy and copyright laws vary from country to country, so check the situation in your location before taking to the air.

If acquiring and flying your own drone seems too complicated, you can always hire one from an agency on a hourly or daily basis. Drones are almost always hired out with a pilot, as flying them requires practice and experience.

The two-dimensional 'Google view' most real estate agents use doesn't make the most of a drone's capabilities. A free choice of perspective from various heights – as shown in the photos of the Einstein Tower in Potsdam, Germany opposite – makes things much more interesting.

Ready-to-fly Drones

Although drone technology is still in its infancy, there is already a wide range of ready-to-fly drones and an even greater range of kits and components available to enthusiasts. Nearly all entry-level drones and kits are based on the two- or three-rotor multicopter principle. Drone mechanics are quite simple compared to those of conventional helicopters with their single lift rotors, because drones don't require the rotor blades to change their pitch (see page 28). Many remote control (and other) components used in drones have been used for model-building for years and are mass produced, making them good value. Standardized components don't require as much customization when you build them into a project, but you may find that the hype surrounding drones makes some items more difficult to get hold of as demand increases.

Pre-built drones that you can fly out of the box are called 'ready to fly' (RTF) and include all the parts you need to get going, including a remote control. Almost ready to fly (ARF) models require some construction work on the part of the purchaser and you will sometimes have to order additional components.

The best way to get yourself a custom multicopter is to purchase a kit, which is often not just cheaper than an RTF model but also cheaper than the sum of the parts it contains. The other major advantage of the kit approach is that you can upgrade your device to provide better performance later on. Well-known and trusted kit manufacturers include Cinestar, Quadrocopter, RC-Drones, Droidworx and SteadiDrone. Many manufacturer websites also offer comprehensive building/flying instructions and really useful user forums in addition to kit and component sales.

Entry-level UAVs (built-in camera)

These devices come ready to fly, have built-in cameras and are controlled either by a simple (supplied) control unit or via Wi-Fi using a smartphone. The borders between 'serious' drones and toys are blurred, and RTF UAVs weighing less than 400 grams (i.e., less than a pound) sell for less than US$300 if you shop around. The 'Parrot' drone shown below belongs to this category and has a camera with a 92-degree angle of view (21mm equivalent) that captures 720p30 HD video and photos. A second QVGA-quality (320×240) camera on the bottom of the hull captures video at 60 fps and serves as a flight control unit. The Parrot does not have GPS and offers a maximum flight duration of 15 minutes and a Wi-Fi control range of 50 meters

Mid-range UAVs (action and compact cameras)

Mid-range UAVs start at between US$500 and US$1,500, although accessories such as a high-end gimbal (see page 31) can add quite a lot to the bill. This type of UAV is usually powerful enough to carry a mirrorless system camera. The DJI Phantom Quadrocopter RTF kit (see opposite) costs around US$700 and includes the UAV, a six-channel GPS control and a manually adjustable mount for GoPro (or similar) action cams weighing up to 200 grams. A two-axis gimbal for the Phantom is available from www.quadframe.us for US$69 (US$140 motorized). The Phantom's successor, the Phantom Vision, has a built-in pivotable 14-megapixel camera.

Pro-grade UAVs (compact and DSLR)

The widest range of drones is available in the US$5,000+ price category. Pro-grade drones can carry cameras weighing up to 2 kg (4.4 pounds), usually have a two- or three-axis gimbal and offer flight durations of 15 minutes or more. Common in the movie and advertising industries, they are now also being used in industrial and policing situations. A complete Aibot X6, with remote control, batteries and charger costs around US$33,000, has a maximum diameter of 1 m, weighs 2.55 kg (5.6 lb) and can carry a 2.5kg (5.5-lb) payload for up to 40 minutes at altitudes of up to 2,000 meters. The Aibot's unique features include eight ultrasonic collision protection sensors with optional support from a smart camera and image processing software, making it extremely safe to use in crowded or remote airspace. The Aibot is controlled intuitively via a standard

Image: Parrot

The 'Parrot' drone from AR.Drone is very good value but provides only limited photographic capabilities

Image: DJI Innovations

DJI manufactures a broad range of components and also markets RFT UAVs like this Phantom quadrocopter

remote control unit or tablet computer interface.

The Microdrone MD4-3000 measures 2 m in diameter, weighs 15 kg (33 pounds) and can fly at altitudes of up to 4,000 meters, while the Skycrane models from service-drone are specifically designed for use with movie cameras, and have eight or 12 rotors that can carry up to 4.5 kg. The Flightcopter FC6-950 RTF hexacopter appears quite cheap in comparison, starting at US$7,000 with a two-axis remote head. Optional accessories include a three-axis gimbal for cameras weighing up to 1.2 kg and video glasses for precision flight control.

Adding your own options to a base model is a great way to save money and end up with a UAV tailored precisely to your own specific needs. For example, the powerful ARF Oktokopter XL from Mikrokopter.de can carry up to 2.5 kg for up to 20 minutes, but costs less than US$6,500 (without a remote control or gimbal). Other manufacturers offer less powerful base-level kits for around US$1,000, while two- or three-axis DSLR-compatible gimbals start at around US$500.

The sections on the following pages explain how the various parts of a multicopter work and what to watch out for when configuring your own UAV.

Image: Aibotix

Cool-looking, powerful and, most importantly, safe. The Aibot X6 from Aibotix International costs around US$33,000 and provides a glimpse of the future of photo drones

Drone Technology

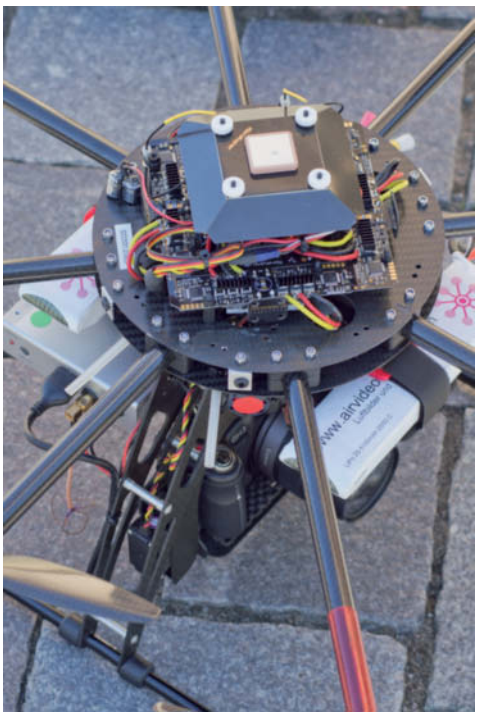
Sleek one-piece photo drones do exist, but most are assembled from random-looking components, often held together with duct tape and cable ties. This DIY approach makes sense when you consider the speed at which drone technology is developing, as it enables you to quickly swap out outdated components or repair damage. It also means you can build your own custom drone to fit your own particular purposes – for example, by adding extra batteries to extend flight times (although more dead weight always means a drone can carry less payload).

You can definitely save money by buying cheap components from Asian manufacturers, but you have to know what you are doing before placing an order. There are dozens of really useful forums on the Web, but take care not to underestimate the time and effort involved in building your own drone. The following sections look at the individual components of a drone and tell you what you can expect them to do and what their limits are.

Chassis

The basic chassis or 'frame' in a drone usually consist of at least two crossed arms to carry the rotors and some kind of landing gear. The number of rotors gives multicopters both their distinctive and their names: a quadrocopter has four rotors, a hexacopter six, an octocopter eight and so on. Even numbers of rotors make it easier to balance the torque produced by the alternating right- or left-rotating propellers. However, three- and five-rotor UAVs do exist and use different control mechanisms or degrees of rotor tilt to balance them in flight. Two motors mounted above one another (i.e., coaxially), let you use twice as many rotors to produce twice as much lift. The more arms (and therefore rotors) your drone has and the greater the distance between them, the smoother its flight but the greater its susceptibility to the effects of wind.

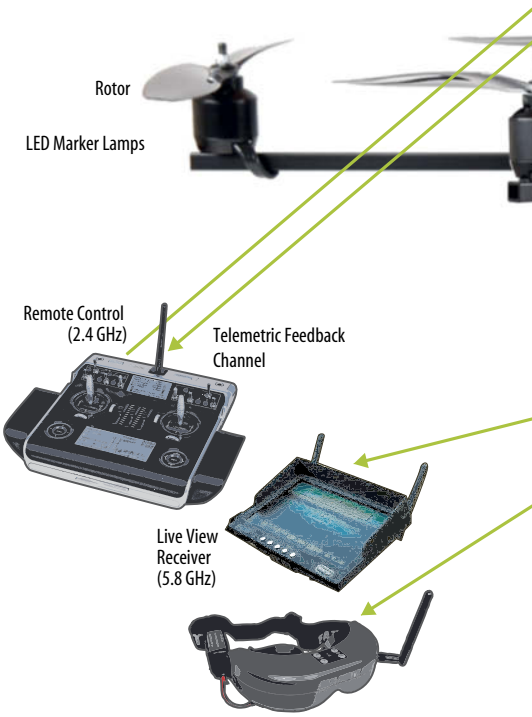
The metal used for the chassis needs to be light and stable and should be capable of damping vibrations. These are the same basic attributes required in a photo tripod, so it is logical that the same materials – i.e., aluminum or plastic strengthened with carbon fiber – are used. Hollow legs are great for mounting cables, while the batteries, control unit and camera mount are usually fixed to the top or bottom of the central point of the chassis, where they are normally covered with some kind of protective casing. Precise distribution of the weight of these components is less important in a multicopter than in a conventional single-rotor helicopter, as any imbalance is easily counteracted by adjusting the individual rotors. It is handy if the arms can be dismantled or folded for transport, especially if you plan to take your drone with you on hike into the mountains. Simple DJI aluminum frames weighing 300 grams start at around US$90, although some basic models can cost as much as US$250.



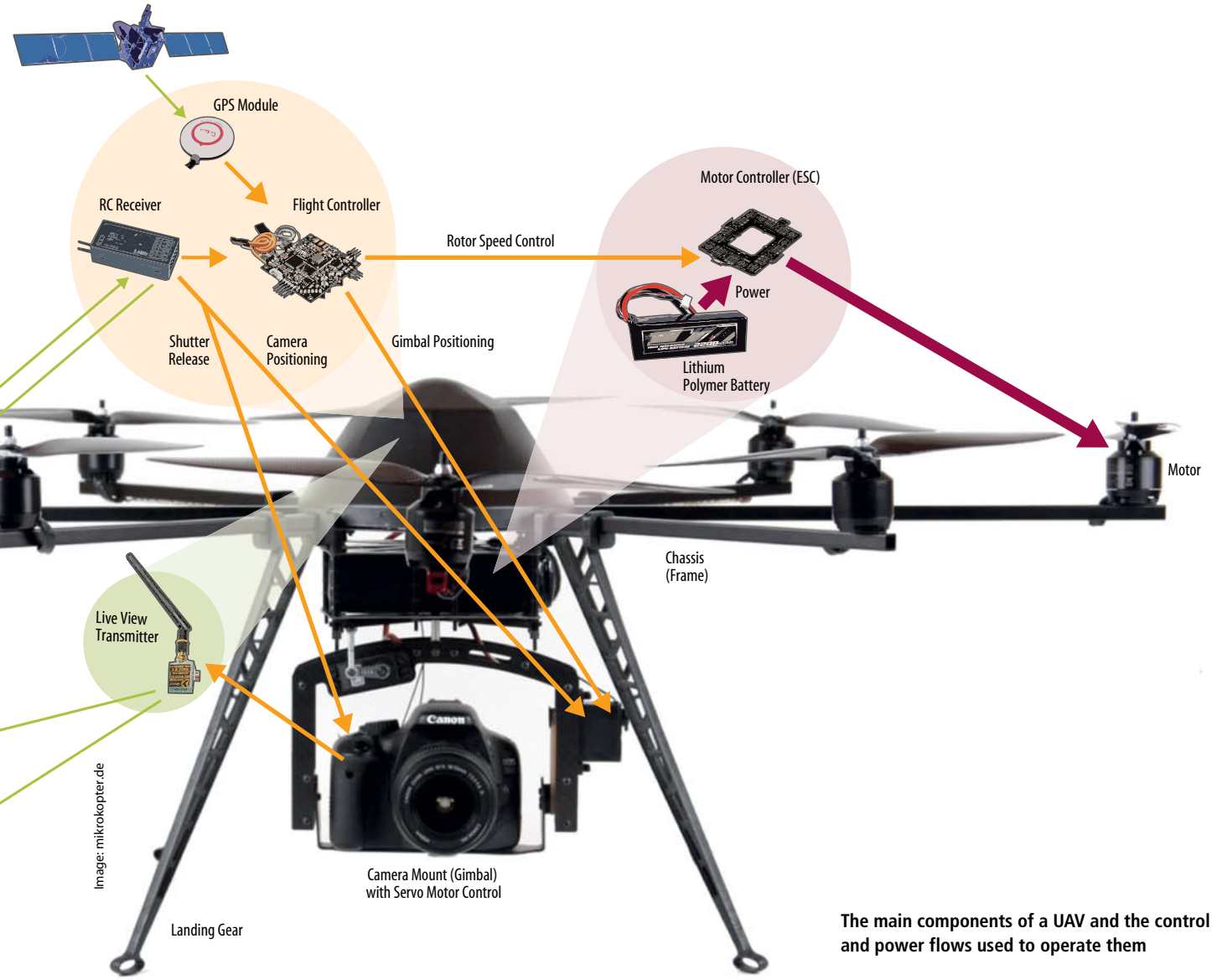
The 'brain' of an octocopter (in this case in an SD 2.0 SE from service-drone) contains a large number of microsensors. The square white component at the top is the vehicle's GPS receiver.

Power Unit

Multicopter motors have to be precision engineered to produce as much power with as little weight as possible. Brushless motors are the most widely used type and usually cost about US$55-75 each. The key metrics are the stated number of watts a motor produces and the number of revolutions per volt (Kv), which, when combined with the power of the onboard batteries, allows us to calculate the maximum number of revolutions at idle. For example, a 1200Kv motor powered by an 11V battery can theoretically be driven at up to 13,000 revolutions per minute (rpm) without a propeller attached. However, the real-world performance of a motor depends on the propeller you use, and the best combination of propeller and motor is what gives you maximum lift.



The two most important propeller metrics are diameter and pitch, both of which are usually quoted in inches as part of a product's name. For example, an EPP1045 propeller has a diameter of 10 inches and 4.5 inches of pitch, which means (theoretically) that one rotation propels it 4.5 inches through still air. The greater the ratio of pitch to diameter, the greater the stream velocity (and therefore



The main components of a UAV and the control and power flows used to operate them

flight speed) a propeller can produce. High velocity is an important factor when combating the effects of wind but makes it more difficult to produce a stable hover position. Most multicopter propellers have a diameter to pitch ratio of 2:1.

Propellers are commonly made of expanded polypropylene (EPP) and are available in stable (but fragile) APC and more expensive carbon-fiber (CF) types. Most multicopters require pairs of clockwise and counterclockwise-rotating propellers, which cost between US$3 and US$30, depending on what they are made of and how well they are made.

The force that lifts a multicopter is called lift and is measured in newtons (N). 1 N can lift about 100 g (3.5 oz) of payload. Doubling the motor speed quadruples the amount of lift but uses eight times as much battery power. The power train is usually set up so that a multicopter can hover at half its maximum motor speed while fully loaded. This leaves enough power in reserve for navigating and flight stabilization.

Motor speed is controlled using electronic speed controllers (ESCs) that regulate the phases of the motors so that one stator moves with the rotating field. Brushless motors are robust but require a complex voltage timing system, making appropriate ESCs more expensive than their conventional counterparts. Each motor requires its own ESC, although combined ESCs designed for use with four or more rotors save space and cabling. ESCs cost between US$30 and US$80 each, although multi-ESCs can work out cheaper (for example, the Hobbywing Skywalker Quattro for about US$40). On the other hand, some multi-ESCs cost far more than the appropriate number of individual components.

Batteries

Drones are powered by rechargeable batteries, which also determine their flight capacity and speed. Battery capacity is measured in milliampere hours (mAh), which, when multiplied by voltage, gives us the maximum amount of storable energy, measured in watt hours (Wh). The lithium polymer (LiPo) batteries used in most drones are rated at 3.7 V and are often mounted in series to provide 11.1 or 14.8 V of power. This nominal voltage declines under load due to the battery's internal resistance, which should, of course, be as low as possible. The maximum amount of power that the battery can provide is measured in terms of a multiple of its nominal capacity, C. For example, the notation '3S 3300mAh 35C' tells us that three batteries are running in series (3S), that they can deliver 3.3 amps for an hour and that the maximum

GPS technology can be used to 'park' a drone in mid-air while you shoot the source images for a panorama. This example shows the Glienicker Bridge between Potsdam and Berlin, constructed from 12 source images.

deliverable current is 115.5 amps (3.3 × 35), which would run this particular battery down in 100 seconds. In practice, each motor uses between five and 20 amps.

One way to increase battery capacity is to run multiple (same voltage) battery packs in parallel, but remember that battery capacity drops significantly in low-temperature environments. Energy density (measured in Wh per kg) is another important indicator of battery performance, as the UAV also has to carry the battery's own weight, further reducing the potential payload it can lift. 130 Wh/kg is a good average value. Prices for a 5000mAh battery pack range from US$45 to US$130, depending on energy density and durability.

The current required to charge a battery is also given as a multiple of its capacity (C). The smaller the charge current, the longer the usable life (and charge time) of the battery. Charge currents of two to four times C are standard, resulting in charge times between 30 and 15 minutes, regardless of battery capacity. If no charge current is specified, use 1 x C, which will take a full hour to charge. To prevent the individual cells in a battery pack from discharging at different rates, their contacts are connected to a balancer, which is an integral part of all good chargers. You can spend as little as US$50 or as much as US$200 on a charger that is worth owning.

LiPos are more sensitive than other types of rechargeable batteries and shouldn't be overcharged or completely discharged. If damaged or short-circuited, they can swell up or even catch fire, and charging them incorrectly or too fat drastically reduces their usable lifespan. UAV batteries have a shorter usable life than the LiPos used for other applications due to the high loads imposed by flying. Depending on battery quality and the nature of the flights you undertake, you can expect to squeeze between 100 and 500 charge cycles out of a set of batteries. The battery is the weakest link in a multicopter's power train, and users everywhere are waiting impatiently for the battery industry to provide improved energy densities that they hope will massively increase flight capacity without making it necessary to alter any other technical aspects of a UAV.

Flight Control

The flight controller, or 'brain' of a drone uses sensors to ascertain altitude, direction and acceleration, as well as ensuring a stable hover position and translating remote commands into real-world movements. Most drone movements can be executed by altering the speed of one or more of the rotors, which are controlled by ESCs capable of altering the electrical pulses sent to the motor quickly and efficiently.

Altering the speed of all the rotors equally causes the drone to rise or fall vertically. To get it to move forward, you increase the speed of the rear rotors. A drone can be rotated by altering the speed of rotors on opposite sides of the hull, which still provides constant lift, but no longer compensates completely for internal torque. Most ESCs also have additional servo output channels that can be used to tilt the axis of a rotor if required, or control the movements of a camera mount. Other output channels provide visual system information (such as a 'weak battery' indicator) via LEDs.

The sensors built into flight controllers enable relative navigation. If you want to utilize absolute waypoint navigation or return-to-home (RTH) functionality, your drone will also have to have built-in GPS. Some controllers – such as the DJI Naza-M and Wookong-M models – have these functions built in and only require you to attach a GPS antenna, while other models, such as the ArduPilot Mega, require you to purchase an additional GPS module (for example, the 3DR GPS uBlox LEA-6 for about US$75).

The race to create autonomous flight control systems is in full swing, and infrared and ultrasonic collision avoidance systems are already fitted to some high-end drones as standard. Time-of-flight cameras can be used to obtain a 3D image of a vehicle's surroundings, regardless of the ambient lighting conditions, and can thus be used to construct extremely precise flight and position control mechanisms. On a simpler note, one or two cheap cameras mounted on the hull and aimed downward can help to make GPS-based navigation more precise or provide navigation data between high buildings, indoors or in other situations where GPS data is unobtainable.

Shot using an Olympus XZ-1 mounted on a custom hexacopter rented from a local company

Remote Control

Conventional model-shop remote control (RC) units that operate in the 2.4 GHz (ISM) frequency band are well suited for use with multicopters. Such units have a range of 300-1,000 meters, which is quite sufficient for flying a drone by sight. The more channels an RC unit has, the more individual functions you can control. Basic flight requires four channels (up/down, left/right, forward/backward and rotation), and you need additional channels to switch between manual and GPS-based navigation and to release the camera's shutter. Camera position control requires one channel per axis and focus and zoom settings also require their own channels if you want to control them remotely. In such cases it makes more sense to work with a two-person team and two remote control units than alone with a 12-channel RC. This way, one person can concentrate on flying while the other operates the camera.

Prices for RC units range from US$150 for a simple six-channel model to more than US$3,000 for an 18-channel Futaba 18MZ. You will also need to build a receiver into your UAV to transmit control signals to the ESCs and other servos. Servo signals are transmitted either singly or summed, either directly or via a signal decoder. The Futaba S.Bus system is widely used and supported by various receiver manufacturers.

Modern digital RC units designed for use on the 2.4 GHz band use 'frequency hopping' and 'direct sequence' spread spectrum (FHSS and DSSS) techniques to compensate for the short breaks in transmission (dead points) caused by shadowing and destructive interference. 'Diversity' systems with two independent receivers are even safer. High-quality RC systems include a separate channel for telemetric feedback, allowing altitude, speed and battery charge status to be displayed directly in the RC unit's readout.

With appropriate controllers, you can use a GPS module to program a complete flight route in advance, with waypoints, flight segments and hover phases. Some flight controllers have appropriate functionality built in, while others require the use of an additional 'autopilot' board such as the NaviCtrl model from skykopter.com for US$265. The functionality can then be used to perform preprogrammed pans or shoot panoramas while hovering. For advanced users with access to a full-function remote head camera mount, waypoint technology can even be used to shoot multi-row panoramas with ultra-precise rotation increments between shots. The same technology can also be used in reverse to keep a single subject in constant view during a flight. Last but not least, GPS functionality enables you to geotag the route your vehicle takes and record the exact position of the photos you shoot for later use with Google Maps and other map services.

As an alternative to radio control, multicopters can also be flown visually via Wi-Fi using a tablet or smartphone interface. The drawbacks of this approach are the limited range and the comparatively high latency of Wi-Fi, which can take 100 milliseconds or more to execute a command. It is also very difficult to control flight and the camera at the same time, although a Wi-Fi circuit is an ideal medium for (re-)programming waypoints.

Here, the camera operator is using a separate remote control unit with its own live view monitor

Camera Technology

Your choice of camera is limited by the carrying capacity of your drone and the dimensions of its camera mount. Live view image transmission takes place via an AV Out or HDMI connector and a drone-compatible camera must have an electronic or infrared shutter release.

Action cams are perfect for the job as they are designed to take a few knocks. Their image quality is not always the greatest, but is usually quite sufficient for uploading to YouTube or printing in a photo book. Their functionality is reduced to a minimum so that they can be attached to helmets or independent moving objects. Popular among snowboarders, white water rafters, surfers and mountain bikers, they are often either waterproof or include an underwater housing. One of the most widely used models is the GoPro Hero, which is extremely small (59×41×21 mm) and light (73 g), does not have a viewfinder or color monitor and is controlled via a small monochrome display. Framing and composition are done by guesswork, aided by the wide 120-degree angle of view of the lens, which captures just about everything that crosses its path.

The US$400 GoPro HERO3 Black Edition weighs just 73 grams 'naked' and includes a simple remote control and an underwater housing that works at depths of up to 60 meters

Some action cams are designed primarily with video in mind. For example, Sony'sHDR-AS15 (US$240) can capture Full HD video at 60 fps, but only 2-megapixel stills. In contrast, the GoPro Hero3 Black Edition (US$400) shoots 12-megapixel images at burst rates of up to 30 fps (or 120 fps in video mode) and captures 4K (3840×2160) video at 15 fps. Both models use Wi-Fi to control their shutter releases and transmit live view images. Unfortunately, cameras as small as this don't support RAW shooting mode.

Compact cameras offer better image quality, zoom lenses and (in some cases) RAW support, but are not so good at capturing video. We used an Olympus XZ-1 (still available for about US$300) to capture some of the photos reproduced in this article. This camera weighs 275 g, has a very bright (f1.8) 4x zoom and captures 10-megapixel stills and 720p video. Its successor, the XZ-2 (US$500) captures 12-megapixel stills and 1080p video at 30 fps. Both cameras support RAW shooting but have a proprietary USB connector for remote release and AV Out, necessitating some creative soldering if you want to use live view and remote release simultaneously. Unfortunately, connecting an HDMI cable is not an option because doing so automatically switches the camera to playback mode.

Canon compacts and some DSLRs present similar connection drawbacks and require the use of a special 11-pin USB/AV combo cable. The well-known CHDK (Canon Hack Development Kit) can be used to add a range of additional functions to most Canon compacts and even enables you to program your own. This makes Canon products more attractive than others for drone-based use. All you have to do to implement the various scripts available on the Web and at the CHDK forum (chdk.setepontos.com) is save them to the camera's SD card. Using these scripts and a little additional electronic trickery, you can release the shutter remotely, zoom in and out or start a continuous shoot. For more details on this and other CHDK functionality, such as RAW and interval shooting, check out the CHDK homepage at chdk.wikia.com.

A drone has to be capable of much heavier lifting if you want to use it to shoot with a DSLR. The Canon EOS 600D/Rebel T3i weighs 500 g (body only), while the EOS 5D Mark III weighs in at 950 g. Adding a bright lens means that your UAV has to be capable of lifting 1.5 kg or more. Zoom lenses are even heavier but are of little practical use in the air, as it is virtually impossible to alter focal length remotely. Mid-range DSLRs with plastic lenses and mirrorless APS-C and Four Thirds cameras are much better suited to aerial use. For example, the Sony NEX models and the Olympus E-PM1 ('PEN mini') both weigh less than 340 g with a pancake lens attached.

Camera Mounts

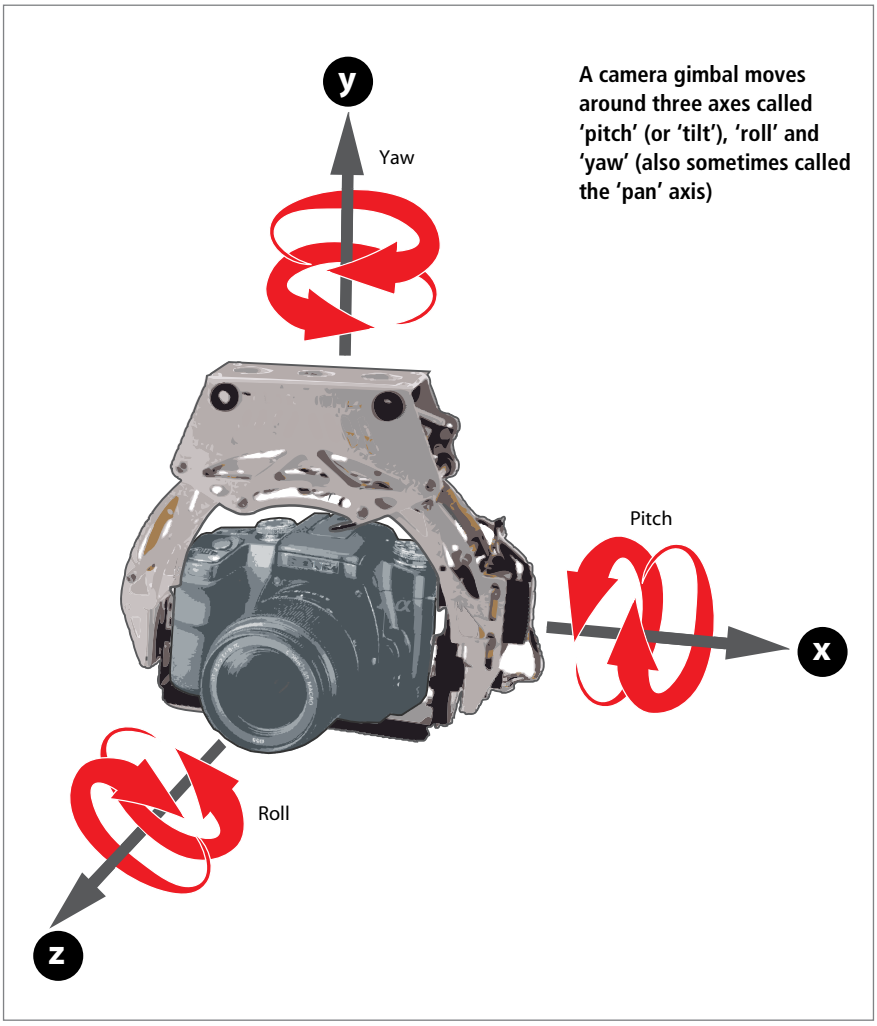
A fixed camera can only shoot in the direction of flight and drone movements – whether part of a predetermined route or executed to compensate for the effects of wind – spoil an otherwise smooth video shot. This makes a servo-controlled gimbal, or 'remote head', indispensable. A gimbal should be capable of performing pitch and roll movements, while yaw capability is useful for shooting complex panorama and the like, but not essential. Most gimbal movements can be duplicated by altering the position of the entire drone, although this is complicated to execute and often results in unwanted judder and overshoot, and is therefore unsuitable for video use. Remote camera control requires one additional RC channel per axis.

The control signals for the servos come straight from the flight controller with its built-in position and velocity sensors, while high-end gimbals have their own stabilizing gyros and stepper motors for fast, precise positioning. Some can even compensate independently for vibrations within the vehicle's spaceframe. The mechanics and electronics built into high-quality gimbals are complex and quite expensive. Two-axis gimbals start at around US$1,000 and a high-end three-axis model such as the Zenmuse Z15 from DJI can cost as much as US$3,500.

Smaller, less complex models suitable for use with compact cameras are less expensive, but you should reckon with spending at least as much as the price of your camera if you want to purchase a worthwhile mount. As with many consumer goods, drone accessory prices are falling all the time. At the time of writing, dronesvision.net was offering a two-axis gimbal for use with the DJI Phantom/GoPro Hero3 combo (controlled by the Phantom's Naza-M) for US$50.

Camera Control

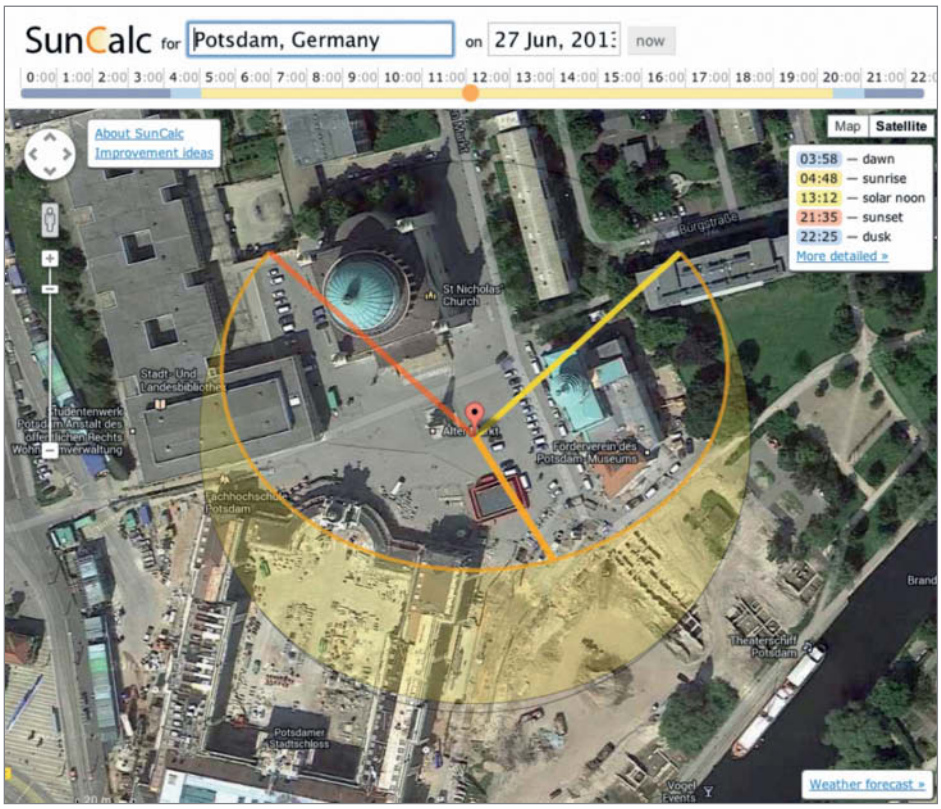
Although it may seem a minor matter, releasing the shutter of a camera in flight can actually be quite tricky. Most conventional wireless releases only work within a very limited range, and it is highly beneficial if you can actually 'see' what is in front of the camera before taking a shot. Not all cameras can transmit live view images via their AV Out connector, but specialized live view transmitter/shutter release units can be used to display the camera image on a remote monitor over distances of 200-300 meters. The transmitter is attached to the camera's flash shoe, and some models even have their own built-in mini-camera to provide a rough view of the surroundings, even if live view transmission doesn't work or is switched off. The units we found only work with DSLRs and some protrude so far that they prevent the camera from being mounted on its gimbal. Better-quality transmitters (such as the 5.8 GHz ImmersionRC EzOSD) can be attached to the camera via a cable. These offer large remote monitors, but rarely include remote release functionality as well.



A camera gimbal moves around three axes called 'pitch' (or 'tilt'), 'roll' and 'yaw' (also sometimes called the 'pan' axis)

Drones are perfect for shooting at fun sport events, allowing you to keep close to your subject without getting in the way or endangering the participants

Image: Airvideo-Service



SunCalc (http://suncalc.net/) is an add-on for Google Maps that displays the position and phases of the sun for a given time of day at a chosen location and can even display the shadows thrown by some well-known objects and buildings. While Google Earth can generate impressive lighting and shadow effects, these are less precise and don't reflect the sun's true position.

A first-person view (FPV) approach offers complete immersion in the flight experience and enables you to use video goggles to follow the flight path of your drone as if you were on board. 'Head trackers' even enable you to alter the position of the camera by moving your head. Always use 5.8 GHz equipment to transmit live view images, as 2.4 GHz gear can interfere with flight commands.

You need to use a free RC channel to release the shutter, either using a relay or a transistor. Construction plans for many RC releases are freely available on the Web, but ready-built infrared models for mounting in front of the camera are available for compatible cameras for as little as US$25 should you prefer. The most complicated approach (but one that works for all cameras) is to release the shutter mechanically using a servo. Again, the Web is the best source for construction plans. Just as complex is the use of airborne follow focus (focus puller) and remote zoom mechanisms. In an ideal world, these settings could be controlled remotely via electrical signals – an approach that is technically possible in compact cameras, but has so far only been realized using CHDK and makeshift mechanics.

The best positioning experience currently available is point-of-interest (POI) or 'follow me' functionality. This latches onto the chosen subject at a constant distance and follows it wherever it goes. The subject must, of course, have its own GPS transmitter or carry a GPS-equipped smartphone that is set up to transmit its position to the vehicle following it. The airborne camera can then use this data and its own position to pinpoint and follow the subject. Comprehensive instructions and a list of the components required are available in the 'International' forum at www.mikrokopter.de.

Shooting in Practice

Once you have solved all your positioning and shutter release challenges, you can concentrate on selecting the right camera settings. Even when stabilized as effectively as possible, a drone is never truly still during a flight, so it is best to use exposure times of 1/500 s or less. The anti-shake systems built into most cameras are attuned to the frequencies produced when humans shoot handheld and are much less effective at higher or lower frequencies. Using shutter-priority mode is the best way to keep the exposure time appropriately short if you are capturing single shots, but the changes in aperture that this mode produces can be a problem if you are shooting a panorama sequence. Most panorama software can handle differently exposed source images, but to be on the safe side, you can use a software-based tool such as Lightroom's *Match Total Exposures* command to balance exposures in a sequence.

Manual mode ensures that your shooting parameters remain constant during a shoot but cannot, of course, compensate for changes in lighting. If you use manual mode, set exposure for the brightest scene you think your sequence will contain and always shoot three-shot bracketing sequences whichever exposure mode you use. This gives you backup shots if the lighting does change and increases the chances of capturing at least one sharp image for each exposure.

After take-off, focus is just as difficult to alter as your exposure parameters. Due to the way they are built, compact cameras produce images with relatively high depth of field anyway, so if you are using one, simply set it to manual mode and focus to infinity. If you can, set the lens to its hyperfocal distance, as this provides the greatest possible depth of focus.

Using autofocus only makes sense if you use live view monitoring. Left to its own devices, autofocus can easily produce unforeseen anomalies or simply focus on the wrong subject. Photos shot with specific depth of field effects in mind can be just as interesting when shot from above, although an aerial shooting position makes it more difficult to convey the three-dimensionality of a subject. Not only that, but you will need a large-sensor camera, a bright lens and a servo-driven focus puller if you want to alter focus during a flight and still capture sufficient detail.

Unstable flying conditions and onboard vibrations are much more problematic when shooting video than they are for stills shoots. Because every stabilizing movement is based on calculations made for a system with a specific weight, it can help to alter the low pass filter settings on your flight controller to suit your particular camera/drone combo. If all else fails, video shake can be cured at the post-processing stage using tools such as the Warp Stabilizer included in Adobe *Premiere*

CS6. If you do use software tools, remember that they crop the frames you treat by about 5-10 percent.

For an exacting aerial shoot with specific foreground and background details and pre-planned lighting, it helps to plan your flight time and route in advance. There are various Web services and apps available that help you calculate and display the sun's position for a given location and time. Nevertheless, even the best-laid plans can go awry and it is sometimes quite tricky to find just the right shooting position when viewing a scene from above. When viewing your material after a shoot, you will often find that a slight change in position would have helped capture just the shot you were looking for, so always plan to make at least two flights per location if you can.

The pilots who fly rental drones spend most of their time working with clients in the industrial, farming and real estate sectors and don't yet have appropriate photographic experience. However, this situation is changing, and some drone services now specialize in film and photo shoots.

Image: service-drone.com

Servo-driven follow focus systems like those used in the movie industry can also be used to automate photo drone functionality

Drone Rental

Drone rental services can be found in most major towns and cities but are generally booked out when fine weather beckons.

Rental companies provide the drone, the camera and qualified personnel, as well as looking after details such as insurance and obtaining flight permission. If you use a rental service, you should agree in advance whether you or the service provider is responsible for getting permission to fly over or shoot material of private property. The contract with a drone service will usually give you the rights to the images captured and release the drone company from any liability regarding the content of the resulting material. Reputable companies will refuse to take on jobs that are obviously of a paparazzi or otherwise questionable nature, and it is up to the provider to make sure that any relevant no-fly zones and military regulations are observed. Some companies refuse to fly over crowds or large expanses of water.

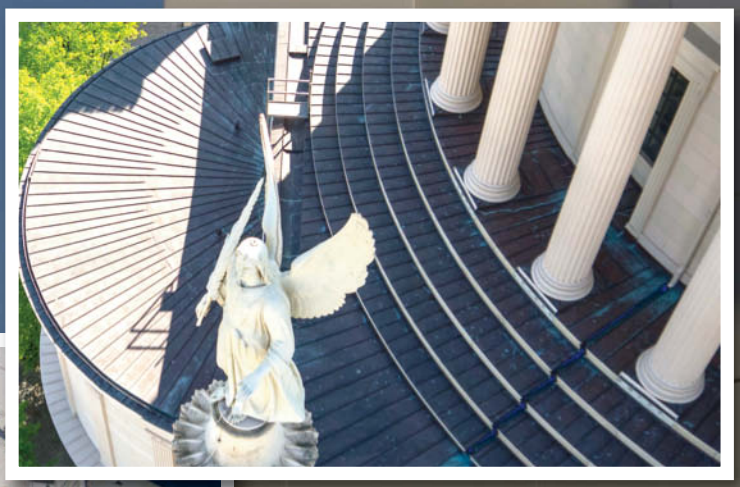
Most companies bill for hourly, half-day or daily rates and sometimes guarantee a minimum number or length of flights or a minimum number of photos. If you book a service, you will generally book the use of a particular camera rather than a specific drone. DSLRs are naturally more expensive than compacts, simply because they are heavier and require more powerful drones to lift them, although some services charge fixed rates up to a certain payload. Likewise, some companies include image processing in their prices while others charge extra for additional services.

Prices for an hour's rental in Berlin using a Panasonic Lumix GH2 start at around US$500, with a half-day rental costing as much as US$1,600. Prices vary according to the specifications of the gear being used and the amount of local competition. We paid EUR800 (about US$1,100) for the half-day shoot that produced the images on the first couple of pages of this article. An Airbot X6 with a pilot and the 36-megapixel Nikon D800 costs about US$2,000 for half a day and US$3,300 for a whole day. Two-person camera/UAV operator teams cost more than a one-person show, and some companies offer a 'sneak peak' trial service, shooting a few pictures of a specified location for a small fixed fee to help you decide whether you want to take on a bigger job. Specialized companies take on complete photo and film projects, with pricing scaled according to the time and effort involved.

Having seen what it can cost to have someone else fly a drone for you, you may be tempted to go out and buy your own, but don't forget that as well as the cost of a new drone with all its associated accessories, there will be additional outgoings for repairs and maintenance and the time and effort it takes to learn to use the device effectively.

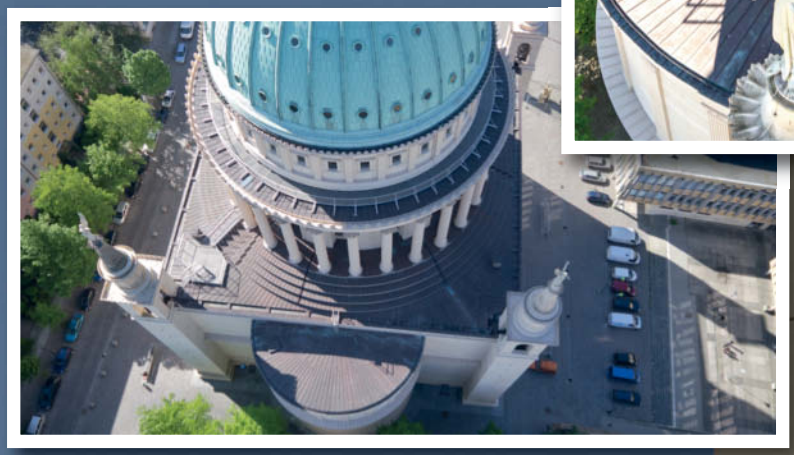
On the other hand, a simple, collapsible drone that fits into a backpack could soon become a standard photo accessory that many photographers pack as standard when heading off on vacation or out into the country at the weekend. It isn't hard to imagine visiting well-known tourist attractions in the near future and finding ourselves surrounded by hundreds of autonomous flying cameras. The continuing development of drone technology definitely offers adventurous photographers a whole slew of new and exciting creative opportunities. (anm) c't

The specialist team from Airvideo-Service controls the drone, while the author views the action live via video goggles



A unique view: Our team captured some truly beautiful images of the city of Potsdam.

These images were captured using a Panasonic Lumix GH-2 mounted on an Octokopter SD 2.0 SE provided by Airvideo-Service in Potsdam



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Something for Everyone

17 cameras to keep at the ready

Today's compact cameras often have features that match those of their DSLR cousins: underwater shooting, zoom ranges of more than 1,000 mm and a raft of pro-grade features packed into pocket-sized bodies. This issue's test takes a comprehensive look at the current compact market, from entry-level snappers through 'super zooms' and rough-and-tumble ruggedized models to high-end, fixed-focal-length cameras with ultra-bright lenses.

In this article:

Technological development is currently forcing the hand of compact camera manufacturers. The ever-increasing quality of smartphone cameras and the falling prices of mirrorless system cameras have the compact market in a stranglehold.

However, compacts are still dominant in many areas and aren't going to disappear any time soon. Our test field ranges from cheap, entry-level devices, through ruggedized, waterproof models to super zooms and high-end models for enthusiasts. Some of the cameras we tested perform extremely well in their own particular niches and are perfect for carrying with you as an addition to a full-blown DSLR system.

Do-it-all Compacts, from Cheap to High-end

Smartphones present stiff competition at the entry-level end of the compact camera market, with the Samsung Galaxy S4, the HTC One and the more recent iPhone models at the top of the heap. Nevertheless, compact cameras at prices way below the US$300 mark still offer occasional photographers a keen set of features that make taking snapshots a pleasure.

Functional Wi-Fi is now available in cameras that costless than US$120, and some also include NFC (Near Field Communication) technology for transferring images directly to a smartphone, seamlessly joining a local network, displaying photos on a TV or even sending e-mails. Three of our entry-level test candidates are equipped with Wi-Fi, which can also be used to control a camera remotely. Imagine taking a family group portrait: everyone takes their place, you check framing on your smartphone's display and then release the shutter with a touch gesture. Nobody has to rush into the frame at the last moment and you can upload the scaled result to the social network of your choice immediately after shooting.

Face recognition, various panorama modes, effect filters and high-speed burst shooting are all features that still give compacts an edge over smartphones, and some of our test models have really simple interfaces that are ideal for children or the older generation, making them ideal for first-time users. See page 42 for the results of our image quality tests.

The entry-level models we tested: Canon Ixus 255/Elph 320 HS, Casio Exilim EX-ZR400, Panasonic Lumix DMC-SZ9, Sony Cyber-shot DSC-WX200.

High-end compacts are generally aimed at producing the best possible image quality rather than giving the user feature overkill. To this end they use large sensors with modest pixel density (10-12 megapixels seems to be the norm in this sector), although the Nikon Coolpix A has the same 16-megapixel APS-C sensor as the D7000 DSLR.

Bright lenses are the other major distinguishing feature of high-end compacts. The Leica D-Lux 6 has a maximum aperture of f1.4 at the wide-angle end of its range and most of our test cameras have maximum apertures of f2.8 (or larger) at the telephoto end, which reaches about 100 mm (equivalent) in most cases.

This kind of performance comes at a price. The Coolpix A costs a 'cool' US$1,100, while Leica cashes in on its name and demands US$800 for the D-Lux 6.

The point at which a compact earns the title 'high-end' is not clearly defined, so we slipped the Olympus XZ-10, with its small sensor and big feature set, into this section too. Its bright lens, high-resolution display and moderate pixel density certainly earn it the accolade in our opinion, and its US$400 price tag helps to cement this impression. Find out whether it makes the grade on page 51.

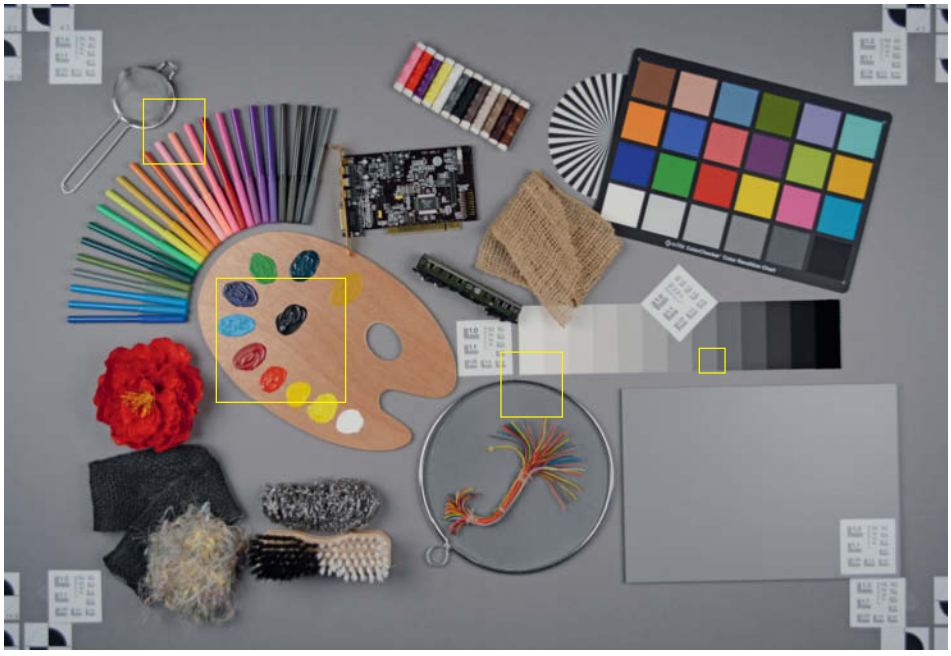
The high-end models we tested: Canon PowerShot G15, Leica D-LUX 6, Nikon Coolpix A, Olympus XZ-10.

How We Tested

For each camera, we shot a standardized sequence of images in our lab using a T42 test chart and analyzed the results using our custom IQ software to give us reliable comparison figures for resolution, maximum contrast, noise characteristics, distortion, chromatic aberration and color reproduction.

To judge image quality visually, we captured our ***c't*** test scene (shown on the right) under laboratory conditions at various ISO settings and judged the results using a calibrated monitor. We also took a series of outdoor shots with each camera to round out our impressions.

The original test files are included on this issue's free DVD.



We built a custom underwater stand for our ruggedized camera test

Travel Zooms and Super Zoom Bridge Cameras

Travel zooms are firmly established in a niche of their own, offering astonishing zoom ranges for a small price (US$250 and upward). An equivalent zoom lens for an APS-C DSLR probably costs twice that much, and that's before you've even bought a camera to go with it!

As a comparison to the travel zoom category, we also tested three 'super zoom' bridge cameras with maximum (equivalent) focal lengths of 1000 mm or more. This kind of performance can theoretically be used to shoot frame-filling photos of the Moon, and switching in the built-in digital zoom gives you the potential to shoot close-ups of its craters. The guts of these cameras are nevertheless still belong very much in compact territory, and none of the sensors we tested exceeded 1/2.3" in size, while the maximum apertures at the telephoto end of the scale start at f5.6 and smaller.

The advantage of travel zooms is that, in spite of their middling lens performance, they still fit in your pocket when you are out and about. The models we tested cost between US$220 and US$450 and feature treats like Wi-Fi, GPS, NFC and touchscreen functionality alongside their more standard capabilities. The results of our lab tests start on page 54.

The zoom cameras we tested: Fujifilm Finepix HS50 EXR, Nikon Coolpix P520, Panasonic Lumix DMC-ZS30/TZ41, Pentax Optio X-5, Samsung WB800F.

Ruggedized Cameras for the Beach or the Mountains

The third set of cameras in this issue's test are the ruggedized, waterproof models that you can take diving without having to use a special housing. These devices start at around US$200 and can cost as much as US$400, depending on their specifications.

GPS and a built-in compass are not standard and were only found in the more expensive cameras we tested. Nikon's AW110 even includes built-in map functionality and can tell you which direction you were pointing the camera while shooting. Wi-Fi is now standard in the US$300-400 price bracket, and two of our test models showed just how well developed this type of function is in today's cameras.

Because of refraction and the way water transmits light, a bright lens is particularly useful in underwater situations. The f/2.0 glass built into the Olympus TG-2 and the Panasonic TS5/FT5 fits the bill perfectly.

Our test results (see page 62) tell you which of these specialists hit the mark and which still have room for improvement, and the sections that follow that also include individual reviews of all the cameras in our line-up.

The waterproof models we tested: Nikon AW110, Olympus Tough/Stylus TG-2 iHS, Panasonic Lumix DMC-TS5/FT5, Pentax WG-3 GPS.

Do-it-all Compacts, from Cheap to High-end

This section of our test covers cameras ranging from pure 'snapshot' models to ones that offer serious competition for entry-level DSLRs. These include the Sony DSC-WX200, with its tiny, overstuffed sensor and the Nikon Coolpix A, with its moderately dense, supersized APS-C sensor.

While high-end compacts offer high image quality, large sensors and bright lenses, the cheaper end of the market has its work cut out differentiating its offerings from the cameras built into smartphones and tablet computers. In spite of this growing challenge, these cameras still account for the most sales, and their manufacturers are fighting a constant battle to make their specifications tempting enough to keep customers buying.

Models for less than US$300

Some entry-level features mirror those found in smartphones, borne out by the fact that three of our four 'cheapies' include Wi-Fi functionality. This ranges from simple ad-hoc networking to automatic access to local networks. Some manufacturers have got in-camera wireless tamed, while others are still having teething troubles, with complex handling that doesn't guarantee smooth communication with other devices.

However, a the main purpose of a camera is to produce high-quality images not to be great at transferring data wirelessly, and the 25-250mm (equivalent) lenses and 1/2.3" sensors built into these tiny electronic miracles are still way beyond anything offered by the current generation of phones.

Edge Weakness

In the lab, all the cameras we tested produced their best results at the wide-angle end of the zoom range. However, the results were only really good at the center of the frame, with serious fall-off toward the edges. For example, Canon's IXUS 255/Elph320 HS produced images with a fantastic 96 per cent of their potential maximum resolution in the center but with quality dropping off a full 20 per cent at the edges. Telephoto image quality was consistently poor in all our test candidates.

So, if you are using a simple compact in tricky lighting conditions, it is best to stick to using a wide-angle setting and keep your subject in

COMPACT CAMERAS – TEST RESULTS, PART 1

	Sensor Resolution [lp/h] better▶	Relative center resolution (ISO 100, wide-angle) Resolution in % better▶	Center resolution (ISO 100) [lp/h] better▶	Center resolution (ISO 400) [lp/h] better▶	Center resolution (ISO 1600) [lp/h] better▶	Center resolution (ISO 3200) [lp/h] better▶	Center resolution (ISO 6400) [lp/h] better▶
Entry-level							
Canon Ixus 255/Elph 320 HS	1500	96	1437	1342	1251	1117	964
Casio EX-ZR 400	1728	84	1451	1175	961	913	–
Panasonic DMC-SZ9	1728	80	1386	1218	896	815	–
Sony DSC-WX200	1836	87	1606	1529	1103	963	–
High-end							
Canon PowerShot G15	1500	94	1403	1332	1206	1095	1010
Leica D-Lux 6	1368	86	1174	1059	963	903	833
Nikon Coolpix A	1632	96	1565	1536	1461	1376	1354
Olympus XZ-10	1488	94	1401	1346	1044	834	663

[1] variable

Resolution was determined visually in units of vertical line pairs [lp/h]. The higher the value, the sharper the image.

COMPACT CAMERAS – TEST RESULTS, PART 2

	Signal-to-noise ratio [S/Nx] ISO 100 better▶	Signal-to-noise ratio [S/Nx] ISO 400 better▶	Signal-to-noise ratio [S/Nx] ISO 1600 better▶	Signal-to-noise ratio [S/Nx] ISO 3200 better▶	Signal-to-noise ratio [S/Nx] ISO 6400 better▶	Visual noise OECF20 ISO 100 ◀better	Visual noise OECF20 ISO 400 ◀better	Visual noise OECF20 ISO 1600 ◀better
Entry-level								
Canon Ixus 255/Elph 320 HS	36	26	19	13	10	1.7	2.3	3.1
Casio EX-ZR 400	34	30	16	10	–	2.1	2.5	4.9
Panasonic DMC-SZ9	31	23	22	16	–	2.0	2.8	2.9
Sony DSC-WX200	26	21	17	20	–	2.2	2.8	3.2
High-end								
Canon PowerShot G15	39	32	27	14	10	1.7	2.1	2.5
Leica D-Lux 6	40	33	17	15	11	1.7	2.1	3.2
Nikon Coolpix A	63	41	22	17	12	1.2	1.8	3.2
Olympus XZ-10	33	26	18	15	13	1.8	2.5	3.7

Higher signal-to-noise values indicate less disruptive noise

the center of the frame. In other words, you are just as restricted in your photographic freedom as you would be using a smartphone, but at least you will get the best possible image quality out of your compact.

Compacts in the US$300+ Range

In the early days of consumer digital photography, you had to use a DSLR if you wanted to produce high-quality images, but technology has progressed to a point at which functionality that would have put early DSLRs to shame is now available in a wide range of compact models.

Sensor size is the key to high-end image quality, and the larger the sensor, the more expensive the camera. The current best-in-class compacts offer APS-C sensors that measure 23.5 × 15.6 mm. The only currently available compact with a full-frame sensor is Sony's ultra-high-end DSC-RX1, which we tested in issue 12 of ***c't*** *Digital Photography*.

To clarify the difference sensor size makes: the tiny 1/2.3" sensors built into most cheaper compacts (and the high-end Olympus XZ-10) has a surface area of just 29 mm^2 (i.e., fingernail-sized), while an APS-C sensor has an area of 370 mm^2 and 12 times as much light-gathering capacity.

There are many sizes of sensor between these two extremes, and the popular 1/1.7" models provide 42.5 mm^2 of surface area (i.e., 50 per cent more than a 1/2.3" chip).

Bright Lenses

The second major yardstick for a high-end compact is its maximum aperture setting. The f1.4 wide-angle aperture offered by the Leica D-Lux 6 is the largest aperture in our test field, while the Canon PowerShot G15 and the Olympus XZ-10 offer f1.8 at the wide end. For cameras with zoom lenses, the maximum aperture at the telephoto end of the scale is almost as important, although both values vary widely from camera to camera.

Canon, Casio and Panasonic have all equipped their entry-level compacts with dedicated macro shooting modes that produce thoroughly usable results.
We captured this sample image of a dandelion using the Ixus 255/Elph 320 HS without flash or a tripod.

Contrast range /subject range ISO 100 [in f-stops] better ▶	**Contrast range /subject range** ISO 400 [in f-stops] better ▶	**Contrast range /subject range** ISO 1600 [in f-stops] better ▶	**Contrast range /subject range** ISO 3200 [in f-stops] better ▶	**Contrast range /subject range** ISO 6400 [in f-stops] better ▶	**Real subject range** [# of tonal values] better ▶	**Color Checker SG** ΔE ISO 100 ◀ better	**Shutter Lag** Wide-angle [s] ◀ better	**Shutter Lag** Telephoto [s] ◀ better
8.9	8.3	7.3	6.7	5.4	255	7.8	0.34	0.39
7.8	7.7	6.1	5.2	–	223	11.3	0.35	0.50
8.0	8.0	7.4	6.8	–	221	8.1	0.33	0.41
7.5	6.7	6.7	6.9	–	212	9.3	0.19	0.41
8.0	8.0	7.7	6.6	5.4	223	9.6	0.38	0.30
8.2	7.9	7.2	7.0	6.1	204	7.9	0.50	–
7.9	7.8	7.3	6.9	6.3	219	8.9	0.63	–[1]
8.1	7.5	6.3	5.7	5.6	189	11.2	0.62	–[1]

The logarithmic density, D, represents the camera's dynamic range in terms of the ratio between the brightness of the subject and the corresponding recorded tonal values. Higher values are better. Real subject range represents the range of tonal values contained in an 8-bit rendition of a test image.

Visual noise OECF20 ISO 3200 ◀ better	**Visual noise OECF20** ISO 6400 ◀ better	**Wide-angle distortion** [%] ISO 100 ◀ better	**Telephoto distortion** [%] ISO 100 ◀ better	**Wide-angle vignetting** ISO 100 [in f-stops] ◀ better	**Telephoto vignetting** ISO 100 [in f-stops] ◀ better	**Wide-angle chromatic aberration** ISO 100 ◀ better	**Standard chromatic aberration** ISO 100 ◀ better	**Telephoto chromatic aberration** ISO 100 ◀ better
4.2	6.4	0.3	0.5	0.8	0.6	0.1	0.4	0.5
6.4	–	0.5	0.1	0.5	0.5	1.4	1.4	2.7
4.3	–	0.4	0.0	0.7	0.4	1.7	0.9	2.3
2.7	–	0.2	0.1	0.8	0.7	1.4	1.3	1.3
4.3	6.0	0.3	0.2	0.5	0.6	0.3	0.5	0.5
3.8	5.3	0.7	0.2	0.6	0.6	0.6	0.6	0.8
4.2	5.9	0.4	–	1.2	–	0.9	–	–
4.6	4.8	0.6	0.0	0.7	0.9	0.7	0.3	0.4

'Visual noise' is a physiologically based judgment of how 'irritating' certain image noise artifacts appear to the viewer. The values are calculated based on the intensity, frequency and color of the perceived artifact.

Canon Ixus 255/Elph 320 HS

This camera squeezes a lot of technology into a small package and offers a good mix of useful photographic and fun features.

Good: Wide body provides good handling and access to the controls, which provide definite orientation points for your fingers. Handling is intuitive and all major functions can be accessed via the FUNC./SET button in the center of the main control dial. Useful features include macro mode (see our sample image on page 43). Battery life was among the best.

Not so good: Battery charging via a separate charger. Battery and memory card cover tricky to open. Stepped zoom almost impossible to adjust precisely, making zooming largely guesswork.

Test results: The IXUS/Elph produced the best resolution and noise results of our four entry-level compacts. High central resolution at all ISO settings and throughout the zoom range, with edge resolution dropping off by up to 20 per cent – for example, shooting at 24 mm and ISO 100 recorded 1440 line pairs in the center of the frame but just 1090 line pairs at the edges. At 250 mm, detail contrast falls off significantly. Visual noise at ISO 100 was a reasonable 1.7 and increases to around 3 at ISO 1600 – a value that indicates obvious disruptive noise.

Image quality: Images are generally clear and contrasty with no obvious noise at low ISO values, resulting in good reproduction for the natural materials in our test scene. ISO 400 is the limit for printable images. Beyond that, edges look frayed and our artist's palette no longer shows visible grain. Details are soft and white areas appear almost burned out.

Daylight photos are some of the best for the budget cameras we tested. Images look natural in spite of Canon's tendency to over-smooth details, and the viewer can certainly still guess at the finer details and textures. Our sample image shows the typical 'bubble gum' colors that Canon firmware produces. Pink turns out squeaky clean and yellows look almost gold-tinged. Such highly saturated colors are definitely a matter of taste.


c't test scene detail

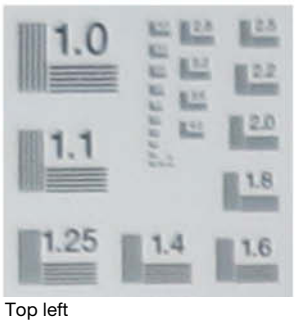

Sample image

ISO 100

ISO 400

ISO 800

ISO 3200



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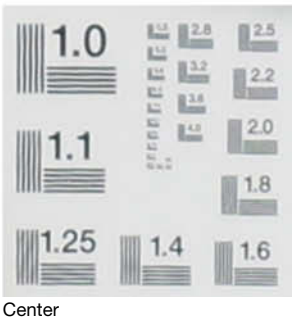


Center

Casio Exilim EX-ZR400

The ZR-400 is a relatively large compact with a broad range of user-controllable settings and a 12.5× optical zoom.

Good: The Casio is nice to handle and easy to use. It was the only one of our entry-level compacts with a separate mode dial, and its P, A, S and M shooting modes offer the user more creative freedom than most cameras in its class. Battery life is very good.

Not so good: This camera's major strength is simultaneously its major weakness, and the number of shooting modes on offer suggests more flexibility than is actually available. For example, aperture priority (Av) mode offers a choice of just two aperture settings, making it no more functional than the less fully featured competition. Wi-Fi functionality is not included.

Test results: In the lab, the Casio produced acceptable results, recording 1450 line pairs (of a maximum possible 1728) at a wide-angle setting and ISO 100. Edge resolution dropped to 1213 line pairs and worsened with increasing focal length. Wide-angle shooting is this camera's trump card, and standard and telephoto shots show obvious weakness. Noise is acceptable at ISO 100 and slightly better than that produced by the Sony DSC WX200. Noise at higher ISO values worsens rapidly.

Image quality: Central contrast is very good and details like the sieve or the palette are well defined. Color detail is also recognizable at low ISO values. Edge performance is not as good, with poor detail rendition and obvious fringing. High-contrast transitions show virtually no differentiation at ISO 400, and the sieve appears to melt into the background. Grain is highly intrusive at ISO 800.

Outdoor shots show neutral colors and are generally dull and slightly blurry. Soft textures such as shrubbery show virtually no detail and grass appears as an indefinable green mass. On the positive side, macro mode is very good, with relatively well-defined colors and good detail rendition.


c't test scene detail

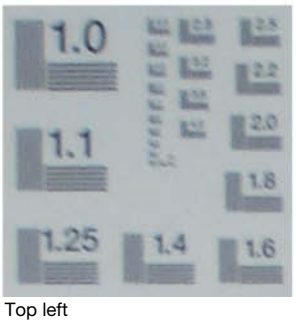

Sample image

ISO 100

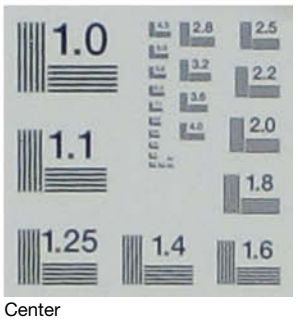
ISO 400

ISO 800

ISO 3200



Top left



Center

Panasonic Lumix DMC-SZ9

The ultra-compact Panasonic aims to please with a Leica lens, built-in Wi-Fi and a 10× optical zoom.

Good: The SZ9 is the only entry-level compact we tested that actually offers enough button-free space to grip the camera with your thumb. Handling is self-explanatory, with a dedicated button for switching modes and a separate 'Quick' menu for speedy adjustment of major settings. The monitor display offers a histogram and two different grid displays. Offers direct battery charging via mains adapter and USB cable, unfortunately with a proprietary plug. We would have preferred to see a standardized Micro USB connector.

Not so good: The SZ9 has tiny buttons and is more difficult to grip than some of the competition. Combined with its light weight, this makes it too easy to drop. Battery life is average and active Wi-Fi quickly shortens it further. Power Save mode reduces monitor brightness and switches the camera off automatically after a preset time. If the battery is exhausted, the camera simply beeps and switches off.

Test results: The Lumix was not a high achiever in the lab. At a wide-angle setting and ISO 100, it managed to produce just 80 percent of its potential center resolution (1386 line pairs from a theoretical maximum of 1728). Resolution drops off towards the edges of the frame, although not as quickly as the competition in this segment. Center and edge resolution are the same at standard focal lengths and worsened steadily with increasing ISO values, although not as significantly as others, including the Casio EX-ZR400. Visual noise is moderate up to ISO 1600 but quickly becomes unacceptable thereafter.

Image quality: The Panasonic firmware produces generally soft-looking images, evident in the textures in the wooden palette and the jute net in our test scene. The jute retains its texture while the woodgrain has been transformed into a pale, uniform surface. At low ISO values, the camera produced frayed edges in the center and at the edges of the frame, while some details show color casts at ISO 400.

Outdoor shots appear clear at a first glance, but actually lack detail and texture. Grass appears as a green-colored carpet with no recognizable tonal variation. Colors are neutral and tend toward cool. Like others in this category, the Panasonic tends to overexpose white areas but offers very good macro functionality.


c't test scene detail

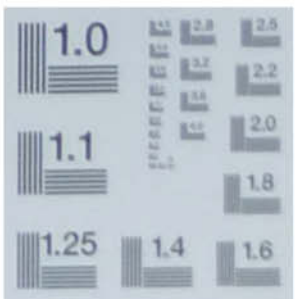

Sample image


ISO 100

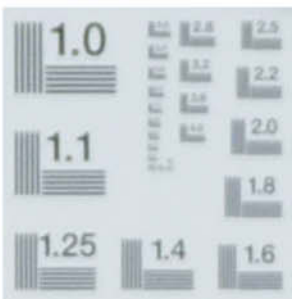

ISO 400


ISO 800


ISO 3200



Top left



Center

Sony DSC-WX200

Sony's DSC-WX200 is extremely small and light, but still offers an 18-megapixel sensor, a 10× optical zoom and built-in Wi-Fi.

Good: The WX200 is the smallest of our entry-level compacts and has a good-quality metallic body that is easy to grip. Handling is simple too, and 'Easy' mode makes it easier for children and older people to use by enlarging the monitor display and disabling all manual settings. Sony uses a standard Micro USB charging connector, which is sure to reduce the number of cables you have to carry.

Not so good: Very few manual settings (no A, S and M modes) means little shooting freedom. No manual focusing. The power switch is too deeply recessed and is tricky to press in a hurry. The camera's small size makes the monitor small too. Macro mode cannot be selected manually. Battery life is only average.

Test results: The WX200 produced great test results in spite of its high pixel count. Wide-angle center resolution was good right up to ISO 800, although edge detail was not so good. Resolution was acceptable across the entire frame at 50 mm. Telephoto results were quite weak and there was too much visual noise (scoring more than 2 at ISO 100). The resulting grain doesn't really spoil the images, but is obvious nonetheless.

Image quality: 18 megapixels leave their mark, with obvious grain in the colors and shadows of our test scene. ISO 400 is the limit for 1:1 enlargements. Textures in natural materials like the jute net and the artist's palette were obviously softened. Reds and yellows were too bright and the photos looked rather two-dimensional.

Outdoor shots displayed relatively high contrast and a good degree of sharpness. Colors were over-saturated (see the red freesia in the sample image below). The Sony firmware tends to over-sharpen fine details such as twigs and stalks, leaving little clear detail as a result.

c't test scene detail

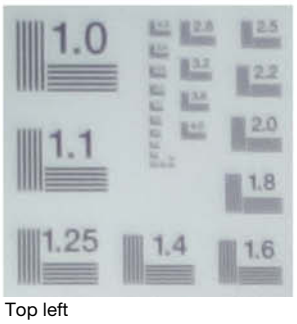
Sample image

ISO 100

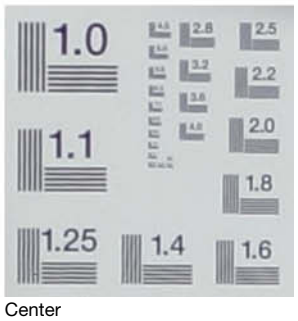
ISO 400

ISO 800

ISO 3200



Top left



Center

Canon PowerShot G15

The Canon has average sensor resolution, a moderate zoom range and a modest set of features, but is easy to use and its relatively small sensor produces high-quality images.

Good: The G15's big selling points are excellent handling and a bright lens. The maximum wide-angle aperture of f1.8 is only topped by the Leica D-Lux 6 and still offers a relatively bright f2.8 at its longest telephoto setting of 140 mm. Although quite chunky in appearance, the camera sits comfortably in the user's hand and is really easy to use, with two distinct rows of buttons, levers and dials and an additional command dial at the top of the handgrip/battery compartment. The controls are easy to reach, even when you are viewing a scene through the viewfinder.

Not so good: The viewfinder is something of a makeshift solution, making the camera more bulky without providing a real alternative to the monitor. It is only really useful in emergencies such as strongly backlit situations. Unlike the 1/1.7" sensor built into the G1X, the G15's 12-megapixel CMOS sensor is only slightly larger than that found in most truly small compacts and only has slightly more resolution than the G12, which has a 10-megapixel sensor.

We also missed the tilt/swivel monitor from the G12, even if this made the G15's predecessor more bulky. You might prefer to spend about US$100 more for the larger sensor and articulated monitor offered by the G1 X, even if its lens is weaker on paper.

Test results: Resolution reached 90 per cent in the center of the frame at ISO 100 and 200 but dropped off by 20 per cent at the edges, even zoomed out. Visual noise is still acceptable at ISO 1600.

Image quality: Images look natural with a slight tendency toward pale colors. Unless you try to capture too much dynamic range, shadow and highlight details are excellent. In spite of its good lab values, the relatively small sensor has its limits and produces images that look rather lifeless in comparison to those from the Nikon Coolpix A.


c't test scene detail

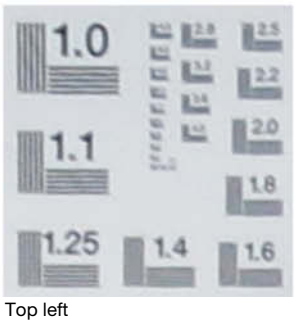

Sample image

ISO 100

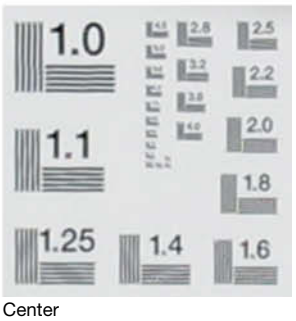
ISO 400

ISO 800

ISO 12800



Top left



Center

Leica D-LUX 6

An f/1.4 lens with a dedicated focus ring and mode switch makes the Leica D-LUX 6 unique in this class of camera. It is easy to use and looks good too.

Good: Technically, the D-LUX is based largely on the Panasonic Lumix LX7, although its overall design is simpler and includes the famous red Leica emblem. The stabilized f/1.4 lens is the brightest we tested, even though the aperture range ends at a rather modest f8. Maximum aperture at the zoom end (90mm) is an unusually bright f2.3. The lens is surrounded by an aperture ring and two switches for altering the aspect ratio and focus mode. The thumb-operated command dial and the separate ND filter switch (for extending exposure times) make the great handling even better. The menu system is easy to understand and includes just about all the options you could ever need, including RAW shooting, HDR functionality and vertical and horizontal panoramas.

Not so good: The 1/1.7" sensor is too small for an US$800 camera. Larger sensors and accordingly high image quality are now standard in this segment. For US$450, the Panasonic Lumix LX7 offers almost the same specification and represents better value for money. Typically for Leica, the lens does not have built-in protection and relies on a conventional lens cap, which is annoying to use after a while.

Test results: Noise characteristics are fine up to ISO 400 and dynamic range of more than eight f-stops (at ISO 100) is also very good. Center resolution exceeds 80 per cent at ISO 100 and 200 over the entire zoom range. Edge resolution is less convincing, with values more like those produced by the PowerShot G15, especially at the wide-angle end.

Image Quality: The (camera JPEG) images delivered by our test camera are quite subtle compared to those from the G15 but provide more detail, especially in the highlights. The woodgrain in the palette showed smoothing artifacts at ISO 100, which we assume is the fault of the Leica JPEG engine. The RAW imports looked much better.


c't test scene detail

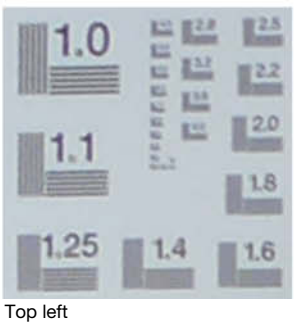

Sample image

ISO 100

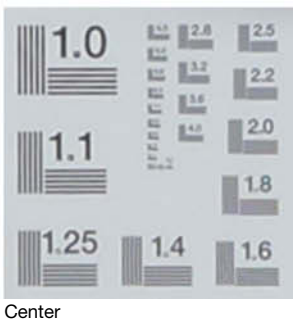
ISO 400

ISO 800

ISO 6400



Top left



Center

Nikon Coolpix A

A bright fixed-focal-length lens, a large DX sensor and a compact body make the Coolpix A a great, highly portable camera for fans of high-quality images who also have money to spare.

Good: The Coolpix A is a good-looking high-end compact that just about fits into a trouser pocket. From the outside the 'A' looks like the Coolpix 330, while its DX (APS-C-sized) sensor and lack of a high pass filter make its inner workings more like those of the D7100 DSLR. The 28mm f/2.8 lens delivers very good results (in JPEG and RAW formats) that are directly comparable with DSLR images, especially when shot in good light. The design is classy and the good selection of controls distributed around the back plate makes handling a breeze. Nikon DSLR owners will quickly get the hang of this camera, and the familiar '**i**' button provides a condensed view of all the major functions in a single screen. The manual focus ring surrounding the lens is a boon and is set up to take priority, even if the camera is switched to autofocus mode.

Not so good: The 28mm fixed focal length won't be everyone's cup of tea, and most of the direct competition uses 35mm lenses. Close focusing distance is quite long, but can be decreased by switching to macro mode, which is hidden away among the other scene modes. Autofocus is slow and sometimes 'pumps' while searching for a setting. An optical viewfinder is only available as an optional extra, making the 'A' a truly expensive device.

Test results: The 'A' delivers excellent resolution (over 95 per cent of the theoretical maximum), as expected. Edge performance is only slightly poorer, and still hits more than 90 per cent at ISO 800 (see the samples below). Visual noise and signal-to-noise ratio are also exemplary all the way up to ISO 400 and only begin to deteriorate beyond ISO 800.

Image quality: In short, colors, bokeh and noise characteristics are all outstanding and, provided there is sufficient light, shooting with the 'A' is a lot of fun.


c't test scene detail

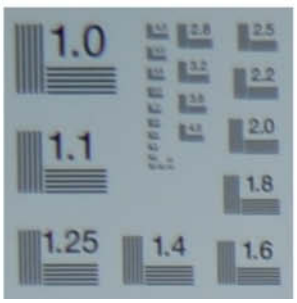

Sample image

ISO 100

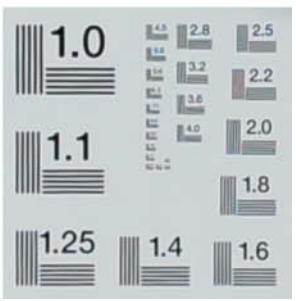
ISO 400

ISO 800

ISO 6400



Top left



Center

Olympus XZ-10

Small body, small sensor, bright lens and lots of features are the basic recipe for Olympus' pocketable high-end compact.

Good: The XZ-10 is marketed somewhere between low-budget and high-end compacts. Its 12-megapixel sensor is backside illuminated but is only 1/2.3" in size. The 5× zoom lens has a maximum wide-angle aperture of f1.8 coupled with f2.7 at the telephoto end, both of which are very good values. Images are stabilized via sensor shift and the menus are full of useful features, including RAW shooting mode and a neutral density filter for extending shutter speeds in tricky conditions (or for creating deliberately blurred motion effects). The built-in touch screen can be used to focus, release the shutter and adjust some of the major functions. Aperture and Exposure time can be adjusted using the ring surrounding the lens. Thankfully, Olympus hasn't overburdened the small sensor with too many pixels.

Not so good: The small sensor and the correspondingly modest test results (see below). The complex menu system with its sometimes illogical organization. However, we appreciate that it is difficult to fit a lot of features into a simple structure, and even the Olympus approach works fine once you have had a little practice.

Test results: Central resolution is good at wide-angle and standard focal lengths up to ISO 800, dropping only 10 per cent from its highest value of 94 per cent. However, performance decreases rapidly toward the edges of the frame. Seventy per cent of the theoretical maximum resolution at a wide-angle setting and ISO 100 is a poor result. Noise performance was much better, with a visual noise rating of about 2 at ISO 100 and 200. Noise increases at higher ISO values and is quite obvious at ISO 400 and above.

Image quality: Our test (JPEG) images confirmed our lab results, with edge and especially corner detail sadly lacking. For better results with this camera, you are better off shooting RAW and developing your images in a dedicated program such as *Lightroom*.


c't test scene detail

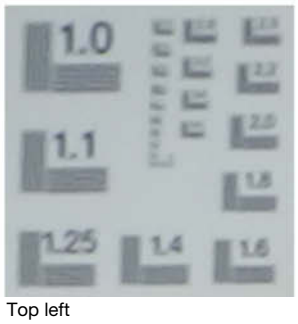

Sample image


ISO 100

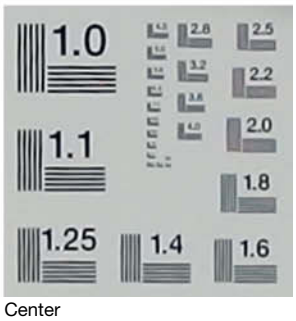

ISO 400


ISO 800


ISO 6400



Top left



Center

UNIVERSAL COMPACTS	ENTRY-LEVEL			
Manufacturer/Model	**Canon Ixus 255 HS/Elph 320**	**Casio EX-ZR400**	**Panasonic Lumix DMC-SZ9**	**Sony DSC-WX200**
URL	www.canon.com	www.casio.com	www.panasonic.com	www.sony.com
Digitization				
Native resolutions (in pixels)	4000 × 3000 (4:3), 2816 × 2112 (4:3), 1600 × 1200 (4:3), 640 × 480 (4:3), 4000 × 2.248 (16:9), 4000 × 2664 (3:2), 2992 × 2992 (1:1)	4608 × 3456 (4:3), 3648 × 2736 (4:3), 2560 × 1920 (4:3), 2048 × 1536 (4:3), 640 × 480 (4:3), 4608 × 2592 (16:9), 4608 × 3072 (3:2)	4608 × 3456 (4:3).3648x2736 (4:3), 2560 × 1920 (4:3), 2048 × 1536 (4:3), 640 × 480 (4:3), 4608 × 2592 (16:9), 4608 × 3072 (3:2), 3456 × 3456 (1:1)	4896 × 3672 (4:3), 3648 × 2736 (4:3), 2592 × 1944 (4:3), 640 × 480 (4:3), 4896 × 2752 (16:9), 1920 × 1080 (16:9)
Sensor type, effective megapixels / Size / Self-cleaning	CMOS, 12 / 1/2.3" (5.6 mm × 4.2 mm)	CMOS, 16 / 1/2.3" (5.6 mm × 4.2 mm)	CMOS, 16 / 1/2.3" (5.6 mm × 4.2 mm)	CMOS, 18 / 1/2.3" (5.6 mm × 4.2 mm)
Image format(s) / Compression rates / Video format	JPEG / 2 / MOV (H.264)	JPEG / 2 / MOV (H.264)	JPEG / 2 / MP4 (AVCHD, MP4)	JPEG / 1 / MTS (AVCHD, MP4)
Video: max. resolution [pixels], fps, length	1920 × 1080, 24 fps, 4 GB or 10 min	1920 × 1080, 30 fps, 4 GB or 29 min.	1920 × 1080, 25 fps, 30 min.	1080p, 25 fps, 2 GB or 29 min.
Memory card type / Internal memory / Average file size[3]	SD(HC/XC) / – / 3 MB	SD(HC/XC) / 52 MB / 7 MB	SD(HC/XC) / 60 MB / 6 MB	SD(HC/XC)microSD/HC, MS / 48 MB / 6 MB
Features				
ISO settings	Auto (100-800), 80, 100, 200, 400, 800, 1600, 3200, 6400	Auto (80-800), 80, 100, 200, 400, 800, 1600, 3200	Auto (100-1600), 100, 200, 400, 800, 1600, 3200	Auto (100-800), 100, 200, 400, 800, 1600, 3200, (6400, 12800)
Max. aperture/ # of f-stops/ Stabilizer (type)	f/3.0-6.9 / 2 / ✓ (Lens shift)	f/3.0-5.9 / 2 / ✓ (Sensor shift)	f/3.1-5.9 / 2 / ✓ (Sensor shift)	f/3.5-5.9 / 2 / ✓ (Sensor shift)
(Long) Exposure times	(15 s) 1-1/2000 s	(15 s) 15-1/4000 s	(30 s) 4-1/6000 s	(4 s) 1-1/6400 s
Zoom range / In mm (equivalent)	10× / 24-240 mm	12.5× / 24-300 mm	10× / 25-250 mm	10× / 25-250 mm
Shortest focus distance wide-angle /macro	1 cm / 1 cm	1 cm / 5 cm	5 cm / 50 cm	5 cm / 5 cm
Focusing	AF (one shot), AL (servo), infinity, spot	AF (one shot), AL (servo), infinity, manual, spot, multi	AF (one shot), AL (servo), infinity, spot, multi	AF (one shot), AL (servo), infinity, spot, multi
AF points / Focus assist lamp	9 / ✓ (orange)	n/a / ✓ (orange)	23 / ✓ (orange)	n/a / ✓ (orange)
Matrix / Center-weighted / Spot metering	✓ / ✓ / ✓	✓ / ✓ / ✓	✓ / – / –	✓ / ✓ / ✓
Programmed auto / Scene modes / Custom presets	✓ (with scene detection) / 18 / ✓	✓ (with scene detection) / n/a / ✓	✓ (with scene detection) / 16 / –	✓ (with scene detection) / 15 / ✓
S / A / M modes	– / – / –	✓ / ✓ / ✓	– / – / –	– / – / –
Exposure compensation	±2 EV in 1/3 increments	±2 EV in 1/3 increments	±2 EV in 1/3 increments	±2 EV in 1/3 increments
Exposure / WB / Focus bracketing	– / – / –	– / – / ✓	✓ / – / –	– / – / –
Self-timer / Burst shooting	2s, 10s / 2 fps, until buffer full	2s, 10s / 30 fps, 30	2s, 10s / 5 fps, n/a	2 s, 10 s / 10 fps, n/a
Interval shooting / Sound recording	– / ✓ (Linear PCM)	– / ✓ (IMA-ADPCM)	– / ✓ (stereo)	– / ✓ (ACC)
Auto WB / # of Presets / Manual WB	✓ / 6 / ✓	✓ / 6 / ✓	✓ / 5 / ✓	✓ / 10 / ✓
Sharpness / Contrast / Saturation adjustable	✓ / ✓ / ✓	✓ / ✓ / ✓	– / – / –	– / – / –
Monitor size / Resolution (dots) / Protector / Viewfinder	3" / 461,000 / – / –	3" / 460,800 / – / –	3" / 460,000 / – / –	2.7" / 460,800 / – / –
4-way selector / Multi selector / Command dials	✓ (with center button) / – / –	✓ (with center button) / 1 / –	✓ (with center button) / – / –	✓ (with center button) / – / –
Flash compensation / Flash connector	✓ / –	✓ / –	– / –	– / –
Playback				
Grid [# of images] / Zoom / Histogram	4, 9, 36, 100 / ✓ (n/a) / ✓	25 / ✓ (up to 8) / ✓	12, 30 / ✓ (up to 16) / ✓	16, 25 / ✓ (up to 8) / ✓
Connectors / Dimensions				
Power source	Li-ion battery (2.9W)	Li-ion battery (6.7W)	Li-ion battery (2.5W)	Li-ion battery (2.3W)
USB / A/V out / HDMI / Printer / Wi-Fi	USB 2.0 / – / ✓ / – / ✓	USB 2.0 / ✓ / ✓ / ✓ / –	USB 2.0 / ✓ (via USB) / ✓ / ✓ / ✓	USB 2.0 / – / ✓ / – / ✓
Wi-Fi / GPS	✓ / –	– / –	✓ / –	✓ / –
Dimensions (W/H/D) / Weight incl. battery	97 mm × 56 mm × 22 mm / 125 g	105 mm × 59 mm × 29 mm / 165 g	97 mm × 57 mm × 21 mm / 119 g	92 mm × 52 mm × 22 mm / 105 g
What's in the Box				
Manual / User guide	Manual, quick start guide, electronic (177-page PDF)	Manual, quick start guide, electronic (199-page PDF)	Manual, quick start guide, electronic (223-page PDF)	Manual, electronic (611-page PDF)
Accessories	USB cable, Li-ion battery NB-4L (3.7 V, 760 mAh), charger, hand strap	USB cable, Li-ion battery NP-130 (1800 mAh), hand strap, AC connector cable	USB cable, Li-ion battery DMW-BCL7E (650 mAh), hand strap	USB cable, Li-ion battery NPBN (630 mAh), hand strap
Optional accessories	AC adapter ACK-DC60	Leather case, charger	Leather case	microSD adapter
Software				
Standalone software (platform)	Canon Utilities: Image Browser 1.1, Camera Window DC 8.10, PhotoStitch 3.1/3.2 (Win/Mac)	–	PhotofunStudio 9.0 AE (Win/Mac)	PlayMemories Home (Win)
Ratings				
Test images[1] (c't test image shot in daylight)				
Color rendition / Exposure	⊕ / ○	⊖ / ○	⊕ / ○	○ / ○
Sharpness / Detail rendition	⊕ / ⊕	○ / ○	○ / ○	○ / ○
Image noise / Other artifacts[2]	⊕⊕ / ⊕	⊕ / ○	⊕ / ○	⊕ / ○
Ease of use	⊕	⊕⊕	⊕	⊕
Feature set	⊕⊕	⊕	⊕⊕	⊕⊕
Price for camera / replacement battery (US$)	120 / 40	200 / 30	200 / 30	175 / 30

[1] Judged by eye on a calibrated monitor (applies only to these cameras and therefore not comparable with earlier tests)
[2] Sharpening and compression artifacts, moirés and axial and longitudinal chromatic aberrations
[3] Measured in the center of the frame using largest native image size and best JPEG quality

⊕⊕ excellent ⊕ good ○ satisfactory ⊖ poor ⊖⊖ inadequate ✓ included – not included n/a not applicable

HIGH-END

Canon PowerShot G15	Leica D-LUX 6	Nikon Coolpix A	Olympus XZ-10
www.canon.com	www.leica-camera.com	www.nikon.com	www.olympus.com
4000 × 3000 (4:3), 2816 × 2112 (4:3), 1600 × 1200 (4:3), 640 × 480 (4:3), 4000 × 2248 (16:9), 4000 × 2664 (3:2), 2992 × 2992 (1:1)	3648 × 2736, 3072 × 2304, 2560 × 1920, 2048 × 1536 Pixel, 1600 × 1200 Pixel, 640 × 480, 3:2: 3776 × 2520, 16:9: 3968 × 2232 Pixel, 1:1: 2736 × 2736	4.928 × 3.264 (4:3), 3.696 × 2.448 (4:3), 2.464 × 1.632 (4:3)	4032 × 3024, 3968 × 2976 (4:3), 2560 × 2976 (4:3), 2560 × 1920 (4:3), 1280x960 (4:3), 3968 × 2232 (16:9), 3936 × 2624 (3:2), 2976 × 2976 (1:1)
CMOS, 12.1 / 1/1.7" (7.5 mm × 5.5 mm)	CMOS, 10.1 / 1/1.7" (7.5 mm × 5.5 mm)	CMOS, 16.2 / APS-C (23.5 mm × 15.6 mm)	CMOS, 12 / 1/2.3" (5.6 mm × 4.2 mm)
JPEG, RAW / 2 / AVI, H.264, iFrame (H.264)	JPEG, RAW / 2 / AVCHD, MP4 (AVCHD, MP4)	JPEG, RAW / 3 / MP4 (H.264, MP4)	JPEG, RAW / 2 / MOV (MPEG-4AVC/H.264)
1920 × 1080, 24 fps	1920 × 1080, 60 fps, 29 min.	1920 × 1080, 30 fps	1920 × 1080, 30 fps, 29 min.
SD(HC/XC) / – / 3 MB	SD(HC/XC) / – / 4 MB	SD(HC/XC) / – / 3 MB	SD(HC/XC) / 43 MB / 6 MB
Auto (80-12800), Auto, 100, 125, 160, 200, 250, 320, 400, 500, 640, 800, 1000, 1250, 1600, 2000, 2500, 3200, 4000, 5000, 6400, 8000, 10000, 12800	Auto (80-6400), Auto/i. ISO/80, 100, 200, 400, 800, 1600, 3200, 6400, 12800, 1/3 increments possible	Auto (100-6400), Auto, 100, 125, 160, 200, 250, 320, 400, 500, 640, 800, 1000, 1250, 1600, 2000, 2500, 3200, 4000, 5000, 6400, H0.3, H0.7, H1	Auto (100-6400), Auto, 100, 125, 160, 200, 250, 320, 400, 500, 640, 8001000, 1250, 1600, 2000, 2500, 3200, 4000, 5000, 6400,
f/1.8-2.8 / 14 / ✓ (Lens shift)	f/1.4-2.3 / 16 / –	f/2.8 / 19 / –	f/1.8-2.7 / ✓ (Sensor shift)
(15 s) 15-1/4000 s	(250 s) 250-1/4000 s	(B) 30-1/2000 s	(30 s) 30-1/2000 s
5× / 28-140 mm	3.8× / 24-90 mm	– / 28 mm	5× / 26-130 mm
1 cm / approx. 30 cm	1 cm / 50 cm	14 cm / 29 cm	1 cm / 10 cm
AF (one shot), AL (servo), manual, spot, multi	AF (one shot), manual, spot, multi	AF (one shot), AL (servo), infinity, manual, spot, multi	AF (one shot), AL (servo), spot, multi
n/a / ✓ (white)	23 / ✓ (orange)	n/a / ✓ (orange)	n/a / ✓ (orange)
✓ / ✓ / ✓	✓ / ✓ / ✓	✓ / ✓ / ✓	✓ / ✓ / ✓
✓ (with scene detection) / 12 / ✓	✓ / 16 / ✓	✓ (with scene detection) / 19 / ✓	✓ / 14 / ✓
✓ / ✓ / ✓	✓ / ✓ / ✓	✓ / ✓ / ✓	✓ / ✓ / ✓
±3 EV in 1/3 increments	±3 EV in 1/3 increments	±3 EV in 1/3 increments	±3 EV in 1/3 increments
✓ / – / ✓	✓ / ✓ / –	✓ / – / –	✓ / – / –
2s, 10s / 2.1 fps, n/a	2, 10+3×2, 10 / 2.5, 11, 40, 60 fps, 100, 100, 12, 40, 60	2s, 10s / 4 fps, until buffer full	2s, 12s / 5 fps, 200
– / ✓ (Linear PCM)	✓ / –	✓ / ✓ (Linear PCM)	– / ✓ (Stereo PCM/16 Bit, 44.1 kHz, Wave format)
✓ / 10 / ✓	✓ / 6 / ✓	✓ / 9 / ✓	✓ / 6 / ✓
✓ / ✓ / ✓	✓ / ✓ / ✓	✓ / ✓ / –	✓ / ✓ / ✓
3" / 922,000 / – / –	3" / 920,000 / – / –	3 / 921,000 / – / –	3" / 920,000 / – / –
✓ (with center button) / 1 / 1	✓ (with center button) / 1 / 1	✓ (with center button) / 1 / 1	✓ (with center button) / 1 / 1
✓ / ✓	✓ / ✓	✓ / –	✓ / –
80 / ✓ (up to 10) / ✓	30 / ✓ (up to 16) / –	72 / ✓ (up to 12) / –	25 / ✓ (up to 14) / ✓
Li-ion battery (7.4W)	1-Battery (4.5W), mains adapter	Li-ion battery (7.4W)	Li-ion battery (3.3 W), mains adapter
USB 2.0 / ✓ (via USB) / ✓ / ✓ / –	USB 2.0 / ✓ (via USB) / ✓ / ✓ / –	USB 2.0 / ✓ (via USB) / ✓ / ✓ / –	USB 2.0 / ✓ (via USB) / ✓ / ✓ / ✓
– / –	– / –	– / ✓	✓ / –
107 mm × 76 mm × 40 mm / 309 g	111 mm × 67 mm × 47 mm / 265 g	111 mm × 64.3 mm × 40.3 mm	102.4 mm × 61.1 mm × 34.3 mm / 200 g
Manual, quick start guide, electronic (314-page PDF)	Manual, quick start guide, electronic (223-page PDF)	Manual, electronic	Manual, electronic (89-page PDF)
USB cable, Li-ion battery NB-10L (920 mAh), charger, hand strap	USB-, AVcable, Li-ion battery ´BP-DC10-E (1250 mAh), charger, hand strap, Lightroom	USB cable, Li-ion battery EN-EL20 (1020 mAh), charger, hand strap, View NX2	USB-, AVcable, Li-ion battery LI-50B (925 mAh)
Battery , battery charger, mains adapter, accessory flash, remote release, flash shoe extension, accessory lens adapter, underwater housing	Leather case, protector, system bag, carry strap, hand grip, electronic viewfinder EVF 3, mini HDMI cable, flash, mini tripod with ball head	Power connector EP-5C, mains adapter EH-5b, optical viewfinder DF-CP1, IR remote control ML-L3, cable release MC-DC2, GPS receiver GP-1, wireless mobile adapter WU-1a, Capture NX 2	–
CameraWindow, ImageBrowser EX, DigitalPhoto Professional	1 (Win), 1 (Mac), Lightroom (Win/Mac)	View NX2 (Win/Mac)	Olympus Viewer 3 (Win/Mac)
⊕ / ⊕	⊕ / ⊕	⊕⊕ / ⊕⊕	⊕ / ○
⊕ / ⊕	⊕	⊕⊕	⊕ / ○
⊕ / ○	⊕ / ○	⊕⊕	⊕ / ○
⊕⊕	⊕⊕	⊕⊕	○
⊕⊕	⊕	⊕	⊕⊕
500 / 45	800 / 70	1100 / 45	400 / 30

Take Me to the Moon – Travel and Super Zooms

Travel and super zooms are one of the fastest-growing non-DSLR segments, providing zoom factors of 40× and more. Bridge-type cameras with equivalent focal lengths of up to 1,000 mm underscore the notion that having a feature is often just as important as actually needing it, and it is quite difficult to shoot shake-free images handheld at these types of magnifications, even with active image stabilization.

Today's long zooms come in a wide variety of packages, from pocket-sized travel zooms to DSLR-sized bridge cameras with more complex handling and a broader range of controls. In spite of their physical size, bridge cameras rarely have sensors that exceed 1/2.3" in size, so there is no real advantage compared with their smaller counterparts regarding noise. We also found that these mega-lenses usually only produce images of average quality anyway.

Lenses

The image quality provided by many 'super zoom' lenses has earned them the less than flattering soubriquet 'soup zoom' in many online forums. Building lenses with such huge zoom ranges presents all sorts of challenges and, while some compacts offer stepped zooms or even no zoom functionality at all, the engineers who design travel and super zooms have to come up with solutions that cover all the bases. Most long zooms produce their best images at wide-angle or short telephoto settings, and reports indicate that most people shoot at focal lengths between wide-angle and 100 mm most of the time anyway. As with most other cameras, resolution is generally much better in the center than it is at the edges of the frame – our test candidates produced differences of up to 20 per cent. Detail rendition often leaves a lot to be desired too, as the sample images below and on our free DVD show. The noise characteristics of small sensors are also challenging and, even if these cameras offer ISO settings of up to 12 800, only the settings up to ISO 400 are genuinely usable in everyday situations. High resolutions of 16 and more megapixels also contribute to less-than-perfect results.

Features

Enhanced feature sets often tempt compact users to step up to bridge and travel zoom models. The ability to adjust aperture and exposure time yourself and thus directly influence the look of an image is a strong argument. Many bridge cameras also offer a real, adjustable aperture instead of a neutral density (ND) filter and have many more dedicated controls, making handling and shooting easier. Some models also have touch screens. Exposure settings were quick and easy to set up in all our test cameras. Built-in Wi-Fi and GPS functionality are finding their way into increasing numbers of compact cameras and are a real aid to travel photography, enabling the user to precisely record locations and travel routes and even look

TRAVEL ZOOM AND SUPER ZOOM CAMERAS – TEST RESULTS, PART 1

	Sensor resolution [Lp/Bh] better▶	**Relative center resolution** (ISO 100, wide-angle) Resolution in % better▶	**Center resolution** (ISO 100) [lp/h] better▶	**Center resolution** (ISO 400) [lp/h] better▶	**Center resolution** (ISO 1600) [lp/h] better▶	**Center resolution** (ISO 3200) [lp/h] better▶	**Center resolution** (ISO 6400) [lp/h] better▶
Fujifilm Finepix HS50 EXR	1728	78	1349	1348	1081	928	883
Nikon Coolpix P520	1836	90	1647	1209	861	680	582
Panasonic Lumix DMC-TZ40	1836	84	1541	1372	1252	1135	–
Pentax Optio X-5	1728	90	1560	1412	1143	1001	696
Samsung WB800F	1728	78	1340	1184	967	894	–

Resolution was determined visually in units of vertical line pairs [lp/h]. The higher the value, the sharper the image.
The logarithmic density, D, represents the camera's dynamic range in terms of the ratio between the brightness of the subject and the corresponding recorded tonal values. Higher values are better.
Real subject range represents the range of tonal values contained in an 8-bit rendition of a test image.

TRAVEL ZOOM AND SUPER ZOOM CAMERAS – TEST RESULTS, PART 2

	Signal-to-noise ratio [S/Nx] ISO 100 better▶	**Signal-to-noise ratio** [S/Nx] ISO 400 better▶	**Signal-to-noise ratio** [S/Nx] ISO 1600 better▶	**Signal-to-noise ratio** [S/Nx] ISO 3200 better▶	**Signal-to-noise ratio** [S/Nx] ISO 6400 better▶	**Visual noise OECF20** ISO 100 ◀better	**Visual noise OECF20** ISO 400 ◀better	**Visual noise OECF20** ISO 1600 ◀better
Fujifilm Finepix HS50 EXR	29	22	15	11	10	2.1	2.8	4.1
Nikon Coolpix P520	27	24	16	16	11	2.1	2.8	4.2
Panasonic Lumix DMC-TZ40	37	28	16	16	–	1.9	2.7	3.9
Pentax Optio X-5	33	31	23	20	14	2.4	2.6	3.0
Samsung WB800F	50	43	30	23	–	1.6	1.9	2.7

Higher Signal-to-noise values indicate less disruptive noise.
'Visual noise' is a physiologically based judgment of how 'irritating' certain image noise artifacts appear to the viewer. The values are calculated based on the intensity, frequency and color of the perceived artifact.
Values below 0.8 represent virtually noise-free images, values below 2 low-noise reproduction and those between 2 and 3 visible but acceptable noise levels. Values above 3 represent disruptive levels.
Values of 5 and above represent extreme, unacceptable noise.

up places of interest in the vicinity. It is only a matter of time until Wi-Fi becomes a standard feature of all digital cameras. Features like automatic saves to your home network and simple uploads to social networks or your own tablet for local presentation are simply too useful to leave out. Samsung, for example, includes Wi-Fi in all its new cameras, and Panasonic is rapidly turning it into a standard feature too. The downside of built-in Wi-Fi is its increased power usage, which is made even more problematic by the recent trend toward in-camera battery charging. Only the Fujifilm HS50EXR includes a separate charger for topping up a spare battery.

The range of scene modes on offer increases all the time and, in addition to the usual sunset and sports modes, many of our test cameras also offer sweep panorama and 3D modes, as well as face detection for (for people and animals) and soft-focus 'beauty' modes, to name just a few. In-camera processing is also on the increase, and the success of the filters and effects built into a lot of smartphones has encouraged their inclusion in camera firmware too.

If you are looking for an all-round camera for your next vacation, don't allow yourself to be blinded by sheer focal length alone. A 1000 mm lens is seldom really useful and cannot be used effectively without a tripod anyway. Compactness and useful features are the best guidelines, and a camera that fits into a jacket pocket is a more comfortable travel companion than one that hangs from your neck. We have found that most large, 'professional-looking' bridge cameras promise more than they can deliver and are only really full-featured compacts in big bodies.

We don't believe it's possible to shoot shake-free photos handheld when the Fuji's zoom is at its longest setting

Contrast range /subject range ISO 100 [in f-stops] better▶	**Contrast range /subject range** ISO 400 [in f-stops] better▶	**Contrast range /subject range** ISO 1600 [in f-stops] better▶	**Contrast range /subject range** ISO 3200 [in f-stops] better▶	**Contrast range /subject range** ISO 6400 [in f-stops] better▶	**Real subject range** [# of tonal values] better▶	**Color Checker SG** ΔE ISO 100 ◀better	**Shutter Lag** Wide-angle [s] ◀better	**Shutter Lag** Telephoto [s] ◀better
7.6	7.5	6.4	5.3	5.4	227	9.0	0.22	0.32
7.7	7.5	6.3	6.1	5.2	206	9.7	0.65	0.62
8.5	7.9	7.4	6.1	–	217	8.1	0.63	0.66
7.9	7.6	6.9	6.5	6.0	222	9.8	0.55	0.81
8.2	7.7	7.2	6.4	–	216	7.6	0.44	0.47

Visual noise OECF20 ISO 3200 ◀better	**Visual noise OECF20** ISO 6400 ◀better	**Wide-angle distortion** [%] ISO 100 ◀better	**Telephoto distortion** [%] ISO 100 ◀better	**Wide-angle vignetting** ISO 100 [in f-stops] ◀better	**Telephoto vignetting** ISO 100 [in f-stops] ◀better	**Wide-angle chromatic aberration** ISO 100 ◀better	**Standard chromatic aberration** ISO 100 ◀better	**Telephoto chromatic aberration** ISO 100 ◀better
5.7	6.1	0.6	0.1	0.7	0.6	1.3	0.4	0.3
4.4	6.5	0.3	0.1	1.0	1.1	0.7	0.3	0.3
4.8	–	0.3	0.2	0.8	1.0	1.5	1.2	2.4
3.8	5.0	0.2	0.1	0.8	0.8	1.3	1.4	3.7
3.5	–	0.1	0.5	0.9	0.8	2.9	3.8	1.5

Fujifilm Finepix HS50EXR

The big-bodied Finepix looks like a DSLR at a first glance and offers a feature set worthy of much more expensive cameras.

Good: The HS50EXR is heavy but well balanced. Build quality is the best we tested and handling is excellent. There are separate zoom and manual focus rings and a 'Quick' menu gives the user fast access to a useful range of major functions that are easy to alter using the command dial and the four-way selector. Not only does it have a built-#in flash, it is also the only super zoom we tested with a dedicated flash shoe. The built-in level is useful, as is the articulated monitor. Hybrid autofocus ensures fast focusing.

Not so good: The HS50EXR is just as heavy as some entry-level DSLRs, making it less fun to use than the truly compact competition. We would expect such a large, well-equipped camera to include Wi-Fi and GPS functionality too.

Test results: This model produced the poorest wide-angle center resolution in our test and things only get worse toward the edges of the frame. Telephoto resolution also took last place across the entire frame. Noise characteristics are average and visual noise is already obvious at ISO 200. The signal-to-noise ratio is correspondingly high. On the plus side, vignetting was very good and made a difference of just 0.6-0.7 stops over the entire range of focal lengths. Shutter lag is minimal and beat all the other test candidates.

Image quality: Our test shots underscore our lab values. Edge detail is extremely poor, blurring images from ISO 200 onward. ISO 800 is only usable in an emergency and for small output sizes. Higher ISO values produce obvious, characteristic Fujifilm color noise.

Outdoor colors tend to be slightly overblown, with heavily saturated unnatural-looking reds, yellows and blues. As with the Nikon, the real-world usefulness of a 42× zoom is still very much a moot point.

c't test scene detail

Main: ISO 100, 24 mm, f5.6

Detail: ISO 100, 1000 mm, f6.4

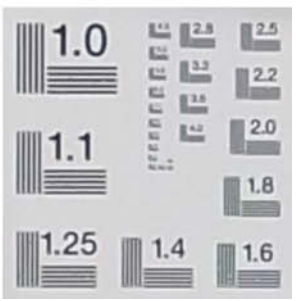
ISO 100

ISO 400

ISO 800

ISO 3200

Top left



Center

Nikon Coolpix P520

The Coolpix P520 is a fully featured bridge camera with built-in GPS and an articulated monitor.

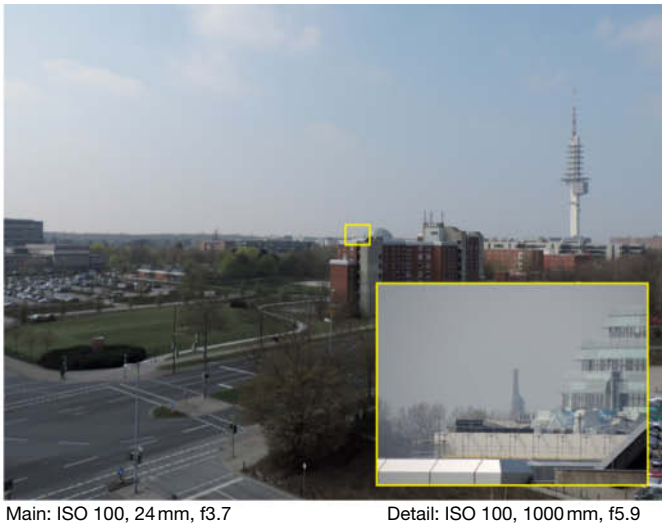
Good: The P520 has an ergonomically pleasing shape that sits well in the user's hand. A dedicated zoom lever, programmable buttons and a separate command dial make it simple to set up the camera to suit your own preferences. The articulated monitor makes it easy to shoot overhead or close to the ground, and the built-in electronic viewfinder (EVF) does good service when the ambient light is too bright for image composition using the monitor. Built-in GPS is perfect for recording image locations.

Not so good: The 42× zoom can only be adjusted via the dedicated lever. The EVF has too little resolution to be really useful. If you use GPS route tracking and compose your images using the monitor, you will need to take a spare battery with you on day trips.

Test results: Our lab tests delivered a positive picture. Although the Nikon (together with the Fujifilm opposite) has the highest-resolution sensor in our test, noise performance up to ISO 200 was fine. Edge resolution was acceptable, while wide-angle and short zoom resolution were the best among our super zoom models. On the other hand, vignetting was the worst in the group throughout the zoom range, allowing a whole stop less light to reach the sensor. Shutter lag was below average.

Image quality: ISO 100 results were quite pleasing with good detail rendition and acceptable edge sharpness. There was some chromatic aberration in the top left-hand corner. The Nikon firmware leaves fine color nuances untouched. Images were softer at ISO 200, with obvious grain in shadow areas in 100% view. Serious loss of detail and obvious artifacts begin at ISO 400. Outdoor shots look natural but with some washed-out detail. Camera shake is hard to avoid when using the 1000 mm (equivalent) zoom setting. (tho)

c't test scene detail



Main: ISO 100, 24 mm, f3.7

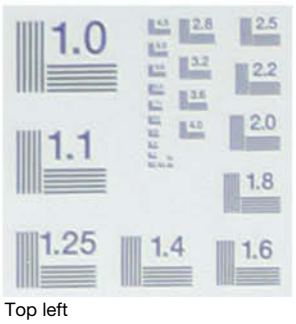
Detail: ISO 100, 1000 mm, f5.9

ISO 100

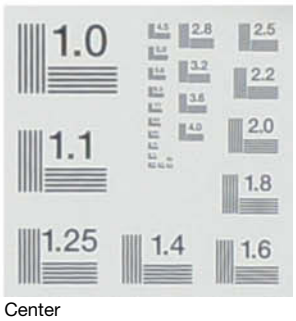
ISO 400

ISO 800

ISO 3200



Top left



Center

Panasonic Lumix DMC-TZ40/ZS30

The TZ40/ZS30 is a pocket-sized travel zoom with plenty of manual options and a full feature set that includes Wi-Fi, GPS and a touch screen.

Good: The Panasonic scores highly with its comprehensive set of features that includes an optically stabilized 20× zoom lens, a multi-touch monitor, GPS, Wi-Fi, manual and semi-automatic exposure settings and much more besides. Simple handling and very good build quality round out the overall picture. Map displays and tips for nearby places of interest have a slightly gimmicky feel but can be useful. The built-in Wi-Fi tools enable the user to control the camera (and the zoom setting) remotely using a smartphone and upload images directly to social networks or display them on a TV.

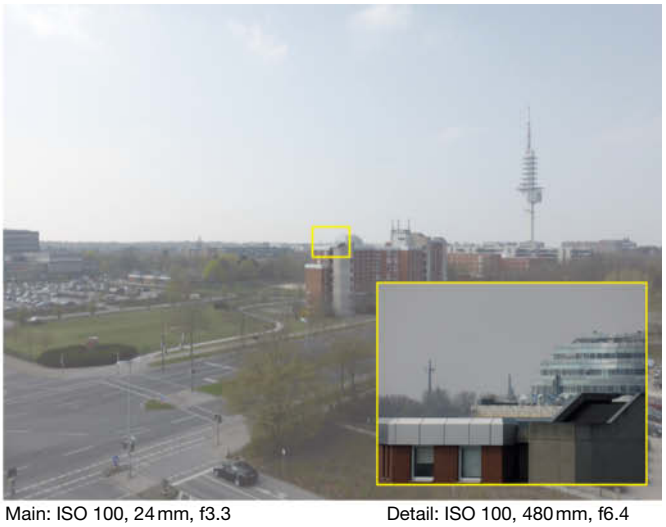
Not so good: The 18-megapixel sensor fulfills marketing needs but unfortunately confirms that increasing pixel density means decreasing image quality, evident in the TZ40's noise performance.

Test results: Our lab tests revealed center resolution that competes with the best in our test field, but edge performance that falls off quite quickly. Noise performance is among the worst we tested. A visual noise score of 1.9 at ISO 100 is good enough, and values for vignetting, distortion, shutter lag and chromatic aberration are average.

Image quality: Once again, real-world tests confirmed our lab results, and this camera showed poor detail rendition at its lowest ISO setting (for example, in the woodgrain and the thread). Color rendition was good and showed only a slight tendency to over-saturation in the red of the flower. The same was true up to ISO 400, after which visual noise and color noise became evident. Higher ISO values produced increasing inconsistencies, making ISO 400 a realistic limit for producing detailed images.

Outdoor images showed similar characteristics with neutral colors and good dynamic range. Fine textures tend to look softened and lack detail. Areas of similar tones such as lawns or fields lack detail. Telephoto performance was similar with no significant vignetting or distortion.

c't test scene detail



Main: ISO 100, 24 mm, f3.3

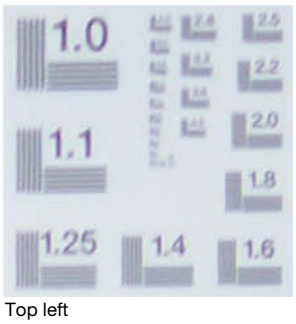
Detail: ISO 100, 480 mm, f6.4

ISO 100

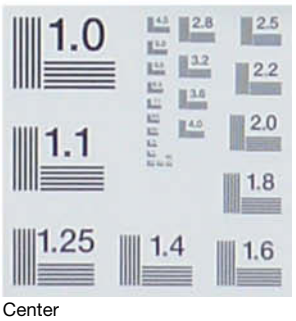
ISO 400

ISO 800

ISO 3200



Top left



Center

Pentax Optio X-5

The Optio X-5 is a 26× super zoom with a DSLR design and looks that aren't matched by its performance.

Good: Build quality is good and the heavy body is well balanced. The 22 mm (equivalent) wide-angle zoom setting is great for shooting in narrow spaces. Power from widely available standard-sized batteries reduces the risk of running out of power in far-flung places. The articulated monitor aids overhead and low-position shooting. The X-5 is the cheapest of the travel and super zooms we tested.

Not so good: What looks like a separate focus ring turns out to be just an adornment. Like with most compacts, zoom settings can only be adjusted using the lever surrounding the shutter button. There are lots of buttons, but they offer little in the way of really useful functionality.

Test results: At wide-angle and standard settings, the X-5's lens provides solid performance that places it at the top of our test ranking at low sensitivity values. Noise-wise, it loses out at lower sensitivities and shows better performances at higher, less useful ISO settings of 800 and more. Distortion performance is excellent, with a negligible measured value of 0.08% at wide-angle and mid-zoom settings. Shutter lag of 0.81 s was the slowest we tested.

Image quality: Images shot at ISO 100 are sharp, with good detail in our woodgrain and jute objects. Excessive smoothing is traded for extra noise but images nonetheless look natural. Images are obviously softer at ISO 200 and unicolor areas show some inconsistency. Images shot at ISO 400 are similar, although dark areas begin to show some artifacts and some details start to look over-softened. Detail rendition and resolution drop off sharply beyond ISO 800.

Even at low ISO values, outdoor shots show some artifacts in monochrome areas, although these consist mostly of luminance noise that gives images an almost analog look. As with many of the other test cameras, grass and trees are softened so much that they appear 'painted' at high magnifications. Obvious fringing occurred at high-contrast edges at telephoto settings.

c't test scene detail

Main: ISO 100, 22.3 mm, f/9.7

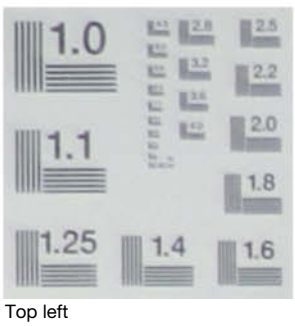
Detail: ISO 100, 580 mm, f/5.9

ISO 100

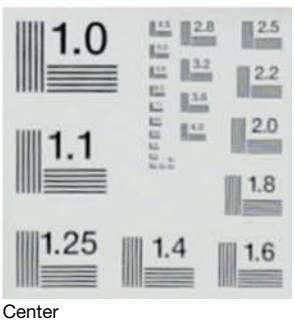
ISO 400

ISO 800

ISO 3200



Top left



Center

Samsung WB800F

The WB800F combines a 21× zoom with Wi-Fi and a touch screen in an inexpensive, compact package.

Good: Samsung combines respectable specifications with a reasonable price and, in line with its 'Smart Camera' policy, has given the WB800F Wi-Fi capability and a touch screen. Build quality is fair and P/A/S/M modes provide a good range of automatic and semi-automatic exposure options. Wireless functionality works well and overall handling is clear and simple thanks to the 'Smart Panel' menu. The recessed buttons prevent unintentional adjustments.

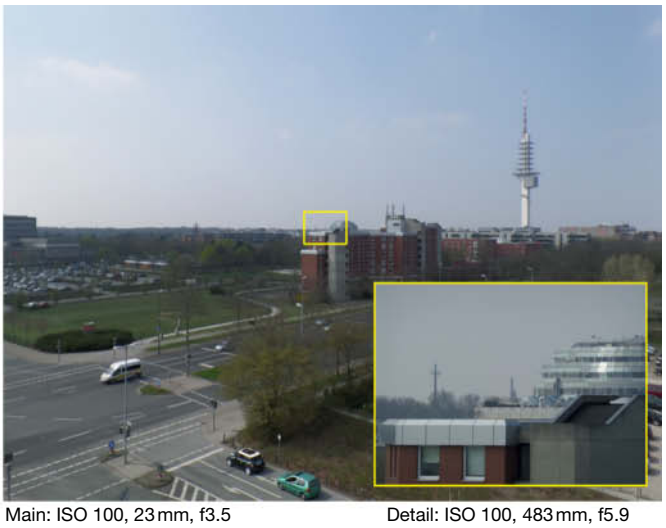
Not so good: Our white test model looked and felt cheap, and the fake leather grain in the hard plastic thumb pad underscored this impression. The pop-up flash arm looks extremely flimsy.

Test results: In the lab, the Samsung delivered average performance with good wide-angle center resolution at ISO 100 that falls off toward the corners of the frame. Visual noise remains low, measuring just 2.2 at ISO 400 and only hits an unusably high 3.9 at ISO 1600 and beyond. The WB800F produced the most natural-looking colors in our test alongside the most obvious fringing artifacts.

Image quality: Slightly soft-looking images with good contrast. Fine details are often lost in processing, as shown by weak reproduction in the woodgrain. Colors were very good. Weak resolution toward the edges of the frame killed some of the detail in the sieve and the scarf. Our resolution chart seemed to have been subjected to additional in-camera sharpening. Some slight artifacts begin to appear in the 100% view at ISO 200, although they don't spoil the overall look of the images. ISO 400 is the clear limit for making high-quality prints.

Outdoors, the Samsung captures sharp images for subjects that display plenty of contrast, but fine details tend to dissolve into indefinable colored blobs. Colors remain authentic in all situations. Telephoto shots have adequate resolution, but tend to include some fringing artifacts.

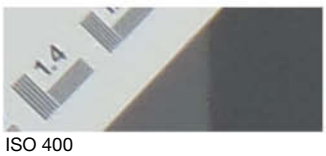
c't test scene detail



Main: ISO 100, 23 mm, f3.5

Detail: ISO 100, 483 mm, f5.9

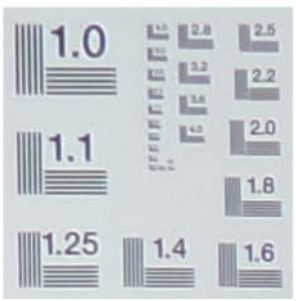
ISO 100



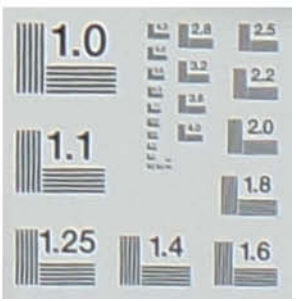
ISO 400

ISO 800

ISO 3200



Top left



Center

TRAVEL AND SUPER ZOOM CAMERAS

Manufacturer/Model	Fujifilm Finepix HS50 EXR	Nikon Coolpix P520	Panasonic Lumix DMC-TZ40/ZS30	Pentax Optio X-5	Samsung WB800F
URL	www.fujifilm.com	www.nikon.com	www.panasonic.com	www.pentax.com	www.samsung.com
Digitization					
Native resolutions (in pixels)	4608 × 3456, 4608 × 3072 (3:2), 4608 × 2592 (16:9), 3456 × 3456 (1:1), 3264 × 2448, 2304 × 1728	4896 × 3672, 4896 × 3264 (3:2), 4864 × 2736 (16:9), 3672 × 3672 (1:1), 3264 × 2448, 2272 × 1704, 1600 × 1200	4896 × 3672, 4896 × 3264 (3:2), 4896 × 2752 (16:9), 3664 × 3664 (1:1)	4608 × 3456, 4608 × 2592 (16:9), 3456 × 3456 (1:1), 3072 × 2304, 3072 × 1728 (16:9), 2592 × 1944, 2592 × 1464	4608 × 3456, 4608 × 3072, 4608 × 2592, 3648 × 2736, 2592 × 1944
Sensor type, effective megapixels / Size	CMOS, 16 / 1/2"	CMOS, 18 / 1/2.3"	CMOS, 18 / 1/2.33"	CMOS, 16 / 1/2.33"	CMOS, 16 / 1/2.33"
Image format(s) / Compression rates / Video format	JPEG, RAW / 2 / MOV (H.264)	JPEG / 2 / MOV (H.264/ MPEG-4 AVC)	JPEG / 2 / MP4, AVCHD (MPEG-4 AVC)	JPEG / 3 / MP4 (H.264/ MPEG-4 AVC)	JPEG / 3 / MP4 (H.264/ MPEG-4 AVC)
Video: max. resolution [pixels], fps, length	1080p, 60 fps, n/a	1080p, 30 fps, n/a	1080p, 50 fps, approx. 40 min.	1080p, 30 fps, 25 min.	1080p, 30 fps, n/a
Memory card type / Internal memory / Average file size[3]	SD(HC/XC) / 25 MB / 5.4 Mb MB	SD(HC/XC) / 15 MB / 6.7 MB	SD(HC/XC) / 12 MB / 6.9 MB	SD(HC/XC) / 75 MB / 4.6 MB	SD(HC/XC) / n/a MB / 5.7 MB
Features					
ISO settings	Auto (100-400, -800, -1600, -3200), 100, 200, 400, 800, 1600, 3200, 6400, 12800	Auto (80-400, 80-800), 80, 100, 200, 400, 800, 1600, 3200, 6400	Auto (100-1600), 100, 200, 400, 800, 1600, 3200	Auto (100-200, -400, -800, -1600, -3200, -6400), 100, 200, 400, 800, 1600, 3200, 6400	Auto (100-400), 100, 200, 400, 800, 1600, 3200
Max. aperture/ # of f-stops/ Stabilizer (type)	f/2.8-5.6 / 10 (wide-angle), 3 (telephoto) / ✓ (Lens shift)	f/3-5.9 / 10 (wide-angle), 4 (telephoto) / ✓ (Lens shift)	f/3.3-6.4 / 9 (wide-angle), 3 (telephoto) / ✓ (Lens shift)	f/3.1–5.9 / 2 / ✓ (Sensor shift)	f/2.8-5.9 / 10 (wide-angle), 4 (telephoto) / ✓ (Lens shift)
(Long) Exposure times	30 s-1/4000 s	8 s-1/4000 s	(30 s) 4 s-1/2000 s	(4 s) 1/4 s-1/1500 s	(16 s) 16 s-1/2000 s
Zoom range / In mm (equivalent)	42× / n/a / 24-1000 mm (KB)	42× / 41 / 24-1000 mm (KB)	20× / 44 / 24-480 mm (KB)	26× / 23 / 22-580 mm (KB)	21× / 16 / 23-483 mm (KB)
Shortest focus distance wide-angle /macro	7 cm / 45 cm	1 cm / 50 cm	3 cm / 50 cm	1 cm / 40 cm	5 cm / 80 cm
Focusing	AF (one shot), AL (servo), infinity, manual, spot, multi	AF (one shot), AL (servo), infinity, manual, spot, multi	AF (one shot), AL (servo), spot, multi	AF (one shot), AL (servo), infinity, spot, multi	AF (one shot), AL (servo), manual, spot, multi
AF points / Focus assist lamp	n/a / ✓ (white)	99 / ✓ (white)	23 / ✓ (orange)	9 / ✓ (orange)	n/a / ✓ (orange)
Matrix / Center-weighted /Spot metering	✓ / ✓ / ✓	✓ / ✓ / ✓	✓ / ✓ / ✓	✓ / ✓ / ✓	✓ / ✓ / ✓
Programmed auto / Scene modes / Custom presets	✓ (with scene detection) / 13 / ✓	✓ (with scene detection) / 16 / ✓	✓ (with scene detection) / 19 / ✓	✓ (with scene detection) / 19 / ✓	✓ (with scene detection) / 13 / ✓
S / A / M modes	✓ / ✓ / ✓	✓ / ✓ / ✓	✓ / ✓ / ✓	– / – / ✓	✓ / ✓ / ✓
Exposure compensation	±2 EV in 1/3 increments	±2 EV in 1/3 increments	±2 EV in 1/3 increments	±2 EV in 1/3 increments	±2 EV in 1/3 increments
Exposure / WB / Focus bracketing	✓ / – / –	✓ / – / –	✓ / – / –	– / – / –	✓ / – / –
Self-timer / Burst shooting	2 s, 10 s / 11 fps, 5 (at full resolution)	2 s, 10 s / 7 fps, 7 (at full resolution)	2 s, 10 s / 10 fps, 6 (at full resolution)	2 s, 10 s / 1 fps, until card full (at full resolution)	2 s, 10 s / 8 fps, 4 (at full resolution)
Interval shooting / Sound recording	✓ / 6 / ✓	✓ / 4 / ✓	✓ / 4 / ✓	✓ / 6 / ✓	✓ / 5 / ✓
Auto WB / # of presets / Manual WB	✓ / ✓ / ✓	– / – / –	– / – / –	✓ / ✓ / ✓	✓ / ✓ / ✓
Monitor size / Resolution (dots) / Protector / Viewfinder (resolution)	3" / 920,000 / ✓ / ✓ (920,000)	3.2" / 921,000 / ✓ / ✓ (201,000)	3" / 920,000 / ✓ / –	3" / 460,000 / ✓ / ✓ (230,000)	3" / 460,000 / ✓ / –
4-way selector / Multi selector / Command dials	✓ (with center button) / 1 / 1	✓ (with center button) / 1 / 1	✓ (with center button) / 1 / –	✓ (with center button) / 1 / 1	✓ (with center button) / 1 / –
Flash compensation / Flash connector	✓ / ✓	✓ / –	– / –	– / –	– / –
Playback					
Grid [# of images] / Zoom / Histogram	2, 9, 100 / ✓ / ✓	4, 9, 16, 72 / ✓ (up to ×10) / –	12, 30 / ✓ (up to ×16) / –	4, 9 / – (n/a) / –	12 / ✓ (up to ×9.4) / –
Connectors / Dimensions					
Power source	Li-ion battery (8.7W)	Li-ion battery (4.1W), mains adapter	Li-ion battery (4.5W)	Standard batteries	Li-ion battery (3.81W)
USB / A/V out / HDMI / Printer / Wi-Fi	USB 2.0 / – / ✓ / ✓ / –	USB 2.0 / ✓ (via USB) / ✓ / ✓ / –	USB 2.0 / – / ✓ / ✓ / ✓	USB 2.0 / ✓ (via USB) / ✓ / ✓ / –	USB 2.0 / ✓ (via USB) / ✓ / ✓ / ✓
Wi-Fi / GPS	– / –	– / ✓	✓ / ✓	– / –	✓ / –
Dimensions (W/H/D) / Weight incl. battery	135 mm × 101 mm × 146 mm / 758 g	125 mm × 84 mm × 102 mm / 550 g	108 mm × 59 mm × 28 mm / 172 g	120 mm × 87 mm × 107 mm / 507 g	111 mm × 65 mm × 22 mm / 218 g
What's in the Box					
Manual / User guide	Quick start guide, electronic (136-page PDF)	Electronic (244-page PDF)	Quick start guide, electronic (314-page PDF)	Quick start guide, electronic (240-page PDF)	Manual, quick start guide, electronic (37-page PDF)
Accessories	USB cable, Li-ion battery NP-W126 (7.2 V/1260 mA), charger, shoulder strap, sun shade	USB/AVcable, Li-ion battery EN-EL5 (3.7 V/1100 mA), charger, shoulder strap	USB cable, Li-ion battery DMW-BCM13E (3.6 V/1250 mA), charger, hand strap	USB cable, batteries, shoulder strap, lens cap	USB cable, Li-ion battery SLB-10A (3.7 V/1030 mA), charger, hand strap
Optional accessories	Remote release, flash, lens protector filter, stereo microphone	Mains adapter, wireless adapter, hand strap	Leather case, HDMI cable	AV cable, mains adapter, remote control, monitor protector	–
Software					
Standalone software (platform	MyFinePix Studio 4.2 (Win), RAW File Converter (Win/Mac)	ViewNX 2 (Win/Mac)	PhotofunStudio 9.1 PE, Adobe Reader (Win)	MediaImpressions 3.1 for Pentax (Win), MediaImpressions 2.1 for Pentax (Mac)	i-Launcher (Win)
Ratings					
Test images[3] (c't test image shot in daylight)					
Color rendition / Exposure	○ / ⊕	○ / ⊕	⊕ / ⊕	○ / ⊕	⊕ / ⊕
Sharpness / Detail rendition	⊖ / ⊖	⊕⊕ / ⊕	○ / ○	⊕⊕ / ○	⊖ / ⊖
Image noise / Other artifacts[4]	⊖ / ⊕	○ / ⊕	⊕ / ⊖	⊖ / ○	⊕⊕ / ⊖
Feature set	⊕	⊕	⊕⊕	⊖	⊕⊕
Price for camera / replacement battery (US$)	450 / 50	450 / 40	400 / 40	220 / –	300 / 19

[1] Sensor sizes 1/2" (6.4 mm × 4.8 mm), 1/2.3" (5.6 mm × 4.2 mm)
[2] Measured in the center of the frame using largest native image size and best JPEG quality
[3] Judged by eye on a calibrated monitor (applies only to these cameras and therefore not comparable with earlier tests)
[4] Sharpening and compression artifacts, moirés and axial and longitudinal chromatic aberrations

⊕⊕ excellent ⊕ good ○ satisfactory ⊖ poor ⊖⊖ inadequate ✓ included – not included n/a not applicable

At the Beach, Under Water or Up a Mountain ...

Whether on vacation at the sea, skiing in winter or on a climbing trip, there are many situations in which you would probably prefer to leave your expensive camera gear at home. And when your children start wanting to learn to take photos, you might be reluctant to let them experiment with your high-end compact. These are all ideal scenarios for the ruggedized cameras that now form part of every major manufacturer's portfolio.

Ruggedized cameras are often more colorful than their less robust counterparts, but they offer a similar range of functions and are often just as suitable for everyday use as for more extreme applications such as diving or snorkeling. Some of the latest models to hit the market have built-in Wi-Fi and GPS too.

We checked out the top-of-the-range models currently offered by Nikon, Olympus, Panasonic and Pentax and, instead of just testing their imaging potential, we also took them swimming! With the assistance of the local voluntary fire brigade, we took them all down to a depth of three meters and photographed our own special underwater test card. The results of this exclusive procedure are included with the more conventional results in the tables below. The models we tested are all theoretically capable of underwater use at depths of up to 13 meters and, thanks to their double-locked battery covers and decent seals, all passed our water resistance test with flying colors. Handling is a trickier prospect, and the buttons were often too small or too imprecise for effective underwater use. The Olympus tap-driven concept scored highly on this front and was quite simple to operate, even when wearing diving gloves.

As well as being water, dust and shock resistant, these models employ an unusual periscope-style lens construction that makes it easier to build the sensitive mechanical components of a zoom lens into the sealed camera body. The downside of this approach is the limited zoom range it allows. The Nikon AW110's 5× optic represents the current state of the art.

The Nikon AW110's playback module displays the location and shooting direction for each photo on the monitor

RUGGEDIZED CAMERAS – TEST RESULTS, PART 1

	Sensor resolution [lp/Bh] better▶	**Relative center resolution** (ISO 100, wide-angle) Resolution in % better▶	**Center resolution** (ISO 100) [lp/h] better▶	**Center resolution** (ISO 400) [lp/h] better▶	**Center resolution** (ISO 1600) [lp/h] better▶	**Center resolution** (ISO 3200) [lp/h] better▶	**Center resolution** (ISO 6400) [lp/h] better▶
Nikon AW110[1]	1728	78	1354	1227	1015	915	–
Olympus TG-2	1488	84	1256	1244	858	885	680
Panasonic Lumix DMC-FT5/TS5	1728	84	1444	1248	1175	1080	–
Pentax WG-3 GPS[1]	1728	87	1511	1428	1211	1051	909

Resolution was determined visually in units of vertical line pairs [lp/h]. The higher the value, the sharper the image.
The logarithmic density, D, represents the camera's dynamic range in terms of the ratio between the brightness of the subject and the corresponding recorded tonal values.
Higher values are better. Real subject range represents the range of tonal values contained in an 8-bit rendition of a test image.

RUGGEDIZED CAMERAS – TEST RESULTS, PART 2

	Signal-to-noise ratio [S/Nx] ISO 100 better▶	**Signal-to-noise ratio** [S/Nx] ISO 400 better▶	**Signal-to-noise ratio** [S/Nx] ISO 1600 better▶	**Signal-to-noise ratio** [S/Nx] ISO 3200 better▶	**Signal-to-noise ratio** [S/Nx] ISO 6400 better▶	**Visual noise OECF20** ISO 100 ◀better	**Visual noise OECF20** ISO 400 ◀better	**Visual noise OECF20** ISO 1600 ◀better
Nikon AW110[1]	44	26	18	16	–	1.7	2.7	3.6
Olympus TG-2	44	31	19	14	13	1.8	2.4	4.0
Panasonic Lumix DMC-FT5/TS5	44	29	16	19	–	1.7	2.	3.7
Pentax WG-3 GPS[1]	32	17	14	10	7	2.3	4.3	5.0

Higher Signal-to-noise values indicate less disruptive noise.
'Visual noise' is a physiologically based judgment of how 'irritating' certain image noise artifacts appear to the viewer. The values are calculated based on the intensity, frequency and color of the perceived artifact.
Values below 0.8 represent virtually noise-free images, values below 2 low-noise reproduction, and those between 2 and 3 visible but acceptable noise levels.
Values above 3 represent disruptive noise levels. Values of 5 and above represent extreme, unacceptable noise.

Underwater Functionality

The increased refractive index and non-linear absorption of light in underwater situations make a bright lens with a useful wide-angle setting and a very small close focus distance ideal. Only the 25 mm f/2.0 lenses offered by the Olympus TG-2 and the Pentax WG-3 pass this part of the test.

All our test models have built-in GPS functionality, but they apply it in very different ways. The Nikon AW110 has onboard maps that enable it to display the location and shooting direction for each image directly after capture. All the others take a more conventional route and require the use of a separate geodata module such as the one built into *Lightroom 4* and *5* to apply the recorded data to your images. The Olympus applies the last recorded position data to the first photo(s) you shoot after reactivating the camera, which can cause serious confusion if you have moved a significant distance between shoots. In contrast, the Lumix FT5 is quick to supply fresh geodata when you switch it on.

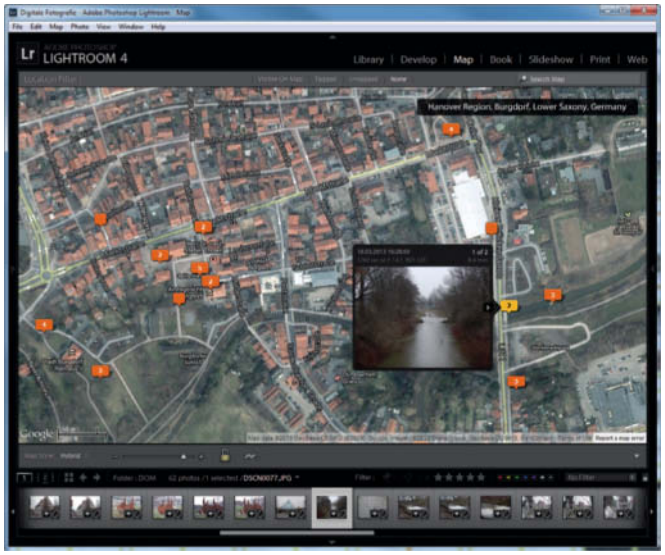
As part of the GPS package, our test models also offer compass, altimeter and depth meter functionality. The TG-2 displays the depth measurement for each shot in playback mode and the Pentax WG-3 has a digital level as part of its display.

The Nikon AW110 and the Panasonic DMC-FT5 also have Wi-Fi capability for cable-free transfer of images to a computer or TV, other mobile devices or social networks. Both cameras can also be controlled remotely from a smartphone using Wi-Fi and a dedicated app. In this respect, the FT5 offers better functionality and gives you remote control over not only the zoom setting and the shutter button but also a whole range of additional shooting parameters.

We assumed that most users of these cameras will prefer to shoot in Auto mode in order to concentrate more on framing, so we set all the cameras to Auto ISO and 'P' mode for our underwater test. To prevent unnecessary shake, we attached our test card to each camera using a metal bracket. Surprisingly, the noise-plagued Pentax selected a high ISO value, although this did mean we were able to shoot our handheld test shots using a usefully long exposure time.

Conclusions

The additional specifications of today's ruggedized cameras are much more comprehensive than they were just a couple of years ago, but image quality seems to be stagnating. Only the Olympus TG-2 and the Pentax WG-3 offer sufficiently wide angles and large enough apertures for satisfactory underwater shooting. We would prefer to see Pentax use a lower-resolution sensor instead of producing unnecessary noise. On the additional specs front, the Nikon AW110 and the Panasonic DMC-FT5 score points with their well-thought-out and effective Wi-Fi and GPS capabilities.



The *Lightroom* Map module evaluates and applies the GPS data recorded by the other models

Contrastrange/ subject range ISO 100 [in f-stops] better▶	Contrast range/ subject range ISO 400 [in f-stops] better▶	Contrast range/ subject range ISO 1600 [in f-stops] better▶	Contrast range/ subject range ISO 3200 [in f-stops] better▶	Contrast range/ subject range ISO 6400 [in f-stops] better▶	Real subject range [# of tonal values] better▶	Color Checker SG ΔE ISO 100 ◀better	Shutter lag Wide-angle [s] ◀better	Shutter lag Telephoto [s] ◀better
8.0	7.6	6.9	6.4	–	207	10.8	0.4	0.6
7.6	7.4	6.3	5.2	5.0	206	8.9	0.4	0.5
10.2	8.1	7.5	6.8	–	222	9.0	0.4	0.7
7.9	7.3	6.6	5.2	4.3	214	8.4	0.3	0.6

[1] At the lowest possible setting of ISO 125

Visual noise OECF20 ISO 3200 ◀better	Visual noise OECF20 ISO 6400 ◀better	Wide-angle distortion [%] ISO 100 ◀better	Telephoto distortion [%] ISO 100 ◀better	Wide-angle vignetting ISO 100 [in f-stops] ◀better	Telephoto vignetting ISO 100 [in f-stops] ◀better	Wide-angle chromatic aberration ISO 100 ◀better	Standard chromatic aberration ISO 100 ◀better	Telephoto chromatic aberration ISO 100 ◀better
4.1	–	0.14	0.01	0.8	0.5	1.3	0.8	2.9
5.3	5.8	0.25	0.05	0.8	0.4	2.0	1.7	1.5
4.2	–	0.41	0.36	0.4	0.4	1.3	1.6	1.8
7.4	11.0	0.58	0.08	0.7	0.5	0.8	2.9	2.3

[1] At the lowest possible setting of ISO 125

Nikon AW110

A seriously robust model equipped with Wi-Fi and GPS, and capable of operating at depths of as much as 18 meters.

Good: 5× zoom lens and high-resolution OLED monitor. Clear menu system with configurable Auto ISO feature. Battery/memory card slot on side of camera body. Waterproof down to 18 meters. GPS with built-in maps and shooting direction display. Remote control via Wi-Fi and smartphone app. Digital compass and altimeter/depth meter. 3D capture. Filter adapter.

Not so good: Lens too close to the edge of the camera and not very bright. Close focus limit 50 cm. Digital zoom, image stabilizer and AF assist lamp settings not included in shooting menu. Self-timer has to be reset every shot. Too few parameters controllable via Wi-Fi. Shake-driven 'Action Button' control tricky to master.

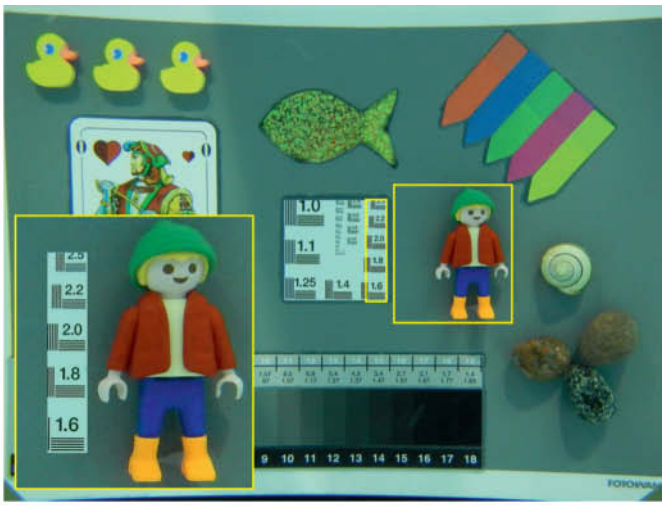
Test results: Center resolution 80 per cent of the theoretical maximum, falling off towards the edges and with increasing ISO values. Middling maximum contrast at ISO 125, decreasing at higher ISO values. Noise levels tolerably low at ISO 125, just acceptable at ISO 800 and poor thereafter. Little distortion and only slight chromatic aberration at telephoto settings.

Image quality: Neutral gray tones and pleasantly warm, bright colors. Woodgrain appears slightly unnatural at ISO 125, but still acceptable up to ISO 400. Low noise at ISO 125 with well-defined textures, although shiny highlights somewhat over-sharpened. The shadow sides of the colored pens show excessive noise but the colors are clear and bright. Sharpness deteriorates toward the edges of the frame. Noise up to ISO 400 still looks natural and is bearable up to ISO 800, but too heavy thereafter. Fine textures hardly recognizable beyond ISO 800. ISO 1600 is the limit for full-screen viewing.

Outdoor shots often overexposed with colored shadows at high-contrast edges. Grass looks unnaturally sharpened. Color in flowers neutral and warm, but flower textures artificially smoothed. Some white highlights almost burned out.

Under water: Good sharpness and contrast, colors somewhat dirty and noisy, causing low-contrast transitions. Grays and whites have a green cast, colors are a little pale, especially reds. Exposure is well balanced, and our shiny fish shows good detail rendition. The snail shell is too bright. The pebbles show distinct chromatic aberration and the material is hardly recognizable.


c't test scene detail

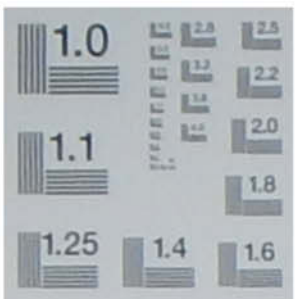

Under water: ISO 800, f3.9, 1/3 s


ISO 125


ISO 400


ISO 800


ISO 3200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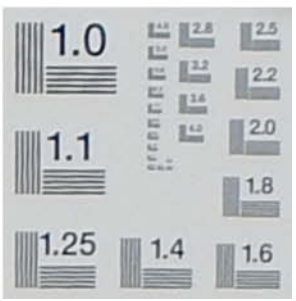

Center

Olympus TG-2 iHS

A tough cookie with a bright lens, Tap Control, GPS and moderate resolution.

Good: Bright lens with 25mm wide-angle setting. Separate mode dial. High-resolution monitor. Major functions easy to operate, with two custom mode settings. LED can be used as movie/macro lamp. Tap Control via camera body also works under water. 12-megapixel sensor not over-specified. Filter adapter. Built-in digital horizon, compass and altimeter/depth meter. Solid body easy to use. Battery can be charged directly via USB. Highly configurable Auto ISO function. HDR shooting. Histogram display while shooting.

Not so good: Battery/memory card slot inaccessible when mounted on a tripod. No battery charger supplied. Replacement battery very expensive. On reactivation, writes old GPS data to new images until new data available. Mode dial too easy to move accidentally. LED lamp not suitable for use at macro distances.

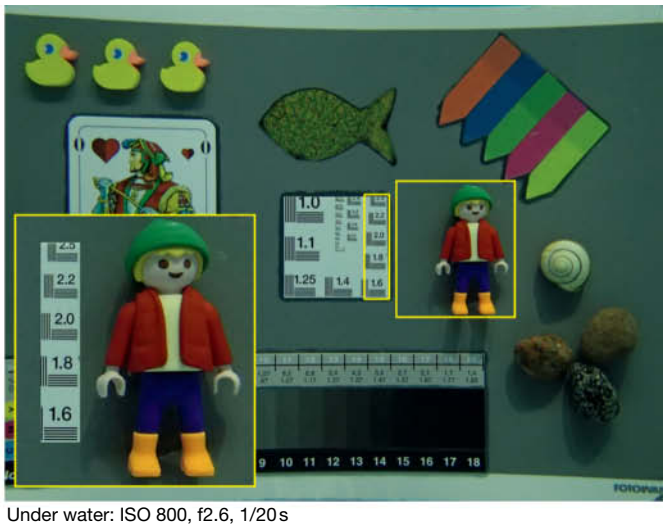
Test results: Center resolution good at ISO100, falling off toward the edges of the frame and at higher ISO values. Maximum contrast good up to ISO 400, dropping off constantly after that. Noise performance good at ISO 100, poor at ISO 400 and too evident beyond that. Serious noise problems at ISO 3200 and higher. Slight chromatic aberration at wide-angle settings.

Image quality: Neutral colors, somewhat cool and matte. Colored pens recognizable, but with weak colors. Woodgrain already looks unnatural at ISO 100, gets worse toward ISO 400 and lacks detectable texture at ISO 800. Circuit board slightly blurred but natural-looking. Fine textures generally well defined. Low noise at ISO 100 and less loss of edge sharpness than the DMC-FT5. ISO 800 is the limit for full-screen viewing with severe loss of detail at higher ISO values. Noise increases continually to become obvious at ISO 800 and seriously disruptive at ISO 6400. Chromatic aberration evident at the edges of the frame.

Outdoor shots with realistic colors, slightly underexposed, but sharp with good contrast. Grass unnaturally sharpened. Flowers overexposed but with realistic colors and excellent detail. Whites partially burned out.

Under water: Very high contrast and very clear detail. Low noise. Grays with a slight green cast but colors otherwise clear and neutral. Slight tendency to underexposure with a little chromatic aberration on the shell. Pebbles look quite natural.


c't test scene detail

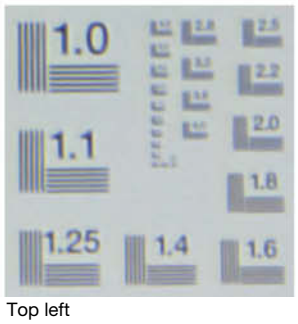

Under water: ISO 800, f2.6, 1/20 s


ISO 100


ISO 400


ISO 800


ISO 3200



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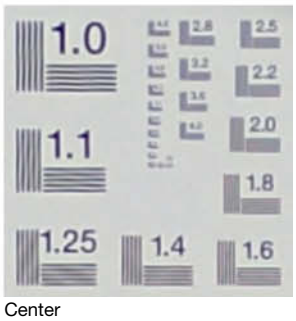


Center

Panasonic Lumix DMC-FT5

A sturdy contender with GPS, Wi-Fi and Full HD video capability.

Good: Robust body with good grip. Side-mounted battery/memory card slot. Five autofocus modes. Resolution and aspect ratio separately selectable. 'i.ISO' feature takes subject movement into account. Slowest auto exposure time selectable between 1/125 and 1 s. Programmable interval shooting, slow-motion video, HDR shooting, 3D sweep capture. Histogram display while shooting. LED lamp. Compass and altimeter. Near Field Communication (NFC), comprehensive remote control via Wi-Fi and smartphone app. Video capture up to 1080 50p.

Not so good: Lens too close to edge of camera body. Buttons too small for effective underwater use. Low-resolution monitor. ISO settings only available via menu. Self-timer has to be reset after each shot. LED lamp unusable for real-world shooting. Replacement battery expensive.

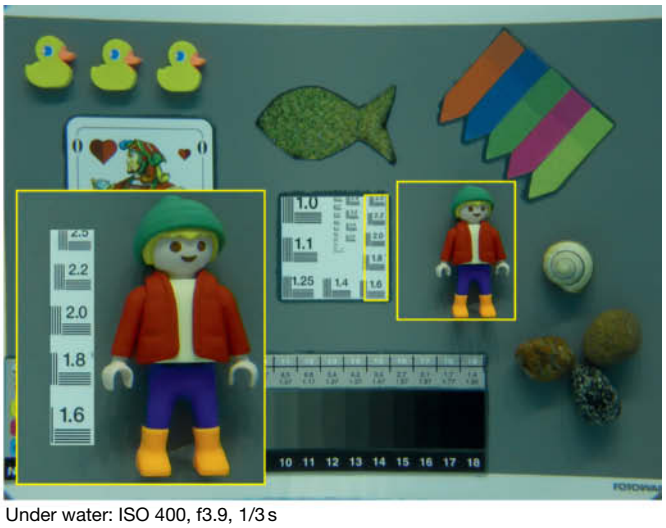
Test results: Good center resolution at ISO 100, falling off toward the edges of the frame. Resolution only partially reduced by increasing ISO values. High maximum contrast at ISO 100, constant drop-off at higher values but still the best of our ruggedized test cameras. Noise performance good at ISO 100, average at ISO 800, poor after that. Little chromatic aberration and vignetting. Distortion average.

Image quality: Magenta cast in the gray tones in our ***c't*** test scene, otherwise warm colors. Woodgrain already unnatural and orange-looking at ISO 100, but remains recognizable up to ISO 800. Low noise at ISO 100. Fine textures well resolved but softish. Circuit board components all identifiable. Colors in the colored pens are bright but could be better saturated. Finer details at the edges of the frame have too little contrast. Dark areas in the grayscale wedge pleasantly free of noise but noise visible in the thread samples. Noise hardly increases up to ISO 400 but more noticeable at ISO 800. Noise very obvious with colored artifacts at ISO 3200. ISO 800 is the limit for full-screen viewing.

Outdoor shots also show warm tones. Grass only moderately sharpened and therefore recognizable. Flowers show generally good detail, even in the white blooms.

Under water: Auto ISO sets low values providing good sharpness, and low noise. Slightly lacking in contrast, with a green cast in the gray tones. With the exception of blue and orange, colors are rather matte. Good exposure with well-differentiated darker gray tones. Shell and pebbles show chromatic aberration at their edges. Pebbles hardly recognizable.


c't test scene detail



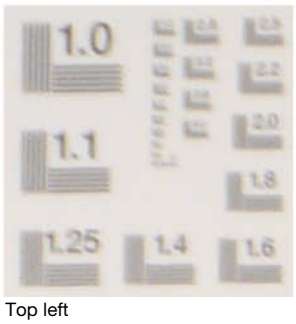
Under water: ISO 400, f3.9, 1/3 s


ISO 100


ISO 400


ISO 800


ISO 3200



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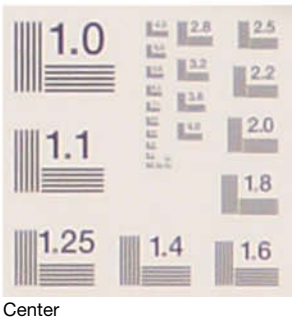


Center

Pentax WG-3 GPS

A unique-looking ruggedized camera with a bright lens, a macro ring light, GPS and lots of shooting options.

Good: Bright lens with 25mm wide-angle setting. Rugged body handles well. Interval shooting, can also be saved as a video clip. 16:9 monitor and additional status display on the front of the camera. LED macro ring light. Histogram display while shooting. Programmable Fn button. Auto ISO and many major functions highly configurable. Electronic level, compass, manometer and altimeter.

Not so good: Tripod thread too far toward the edge of the camera making it unstable when mounted. Bulkier than the predecessor model but still with moderate monitor resolution. ISO setting resets when camera deactivated (but can be programmed to 'stick').

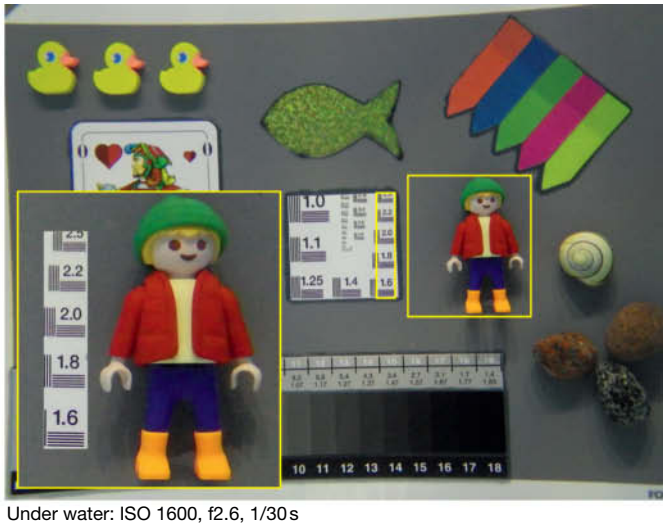
Test results: Produced the best resolution of all our ruggedized test models but, like all three competitors, still with weakness at the edges of the frame. Good maximum contrast at ISO 100, average thereafter. Noise already evident at ISO 100, increasing at ISO 200 and destructive at ISO 1600. Best ColorChecker values in our test. Slight distortion at wide-angle settings and chromatic aberration at standard and telephoto focal lengths. Fastest wide-angle shutter lag.

Image quality: Warm, bright colors and fairly realistic-looking woodgrain at ISO 100 (too artificial-looking at ISO 800). Noise visible at ISO 100, increasing up to ISO 800, after which it becomes unacceptable in larger monochrome areas. Noise at ISO 3200 disruptive with colored artifacts and a tendency to produce strong chromatic aberration. Fine textures rather lifeless, with our thread samples looking frayed due to noise. The sieve and some of the circuit board's components have a slight magenta aura. The colored pens suffer from noise at ISO 100 and the red flower looks less natural than the others. ISO 400 is the limit for artifact-free full-screen viewing (ISO 1600 if you are prepared to accept some noise).

Outdoor shots pleasantly warm but with slightly less contrast than indoors. Grass over-softened, flowers look artificial with partially burned out white bloom.

Under water: Auto ISO tends to select high values to reduce exposure time. Strong color noise in gray tones and some dissolution in colored areas. Some detail lost, but colors neutral and comparatively natural and bright. Strong blues. Exposure balanced, but our glittery fish is blurred. The shell shows some noise, but no chromatic aberration. Pebbles hardly recognizable as such. (pen)


c't test scene detail



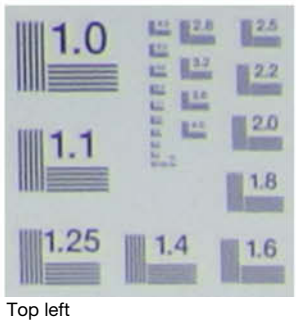
Under water: ISO 1600, f2.6, 1/30 s

ISO 100

ISO 400

ISO 800

ISO 3200



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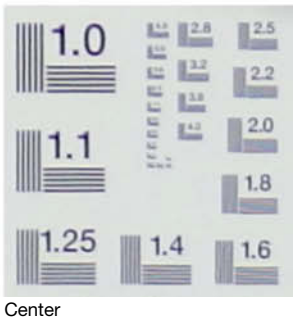

Center

RUGGEDIZED CAMERA OVERVIEW

Manufacturer/Model	Nikon AW110	Olympus TG-2	Panasonic Lumix FT5/ST5	Pentax WG-3 GPS
URL	www.nikon.com	www.olympus.com	www.panasonic.com	www.pentax.com
Digitization				
Native resolutions (in pixels)	4608 × 3456, 4608 × 2592 (16:9), 3264 × 2448, 2272 × 1704, 1600 × 1200, 640 × 480,	3968 × 2976, 3200 × 2400, 1920 × 1440, 640 × 480	4608 × 3456, 3648 × 2736, 2560 × 1920, 2048 × 1536, 1280 × 960, 640 × 480, 3456 × 3456 (1:1), 4608 × 3072 (3:2), 4608 × 2592 (16:9)	4608 × 3456, 3072 × 1728, 2592 × 1944, 2048 × 1536, 1024 × 768, 640 × 480, 3456 × 3456 (1:1), 4608 × 2592 (16:9), 1920 × 1080 (16:9)
Sensor type, effective megapixels / Size	CMOS, 16 / 1/2.3" (5.6 mm × 4.2 mm)	CMOS, 12 / 1/2.3" (5.6 mm × 4.2 mm)	CMOS, 16 / 1/2.3" (5.6 mm × 4.2 mm)	CMOS, 16 / 1/2.3" (5.6 mm × 4.2 mm)
Image format(s) / Compression rates / Video format	JPEG / 2 / MOV (H.264)	JPEG / 2 / MOV (H.264)	JPEG / 2 / MTS (AVCHD)	JPEG / 3 / MOV (H.264)
Video: max. resolution [pixels], length, fps	1080p, 30 fps, 4 GB or 29 min.	1080p, 30 fps, 4 GB or 29 min.	1080p, 50 fps, 35 min.	1080p, 30 fps, 25 min.
Memory card type / Internal memory / Average file size[3]	SD(HC/XC) / 21 MB / 6.1 MB	SD(HC/XC) / 22 MB / 4.5 MB	SD(HC/XC) / 10 MB / 6.2 MB	SD(HC/XC) / 70 MB / 4.6 MB
Eye-Fi / FlashAir	✓ / –	✓ / –	– / –	✓ / ✓
Rugged Features				
Waterproof to depth of (duration)	18 m (1h)	15 m (1h)	13 m (1h)	14 m (2h)
Shockproof / Pressure resistant	Up to 2 m drop height / n/a	Up to 2 m drop height / up to 100 kg	Up to 2 m drop height / up to 100 kg	Up to 2 m drop height / up to 100 kg
Freezeproof (min. temperature)	-10 °C	-10 °C	-10 °C	-10 °C
Features				
ISO settings	Auto (125-1600, 125-800, 125-400), 125, 200, 400, 800, 1600, 3200	Auto (100-6400), 100, 200, 400, 800, 1600, 3200, 6400	Auto (100-1600, 1600-6400), 100, 200, 400, 800, 1600, 3200	Auto (125-200, 125-6400), 125, 200, 400, 800, 1600, 3200, 6400
Max. aperture/ # of f-stops/ Stabilizer (type)	f/3.9-4.8 / 2 / ✓ (Lens shift)	f/2.0-4.9 / 3 / ✓ (Sensor shift)	f/3.3-5.9 / 2 / ✓ (Lens shift)	f/2.0-4.9 / 2 / ✓ (Sensor shift)
Exposure times (long exposure time)	1 s-1/1500 s (4 s)	1/4 s-1/2000 s (4 s)	4 s-1/1300 s (30 s)	4 s-1/4000 s (4 s)
Zoom range / In mm (equivalent)	5× / 20 / 28-140 mm (KB)	4× / 20 / 25-100 mm (KB)	4.6× / 16 / 28-128 mm (KB)	4× / 20 / 25-100 mm (KB)
Shortest focus distance wide-angle /macro	1 cm / 50 cm	1 cm / 10 cm	5 cm / 30 cm	1 cm / 40 cm
Focusing	AF (one shot), AL (servo), infinity, manual, spot, multi	AF (one shot), infinity, spot, multi	AF (one shot), AL (servo), infinity, spot, multi	AF (one shot), AL (servo), infinity, manual, spot, multi
AF points / Focus assist lamp	99 / ✓ (white)	n/a / ✓ (white)	23 / ✓ (white)	9 / ✓ (red)
Matrix / Center-weighted /Spot metering	✓ / ✓ / ✓	✓ / ✓ / ✓	✓ / – / –	✓ / ✓ / ✓
Programmed auto / Scene modes / Custom presets	✓ (with scene detection) / 20 / ✓	✓ (with scene detection) / 23 / ✓	✓ (with scene detection) / 16 / –	✓ (with scene detection) / 17 / ✓
S / A / M modes	– / – / –	– / – / –	– / – / ✓	– / – / –
Exposure compensation	±2 EV in 1/3 increments	±2 EV in 1/3 increments	±2 EV in 1/3 increments	±2 EV in 1/3 increments
Exposure / WB / Focus bracketing	– / – / –	– / – / –	– / – / –	✓ / – / –
Self-timer / Burst shooting	2 s, 10 s / 8 fps, 6 (at full resolution)	2 s, 12 s / 5 fps, 25 (at full resolution)	2 s, 10 s / 10 fps, 7 (at full resolution)	2 s, 10 s / 1 fps, until card full (at full resolution)
Interval shooting / Sound recording / Comments	– / ✓ (WAV) / ✓	– / ✓ (PCM) / ✓	– / – / –	✓ / ✓ (WAV) / –
Auto WB / # of Presets / Manual WB	✓ / 5 / ✓	✓ / 5 / ✓	✓ / 4 / ✓	✓ / 4 / ✓
Sharpness / Contrast / Saturation adjustable	– / – / –	– / – / –	– / – / –	✓ / ✓ / ✓
Monitor size / Resolution (dots) / Viewfinder	3" / OLED / 614,000 / –	3" / LCD / 610,000 / –	3" / LCD / 460,000 / –	3" / LCD / 460,000 / –
4-way selector / Multi selector / Command dials	✓ (with center button) / – / –	✓ (with center button) / 1 / –	✓ (with center button) / – / –	✓ (with center button) / – / –
Flash compensation / Flash connector	– / –	– / –	– / –	– / –
Playback				
Grid [# of images] / Zoom / Histogram	4, 9, 16, 72 / ✓ (up to 10×) / –	20 / ✓ (up to 10×) / ✓	12, 30 / ✓ (up to 16×) / ✓	3, 12 / ✓ (up to 10×) / ✓
Connectors / Dimensions				
Power source	Li-ion battery (3.9W)	Li-ion battery (4.6W), mains adapter	Li-ion battery (4.5W)	Li-ion battery (3.5W)
USB / A/V out / HDMI / Printer / Wi-Fi	USB 2.0 / ✓ (via USB) / ✓ / ✓	USB 2.0 / – / ✓ / ✓	USB 2.0 / – / ✓ / ✓	USB 2.0 / ✓ (via USB) / ✓ / ✓
Wi-Fi / GPS	✓ / ✓	– / ✓	✓ / ✓	– / ✓
Dimensions (W/H/D) / Weight incl. battery	110 mm × 65 mm × 25 mm / 193 g	112 mm × 67 mm × 29 mm / 230 g	110 mm × 67 mm × 29 mm / 214 g	125 mm × 65 mm × 32 mm / 229 g
What's in the Box				
Manual / User guide	Manual, electronic (252-page PDF)	Quick start guide, electronic (106-page PDF)	Quick start guide, electronic (277-page PDF)	Quick start guide, electronic (260-page PDF)
Accessories	USB/AVcable, Li-ion battery EN-EL12 (3.7 V/1050 mA), charger, hand strap, filter adapter, cleaning brush	USB cable, Li-ion battery LI-90B (3.6 V/1270 mA), hand strap, lens ring	USB cable, Li-ion battery DMW-BCM13E (3.6 V/1250 mA), charger, hand strap	USB cable, Li-ion battery D-LI92 (3.7 V / 880 mA), charger, hand strap
Optional accessories	Mains adapter EH-62F, neoprene sleeve case	Charger, underwtaer housing, neoprene case, telephoto and fisheye accessory lenses	Neoprene case and hand strap, HDMI cable	IR remote control, underwater belt, bike mount
Software				
Standalone software (platform	ViewNX 2, ArcSoft Panoramabuilder (Win/Mac)	Olympus Viewer 3, A-GPS utility (Win/Mac)	PHOTOfunSTUDIO 9.1 PE, LoiLoScope (Win)	ArcSoft MediaImpression LE (Win/Mac)
Ratings				
Test images[1] (c't test image shot in daylight)				
Color rendition / Exposure	○ / ⊕	○ / ⊕	○ / ⊕	○ / ⊕
Sharpness / Detail rendition	○ / ○	○ / ○	○ / ○	○ / ○
Image noise / Other artifacts[2]	○ / ○	○ / ○	○ / ○	⊖ / ⊖
Underwater performance	○	⊕	○	○
Ease of use	⊕	⊕⊕	⊕	⊕
Feature set	⊕⊕	⊕⊕	⊕⊕	⊕⊕
Price for camera / replacement battery (US$)	350 / 35	380 / 25	400 / 33	350 / 40

[1] Judged by eye on a calibrated monitor (applies only to these cameras and therefore not comparable with earlier tests)
[2] Sharpening and compression artifacts, moirés and axial and longitudinal chromatic aberrations
[3] Measured in the center of the frame using largest native image size and best JPEG quality

⊕⊕ excellent ⊕ good ○ satisfactory ⊖ poor ⊖⊖ inadequate ✓ included – not included n/a not applicable

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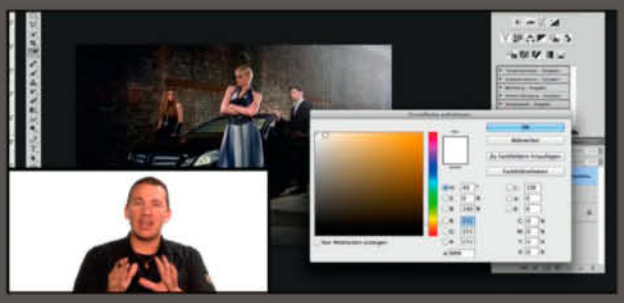

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Torsten Andreas Hoffmann

Images from the Urban Jungle

At their best, big cities are harmonious, highly complex, mature environments. At their worst – Dubai and the mega-cities of China spring to mind – they look playgrounds of architectural sterility that seem to have sprung up out of nowhere.

What makes cities so fascinating is that they are teeming with life, buzzing with interactions between people of many different nationalities and full of architectural paradoxes.

Photographers started showing an interest in cities when photography was just getting under way – think of Brassaï's evocative photos of Paris at the beginning of the 20th century and his contemporary, Alexander Rodchenko, whose extraordinary images turned the modern world upside down following the Russian Revolution.

Street photography, a particularly interesting sub-genre of city photography, developed in the 1920s. Street photographers were interested not so much in specific events but rather in the ostensibly ordinary, everyday scenes that reveal much about a society. Lee Friedlander is considered to be one of the most important exponents of the art, particularly during his pioneering phase in the 1960s and 70s.

The aim of this article is to clearly set out some ways to use your camera to get 'under the skin' of a big city.

Big cities are a real creative challenge. There is so much movement and so much to stimulate the senses in urban environments that it is considerably harder to compose good photos there than it is in quieter rural settings. We hope you enjoy trying out our ideas for a fresh take on cities away from well trodden paths.

Choosing a City

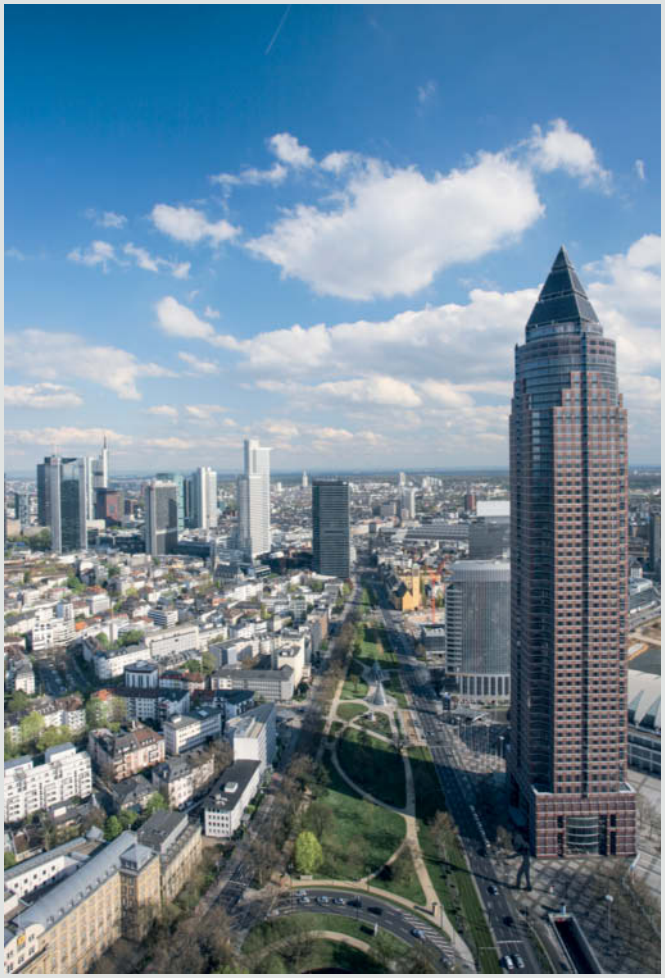
An understanding of photography as a creative act requires us to know what it is we wish to express. What kind of mood are you intending to evoke? What feelings do you want your photo to trigger?

Photography can never be impartial. For example, a beautiful shot of the ocean that belies the fact that the skyscrapers of Dubai lie directly behind its 'idyll' makes this very clear. While they may be authentic, photos are not objective.

This provides photographers with all the more reason to acknowledge and embrace the subjective nature of their work. Photography is a superb way to express our own inner thoughts and feelings by striving to find their equivalents in the outside world.

In order to experience your inner self more fully, it is helpful to spend time in places that instinctively attract you, and the same applies to the city you choose to work in. It is also vital to allow plenty of time so that taking photos doesn't become stressful and instead gives you the freedom 'get with the flow' as your enthusiasm builds. Once you have found your rhythm, your photos will really communicate on an emotional level.

Ultra-contemporary or peaceful and pretty? Asked where they would rather live, most people give the same answer, but asking which settings best enable us to express our thoughts and feelings is a different question entirely. The photo of Heidelberg on the left portrays a safe haven and a sense of harmony and warmth.



The photo of Frankfurt on the right has a more sober mood that conveys a certain coolness and austerity. The buildings belong to banks and embody power and strength. What do you want to express in your photographs?

Grand Entrances or Humble Backyards?

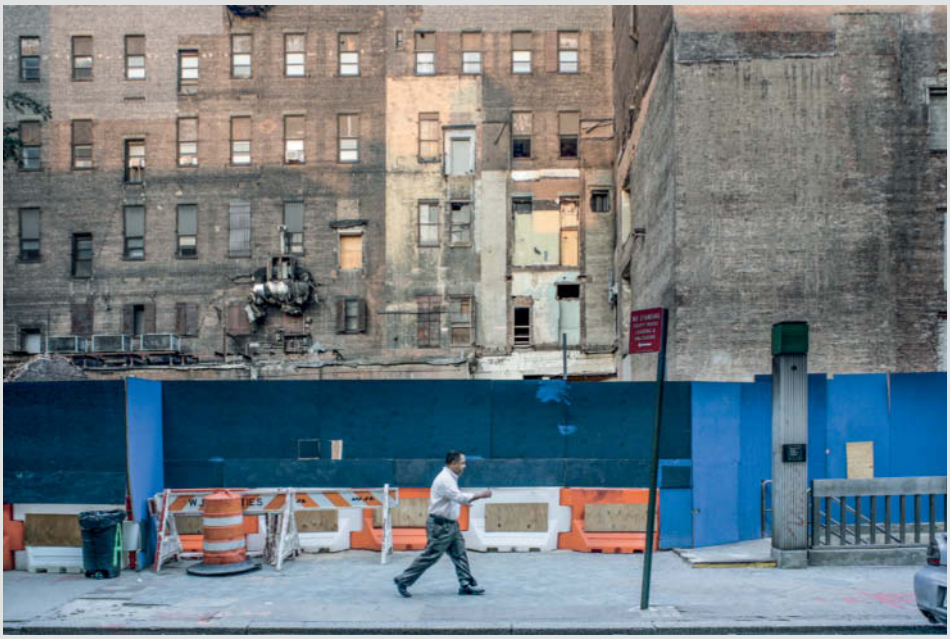
Having decided on a city, you now have to figure out how to get to know it and capture it in photographs. At this point, if not before, it is essential to know what you actually want to express.

What are your opinions about the state of the world and society these days? Are you all for it, fairly supportive, skeptical or critical? Find out about the city you have chosen and check out photos on the Internet before you start taking your own. Which of the images really move you? Now visit those places. Don't let travel guidebooks lead you astray by diverting your attention to familiar tourist attractions. That has been the route to bitter disappointment for many photographers, since the 'sights' aren't always the most authentic places in a city and usually have to be shared with masses of tourists anyway.

Other places to keep away from are the ubiquitous pedestrian zones, which tend to look the same the world over. Instead of trying to give generic locations an individual flavor, try lesser-known corners of the city, or side streets, courtyards and backyards.

In short, try to make your own way through your chosen city, letting your photographs mark the route you have taken.

This magnificent building on the outskirts of Frankfurt makes a gentrified statement. Only once all the lights were switched on did it come alive, take on a personality and lose its empty, superficial look.



Placing the pedestrian in the middle gives this image its structure. Together with the light-colored section of the building, the man provides the main axis of symmetry.

Color or Black and White?

For much of the 20th century, black-and-white photography was considered the ultimate artistic medium, but color has now also reached the same exalted status.

Even though most cameras have a dedicated black-and-white mode, I recommend shooting in color but thinking in black and white. Most decent image processing programs offer a number of ways to convert images to black and white at a later stage, including simulating the yellow or red filters used in analog photography.

Nonetheless, there are distinct disadvantages to color photography in cities. If the weather is nice, the blue sky tends to make color photos look like a stereotypical postcard, and clichés are exactly what we are trying to avoid.

If you are taking wide-angle shots that include the sky or buildings, I recommend black and white. On the other hand, if it is the colors that make the shot special for you, let the colors and the composition complement each other. All the elements should be organized just as a painter would arrange them, with nothing superfluous in the frame. But be warned: this kind of balance is often quite difficult to achieve in urban situations.

A good way to get to know a really big city is to start from the highest point you can reach. The Rockefeller Center in New York was the perfect vantage point for these photos. The color version of the photo above looks like any standard postcard, but the sky looks much more interesting in black and white. The city becomes even more intriguing viewed through a window, which introduces a graphical framework that lends the photo energy and immediacy.

Still Life with Rooftops

Before you immerse yourself in the urban environment at street level, try capturing some shots from an elevated viewpoint. You may be surprised to discover that the roofs of a city have a life of their own.

Roofs can tell stories about a city and its inhabitants. Looking out over Manhattan, for example, everything seems orderly at first, but if you study the scene more closely, you'll notice interesting and unusual-looking water tanks everywhere. The appeal of half-timbered buildings in a German city seen from above lies in the complex patterns of the red-tiled roofs, whereas the roofs of Paris are singularly romantic, even though they appear mostly gray at first. A closer look reveals that the multitude of small red-brick chimneys that make the Paris skyline unique.

A telephoto lens can be used to cluster shapes and patterns quite effectively, while a polarizing filter augments the color of the walls and increases the contrast between the sky and the clouds.

Rooftop still lifes are where the high resolution provided by a good sensor really comes into its own, as poor-quality sensors and cheap lenses often fail to render the richness of the available detail in enlargements.

It is the countless small chimneys that give the famous roofs of Paris their special appeal, whereas the roofs of Old Delhi are at their most magical at twilight. The exposure below had to be managed very carefully so that the detail in the highlights of the shopfronts could still be made out.

Architecture

Architectural photography is the heart of photography in large cities and the first stage in becoming comfortable with composing urban images. The second stage, street photography, is more difficult to master.

Many people associate the term 'architectural photography' with lifeless images that serve only to represent buildings as architects envisage them. Large-format cameras are still popular for this genre because they enable the photographer to shift the film plane and the lens plane, thus making it possible to avoid capturing converging lines at all focal lengths. Using a specialized wide-angle tilt/shift lens is another way to solve the same problem.

If you are sticking to architectural photography in a big-city shoot, it is important to understand the effect of focal length. Wide-angle lenses produce more dynamic compositions and give architectural structures a lighter look, while telephotos compress details and make them look bulkier than they actually are. Wide-angle shots usually mean that you have to deal with sharp angles and converging lines, which a proficient photographer can incorporate into a dynamic composition, whereas telephoto lenses tend to produce more static-looking photos that emphasize vertical and horizontal lines.

Including the street sign worked well in this photograph of a modern glass-fronted building. As well as symbolically surrounding the building, the sign adds a strong black element that offsets the gray tones and makes the image interesting despite the dull weather.
A graduated filter was used to darken the sky towards the top of the image.

This photo was taken using a 17mm ultra-wide-angle lens that comes very close to a fish-eye lens in its ability to encompass the curves in the 'Omega Haus' office complex in Offenbach. The leafless tree provides a natural foil to the clean lines of the man-made structures. The tree trunk lies more or less on the left-hand vertical dividing line and gives the image its underlying structure.

Visualizing a City Graphically

Black-and-white photography can be very compelling, since it's all about refraining from color in order to bring form to the fore.

A basic building block of black-and-white photography is the relationship between light and shadow. Once you start to look, you will find interesting graphic forms everywhere in modern buildings, steel bridges and scaffolding. As well as having good composition skills you will need to expose your images carefully to avoid drowning out shadow detail or burning out the highlights.

Most good digital cameras display a blinking black or red highlight on the monitor if shadow or highlight clipping threatens. Don't ignore this, because burned out highlights are virtually impossible to repair during image processing.

While the General Electric Building is one of the most interesting Art Deco buildings in New York, a 'straight' photo from this perspective would not have been particularly attractive. The key was to embed the subject in an additional, abstract structure which, after a lengthy search, was supplied by the scaffolding in the foreground.

The photo below shows one of New York's fascinating West Side Line raised railroad stations. The 93mm focal length made it possible to compose the graphic elements of the image from a distance and then wait until a man wearing a light-colored jacket emerged from the blackness of the background at just the right place.

People in Urban Scenes

Street photography is probably the most difficult aspect of city photography to master because it involves depicting human beings within the built environment.

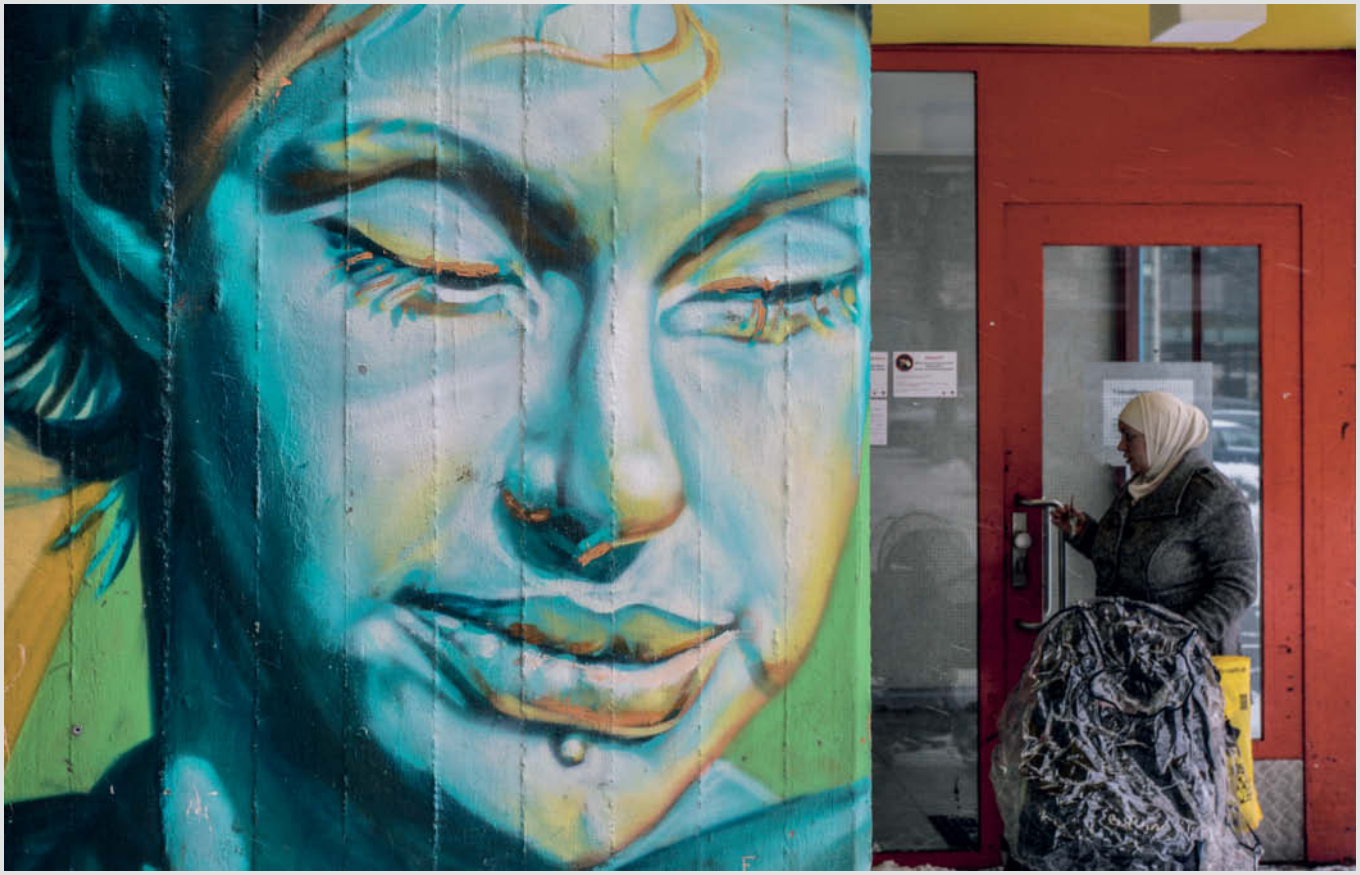
Big cities are so full of life and a vast and incredibly diverse range of moving subjects that a photographer has to crop incisively and release the shutter at precisely the right moment to produce a clear, well-composed image.

Henri Cartier-Bresson was a master of this type of photography and captured magical moments like no-one else could. He had the gift of being able to discern how complex situations would develop so that he knew where he had to be, when, and with which lens, in order to make the exposure at exactly the right second.

In Cartier-Bresson's work, the moments of time frozen in incredibly clear, complex

These photos were shot in totally different surroundings. In the one on the left, which was shot in New York, the form and color of the sculpture dominate. The one on the right, shot in Varanasi, India, is invigorated by the juxtaposition of the yellow and orange tones.

All I had to do to capture this piece of street art in an apartment building in Berlin was wait for the 'right' person to provide a suitable contrast to the painted face



compositions were usually spectacular or significant in some way. Garry Winogrand and Lee Friedlander, on the other hand, devoted their equally exceptional work to the commonplace aspects of everyday life.

Street photography is a very good exercise in concentration. Macro subjects and landscapes are 'patient' and grant photographers the luxury of letting their thoughts stray now and then, but in street photography, a moment's inattention can cost you everything. The crucial moment is gone forever, uncaptured.

So embrace the opportunity street photography gives you to put everything else aside, work without preconceptions and blend in with your environment so that all your photos come into being almost of their own accord. As a street photographer, you are of course 'allowed' to use your camera's auto features to help you concentrate on the capturing the critical moment.

The success of these two images lies in the clever use of form, so they come across best in black and white. The photo on the far left shows a typical urban scene in Ludwigshafen, Germany. This particular scene had to be underexposed because of the strong backlight, and we used *Photoshop* selection and layer techniques to brighten the tall building and the foreground later on. In the photo on the right, the two women stand out in an eye-catching composition that comes alive thanks to the various contrasts between light and dark.

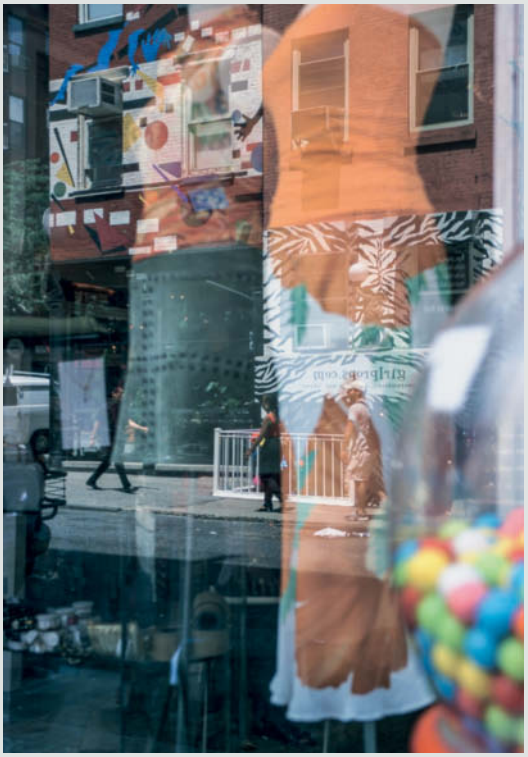
Below: The skyline of New York's largest business district, Midtown Manhattan. Including the silhouette of a group of young people adds the energy this image would otherwise lack.

Reflections

Photography doesn't always have to stick to the dogmatic idea that it must mirror reality, and is quite capable of moving into the realms of abstract art. Photographing reflections is a great way to begin expanding your view of reality.

Cars are often a nuisance for photographers who want to take photos of buildings. But that just makes it all the more interesting if you use them differently, perhaps by using the reflections they create as part of the composition. Plus, there is no longer any need to point the camera upward at a steep angle to capture, say, a skyscraper, so you won't have to deal with converging lines later either.

Another way to alter your viewpoint is to direct your gaze to window panes, where you will often find completely unrelated subjects merging into one. The best results come from single-glazed windows, as double- and triple-glazed windows tend to produce irritating multiple images. It's best to use a wide-angle lens and stop it right down to create sufficient depth of field. Using reflections creatively is an excellent way to practice developing complex compositions. Once again, try to think like a painter to get the right match between form and color.



Above: A visual symphony achieved with the help of reflections in a shop window in New York. The colors of the clothing on display tone in with the brick wall, while the colored elements on the wall at top left echo the bubble gum in the dispenser in the foreground.

Left: A church in Manhattan is reflected not once but twice – first on the roof of the car and again in the windshield. This photo was shot with a digital camera using a 19mm lens. Since the reflection on the roof of the car is darker than the scene itself, we selected it using *Photoshop* Lasso tool before brightening it separately from the rest of the image.

Surreal City Scenes

The art of successful surreal photography lies in tapping into reality at unreal moments to capture moods and objects that don't seem to fit together or make sense.

Surreal photos often seem to be part of another world or a daydream, taking viewers to a metaphorical place where they see things differently. Images with a touch of surrealism create relationships between objects that would never take place in the logical, rational world, and it is precisely this peculiarness that gives them the ability to penetrate our subconscious. And remember, the subconscious is the source of all creativity, or at least it is according to the founder of the surrealist movement, André Breton.

French photographer Edouard Boubat said that people are automatically attracted to the images which they have inside themselves, and the expression of inner images and dreams is what surrealism is all about.

If you make the effort, big cities are sure to yield locations that convey surrealistic moods and express your own inner imagery. Here, once again, we need to ask ourselves what it is we wish to express and what really matters to us. Do you have surreal images within you? Can you find a place that corresponds to them in the real world?

Below: Surely the scene in the photo below must end in a dreadful crash? An airplane heading straight for a building, no runway in sight…
The photo is a riddle – but not for the people of Berlin, who know that the local Museum of Technology has an airplane exhibited in a way that makes this shot possible.

Left: Turning something on its head is a great basis for creativity. After all, our eyes actually produce upside-down images and it is our brain that turns them the 'right way up'. The world as we perceive it is much more fragile when you start really thinking about it, and there are good reasons to take a surreal view of things.
The photo on the left shows a sculpture attached to the underside of a freeway in Hanover.

Using Multiple Layers

Visual communication can be ambiguous and, unlike logical language, communicates using emotions rather than thoughts. You can heighten this ambiguity by including multiple layers in an image.

Multi-layer compositions in which not all layers are captured in sharp focus are becoming an increasingly prevalent part of the contemporary photographic scene. Andreas Herzau is one of the pioneers of this technique, and his photos of Moscow life illustrate it to great effect. But even back in the 1960s, Saul Leiter played most engagingly with multi-layered compositions, portraying melancholy scenes of people photographed through window panes in the rain.

We can usually look at images of this type for quite some time without decoding everything they have to tell us. They work with hints and allusions, not spelling everything out clearly to the viewer, and the ability to spark a viewer's curiosity months or even years later can make a photo really valuable. Thinking about things more prosaically, it often simply makes sense to include several layers in an image. In documentary photography, an event can often be described more effectively if it is portrayed in more than one dimension.

In reality, however, it is not always easy to squeeze several layers into a single image, especially when you are concentrating on composing a picture of a busy scene. You need to be super alert if you are to succeed in positioning all the objects correctly within the frame – but that's all part of the fun, and practice makes perfect!

Like no other medium, photography relies on capturing a specific, miniscule moment in time, and there is no place better than a bustling city to practice paying one hundred percent attention to what's going on in front of the camera.

Right: Three layers of images. This photo was shot through the window of a New York subway, so the first layer is the reflection in the window at bottom right. The second layer shows the interior of the subway carriage and the third layer shows the view through the two windows in the train door, looking toward the other side of the platform where we see a woman leaning against a pillar and a young man wearing a cap. We can also see part of a second man, and behind him is the façade of a building. The elements are elegantly interleaved and if you analyze the image, you will realize that it even follows the basic rules of balanced image composition.

Left: The streets of Bali are lined for miles at a stretch with small shops that sell huge devotional statues. The best way to photograph these was to shoot from the other side of the road and incorporate a second layer. A shutter speed of 1/80 s created just the right amount of motion blur in the passing motorcycle.

Incorporating Irony

Photos don't have to be deadly serious all the time. The environment of a big city often satirizes itself if you can find the right viewpoint.

There is quite a tradition of irony in the fine arts. For example, Rococo painter Jean Antoine Watteau became popular amongst the bourgeois and aristocratic members of society who commissioned him to paint their portraits. He cunningly incorporated subtle, ironic exaggerations that they didn't notice but have been appreciated by viewers of his work ever since.

Amongst photographers, Magnum member Elliot Erwitt is legendary for his humorously ironic work, especially his photos of dogs and their owners.

Using humor in photography requires a fine eye for detail, as city dwellers often try to look more sophisticated than they really are. If you portray people in an ironic way, you have to go about it very carefully, especially if you intend to publish your photos. Always take care not to invade other people's privacy and, if you are in any doubt, always show your subject the image directly after capture and ask for permission to publish.

Conspicuously contradictory: an ugly sign promotes a company name that is also the German word for 'beautiful'. Not everyone finds the scenery beautiful in modern Dubai, a city that has recently sprung up in the wilderness. The photo is axially symmetrical, with the column supporting the advertisement embodying the vertical, and the upper and lower edges of the billboard the horizontal axes.

Subtle irony: Eight legs and a railing. Even the dog seems to be looking out pensively from Berlin's Oberbaum Bridge to the River Spree below, and the woman's clothing makes a bold statement about people's tastes in the modern world.

Nighttime in the Metropolis

Even in the digital age, night shots remain a technical challenge that involve working around the limitations of electronic image sensors.

When you're working in color, you soon find out that red neon lights and the rear lights of vehicles often look unnatural or mushy if captured using a camera with a low- or mid-range sensor. Higher-quality cameras produce better results, but the image quality that can be achieved ultimately depends on the RAW converter you use. For night photography, I get my best results using *Capture One*.

The extreme range of brightness between artificial light and the parts of the image that are bathed in shadow can also be a problem. HDR techniques can help here (see sample photos) but very few digital cameras are up to photographing a starry night sky using an extremely long exposure during which time the stars travel quite a distance. Image sensors generate too much activity of their own during long exposures, from background noise to over-bright 'hot' pixels. You also need to be aware that stopping the lens down as far as f22 or f32 results in images that are less sharp and have less contrast than those shot at f8 or f11. However, most high-quality cameras can now shoot in RAW format, which is much better for handling night lighting situations.

HDR (high dynamic range) techniques helps in tricky lighting situations like this. If you expose correctly for the building, the highlights in the snow will burn out, but if you expose correctly for the snow, the shadows in the building will become swamped. Programs like *Photomatix Pro* come to the rescue by combining multiple, differently exposed images into a single photo with good detail in the highlights and shadows. To create an HDR image, you generally need three source images exposed 1½ to 2 stops apart.

Frankfurt is said to be home to some of Germany's grossest architectural contrasts. November fog provides an ideal atmospheric setting against which to point this out. November is certainly the best month for night shots in the northern hemisphere. Because I was able to capture the entire range of contrast in a single shot, I could rely on the camera's built-in light meter to expose this shot correctly.

I can just imagine Hitchcock filming in this ghostly atmosphere – an abandoned silo behind a closed gate, with shadows from an unidentifiable source. This shot was captured at the harbor in Braunschweig, which is deserted at night. It was important to avoid overexposing the light metal posts of the gate while calculating the exposure.

Problematic Situations

Especially in cities, pointing a camera at strangers can sometimes be an extremely uncomfortable experience.

Sometimes, for religious, cultural or personal reasons, people do not take kindly to being photographed. But what about travelling in developing countries, where poverty and degrading circumstances are omnipresent and cannot be disguised? Is it right to pull out a camera in such situations? My thoughts are along the same lines as those of the world's best-known image agency, Magnum, which has nailed its colors to the flag and clearly stated that it's aim is to show the world as it is.

While some professionals see it as their duty to the public to photograph any and every subject, amateurs should probably take a back seat when faced with controversial subject matter.

An important basic principle when photographing difficult human situations is preserving the dignity of the people portrayed in the photos. I have conflicting feelings about taking photos of people who are opposed to the idea. Of course, you can always shoot unnoticed using a telephoto lens or by shooting 'from the hip', but whichever approach you take, you will always be walking a very fine line.

To me, women in burqas often look out of place in the non-Muslim world. In this shot, taken in New York, I used the contrast between the two women and a billboard presenting Western values and ideas of beauty as a deliberate stylistic device.

The atmosphere in this Orthodox Jewish area of Brooklyn, New York was oppressive. Even though it was 44 degrees Celsius in the shade, almost everyone I saw was wearing the heavy clothing prescribed by their community. It was very quickly made clear to me that photographers were not welcome here.

About the Author

Torsten Andreas Hoffmann is a photographer, author and photography tutor. He was born in Duesseldorf and studied art education at the Braunschweig University of Art where he majored in photography. He has travelled in India, Indonesia, Mexico, Nepal, Turkey, the United States, the Sahara and the United Arab Emirates.

His work can be found in private collections and is also displayed in high-profile galleries and published in more than 20 books, as well as a range of national and international magazines.

His highly praised work on New York includes three photo sequences, an art calendar and still lifes dealing with the events of September 11, 2001.

Hoffmann's classic work, *The Art of Black and White Photography*, is available in six languages. In addition to conventional black and white, he also works conceptually using paired images, such as those in his *Janus Views* sequence.

He is a member of the Munich image agency LOOK, BBK Frankfurt (a professional artists' association) and the German Photographic Association (DGPh). (keh)

When I'm in India, I often feel much less self-conscious about taking photographs, possibly because the streets are so chaotic and full of activity that no-one notices a photographer. The challenge in capturing the photo shown above was to incorporate the various elements into a halfway balanced composition. Even now, beggars in India are deliberately mutilated by a kind of begging 'mafia' in the hope of making more money.

Florian Mihaljevic, Joachim Sauer

Tripod Test

Tripods differ not only in weight and price, but also in the materials they are made from and the degree of complexity of their individual components. Do you need lightweight carbon fiber or is aluminum sufficient? Are you better off using a three-way pan/tilt head or is a ball head more suited to your needs? To help you navigate your way through the tripod jungle, we tested 12 very different models, from lightweight travel to mid-weight semi-professional.

When light is in short supply – whether indoors, at dusk or on a night shoot – using a tripod is usually the best way to keep on shooting. But many shots are difficult or even impossible to capture in the daytime too, unless you have a stable camera support. Many macro, HDR and panorama situations demand the use of a tripod, and some portraits and landscapes are easier to master if you don't have to shoot handheld. As well as preventing camera shake, using a tripod slows down the process of capturing photographs and forces you to take time composing and framing each image

It is important to consider how you will usually be using a tripod before you go out and buy one. If yours is destined to end up in a backpack on trekking tours, light weight will be your priority, whereas a tripod that you are going to use in a home studio needs to be stable and should provide maximum positioning flexibility, so is bound to be heavier. If you want to shoot video or panoramas, you will need a tripod head with fine-tunable friction settings that can be panned accurately. A three-way pan/tilt head with a dedicated pan bar is ideal but will be heavier and more expensive than a simpler model, and the quick-release plates that make mounting and unmounting a camera much easier also increase the risk of dropping the camera at the moment of release. Most manufacturers use dedicated security mechanisms to deal with this issue.

Carbon or Aluminum?

To keep costs down, most value tripods are made of aluminum, while higher-quality models are made of lighter but more expensive carbon fiber. Ideally, carbon fiber legs should be coated with neoprene, as they are very sensitive to knocks and scrapes. If you are planning to use your tripod in a cold climate, neoprene coating makes aluminum legs more pleasant to handle, and the controls need to be large enough to allow you to manipulate them while wearing gloves. Some tripods also offer metal spikes along with standard rubber-coated feet for better grip in outdoor situations.

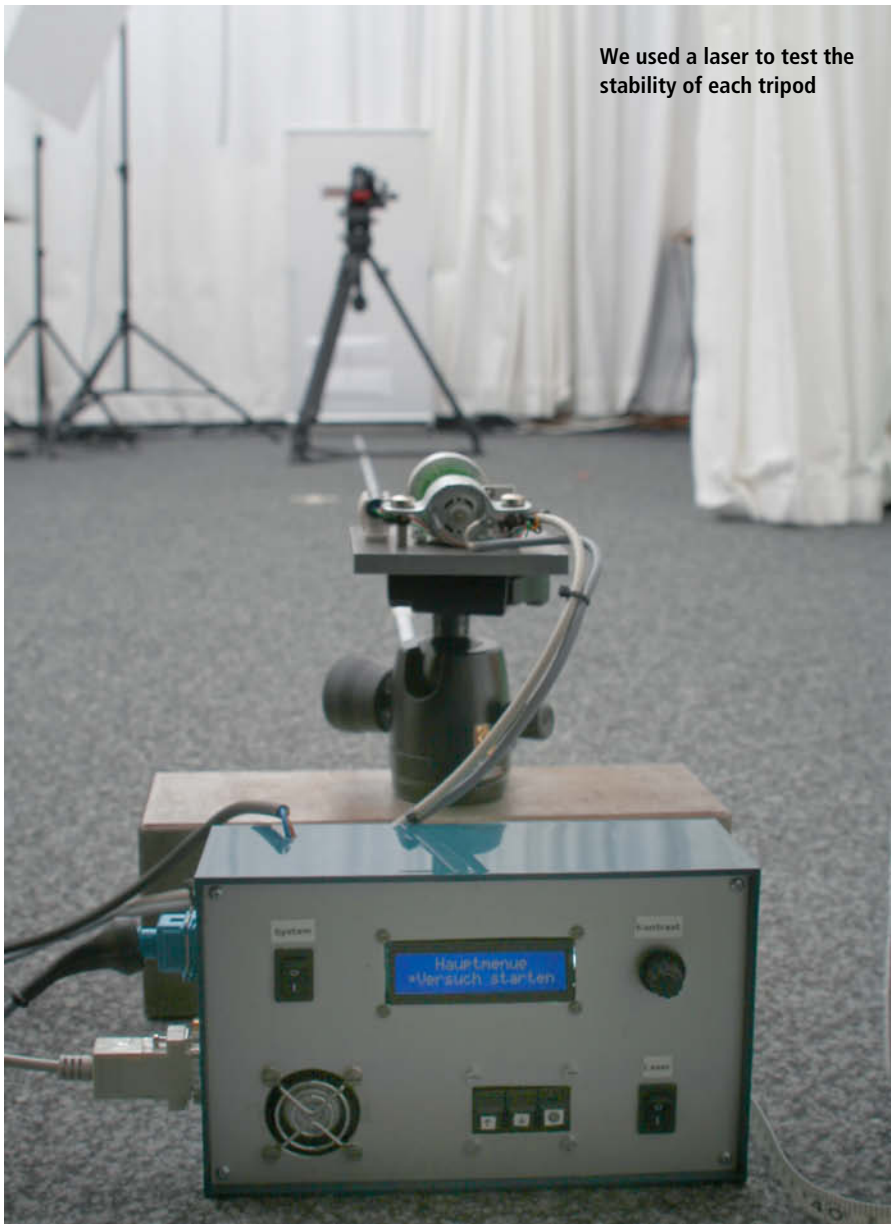
The table of details on page 99 includes height measurements with and without the central column. Because most tripods vibrate if the column is extended, the 'without' measurement is most relevant to everyday photographic use. You have to take great care to avoid camera shake when shooting with an extended column, and we recommend that you do without as often as possible. A reversible center column that allows you to mount the camera very close to the ground is a useful feature for macro photographers.

Multiple leg-spread positions make it easier to set up your tripod. Most models offer three fixed positions, while some offer only two. Stability is only guaranteed if the click stops for the leg position work cleanly. Some of our test tripods use mechanisms that automatically click to the next available position, while others have to be adjusted by hand, but both approaches work once you get used to them.

Tripod legs consist of multiple sections that can be locked at various lengths, usually using quick-release clamps. However, most lightweight models use T-screws, which are more difficult to use, especially if they are very small. T-screws should be capable of locking and unlocking within a maximum of half a rotation, and our tests show that most manufacturers stick to this unwritten rule.

How We Tested

A wealth of features is nice to have, but the most important criterion when choosing a tripod is whether it can support the weight of your equipment. A system camera with a heavy lens places very different demands on a tripod than a compact. Large lenses often make the tripod head sag slightly once it has been positioned, and tightening the various adjusters causes further measurable deviation from the intended position. In addition, the movement of the mirror in DSLRs can be significant enough to cause vibrations in the



We used a laser to test the stability of each tripod

entire camera/tripod setup at certain shutter speeds. It is therefore extremely important that a tripod is resistant to all types of vibration.

To measure stability and vibration, we attached a laser to the head of each tripod and aimed it a wall five meters away. To measure the deviation caused by fixing the head in position, we began by loosening all the available head adjusters to a point at which the laser didn't quite begin to tip. We then fully tightened each lever and measured the deviation in the position of the laser beam on the target wall. To measure deviation under load, we attached a 1 kg (2.2 lb) weight to an outrigger attached to the head and once again measured the deviation of the laser point from its original position.

Measuring vibration was slightly more difficult. Because vibrations are caused by a specific combination of camera, tripod head and shutter speed, we had to use fairly broad-based measurements to get usable results. Our procedure involved attaching a flywheel to the tripods and accelerating it from zero to 10,000 revolutions per minute and back to zero. Once again, our laser produced corresponding patterns on the target wall, this time in the form of ellipses and straight lines. We sampled these movements during the entire experiment and entered the largest peak value in our table of results.

Resistance to vibration is less relevant for mirrorless cameras and cameras with static, semi-transparent mirrors. DSLR users can also reduce the risk of mirror-based vibrations by using the camera's mirror lock-up feature, which raises the mirror before the shutter opens and only lowers it again once the image is 'in the can'.

Conclusions

As with all photographic technology, there is no single tripod that does it all. In fact, we found that some tripods do not perform well at all in some areas of operation. Of all our test candidates, only the heavy Vanguard Abeo Plus 323CB proved adequately resistant to vibration. The Vanguard also came up with very good results in the handling and functionality stakes, but its size and weight make it more suitable for studio use. Among the heavier models we tested, the only other one to produce acceptable results was the cheaper Cullmann Magnesit 528C MB6.5, although this particular model is really only suitable for use with mirrorless cameras.

If you want to use a truly lightweight tripod, you can only do so confidently if you don't use a DSLR. The best lightweight model we tested was the very expensive Gitzo Traveller, while the Feisol CT-3441S CB30C costs half as much as the Gitzo, offered better usable height and was easier to use. At the lower end of the scale, the Mantona Titanium Carbon 2 in1 costs half as much again but couldn't really compete with the performance of the two high-end models. (pen)

Bilora TravelLux 3360

At 1.16 kg , this is the lightest model in our test in spite of being made of aluminum. The US$165 price tag is reasonable, but the tripod provides only 133 cm of usable height with the center column raised and just 110 cm without.

The legs are rotated through 180 degrees for transport and cover up the center column and the head, providing a tiny overall travel length of 31 cm that is perfectly suited to stowing away in a backpack on trekking tours or country walks.

The legs have five sections that are locked using rotating locks and three manually selectable leg spreads. The TravelLux is not neoprene-coated, so it is less comfy to use in winter. Each leg has a rubber-coated foot but no spike.

The very small head has a rubber-coated quick-release camera mount which, while it doesn't lock automatically, does prevent you dropping the camera accidentally. The ball head and the smooth pan movement have their own rotating fixing knobs. The ball itself is too small for semi-fixing with deliberate friction, especially when used with larger cameras.

Our test results show that the Bilora is poorly insulated against vibration and its load deviation of 12 cm over a distance of five meters is not good at all. The locking deviation measurement was acceptable at 2.7 cm.

The head is small and reacts badly to vibration and heavy loads

The TravelLux 3360 is made of aluminum but is still the lightest model we tested

Cullmann Magnesit 519 CW25

At around US$100, the Cullmann Magnesit 519 is the cheapest tripod we tested. Made of aluminum, it weighs just 1.68 kg and is one of the lighter models we looked at. The downside of its light weight is its low usable height (without its center column) of 123 cm. With the column raised, the Magnesit reaches a height of 158 cm, which is pretty good for an aluminum model. Its packed length of 62 cm makes it less suitable for travel use.

In spite of being relatively thin, the neoprene-coated legs have large quick-release locks and built-in spikes, making this model great for winter use.

In contrast to the competition, Cullmann uses a two-way pan/tilt head with a separate pan bar, making the Magnesit ideal for sport and nature photographers who have to track moving subjects. This feature also makes it a good choice for video shoots, although it doesn't rotate as smoothly as a dedicated video head.

The vertical tilt movement is locked and released by rotating the pan bar, while the pan and portrait movements are locked using separate wingnuts.

Locking deviation measured six centimeters and load deviation measured 13 cm over our test distance of five meters – both very poor results. This model is also very susceptible to vibration.

This was the only model we tested with a two-way pan/tilt head, which offers significant advantages when tracking moving subjects

- Weight
- Price
- Usable height
- Only good with light cameras

The aluminum Magnesit 519 is the cheapest tripod we tested

Feisol CT-3441S, CB-30C

This tripod is no bargain at US$500 but does represent a successful combination of low weight and above-average usable height. The two-piece center column reaches a maximum height of 182 cm, which is great for a tripod that weighs just 1.39 kg. Without the center column, usable height comes in at 133 cm, which is average for a tripod of this weight. The disadvantage of the high center column is that the tripod becomes top-heavy when it is fully extended, although its lower end has its own threaded head mount, enabling you to mount the head at the bottom. Fold-up legs give it very small packed-down dimensions.

The legs have four sections, which are easy to handle thanks to their large diameter and neoprene coating. Three spread positions lock automatically, but there are no spikes to aid bad-weather stability.

The CB-30C ball head that we tested has a single friction-controlled knob for locking the ball but no separate pan movement. Friction control allows you to adjust friction to suit the weight of the camera you are using. The rubberized quick release plate locks automatically and is Arca-Swiss compatible and drop-protected. In our lab test, the Feisol produced an unbeatable locking deviation value of just 3 mm. It damps mirror slap vibrations fairly well but fails when it comes to deviation under load and is therefore not suited to use with heavy lenses.

The Feisol's head is small and lacks a built-in pan movement, but overall stability is very good

- Weight
- Handling
- Usable height
- Price

The Feisol is quite expensive but is light and well equipped

Giottos Vitruvian 6kg VGR8255

At 1.35 kg, the Giottos Vitruvian is one of the lightweights in our test field. Moderately priced at US$425, it offers carbon fiber construction, a ball head and a usable height of 143 cm (166 cm with the column extended). Once again, reversible legs mean that this model can be packed down to just 40 cm in length.

The five-section, spikeless legs are neoprene coated and have rotating locks that are large enough to be operated while wearing gloves. This is one of the few models that only offer two spread settings, but the Vitruvian scores well with its reversible center column, which can be also be attached to one of the legs for use as a monopod.

Like most of our test models, the Giottos has a ball head with separate locking knobs for the ball and pan movements, and the latter has an engraved scale to help you shoot precise panoramas. Two built-in spirit levels also help to keep the setup level. All movements are smooth, but locking deviation is below average at 3 cm and deviation under load measures 14.5 cm, which is unacceptable. Vibration resistance is in the lower middle range of our test field.

The engraved scale and separate pan movement provide extra flexibility, although this tripod is only really suited for use with mirrorless or compact cameras

- Weight
- Size
- Build quality
- Only good with light cameras

The reasonably priced Giottos Vitruvian is light and flexible in use

Gitzo GK1580TQR5 Traveler Kit

At US$900, this is the most expensive tripod we tested as well as being the lightest of the carbon fiber models. Only the Bilora mini weighs less than the Gitzo's 1.17 kg. This model has typical dimensions for its weight, with a usable height of 129 cm without and 148 cm with the center column. Its low weight and packed length of just 36 cm make it ideal as a travel companion. Like the other ultra-small models we tested, Gitzo uses reversible legs to keep the size down.

The legs have five sections but only two spread settings, which makes the tripod less flexible. Their fairly small rotating locks and the absence of neoprene coating make the Gitzo lighter but more difficult to use in the cold.

The ball head has just one locking knob for the ball and pan movements, making this model unsuitable for panorama shoots. The ball has very little play, giving the head no leeway for using friction to support heavier gear and just two distinct positions, 'open' and 'closed'. On the other hand, this characteristic means that the Traveler shows very little locking deviation (6 mm) and an acceptable load deviation of 6 cm. Vibration resistance is slightly below average.

The head doesn't have separate pan movement but produces very good deviation values for its weight. Its size makes it quite sensitive to vibration.

- Weight
- Size
- Features
- Value for money

The featherweight Gitzo Traveler is extremely light but is by far the most expensive tripod we tested

Mantona Titanium Carbon 2 in 1

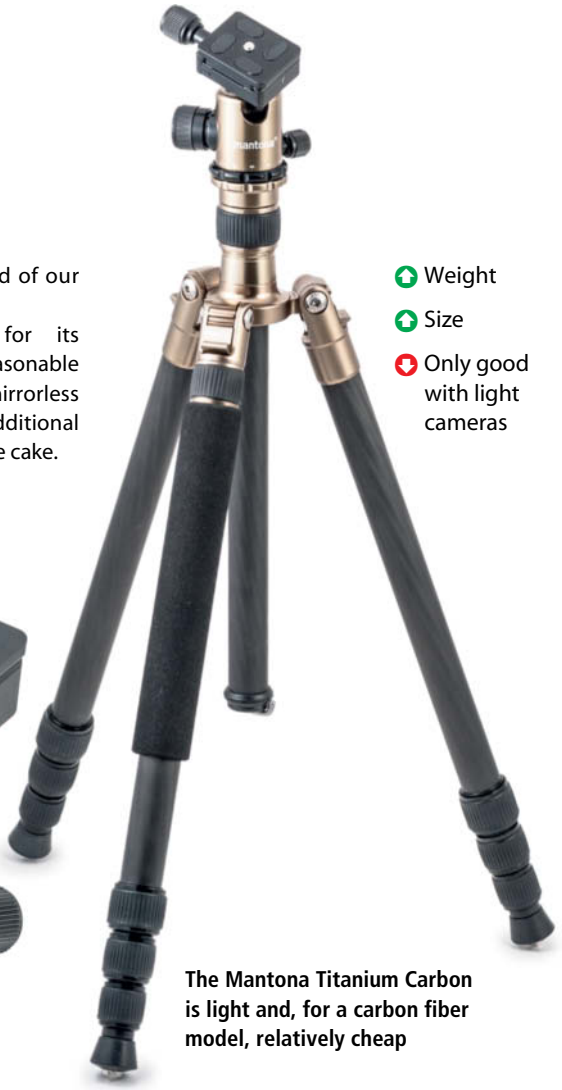
The tops of the legs, the central collar and the head all shimmer with a light gold color and contribute to the high-end feel of this reasonably priced carbon fiber tripod. The US$300 '2 in 1' weighs 1.41 kg and is one of the lighter models we tested, although it still measures 166 cm extended and 141 cm without its center column. Reversible legs give it a packed length of just 43 cm, making it a useful travel tool.

One of its legs is detachable for use as a monopod and only this leg is coated with neoprene. The large, four-section legs have good-sized rotating locks. We would have preferred to see neoprene coating on all three legs, but the manufacturer has at least included spikes for extra stability.

Like most of our test models, the Mantona has a ball head. A large, knurled knob is used to lock the ball and a smaller one adjusts the pan movement, which has its own scale. Both movements are smooth and precise, and the locking deviation measured an excellent 5 mm. On the downside, it sagged 9.5 cm during our load test, making it completely unsuitable for use with heavy lenses. Its vibration resistance it showed placed it in the lower third of our test field.

This model scores highly for its combination of light weight and reasonable price and is ideal for use with mirrorless cameras and smaller lenses. Its additional monopod function is the icing on the cake.

The head has a separate pan movement and a panorama scale



- Weight
- Size
- Only good with light cameras

The Mantona Titanium Carbon is light and, for a carbon fiber model, relatively cheap

Vanguard Espod Plus 233CB

The 1.3 kg carbon fiber Vanguard Espod Plus 233CB costs US$300 and offers an extended height of 160 cm or 129 cm with the center column retracted. Its 61 cm packed length is too large for stowing in most backpacks.

Two of the three legs are neoprene-coated, and the three-section construction offers quick-release clamps and spikes. Like most of the competition, the Espod's center column can be inverted. The head is quite small and offers just one large lever for locking and releasing the ball and no separate pan movement. The camera mount doesn't lock automatically or prevent the camera from falling accidentally, so use of this particular model requires great care.

The very good locking deviation of just 1 cm is typical for small ball heads that are either fully open or completely locked down and the other bright spot on the horizon is vibration resistance, which is adequate for this class of tripod. This particular head cannot hold up a heavy lens at all and tips completely under load.

The head is tiny and heavy lenses can cause it to tip over completely

- Weight
- Price
- Size
- Only good with light cameras

The inexpensive Espod Plus 233CB is quite large considering how light it is

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Cullmann Magnesit 528C MB6.5

The Cullmann Magnesit 528C with the MB6.5 ball head weighs 2.4 kg but provides only 140 cm of height (or 170 cm with the center column extended). Its 63 cm packed length is not the smallest, but is OK for the price (US$425).

The thick carbon fiber legs are fully coated with neoprene and very easy to handle, as are the large quick-release locks. Care is required when tightening the wing nuts on the relatively fragile carbon fiber center column, as it is all too easy to cause damage if you tighten them too far. Spikes take care of stability in tricky situations.

The MB6.5 ball head is one of the largest we tested and is fitted with a separate, scaled pan movement and a large locking knob for the ball. Friction for the ball is variable and the pan movement is smooth and precise. Locking and load deviation are both good at 1.5 and 2.3 cm, but vibration resistance could be better.

The solid MB6.5 head is really easy to use and extremely stable, but the unit's susceptibility to vibration makes it better for use with mirrorless or fixed-mirror cameras

- Functionality
- Handling
- Weight
- Sensitivity to vibrations

The Cullmann Magnesit 528C offers a full feature set at a reasonable price

Hama Omega Carbon II

The Hama Omega Carbon II is quite tall, measuring 153 cm (176 cm with its column extended), but this also makes it heavy (2.56 kg) and long (72 cm) when folded down. However, the US$350 price tag is reasonable in light of the quality it offers.

The four-section legs are broad and fully coated and have three manually lockable spread settings. The quick-release leg locks have slightly sharp edges but are easy to operate with gloved hands. Built-in spikes ensure good stability on slippery surfaces.

The head includes separate locking knobs for the pan movement, ball head and friction settings, and the drop-protected camera mounting plate locks firmly in place. The pan movement has plenty of friction, even at its loosest setting, but is smooth to use. The ball also moves smoothly and friction can be very finely tuned.

In spite of its fine appearance and handling, the head produced 5.7 cm of locking deviation and 4.8 cm under load. Unfortunately, this model is extremely sensitive to vibrations and produced the second-poorest result in our test.

Stability was poor in spite of the large, well-engineered head

- Features
- Price
- Size/Weight
- Only good with light cameras

The Hama Omega Carbon II is the cheapest carbon fiber tripod we tested

Induro Adventure AKP1

The US$200 Induro Adventure AKP1 is the most expensive aluminum model in our test, although the price does include a useful three-way pan/tilt head. It weighs 2.29 kg in spite of its relatively low height measurements of 137/160 cm. Folded down, it measures 70 cm, which is not really backpack compatible.

The legs are thick enough for easy handling with gloves, but only one has a neoprene sleeve. The quick-release leg locks are large and precise, but the rubber feet don't have spikes.

The fully featured three-way pan/tilt head has two separate rotating locking levers and the pan movement has its own large knurled knob that is easy to operate with gloved hands. All movements have precisely controllable friction, making the AKP1 well suited to video and sport/wildlife use. The large quick-release camera mount automatically locks in place.

Over our test distance of five meters, the head deviated by 5.8 cm under load, but only 2.4 cm during locking. Only two of the other test candidates proved more resistant to vibrations.

The three-way pan/tilt head is a pleasure to use and is well suited to video use. Overall stability is, however, only average.

- Video capability
- Handling
- Size
- Heavy lenses taboo

The Induro's aluminum construction makes it relatively heavy for its size but it nevertheless scores on price

Manfrotto MK294C3-A0RC2

This Manfrotto model carries the somewhat cryptic name MK294C3-A0RC2 and weighs 1.97 kg. It measures 151 cm retracted and a useful 181 cm extended, which results in a less backpack-friendly packed-down length of 71 cm. It is moderately priced at US$320.

The three-section legs are thick enough to do without neoprene coating, although we would still prefer to see it used. The legs have two spread settings and no spikes.

The head is one of the largest we tested yet does not have separate pan movement. On the plus side, friction can be adjusted using a dedicated knob, allowing you to set up the head to suit whichever camera you are using. The movement of the ball is not particularly smooth but has an unusually large tilt range of ±90 degrees. The 2.2 cm locking deviation value is one of the better ones we tested and 4 cm of deviation under load is above average. On the downside, vibration resistance was poor.

The Manfrotto head is averagely stable but reacts badly to camera mirror slap

- Robustness
- Handling
- Features
- Sensitivity to vibrations

This tripod provides an almost unbeatable mix of low weight, great reach and sensible pricing

Vanguard Abeo Plus 323CB

The Abeo is the heaviest tripod in our test, tipping the scales at three kilograms. It is also among the more expensive models, but it still offers good value for money at US$440. Larger than the competition in every respect, it measures 191 cm with the center column extended and 155 cm when retracted. This of course means that it is larger when folded down, and its 79 cm packed length is also the longest in our test. All in all, the Vanguard's large dimensions make it most suitable for stationary outdoor or studio use. Its rubber feet are equipped with extra rubber 'overshoes' and spikes that guarantee stable positioning, even in the slipperiest conditions. The large, neoprene-coated legs and easy-to-use clamps make handling simple in all weather conditions.

The ball head has a prominent, almost space-age design and scores well with its smooth but firm pan movement and panorama scale. The ball itself locks into the upright position, giving you an additional reliable axis for aligning panorama shots. The ball functions without noticeable shake and variable friction can be applied using the locking knob. Fixing and load deviation are both good, scoring values of 1.7 and 2.5 cm respectively. Vibration resistance was by far the best we tested.

It may look like an alien spaceship, but the Vanguard head works very well. Very good overall stability and resistance to vibrations make this model very suitable for use with heavier gear. The separate pan movement with its own rotation scale makes aligning your camera a breeze.

The large, square feet provide a really stable base and have additional spikes for use in tricky terrain. Neoprene-coated legs with large quick-release clamps make handling quick and easy.

- Stability
- Features
- Resistance to vibration
- Not suitable for travel

The Vanguard is the heaviest tripod in our test and the most expensive of the middleweight models, but the price is justified by a rich feature set

LIGHTWEIGHT TRIPODS

Manufacturer	Bilora	Cullmann	Feisol	Giottos	Gitzo	Mantona	Vanguard
Product	**TravelLux 3360**	**MAGNESIT 519 CW25**	**CT-3441S, CB-30C**	**Vitruvian 6kg VGRN8255**	**Traveler Kit GK1580TQR5**	**Titanium Carbon 2 in1**	**Espod Plus 233CB**
URL	www.bilora.de	www.cullmann.de/en	www.feisol.net	www.giottos.com	www.gitzo.us	www.mantona.de	www.vanguardworld.com
Tripod							
Material	Aluminum	Aluminum	Carbon fiber	Carbon fiber	Carbon fiber	Carbon fiber	Carbon fiber
Leg sections	4	2	4	4	4	3	2
Nominal carrying capacity	4 kg	4 kg	8 kg	6 kg	5.5 kg	5 kg	4 kg
Height without center column	110 cm	123 cm	133 cm	143 cm	129 cm	141 cm	129 cm
Height with center column	135 cm	158 cm	182 cm	166 cm	148 cm	166 cm	160 cm
Length (folded)	31 cm	62 cm	43 cm	40 cm	36 cm	47 cm	61 cm
Center column reversible	✓	✓	✓	✓	✓	✓	✓
Neoprene-coated legs	–	✓	✓	✓	–	Partially	Partially
# of spread settings/auto lock	3/–	3/✓	3/✓	2/✓	2/✓	3/✓	3/✓
Rubber feet/Spikes	✓/–	✓/✓	✓/–	✓/–	✓/–	✓/✓	✓/✓
Leg locks	Rotating	Quick-release	Rotating	Rotating	Rotating	Rotating	Quick-release
Head							
Type	Ball	Two-way pan/tilt	Ball	Ball	Ball	Ball	Ball
Separate pan movement	✓	✓	–	✓	–	✓	–
Removable camera mount	✓	✓	✓	✓	✓	✓	✓
Camera mount coating	Rubber	Rubber	Rubber	Rubber	Rubber	Rubber	Rubber
Panorama scale	✓	–	–	✓	–	✓	✓
Spirit level	–	✓	✓	✓	–	–	✓
Bag	✓	–	✓	✓	–	✓	–
Comments	Small size due to reversible legs		Small size due to reversible legs, thread at bottom of center column	Small size due to reversible legs, one leg detachable for use as monopod	Small size due to reversible legs	Small size due to reversible legs, one leg detachable for use as monopod	
Rating							
Handling	⊖	⊕	⊕⊕	○	○	⊕	○
Features	○	⊕	⊕	⊕	⊕	⊕	⊕
Stability	⊖⊖	⊖⊖	⊕	⊖⊖	⊕	○	⊖⊖
Fixing deviation	27 mm	60 mm	3 mm	30 mm	6 mm	5 mm	10 mm
Deviation under load	124 mm	130 mm	80 mm	145 mm	59 mm	95 mm	Sags noticeably
Amplitude	741 pixels	365 pixels	229 pixels	285 pixels	316 pixels	273 pixels	293 pixels
Weight	1.16 kg	1.63 kg	1.39 kg	1.35 kg	1.17 kg	1.41 kg	1.3 kg
Price (approx. in US$)	165	100	500	425	900	300	300

MID-WEIGHT TRIPODS

Manufacturer	Cullmann	Hama	Induro	Manfrotto	Vanguard
Product	**MAGNESIT 528C MB6.5**	**Omega Carbon II**	**Adventure AKP1**	**MK294C3-A0RC2**	**Abeo Plus 323CB**
URL	www.cullmann.de/en	uk.hama.com	www.indurogear.com	www.manfrotto.com	www.vanguardworld.com
Tripod					
Material	Carbon fiber	Carbon fiber	Aluminum	Carbon fiber	Carbon fiber
Leg sections	3	3	3	2	3
Nominal carrying capacity	7 kg	4 kg	8 kg	5 kg	12 kg
Height without center column	140 cm	153 cm	137 cm	151 cm	155 cm
Height with center column	170 cm	176 cm	160 cm	180 cm	191 cm
Length (folded)	63 cm	72 cm	70 cm	71 cm	79 cm
Center column reversible	✓	✓	✓	✓	✓
Neoprene-coated legs	✓	✓	Partially	✓	✓
# of spread settings/auto lock	3/–	3/–	3/–	2/✓	3/✓
Rubber feet/Spikes	✓/✓	✓/✓	✓/–	✓/–	✓/✓
Leg locks	Quick-release	Quick-release	Quick-release	Quick-release	Quick-release
Head					
Type	Ball	Ball	Three-way pan/tilt	Ball	Ball
Separate pan movement	✓	✓	✓	–	✓
Removable camera mount	✓	✓	✓	✓	✓
Camera mount coating	Rubber	Rubber	Rubber	Rubber	Rubber
Panorama scale	✓	✓	✓	–	✓
Spirit level	✓	✓	✓	–	✓
Bag	–	✓	✓	–	–
Rating					
Handling	⊕⊕	⊕⊕	⊕	⊕	⊕⊕
Features	⊕⊕	⊕	⊖	⊕	⊕⊕
Stability	⊕⊕	⊖⊖	○	⊖	⊕⊕
Fixing deviation	15 mm	57 mm	24 mm	22 mm	17 mm
Deviation under load	23 mm	48 mm	58 mm	40 mm	25 mm
Amplitude	293 pixels	434 pixels	231 pixels	308 pixels	165 pixels
Weight	2.4 kg	2.56 kg	2.29 kg	1.97 kg	3 kg
Price (approx. in US$)	425	350	200	320	440

⊕⊕ excellent ⊕ good ○ satisfactory ⊖ poor ⊖⊖ inadequate ✓ included – not included n/a not applicable

Ralph Altmann

A3 Printers in Practice

Running your own large-format printer gives you independence from third-party print services and often produces better results at a lower cost. We tested a range of large-format printers with a selection of different papers to help you decide when high-end home printing is worth the effort and when you are better off using a dedicated print service.

Inkjet printers are the best choice when it comes to producing small numbers of high-quality prints. High-end printers that use multiple color cartridges can easily trump the quality of 'real' prints from a lab, so we decided to find out just how much effort is involved and what it costs to make your own high-end prints.

We tested Canon's PIXMA PRO-1 and PRO-100 models and the Epson Stylus Photo R3000. All three support the A3+ (13-inch) print format, although you will find that some printers in this class actually support paper formats up to 14 inches wide. Hewlett-Packard (HP) no longer competes in this category, and the smallest fine art printer it offers is the 24-inch Designjet Z2100 model. High-end printer specifications are based on the narrow side of the paper being used, and the length of a print is, theoretically, only limited by the length of the paper, although most devices have their own built-in limits. The R3000 prints up to 3.27 m (nearly 11 feet), while the Canon models we tested can print up to 67 cm (26.4 inches).

The Cost of High-end Home Printing

In purely economic terms, owning your own high-end printer makes sense if the time you spend and the cost of materials (and running costs) for all the prints you make during the printer's amortization period add up to less than it would cost to have prints made by a third-party service and delivered to your door. It is difficult for hobby photographers to estimate how many prints they will make over a given period of time, and the economic aspects listed above don't take the fun factor or the additional artistic flexibility of home printing into account. If you like to experiment with printing on unusual papers or other materials, you will have to use your own printer, and the immediate availability of a home printer is another aspect of ownership that isn't included in a purely monetary view.

Ink is the most expensive aspect of home printing. A 13 ml color cartridge for the Canon PIXMA Pro-100 typically costs about US$17, which equates to a bulk price of US$1,300 per liter. Larger cartridges are cheaper and mean that your printer goes through its head cleaning routine less often, which also saves ink (most printers clean all the nozzles, even if you only swap out a single cartridge). A 36 ml cartridge for the PIXMA PRO-1 typically costs about US$36 (US$1,000 per liter), while the 80 ml cartridges sold for use with the Epson Pro

printer models cost around US$50, which equates to a relatively low price of around US$625 per liter. The real cost of the ink you use also depends on the number of colors your printer uses, the type of paper (matte paper requires more ink) and of course on the nature of the image itself. The Canon website (see note [1] below) lists ink yields for a sample image for all its available printers, and quotes usage figures that equate to ink costs of about US$2 for a single A3 print. Not surprisingly, manufacturer-independent tests come up with figures of US$2.50 and more per print.

Third-party inks are a lot cheaper but aren't necessarily capable of reproducing as many colors and aren't usually as durable as manufacturers' own products. If you do decide to use third-party inks, you will definitely have to profile your print workflow accordingly if you want to be sure of avoiding color errors.

High-quality papers are expensive too. In order to produce genuinely long-lasting prints, paper has to be acid free and its ink-absorbing layer has to be lightproof. Paper coatings have to be absorbent but protective if they are to provide sufficient color longevity. You can assume that your paper costs will range from US$1.20 per sheet for mid-range

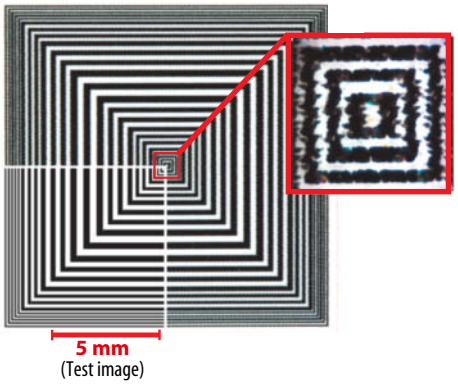
How We Tested

We printed our test images using the following papers:

– Glossy papers recommended by the manufacturer: Photo Pro Platinum (PT-101, 300 g/m²) for the Canon models and Epson's own Premium Glossy Photo Paper (255 g/m²) for the R3000

– Hahnemühle Harman Gloss Baryta (320 g/m²): a high-quality glossy paper with a fine texture and very small artificial brightener component

– Hahnemühle FineArt Museum Etching (350 g/m²): an extremely matte fine art paper with no brighteners.

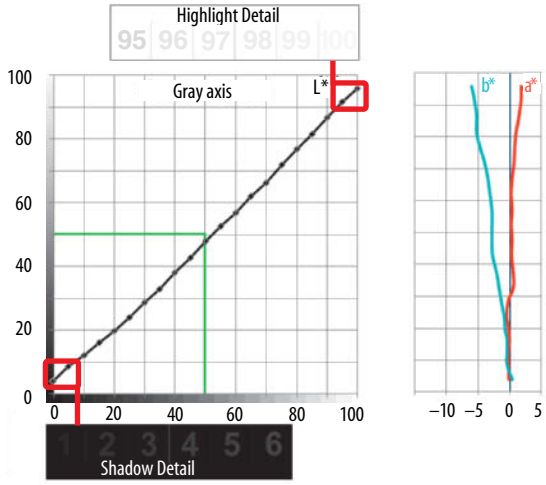


The narrowest lines in our test pattern are 1 pixel wide, which equates to 0.07 mm in print. The bottom left corner shows the original image. The enlargement was created using a USB microscope and measures 1 mm across.

Our test images had a resolution of 360 ppi and were saved in the eciRGB(v2) color space, which is better suited to the printers' color space than AdobeRGB. Alongside details from actual photos with challengingly saturated colors, our test images also contained skin tones, color gradients, a color space test wedge and patterns designed to help judge print sharpness. We printed from the *Photoshop* interface using the program's own color management settings. We used the generic color profiles provided by the paper and printer manufacturers and at least one of our own custom profiles.

We analyzed the results visually and using an i1Pro 2 spectrophotometer. We produced Yxy 'horseshoe' diagrams for the measured colors and the outline of each color space to help us compare the reuslts and generated graphs showing the shape of the gray axis in the Lab color space.

We used the ColorCheck Online service (www.colorcheck-online.net) to provide qualitative analysis of our data and the



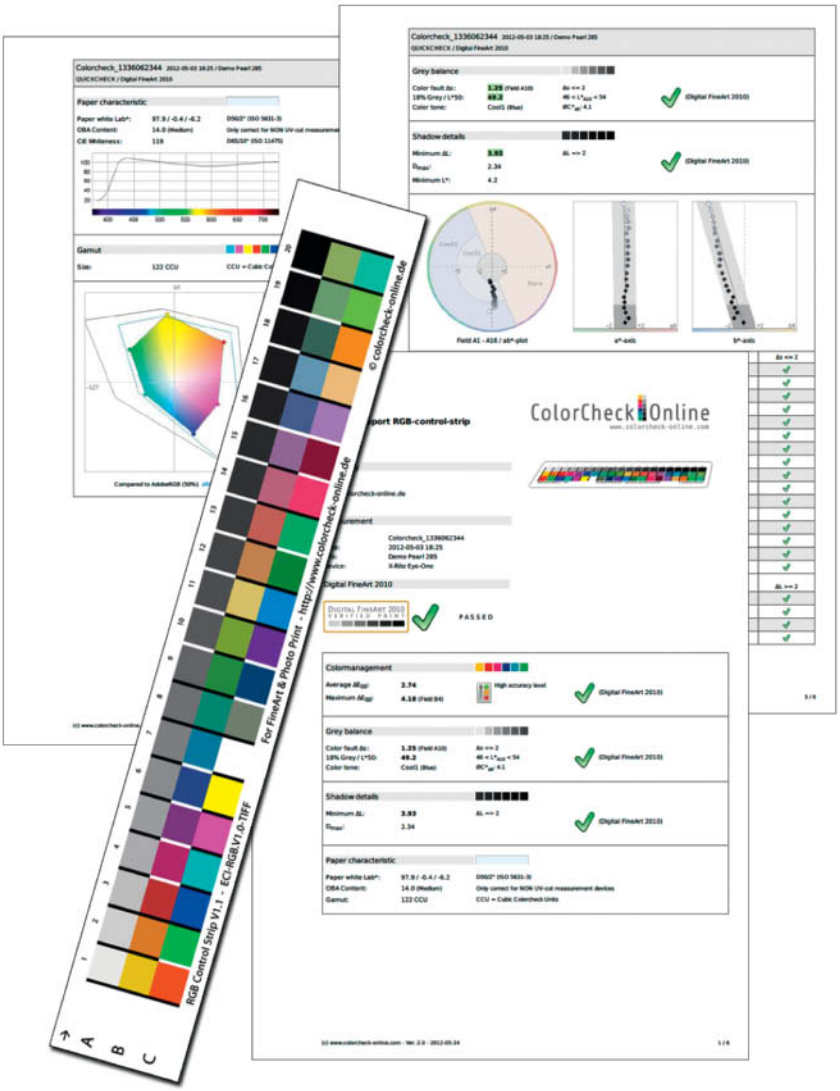
The curve on the left represents the measured Lab lightness (L*) values for a grayscale wedge, while the two curves on the right represent the a* and b* color components. The ends of the curves represent the base lightness and color values (i.e., the white and black points) of the paper. Ideally, the L* curve forms a linear pattern between these two points. The color curves should stick closely to the vertical '0' axis (i.e., neutral gray). However, in reality, papers tend to have a slight yellow cast, causing the b* curve to shift to the right (i.e., toward positive values). Optical brighteners shift white tones toward blue, which in turn shifts the b* curve to the left. The steeper the L* curve close to the white and black points, the better highlight and shadow detail rendition will be.

A3 paper to as much as US$5 or more for high-end fine art paper. The Harman Gloss Baryta paper we used in our test costs about US$3 per sheet, while the Hahnemühle Museum Etching cost closer to US$5.

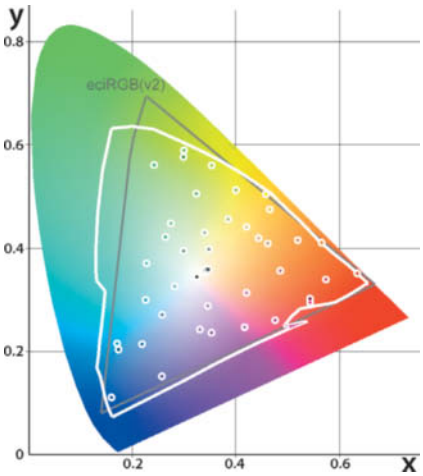
The cost of the energy required to make prints is negligible compared to the other costs involved. Even if you spend two hours per day printing, the annual energy cost is unlikely to exceed six or seven dollars, although standby costs will be more than that unless you unplug your printer when you are not using it. Even if you only print occasionally, you should still print a test page every couple of weeks. This prevents many printers from performing an ink-wasting nozzle cleaning routine when you switch them on after a period of non-use.

At the end of the day, each high-end print you make will cost US$4-8. Most of the print services we found charge between US$17 and US$25 per A3 print, so, measured in material costs alone, making your own prints represents a real saving. Assuming a price of US$16 per print (excluding delivery) and 20 prints per year, even the most expensive of our test printers will pay for itself within five years, and even faster if delivery costs are taken into account.

A full quality control analysis run at ColorCheck online (www.colorcheck-online.net) costs about US$1.50. The illustration here shows three of the six pages in the report. To have a report generated, you first have to download and print the media wedge shown here and analyze the results using a spectrophotometer.



deviation of our printed colors, the gray balance and shadow detail compared with predetermined reference values. These results are honored with up to three positive 'ticks', which we also awarded a corresponding number of points in our own analysis. The full results for one of the paper types are shown on the right.



The color space covered by a modern printer (the white outline shown here represents Harman Gloss Baryta paper used with a Canon PIXMA PRO-1) is broader in places than both AdobeRGB and the slightly larger eciRGB space (represented here by the gray outline). The white-outlined points represent the colors we measured for our test. The greater the extent to which each point fills the white outline, the better the utilization of the gamut associated with the color space in question.

Canon PIXMA PRO-100

The PIXMA PRO-100 uses eight dye-based Canon ChromaLife inks, including black, gray and light gray. Dye-based inks do not differentiate between photo black and matte black (for glossy and matte papers respectively), so you don't have to swap cartridges when you switch from glossy to matte paper the way you do with other types of ink. The other colors are two differently saturated cyans and magentas and a single yellow. The 13ml cartridges are mounted with the print head in a holder and can be swapped out individually. The maximum print resolution is 4800×1200 dpi and the droplets produced have a volume of approximately three picoliters.

Normal photo paper is stored in the upper tray (which Canon calls the 'rear' tray). Thicker media (up to 0.6 mm/350 g/m²) have to be printed via the manual feed tray (which is actually located behind the 'rear' tray), where they are also bent during feeding, but not as much as paper fed via the rear tray. The manual feed tray can be lowered to a horizontal position, but only for removing paper jams. The maximum printable paper width is 35.6 cm (14 inches), a size also known as A3++. For reasons that we were unable to divine, the maximum print length is limited to 67.6 cm (26.6 inches). A special tray is provided for printing CDs and DVDs.

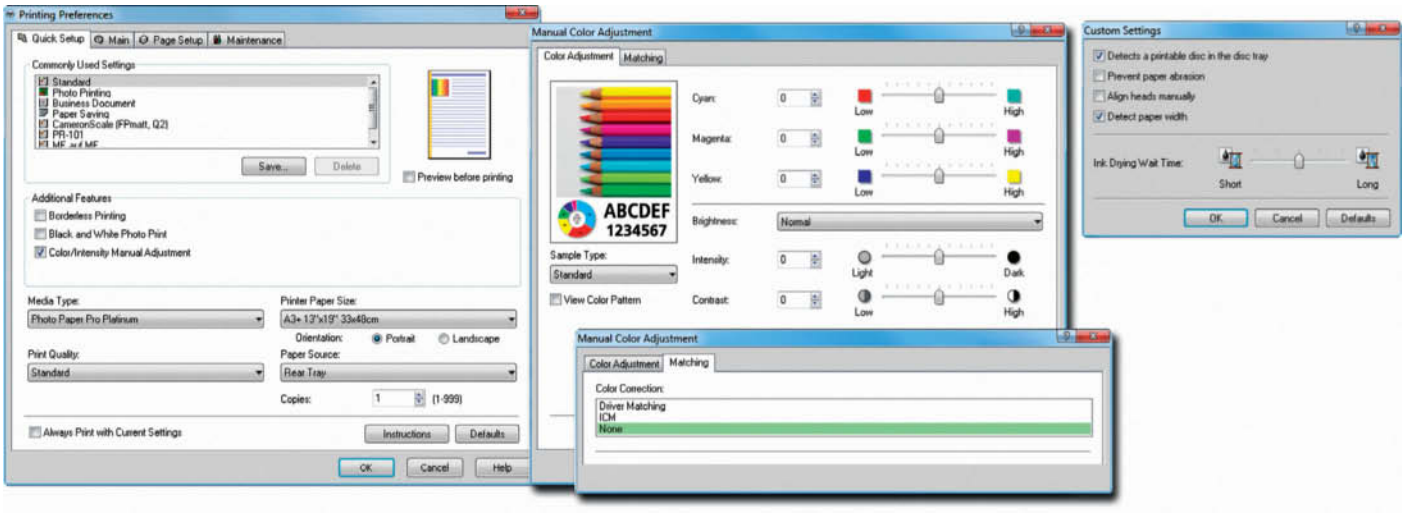
Handling

Use of the printer requires a connection to a computer and installation of the appropriate driver, which is available in Windows and Mac versions. An 'IJ' driver is installed by default, but you can also opt to install an 'XPS' driver, which is useful if you are printing 16-bit image files, as it is the only one that can handle the finer tonal gradations these contain.

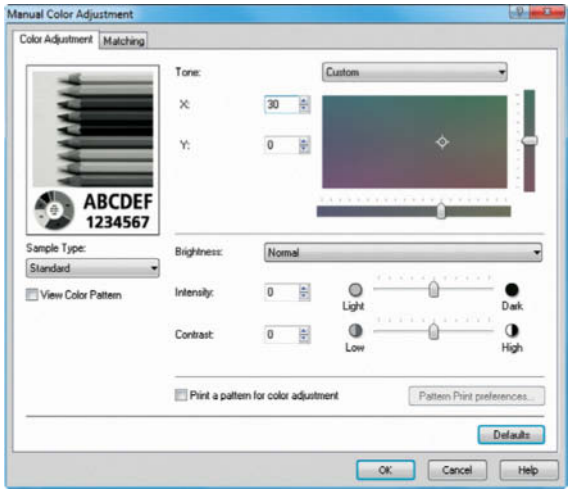
Both driver windows are multi-leveled and not particularly user-friendly. For example, the otherwise highly practical Quick Setup tab doesn't even mention that you have to navigate your way through at least two sub-dialogs before you can switch off the printer's own color management functionality. Custom print settings can be saved as Commonly Used Settings, although this function is not particularly easy to use either.

You can make manual color adjustments even when you are working with ICC color management. Color balance for cyan, magenta and yellow can be adjusted, as can overall intensity and contrast. Brightness can be set to light, normal or dark, and influences midtones especially. The Sample Type function shows the potential effect of these corrections using a range of patterns, but there is no color-managed preview available. Canon's *Print Studio Pro* software is a lot better than the standard driver in various respects.

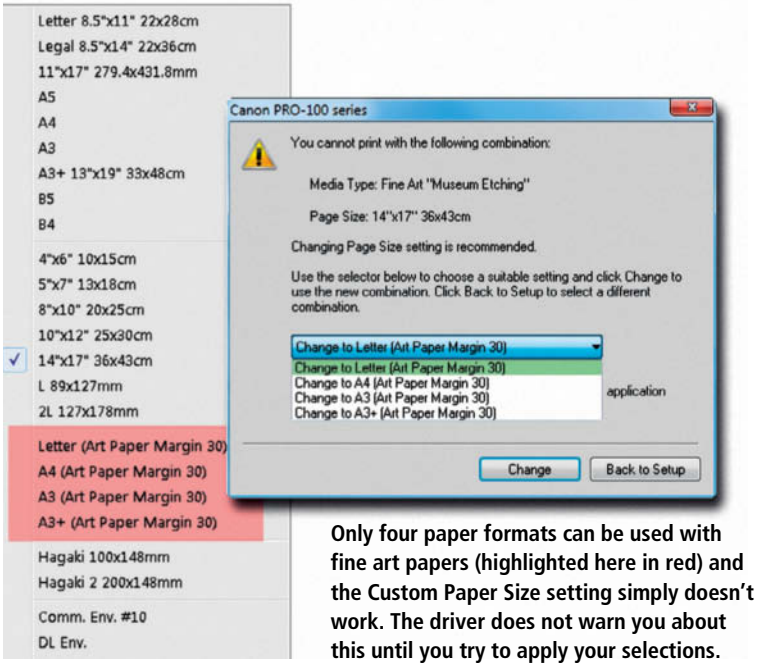
The PIXMA PRO printers wouldn't print the upper and lower edges for the four selectable fine art paper types. Canon says this is to retain print quality, but it also means that 30 mm of print area at both ends of the paper is unusable. it also makes borderless printing,



The Canon driver distributes important printer settings over several tabs, and some are quite difficult to find. To prevent incorrect settings, the Manual Color Adjustment tab (bottom center) should be (but isn't) part of the Quick Setup tab (on the left). The Ink Drying Wait Time setting that is so important for special paper types is hidden away in the Maintenance tab under Custom Settings (on the right).



If you are printing in black and white, you can adjust the mood of the grayscale tones you use. Neither PIXMA printer allows you to make pure monochrome prints without the use of colored inks.



Only four paper formats can be used with fine art papers (highlighted here in red) and the Custom Paper Size setting simply doesn't work. The driver does not warn you about this until you try to apply your selections.

which is feasible for a small range of standard paper types, impossible on fine art paper.

Test Results

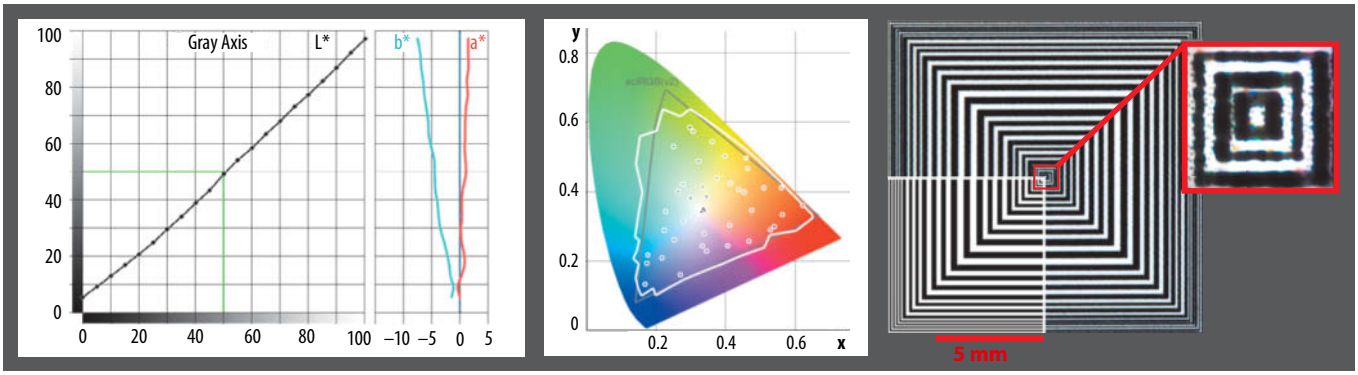
Canon recommends the Pro Platinum PT-101 paper for use with the PRO-1 and PRO-100 printers. Because it is not classed as a fine art paper, this stock can be printed without borders. The same is true of the Harman Gloss Baryta paper we tested, and the manufacturer recommends using it with the *Other Glossy* media type option. The Museum Etching paper has its own Canon profile, which we used for our test.

The PRO-100's prints all came out looking warmer than those produced by the more expensive PRO-1 and we couldn't see any evidence of the supposedly larger color space produced by the dye-based inks. Both pigment ink printers performed better on glossy paper. Sharpness is excellent: even in standard mode, it is better than that produced by many third-party print services.

Pro Platinum PT-101: Even Canon's generic profile produced very good results. Because its profiles are already optimized, Canon recommends switching off black point compensation when using the Relative Colorimetric rendering intent – an option that indeed produced better results with a lower black point. Shadow detail turned out best using the Perceptual rendering intent. We managed to produce slightly better colors, a slightly larger color space and more neutral grays using our own custom profile, but we weren't able to equal the Canon profile's deep black point.

Hahnemühle Harman Gloss Baryta: The generic profile for this paper produced disappointing results, with obvious color stepping effects and poor shadow detail. The profile we created using the *Canon Color Management Tool Pro* (CCMTP) wasn't much better and produced even poorer gray balance than the generic version. We achieved our best results (three ColorCheck points) using the Perceptual rendering intent and the profile we created using an i1Profiler and the Perceptual rendering intent. The extremely high black point (with L* values of 16 or 17 and more) was obvious in all our prints, and was not as good as the results produced using matte paper types. We can only assume that the printer's dye-based inks don't take well to the surface of the baryta paper.

Hahnemühle Museum Etching: We achieved very good results with dark, silky blacks (L* = 12.7) and great shadow detail using the generic Canon profile and both the Perceptual and Relative Colorimetric rendering intents (both without black point compensation). Our custom CCMTP and i1profiler profiles didn't produce much of an improvement and creating them turned out to be a waste of effort. The generic Hahnemühle profile produced measured values that were not as good as those produced by the Canon profile and the color deviations lay beyond the ColorCheck tolerance values.



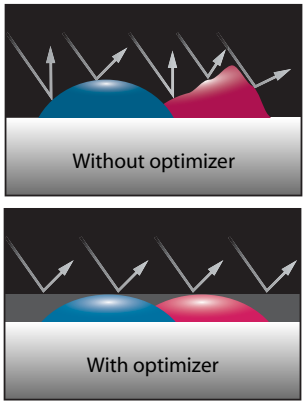
The results produced by the Canon PIXMA PRO-100 used with Pro Platinum PT-101 paper. The diagrams show the Lab lightness curve for our grayscale wedge and the a* and b* components alongside our sharpness test pattern.

Canon PIXMA PRO-1

Canon's top-of-the-range A3+ printer uses no less than twelve 36ml ink cartridges (i.e., the cartridges are at least twice the size of those in the PRO-100). The printer uses a maximum of ten separate colors per print and differentiates between photo black and matte black. There are additional 'photo' cyan and magenta inks, and gray, light gray and dark gray inks complement the two blacks to produce extremely fine color gradients and natural-looking skin tones. An additional red ink extends the reproducible color space and the twelfth tank contains a transparent varnish called 'Chroma Optimizer', which is sprayed onto the surface of glossy media to provide an even finish with dark, well-saturated shadow tones and blacks.

Each cartridge has its own print head, so you don't have to waste ink cleaning the nozzles every time you switch paper types. The ink tanks are housed separately from the print head and connected to it using tubes.

The PRO-1 looks rather more elegant than the PRO-100 but is a lot larger and weighs a hefty 28 kg (61 lb). The media types it can handle and the arrangement of its trays are the same as those we have already described for the cheaper machine, including the annoying limitation of media length to 67.6 cm (26.6 inches) and an even broader 'fine art margin' of 35 mm.



Chroma Optimizer fills the gaps between ink droplets, producing uniform, less obvious reflections

Handling

The driver dialogs and overall handling are virtually identical for both Canon machines, although the PRO-1 dialog has two additional tabs. The first, Clear Coating, controls the application of Chroma Optimizer via Auto, Overall and Custom settings. The Overall setting coats the entire print area, while the Custom setting uses a 'form file' created by the user to control the print job. The coating is applied where the 'form' is pure white but not in other areas. Forms only apply to the paper format and alignment for which they were created and can be inverted and/or combined with other patterns. The printer driver issues a warning if you attempt to apply a form to paper with a differing format. The only way to switch off Chroma Optimizer usage is to apply a full-page form created using a completely black pattern that is the same size as the page you want to print.

The second PRO-1-specific tab, Effects, is only present in the IJ driver. The only really useful features it offers are the monochrome tint effects that can be used to add a sepia (or other) tint to a print. However, the Effects tab does not have a preview or any other controls for adjusting the effects it offers, so you are much better off making any necessary adjustments using a dedicated image processing program.

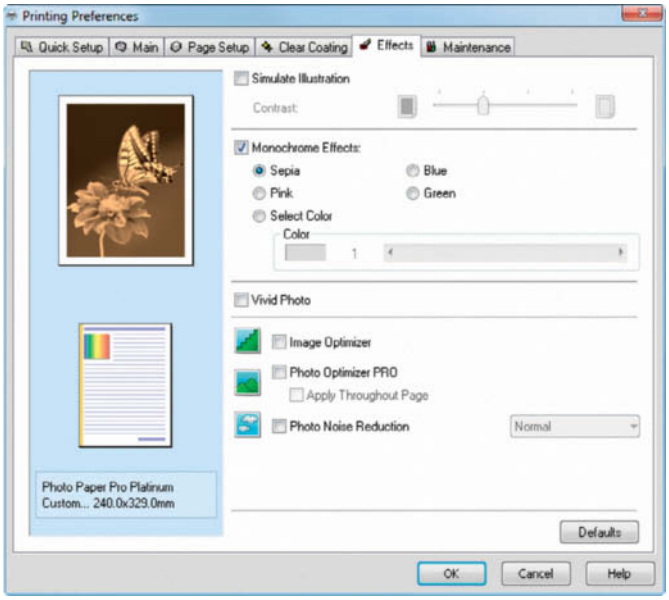
Chroma Optimizer costs just as much as conventional ink, and because of the larger number of cartridges, ink consumption costs more per image than it does using the comparable Epson R3000. The PRO-1 warns the user several times if a cartridge is nearly empty, although we found that we could continue printing for a while after the warnings were issued. The printer simply stops printing and ejects the paper if a cartridge genuinely runs out, which is probably a more economical approach than throwing away a small amount of remaining ink.

Test Results

Because of the pigment-based inks it uses, we expected the results to differ from those produced by the PRO-100, even using the same media, but we were still amazed by the scale and type of the differences. Both printers have their own particular strengths that depend on the type of media in use, so there is no clear winner. The PRO-1 also produces extremely sharp prints, and, in contrast to the PRO-100, roughness only becomes apparent at very fine edges and high magnifications.

Pro Platinum PT-101: Printing on Canon's own paper with its own generic profile produced surprisingly poor results. None of the three available rendering intents was able to tick all three ColorCheck boxes, and Perceptual even managed to score three negative points. The prints we made using our custom i1Profiler profile had the best color rendition and acceptable shadow detail in a color space that turned out much larger than the one we were able to produce using the PRO-100. The black point ended up at L* = 3.5 (i.e., equivalent to a color density value of 2.4) for all our prints, regardless of which profile we used, providing better overall results than the PRO-100.

Hahnemühle Harman Gloss Baryta: The paper manufacturer's own profile for this paper/printer combination failed almost completely, producing strong color deviation, color casts in the gray tones and obvious stepping in color gradients. Hahnemühle failed to respond to our



The Effects tab in the PRO-1 IJ driver does not provide any genuinely useful functionality

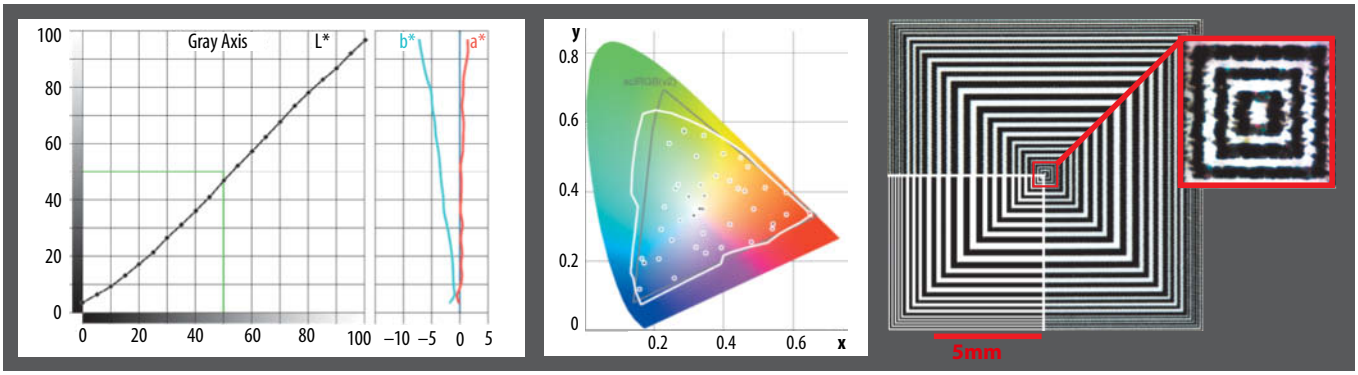
The useful Pattern Print window only reveals its true power when used with *Print Studio Pro*, which enables you to view a complete preview and select cropping options

requests for an explanation. In contrast, the results we achieved with our custom i1Profiler profile were excellent. The profile we created using the *Color Management Tool Pro* software showed weakness in its gray balance. Interestingly, using the baryta stock, the PRO-1 produced a satisfyingly deep black (at L* = 3.8, hardly worse than that produced using the PRO Platinum paper), while the PRO-100 only managed to produce dark gray.

The print head in the PRO-1 produced slight scratches in the first centimeter of each print, leading us to conclude that either the stock was too thick or it had been bent too much during feeding. However, we then discovered the 'Prevent paper abrasion' setting in the Custom Settings section of the Maintenance tab, which increases the clearance between the print head and the paper and cured the problem. If you use this option, the printer driver issues a warning concerning potential reduced print quality, which you have to agree to before printing begins. Though not apparent in a normal print, this quality loss was visible in the fine lines of our sharpness test image.

This hidden option is the only way to adjust print head clearance in the Canon printers.

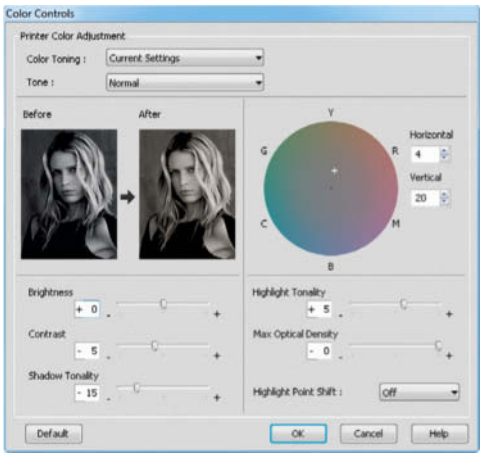
Hahnemühle Museum Etching: Once again, the paper manufacturer's own profile produced disappointing results with obvious color deviation and a very high black point value (L* = 20.6 in Relative Colorimetric mode). The Canon profile produced better results, including a black point value of L* = 17.4 (with a density of 1.62) in Perceptual mode – still much poorer than the results the PRO-100 produced using the same paper. The Museum Etching stock is obviously poorly suited to use with pigment-based inks – an assumption that was backed up by the performance of the Epson R3000. Both pigment-ink printers only produced results inferior to those of the PRO-100 on this paper. The i1Profiler profile was the better of the two custom profiles and fulfilled all three ColorCheck criteria in spite of its visually substandard shadow detail.



The results produced by the Canon PIXMA PRO-1 used with Pro Platinum PT-101 paper. The diagrams show the Lab lightness curve for our grayscale wedge and the a* and b* components alongside our sharpness test pattern.

Epson Stylus Photo R3000

The R3000 prints using eight of nine different pigment-based inks including a particularly highly saturated magenta called UltraChrome K3 Vivid Magenta. Two additional gray cartridges and Light Cyan and Light Vivid Magenta inks help to increase overall resolution. Photo and matte black complete the spectrum in tanks that each contain 25.8 ml of ink. The two black cartridges share a print head, which means that a lot of ink is wasted every time you switch media. Maximum print resolution is 5760 × 1440 dpi and adjustable droplet size helps to fine-tune the results.



Tonal values and monochrome tints can be precisely configured using the Epson's driver tools. Unfortunately, the preview only shows a generic sample image.

The Epson doesn't look quite as up-market or robust as the Canon printers but does include a color monitor in its control panel that displays the current ink levels and printer settings, as well as providing help and issuing error warnings. It also scores well with its variable paper feeds, which include the ability to feed flat (i.e., non-bendable) media up to 1.3 mm thick. Such media are fed singly from the front, which can be tricky and often doesn't work at all. Unfortunately, we can confirm many of the complaints that we came across online. Normal paper is fed via the automatic sheet feeder at the rear. The Epson is the only printer n our test that also supports roll paper (up to 329 mm/13 inches wide). The maximum printable length is 327 cm (129 inches), but the maximum printable width is slightly less than either of the Canon printers offers. The manual feed slot doesn't support paper that is significantly smaller than A4.

Handling

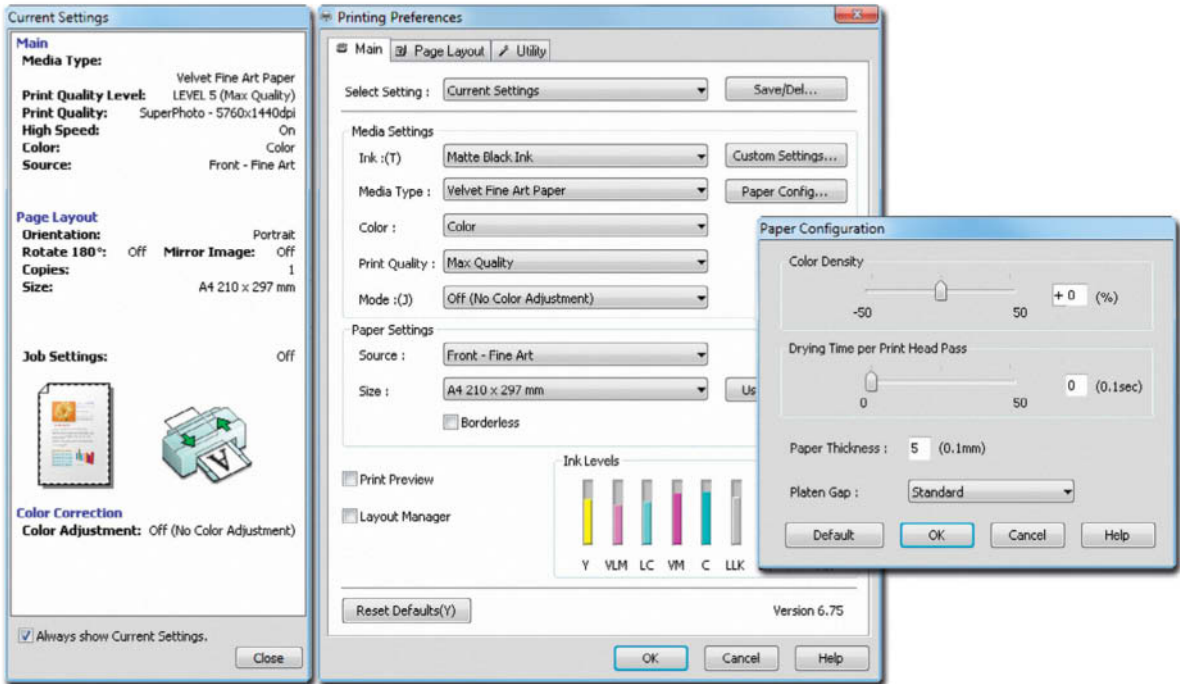
We much preferred the setup of the Epson Windows driver dialog to its Canon counterpart. The settings are laid out more clearly and the optional info window displays the current color settings. You can save print settings (including media settings) as a preset, allowing you to use custom names for settings you have made for third-party media. Another useful feature is the ability to change the order in which media appear in the menu and to hide any you don't currently need. Presets can also be exported for use with other printers. The Paper Configuration window includes settings for paper thickness (in increments of 0.1 mm), Drying Time (per print head pass) and print head clearance ('Platen Gap').

The only complications we encountered during our test occurred when we used fine art paper. This has to be placed extremely precisely onto a kind of template in the feed tray, and the printer issues warnings or simply ejects the paper due to tiny positioning inconsistencies that we were unable to see under normal circumstances. Try to avoid using paper that is already printed in the upper tray, as this confuses the (presumably optical) paper sensor. If you do print multiple test strips on a single sheet, you can avoid this issue by starting at the bottom and working up.

Once the paper has been successfully fed into the machine it is 'parked' on the sloped rear support that is usually used for roll paper. Once we realized how this worked, we simply had to try feeding paper directly into the roll paper slot. If you want to do the same, make sure you select one of the roll paper source settings and the appropriate width using the *User Defined* size option, then insert your paper as far as you can into the open slot and hold it in place until the printer grabs it. The disadvantage of this method is that printing begins 35-40 mm from the leading edge of the paper and stops about two centimeters from the trailing edge.

The Epson doesn't force you to print margins when using fine art paper the way the Canon machines do and offers a range of seven different borderless printing widths at lengths up to the machine's default maximum.

The printer strictly prohibits adjustments to color and brightness if you use application-controlled color management or the ICM or Off (i.e., no color management) Mode settings in the printer driver's Main tab. All the other modes allow corrections, although we don't recommend that you interfere, as the changes you make are once



The Epson driver window displays the main settings in a single interface. Further media settings can be made in the Paper Configuration window.

again only shown in a generic preview image, not on a live preview of the image you are actually printing.

The *Grayscale* monochrome conversion option is only available for standard papers and some inkjet media, while the *Advanced B&W Photo* option enables you to fine-tune brightness, contrast and shadow/highlight tonality. There is even a Max Optical Density slider for reducing color density. Increasing density is a risky undertaking and can only be performed via the paper configuration settings.

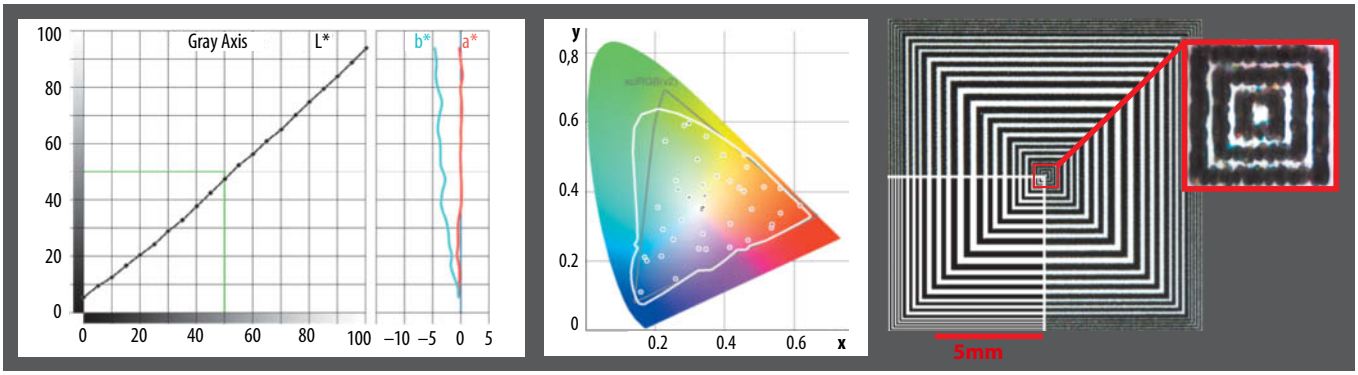
Test Results

Epson Premium Glossy Photo Paper: This premium glossy stock counts as photo paper and can thus be loaded via the rear sheet feeder and printed using a generic Epson profile. We used the Hahnemühle profiles for the (front-loading) fine art papers. Epson doesn't provide an equivalent to the Canon *Color Management Tool*, so we used the i1Profiler to create custom profiles for all three test papers. Overall sharpness was very good and, at medium and high settings, beat that produced by some third-party print services.

The Epson profile produced a usable black point with a D_{max} value of 2.32 (L* = 4.3) and very good shadow detail, but let itself down in the color deviation stakes, which ended up costing it a ColorCheck point. Everything worked fine using our custom profile, regardless of whether we used the Perceptive or Relative Colorimetric (with black point compensation) rendering intent. The custom profile also slightly enlarged the color space but produced a slightly higher black point with an L* value of 5.2.

Hahnemühle Harman Gloss Baryta: The manufacturer's profile only produced acceptable results using the Relative Colorimetric intent with black point compensation, while Perceptive produced significant color and neutrality deviation. Our custom profile produced fine results with both intents, although Perceptive generated better shadow detail and a relatively low black point (L* = 4.8). Judged visually, the Epson prints were indistinguishable from the PIXMA PRO-1 prints made on the same papers using the i1Profiler profile.

Hahnemühle Museum Etching: The results were reversed with this paper. The manufacture's own profile produced the best results when used with the Perceptive rendering intent (three ColorCheck points), while the Relative Colorimetric intent (with black point compensation switched on, of course) almost completely swamped the shadow detail. Perceptive was the better choice for shadow detail using our custom profile, while Relative Colorimetric produced a slightly larger color space. Overall, the R3000 produced rather poor black density values on par with those of the PIXMA PRO-1. The best density value was almost 1.6, which equates to an L* value of 18.5.



The results produced by the Epson R300 used with Premium Glossy Paper. The diagrams show the Lab lightness curve for our grayscale wedge and the a* and b* components alongside our sharpness test pattern.

Conclusions

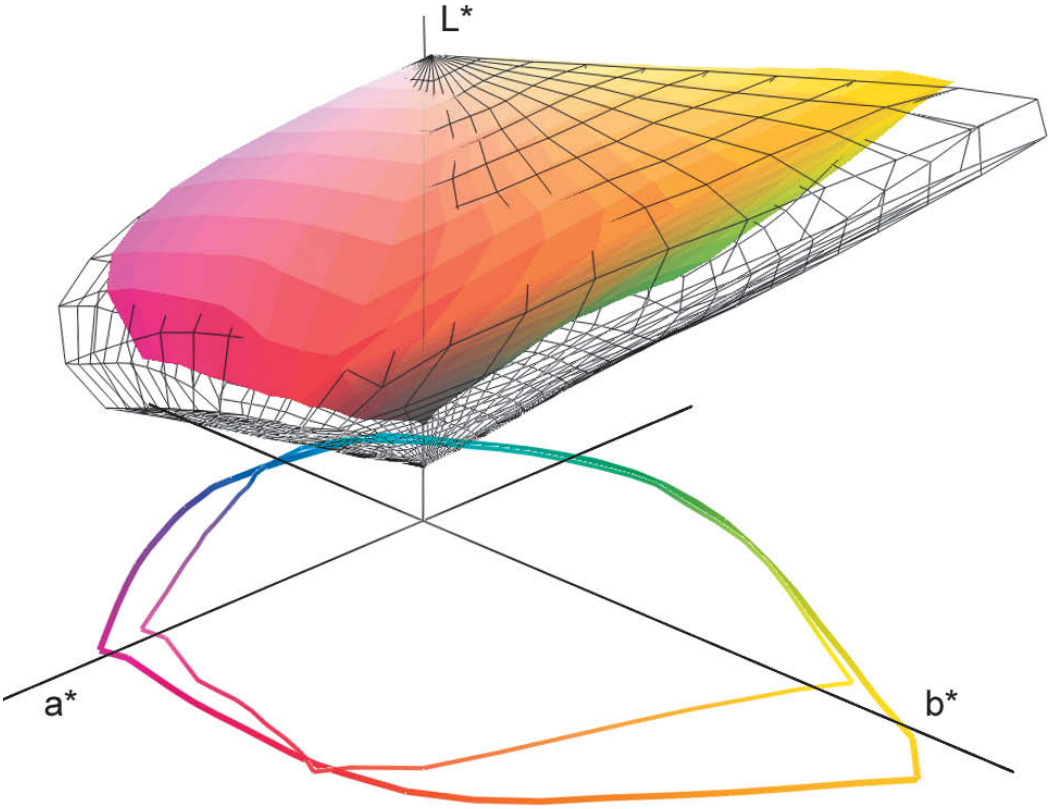
Used with appropriate profiles and well-chosen paper, all three printers produced excellent results with sharpness that beats many of the commercial offerings we have tested. The differences between the printers and the various profiles lay mostly between 'very good' and 'excellent' and were only detectable using lab-based test methods. Nevertheless, we still came across a number of notable exceptions to the downside, such as the result of using Harman Gloss Baryta paper with the generic Hahnemühle profile. Our tests also showed clearly that not every paper is suited for use with every printer. The Gloss Baryta is not suited for use with dye-based inks but produced very good results with pigment inks. On the other hand, the pigment-ink printers weren't as convincing as the PRO-100 when it came to printing on the highly matte Museum Etching stock. Such anomalies are due mostly to the reaction of the inks to the physical structure of the paper's surface and cannot be rectified, even using ICC profiles. The pigment-ink printers generally performed better and produced brighter colors than the PRO-100 on any type of glossy paper. Our tests also refuted the widely held belief that dye-ink printers generally produce a larger range of colors than pigment-ink printers.

Even if you are using the best possible profile, the rendering intent also plays a significant role in the quality of the results. Using the wrong intent can make a perfectly good profile useless, but unfortunately there are no hard and fast rules for determining which is the best setting to use. We found that Canon profiles (including those created using the *Color Management Tool*) should never be used with the black point compensation option activated in Relative Colorimetric mode, while the opposite is true of other manufacturer profiles and those created using other profiling software. In these cases, shadow detail is usually swamped if black point compensation is *not* switched on. This creates problems when you are using driver-based color management, where the option is not available.

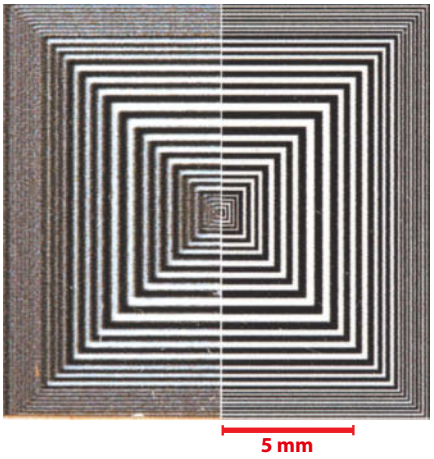
These kinds of subtleties make printer driver settings, which are tricky to master at the best of times, even more confusing, and a single incorrect or forgotten setting can make a print unusable. Dedicated print tools like Canon's *Print Studio Pro* and *Mirage* replace generic drivers and offer custom settings designed to make setting up the print workflow simpler and easier to understand.

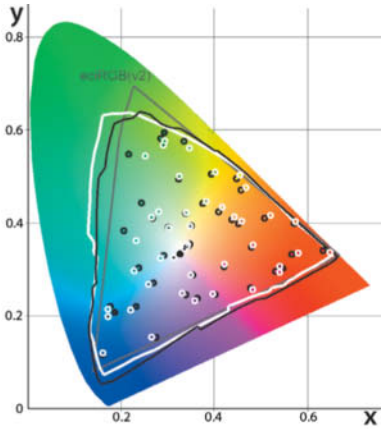
Our test didn't result in a clear recommendation for your next printer purchase. The less expensive PIXMA PRO-100 scores highly on the price and speed fronts, and produces very good results using a variety of papers. Pigment-ink printers generally produce even higher-quality colors (although not on all papers) and have a better reputation for print longevity. The PIXMA PRO-1 and the Epson R3000 are directly comparable quality-wise. The PRO-1 is more robust than the R3000 and there were no difficulties with its paper feed, but it still suffers from an inexplicable print length restriction. The Epson has no such restriction and a much more user-friendly driver. It also stops printing when an ink cartridge is empty and starts where it left off once the cartridge has been replaced, while the PRO-1 simply ejects half-printed paper. The PRO-100 can be persuaded to carry on printing with an empty cartridge if you ignore multiple error warnings, although doing so can cause unwanted stripe patterns in the finished print. This can definitely be seen as a positive feature compared to the other two machines, both of which refuse to print when a single cartridge is empty, even if the print you are making doesn't need that cartridge. The PRO-1 also goes on strike when the Chroma Optimizer tank is empty.

Canon's PIXMA PRO-10 can be seen as an alternative to the PRO-1, although it uses two fewer black inks and is therefore less



The dye-ink PIXMA PRO-100 produced better saturated dark tones and thus a much larger color space than either of the pigment-ink printers when used with Museum Etching paper. The PRO-1 results are shown here as a wireframe.





Our custom Harman Gloss Baryta/PIXMA PRO-1 profile (denoted by the white outline) produced a slightly larger range of colors than the FapFab online print service did for the same paper (denoted by the black outline). However, the individually measured colors (shown as points outlined in black and white) were almost identical, with FapFab only exploiting the color space a little better in the blue/green region. Judged visually, the two sets of prints were virtually indistinguishable.

suitable for making grayscale prints. In the Epson camp, the Stylus Pro 3880 prints up to A2+ (17-inch) paper using the same inks as the R3000 in larger (80ml) cartridges that even out the purchase price differential between the two machines. At the time of writing, this particular model was being offered in an attractive bundle with the *Mirage* pro printer software package, so it's worth keeping an eye out for that if it's still available.

At the end of the day, we can safely say that purchasing your own large-format printer is a viable alternative to using a third-party print service, whichever device you choose. We were pleasantly surprised by both the quality and the relatively low price of our home-brew artworks, even working on the basis of making just a few prints per year. (pen)

References

[1] www.usa.canon.com/cusa/consumer/standard_display/resources-and-learning-consumer/reference_materials-consumer/Page_Yield

A3+ PRINTER OVERVIEW

Model	Canon PIXMA PRO-100	Canon PIXMA PRO-1	Epson Stylus Photo R3000
Web	www.canon.com	www.canon.com	www.epson.com
Windows Driver	Win 7 / Vista (SP1 / 2) / XP (SP3)	Win 7 / Vista / XP (SP2 / 3)	Win 7 / Vista / XP
Mac Driver	OS X (10.5.8 and later)	OS X 10.4.11 to 10.7	OS X (10.4.11 and later)
Width × Depth × Height	689 mm × 385 mm × 215 mm	695 mm × 462 mm × 239 mm	616 mm × 319 mm × 228 mm
Weight	19.7 kg	27.7 kg	15.9 kg
Features			
Included Software	Canon Print Studio Pro, My Image Garden with Full HD-Movie Print	Easy Photoprint EX / Pro, Easy Webprint EX, Solution Menu EX, Color Management Tool Pro	Easy Photo Print; Epson Print CD; EpsonNet Setup
Print Method	Thermal	Thermal	Piezoelectric
Nozzles	8 × 768	12 × 1024	8 × 180
Tube-based Ink Feed	–	✓	✓
Max. Resolution (hor. × vert.)	4800 dpi × 1200 dpi	4800 dpi × 1200 dpi	5760 dpi × 1440 dpi
Ink	Chroma Life 100+	LUCIA pigment inks with Chroma Optimizer	Epson UltraChrome® K3 Vivid Magenta
Ink Cartridges	8 × 13 ml, 8 colors	12 × 36 ml, 10 colors	9 × 25.8 ml, 8 colors
Colors	Black, gray, light gray, cyan, photo cyan, magenta, photo magenta, yellow	Black (photo and matte), dark gray, gray, light gray, cyan, photo cyan, magenta, photo magenta, yellow, red	Black (photo and matte) light black, light light black, cyan, light cyan, yellow, vivid magenta, vivid light magenta
Minimum Droplet Size	3.0 picoliter	4.0 picoliter	2.0 picoliter
Connectors	USB, LAN, Wi-Fi	USB, LAN	USB, LAN, Wi-Fi
Direct Print Interface(s)	PictBridge, Apple AirPrint, Adroid Devices, iPhone, iPod touch, iPad	PictBridge	PictBridge
Media			
Auto Sheet Feed / # of Sheets	Top / 150	Top / 150	Top / 120
Format (W × L)	89-329 mm × 127-676 mm	89-329 mm × 127-676 mm	89-329 mm × 89-3277 mm
Thickness/Weight	64-200 g/m²	64-200 g/m²	0.08-0.3 mm
ManualFeed	Rear	Rear	Front
Format (W × L)	89-356 mm × 127-676 mm	89-356 mm × 127-676 mm	210-329 mm × 279-3277 mm
Thickness/Weight	0.1-0.6 mm	0.1-0.6 mm	0.3-0.7 mm
CD/DVD Printing	✓	✓	✓ (front)
Notes	Only 4 fine art formats available with 30 mm borders	Only 4 fine art formats available with 35 mm borders	Roll paper printing (0.08-0.1mm / 64-90g/m²) Poster card printing (0.7-1.3 mm)
Price (approx.)	US$400	US$1,000	US$800

✓ available – not available

Bojan Radojkovic

How to Retouch

Fine Art Prints

Even if the digital original is perfect, fine art prints often suffer from unwanted dust specks, scratches on the surface of the paper or damage caused by inappropriate storage and transport. Professional archiving and retouching services offer help at a price but, with a little patience and practice, you can perform your own repairs on damaged inkjet prints. This article, written in the author's own workshop, shows you how.

Even the best digital original and the highest-quality printing environment cannot always prevent blemishes and unforeseen damage from spoiling a print. Dust particles on the surface of the paper show up as white spots, while incorrect transport or storage can cause lasting damage to the coating. Handling a finished print can be a risky business too.

If you decide to take an analog approach, you can either get a professional retoucher to do the work for you or attempt the repairs yourself. If you make a lot of high-end prints, doing your own retouching is certainly the cheaper option and is often easier than finding a restoration service that is sufficiently experienced in handling contemporary inkjet media.

The person repairing a print needs to know all about the specific ink, paper and printer used, the photographer and date of printing, what the problem is and any special treatments that have been applied to the print's surface. Making a note of this data at the time of printing makes the repair process easier later on.

It is virtually impossible to check roll paper and canvas for blemishes before printing. Many resin-coated papers become electrostatically charged when you remove them from their packaging, so it is always a good idea to clean them with a soft anti-static brush before printing.

Retouching Techniques and Print Handling

In the days of analog photography, there was really no such thing as a perfect print, and learning how to retouch was part of every photographer's education. In our fast-moving digital times, this specialized knowledge is rapidly being lost, possibly forever.

The two basic approaches to analog retouching involve either carefully removing the damaged part of the emulsion using a scalpel or applying special albumen-based inks and glazes using a fine brush. Some photographers have developed their own chemical methods for handling damaged prints but, in the world of fine art inkjet prints, the brush-based method is the only real alternative.

Print damage is easiest to see if the original is mounted vertically and lit from the side or diagonally from above

**UV-resistant eyedropper bottles are perfect for long-term storage of pigment inks rescued from apparently empty ink cartridges.
A precision digital scale capable of weighing in increments of 0.01 g makes it possible to mix colors extremely precisely.**

You can prevent a lot of damage from happening at all if you keep your print environment clean, maintain your printer properly and store and handle your paper professionally. Dust causes many surface blemishes before printing has even begun and incorrect paper handling after printing adds to the problem. If possible, always clean paper with an anti-static brush before loading it into your printer. Sensitive baryta papers are better cleaned using compressed air from a lab-grade compressor or an aerosol can. If you make a lot of high-end prints, it might be worth investing in an anti-static ionizing air gun for around US$400. It only takes a few minutes to thoroughly clean your printer if you do it regularly.

Wearing archive-grade cotton gloves and placing acid-free tissue paper between individual sheets are simple ways to prevent scratches and grease marks from spoiling your prints. If your printer remains unused for days at a time, use a dust cover.

Basic Materials

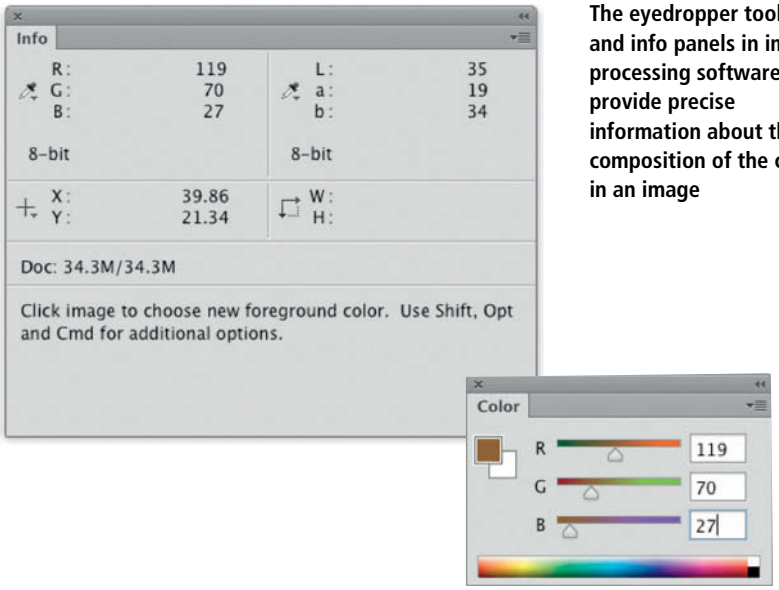
You don't need much equipment to perform your own retouching. High-quality watercolor brushes are essential, and we recommend

Pro-grade printers have drawbacks too. Every time a large-format printer is used, the built-in cutter produces dust that settles inside the machine's housing.

using brushes made from Kolinsky red sable in sizes ranging from 10 to 000. Winsor & Newton Series 7 and Da Vinci Maestro are reliable brands with deservedly great reputations. You will also need a 5500K daylight lamp and a magnifying glass (loupe). Lamps with built-in magnifiers or head-mounted magnifiers are ideal. A +5-diopter magnifier enables you to work at a comfortable distance of 20-25 cm from the paper.

Inkjet printer manufacturers don't produce their own retouching inks, so photographers simply have to improvise. Most large-format ink cartridges contain a separate bag for the ink, and even supposedly 'empty' home-printer cartridges usually still contain a couple of milliliters of ink, which is more than enough for making most repairs. Once you have carefully opened your old cartridges, you can store the ink you extract in labeled bottles. Always use original ink (or the same brand as you used for your print) if you want your repairs to be truly invisible.

Generally speaking, eight colored and four monochrome inks will be enough for most repairs. Use distilled water to dilute your ink and a palette (preferably with multiple mixing areas) made of china or plastic. Use medium-weight tissue paper (18-25 g/m²) to mask and protect your prints while you work.



The eyedropper tools and info panels in image processing software provide precise information about the composition of the colors in an image

Mixing Colors

Retouching isn't witchcraft, but it does require patience, practice and a steady hand.

Early pigment printers used a system of subtractive color mixing based on five color and two black ink cartridges, while more recent models have added additive colors (red, green and blue) to provide a greater range of color reproduction. An additional orange cartridge (i.e., mixed red and yellow) further extends the color range of Epson's high-end printers. A very small number of printers also use a separate gloss enhancer cartridge.

The 'color wheel' familiar to most painters is a great aid to finding the right retouch color, as is the eyedropper/info tool built into most image processing software.

You will need to mix at least two colors when repairing monochrome or tinted prints. In order to avoid metamerism (the incorrect appearance of colors due to the nature of the light source illuminating them), most pigment printers use complex mixtures of black, gray and colored inks and, because black and white pigment inks produce tones that are warmer than pure black, they have to be mixed with other colors to produce neutral-looking monochrome prints.

Even if you notice an error immediately after printing, you will have to wait at least 10 minutes and possibly up to two hours before the pigment inks are dry enough for you to accurately judge their color. If you want to be absolutely sure, it is better to leave a print to dry overnight before analyzing or repairing it.

Always work on a large, empty table and use weights at the corners to prevent the print

Cutting cotton or cellulose papers produces visible dust specks. Using an earthed anti-static brush or a custom broad blower brush designed for use with large-format printers helps to keep your prints dust free. Alternatively, a dust-off aerosol is cheaper and can be just as effective.

The brush is ready, the color is mixed, the print is masked with tissue paper and the magnifying lamp perfectly illuminates the blemish. Let retouching begin!

from slipping. Cutting off the tips of the thumb and forefinger of your cotton gloves can make it easier to manipulate the brush.

The color and reflectivity of a palette are sure to be different from those produced by the paper you are working on, so it is only possible to judge whether you have mixed a color correctly by trying it out on a sample of the same paper. Always keep offcuts of each type of paper you use for experiments. Pigment inks and distilled water work well together when mixing lighter tones because they have very similar densities. Use a dry sponge to remove excess mixed ink from your brush before you actually put brush to paper. Build up repairs slowly using multiple soft brush strokes. If you make a mistake, wait for the ink to dry and paint over it. Once applied, excess ink cannot be washed off, and trying to remove it with a scalpel ruins the paper's coating and quickly leads to a reprint.

Yes or No?

When deciding whether to do your own print retouching, you will have to weigh up the potential benefits against the time it takes to practice and perform your own repairs. The material costs are relatively low, and a set of high-quality brushes pays for itself quickly when compared with the cost of producing flawed A2-sized prints. With a little practice, you will be able to repair prints in just a few minutes, avoiding the need to make another print and saving time, money and valuable resources into the bargain. (jr) c't

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Dmitri Popov

Create Your Own Photo Website with Koken

Koken is a simple Web publishing solution aimed at photographers, designers and other creative types. This article introduces the program and its functionality, and explains how to get your own professional-looking photo website up and running.

Photographers who want to host their own photo publishing solutions have essentially two choices. You either have to go with a photo gallery application such as *Piwigo*, *Zenphoto*, or *Gallery*, or opt for a publishing platform like *WordPress* (see issue #10 of ***c't*** *Digital Photography* for more details). Both solutions have their advantages and drawbacks. Galleries are perfect for sharing large collections of photographs, and they usually provide the necessary tools for organizing and managing photos and albums. However, gallery applications are less suitable for maintaining photo blogs and working with text-based content. A publishing platform like *WordPress* is flexible and powerful enough to serve a variety of purposes and, with the right plug-ins, tweaks and customizations, can be used for anything from a photo blog to a full-blown photographic portfolio. But turning a *WordPress* installation into a customized photographic solution requires time and effort, and often involves additional costs.

Koken (koken.me) provides an alternative to both solutions. This content management system (CMS) is built for photographers and is designed for easy installation and maintenance. *Koken*'s developers went to great lengths to make the application as easy to use as possible and, as a result, the program has a truly gentle learning curve. This is important, as not all photographers have the technical knowledge, the will or the time to deal with installing, configuring, customizing and maintaining a self-hosted photo publishing application. When it comes to managing content, *Koken* offers dedicated tools for working with photos and text, so the application is equally suitable for publishing photos, articles or mixed-content pages. Better still, the *Publish Services* plug-in can be used to integrate *Koken* with Adobe *Lightroom*.

Installing Koken

First of all, make sure that your server or web hosting solution has the required software installed. Being a web-based application, *Koken* relies on the Apache web server (with PHP) and the MySQL database server. The application also requires the *ImageMagick* or *GD* image processing library to be installed on the server and to manage videos, it requires *FFmpeg*. Most web hosting providers offer plans that include the required software, but, if you run your own server, you will have to learn how to install *Apache*, *MySQL* and *ImageMagick*. There are plenty of tutorials on the web that can help you with the details. Before you install *Koken*, you also need to create a separate MySQL database for use with the application.

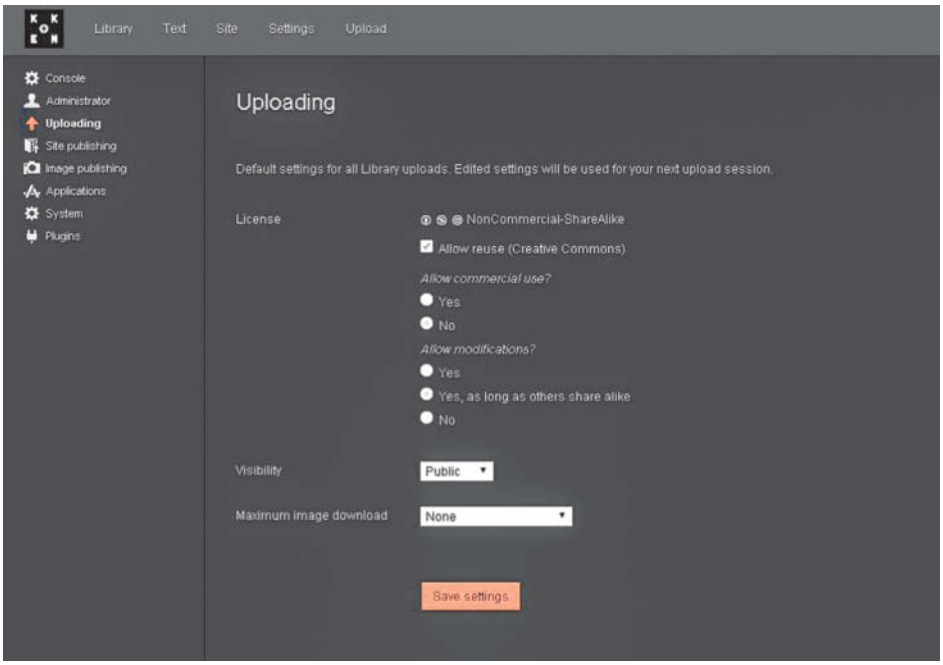
Next, download the installer package from the project website, unpack the downloaded archive and move the *Koken* folder from the resulting installer directory to the server, and point your browser to http://yourserver/koken, replacing 'yourserver' with your own server's IP address or domain name. This automatically kicks off the installer script which guides you through the entire process. Once installed, *Koken* drops you into the administration section of the application. Provide the e-mail address and password specified during installation and click the 'Sign In' button to log into the *Koken* administration interface.

Getting Started

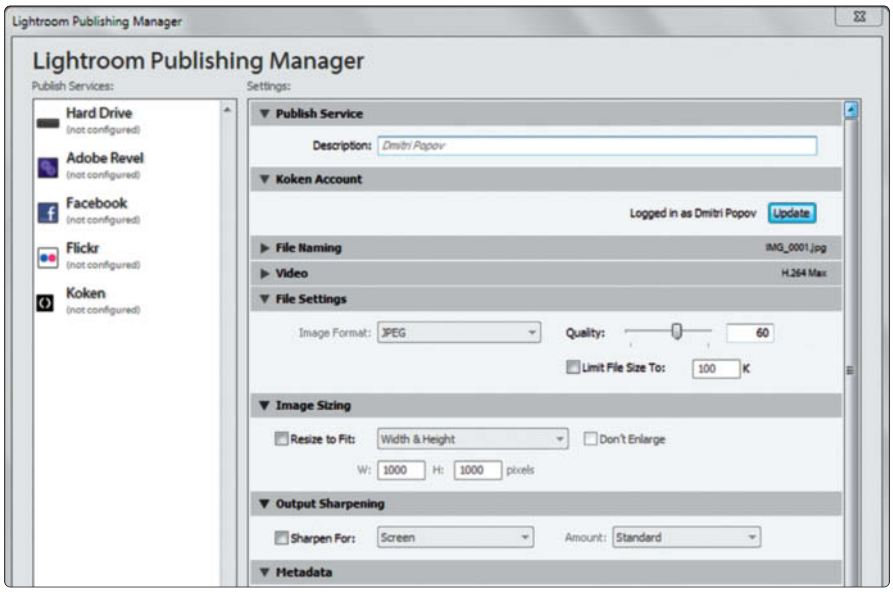
Once *Koken* is up and running, you need to populate it with photos. To do this, you can either publish photos directly from *Lightroom* using the dedicated plug-in described above or add them using the program's own upload tools. To do the latter, you can either drag and drop photos into the main program window or use the 'Choose photos and videos' button. Once you have added your photos, specify their visibility in the status bar at the top of the window and click the 'Start upload' button. When the upload operation has been completed, *Koken* automatically switches to the 'Last upload' library where you can edit the properties of the uploaded media.

Organizing Content

The Library section is split into three columns. The left-hand sidebar contains a list of all predefined libraries. The 'All content' and 'Last upload' entries display all and recently uploaded photos respectively, while the 'Favorites' library shows photos tagged as such. Photos added to the 'Featured content' library are automatically displayed on the main page of your *Koken* site as a slideshow. If you want to display albums rather than individual photos on the main page, add the appropriate albums to the 'Featured albums'



The Settings section handles basics like enabling the Creative Commons license, specifying a site's title and tagline, and configuring image publishing options



The *Lightroom Publish Service* plug-in acts as a link between *Lightroom* and *Koken*, enabling you to upload photos directly from the *Lightroom* interface

library. The 'Quick collection' library acts as a temporary container where you can store photos due for editing or other tasks. Adding photos to any of these libraries is a simple matter of selecting them and dragging them to the target library. In addition to its predefined libraries, the Library sidebar contains the Date Captured section, which filters photos by year and month, and the Collections section, which lists public and unlisted albums and sets. The working area in the center of the Library window is used to view and manage photos in the currently selected library. The toolbar at the top of the working area contains Edit, Sort, Filter and Share menus.

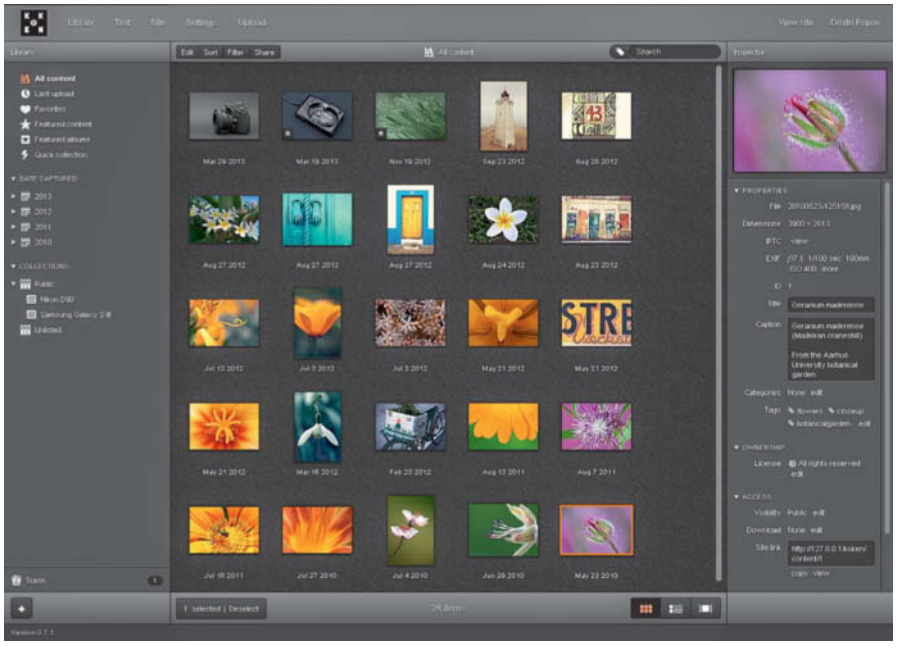
The Inspector sidebar on the right lets you edit the properties of the currently selected photo. *Koken* automatically imports Exif metadata during upload, so the basic data, title, description and tag fields will usually already contain imported information.

Koken enables you to organize photos into albums which can then be grouped into sets. To create an album, click the 'plus' button at the bottom of the Library sidebar. In the 'Create new collection' dialog that appears, select the collection type (i.e., Album or Set), give the album a title and provide a description. Assign tags and categories if necessary and click the 'Create collection' button. By default, the new album's visibility is set to Unlisted, but you can change that by selecting the album in the 'Unlisted collection' library and changing the album's visibility status to Public.

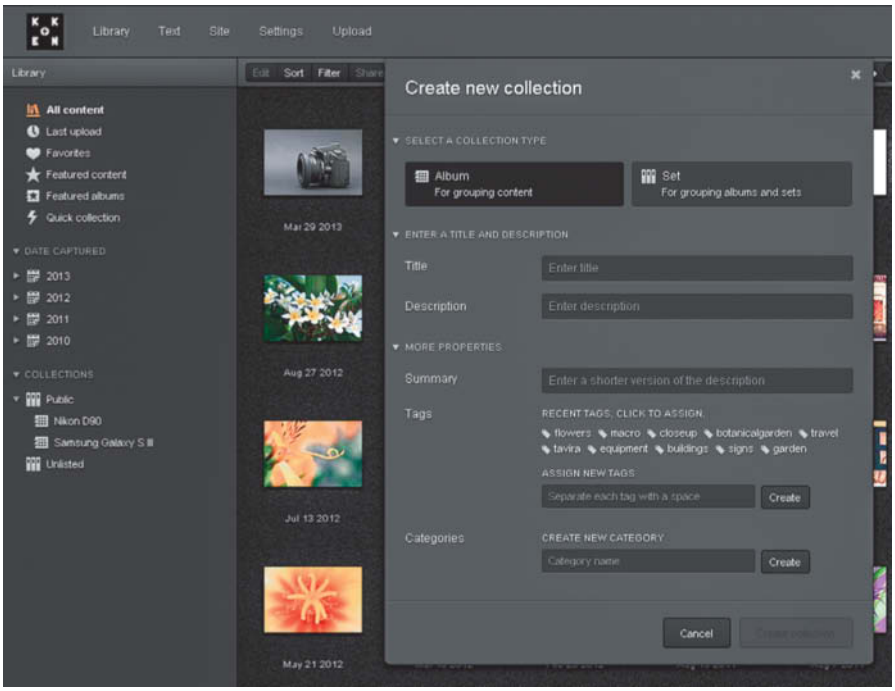
While the Library section is designed for organizing, managing and publishing photos and albums, the Text section is used to create and edit text-based content. *Koken* can handle two basic types of content called Essays and Pages. The Essays format is perfect for publishing news, articles, tutorials and the like, while Pages are better suited to publishing custom static content such as introductions, contact information, client lists, etc.

To create a new Essay or Page, click the 'plus' button at the bottom of the Text sidebar, select the desired type, give the new item a title and click 'Create'. You can then start editing right away in the writing area. All text formatting features are available via a context menu.

To insert a photo or video into the currently opened Essay or Page, click Enter, click on the new paragraph that appears and select the appropriate item from the context menu. You can embed individual photos or videos from the *Koken* libraries, insert entire albums as slideshows or upload new items directly from other locations on your local machine.



***Koken* features a user-friendly interface that provides quick access to all the necessary site-building tools. The Library section is used to manage photos, and contains several predefined libraries as well as sorting, filtering and search tools. The Inspector sidebar can be used to edit the properties of photos stored in the library.**



***Koken* lets you organize photos into Albums and Sets. Public Albums can be embedded in a site as slideshows.**

The Site section is used to edit and preview a site prior to publishing. This section features Themes, Draft and Live views, and you can switch between them using the buttons at the bottom of the main window. The Themes view allows you to preview all the installed themes and pick the one you wish to use for your site.

To customize a site, switch to the Draft view. Here, you can preview the site as well as edit its basic settings. The Site sidebar contains a list of editable items organized into two groups called Primary (Albums, Content, and Essays) and Footer (Home and Albums).

To tweak the settings of the current theme, click the gear icon in the top right-hand corner of the main toolbar. This displays the floating Settings palette in which you can configure the theme style, the site title appearance, typography and colors.

Strengths and Weaknesses

When it comes to sharing photos and maintaining a photography-focused website, there are plenty of site-building options, ranging from third-party services like SmugMug, 500px, WordPress.com and Flickr, to self-hosted applications such as *Gallery*, *Piwigo*, *Zenphoto*, and *WordPress*.

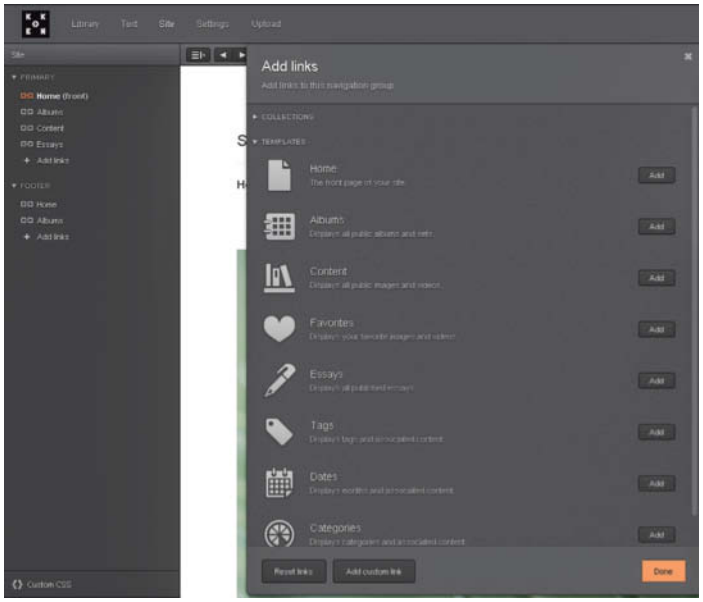
So what makes *Koken* stand out from the crowd? Most importantly, it combines features and tools for publishing photos and text-based content. The program allows you to showcase individual photos and albums, while the tools available in the Text section make it easy to write, manage and publish text-based content with integrated photos and slideshows. This feature alone makes *Koken* preferable to a pure gallery-type application. Its advanced functionality is packaged in a user-friendly interface that makes it easy for photographers to get to grips with the application.

However, *Koken* does have some limitations. It is a strictly single-user application and, although its default functionality can be extended using plug-ins, there are not a great many modules to choose from. The same is also true for themes, and there are only handful available.

If you are looking for a more powerful and customizable solution that can handle multiple users, *WordPress* may be a better choice. Additionally, *Koken* is not designed as a medium for selling photos and prints, making services like SmugMug and 500px better for monetizing your photography skills. However, if you want to set up a sleek personal site to showcase your photos and publish articles with a minimum of effort, *Koken* is hard to beat.

Author's Note

Please note that this article covers *Koken*'s key tools, and any new features that may be included in versions published after our press deadline are not essential to the program's core functionality. The program is under active development, so by the time you read this article, it is sure to have expanded to include some new functions and tools. (sea) c't



In the Site section, you can modify the default navigation links and add custom links to your site. *Koken* offers various templates for use with custom links.

Sascha Steinhoff

Faster Image Processing with Hardware Acceleration

Editing digital images can be frustrating, especially when your hardware can't keep up with the effects you are applying. But never fear, hardware acceleration is here to help. We tested the effectiveness of a wide range of graphics cards and onboard graphics chipsets and checked how well applications use the available resources. The results are sometimes quite surprising, and some applications squeeze better performance out of an office-grade graphics card than others can ever get out of high-end hardware.

In this article

Graphics processors (GPUs) are usually capable of performing tasks normally performed by a computer's CPU, using a process called General Purpose Computation on Graphics Processing Unit (GPGPU). *Firefox*, *Chrome*, various operating systems and some file compression tools use GPGPU functionality, and even Microsoft's *Office* suite uses graphics power to perform some functions. This approach takes the pressure off the CPU and can make a system run appreciably faster.

In the world of 2D image processing, retouching, applying filters and converting images from one format to another all take time and require a lot of computing power. For example, the *Photoshop* Liquify filter can take several minutes to apply, even if your system runs on an up-to-the-minute i7 processor. Generally, you can expect added GPU processing power to produce smoother filter applications and accelerate file conversion processes. We tested graphics cards from all price segments in a range of real-world situations and analyzed which software is the best to use to speed up the daily photo workflow.

Prerequisites

Today's powerful graphics cards use only a tiny fraction of their processing power in normal everyday use (i.e., when you are not running games or 3D applications), so it is a logical step to harness all that unused power for other processes.

However, because graphics cards can only deploy their full power under certain conditions, using an additional GPU doesn't guarantee faster computing. To benefit from this kind of acceleration, an application has to support parallel processing, which splits a task

Image: Sapphire

High-end gaming graphics cards like the Radeon HD 7970 (about US$400) require active cooling and a dedicated power supply. The difference using a GPU like this makes to 2D image processing does not justify the price differential between it and a US$80 card.

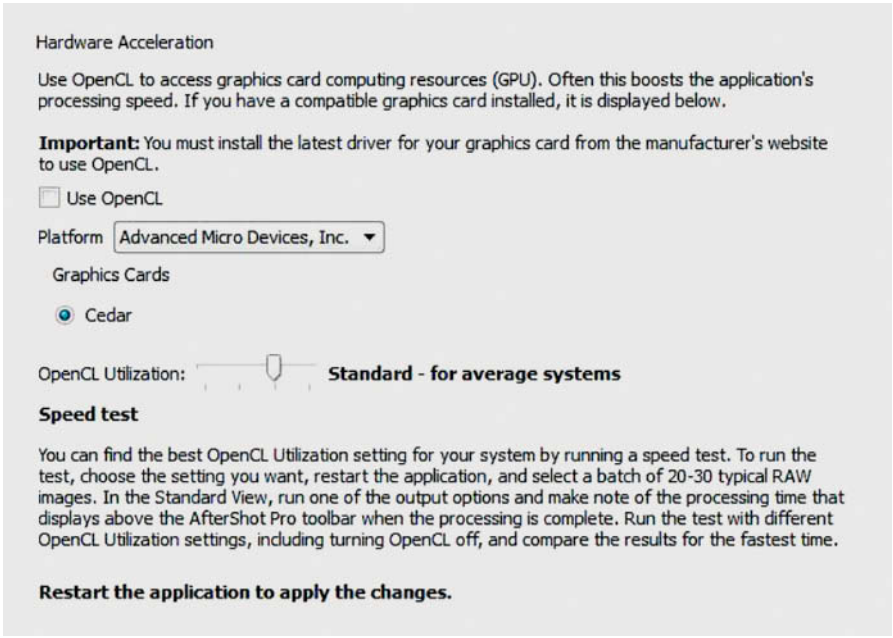
such as a *Photoshop* filter into a batch of smaller sub-tasks. If it can process these sub-tasks simultaneously, a graphics card is often faster than a CPU, whereas the CPU is usually faster when dealing with tasks that have to be processed sequentially.

If, for example, you monitor a system's CPU and GPU performance when it is performing an accelerated *Photoshop* action, you will find that the process continually switches between the two processors while allocating resources. A graphics card can only realize its full potential if it is used in conjunction with a sufficiently powerful CPU. Sub-par CPUs are well known for their ability to slow down even the best graphics cards.

GPU acceleration is a complex process that is tricky to program, and can cause a drop in performance or even system crashes, which is why most applications that use hardware acceleration have an option for switching it off. Windows itself has no such option, so you will have to look in your application's preferences for the appropriate settings.

An application's programming interfaces (APIs) are an important factor in the success of hardware acceleration processes, so all components in the process have to be capable of communicating with one another. Because of this, the trend is finally swinging toward open standards following an era in which Adobe, for example, used the proprietary NVIDIA **CUDA** (Compute Unified Device Architecture) architecture in all versions of *Photoshop* between CS2 and CS5. CS6 uses the new Mercury Graphics Engine (MGE), signaling the end of CUDA usage in the Adobe camp. Many programmers are now switching to the **OpenGL** (Open Graphics Library) and – more recently – the **OpenCL** (Open Computing Language) interfaces, both of which are manufacturer independent.

OpenGL is a rendering API, while OpenCL is a framework for writing executable programs. Both can be used to accelerate image processing. If you want (or have) to use CUDA, you need a graphics card with an NVIDIA chipset, while OpenCL and OpenGL both work with AMD and Intel graphics chips. Together, these three manufacturers have the mass market for graphics cards pretty much sewn up.



Some programs (the illustration shows Corel *AfterShot Pro*) allow you to configure hardware acceleration in the preferences dialog, although the option to adjust the level of OpenCL support is rare

OpenGL – a Proven Multi-talent

Since its introduction with CS4, OpenGL has provided *Photoshop* users with ultra-smooth zooming no matter how large a file may be. All graphics cards support OpenGL in one form or another and GPU manufacturers always provide OpenGL drivers with their products. However, it is still worth taking a

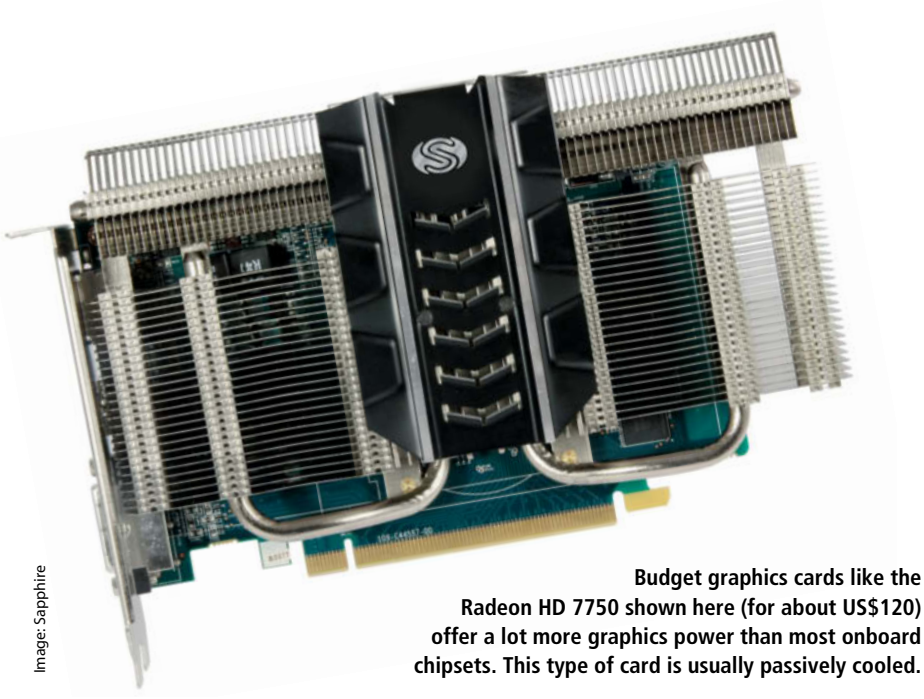


Image: Sapphire

Budget graphics cards like the Radeon HD 7750 shown here (for about US$120) offer a lot more graphics power than most onboard chipsets. This type of card is usually passively cooled.

look at the OpenGL version supported by a particular product. Intel especially has a reputation for delivering outdated versions with its onboard graphics chipsets and also makes it quite difficult to find the exact specifications of its graphics solutions. Generally, updating the drivers makes it possible to use current versions of OpenGL, but you have to rely on your card's manufacturer providing appropriate software.

OpenGL is a highly underestimated image processing API that is often overshadowed by the powerful media presence enjoyed by OpenCL. *Photoshop CS6* and *Musemage* include many more filters based on OpenGL than on OpenCL. In fact, only the HDR function in *Musaemage* is based on OpenCL. And don't allow yourself to be deceived by the low-grade OpenGL system requirements listed by Adobe for *Photoshop CS6*. Contemporary OpenGL-based filters such as Liquify, Adaptive Wide Angle and Oil Paint only work adequately with a powerful graphics card, especially if applied to large image files.

OpenCL – The Young Upstart

OpenCL is an open, platform-independent standard originally developed by Apple, although its further development is now overseen by Khronos (www.khronos.org), a non-profit industry consortium.

OpenCL was introduced in 2009 and, in spite of its relatively poor market penetration on an application level, is part of several programs that are of interest to photographers. The latest versions of Corel *AfterShot Pro* and Phase One's *Capture One* use OpenCL to accelerate RAW conversion processes.

Current hardware is still not fully OpenCL-compatible. For example, the onboard graphics in Intel's Sandy Bridge chipsets don't support OpenCL, making it impossible to run an OpenCL benchmark in GPU mode. Because this is, in fact, an artificial restriction built into the Intel driver, you can work around it by installing an AMD driver, which then gives the Sandy Bridge graphics chip access to the AMD driver's API, even if there is no AMD graphics card installed. However, this trick is not a practical solution for everyday use, and the OpenCL benchmark values delivered by a Sandy Bridge GPU with an AMD driver are terrible. The Intel Ivy Bridge chipsets introduced in 2012 finally supported Open CL 'officially'.

NVIDIA does not give the public any indication of the level of OpenCL support it offers and, at the time of writing, its website didn't offer any usable specifications. We cannot see any reason for such concealment tactics, especially when you consider that the NVIDIA drivers actually include OpenCL support anyway. Perhaps the company is concerned that OpenCL will soon supersede its proprietary CUDA API. Publishing specifications would certainly be a more customer-friendly approach, and Intel at least provides some minimal information on its website. NVIDIA's behavior is particularly inexplicable in light of the fact that it pioneered the development of OpenCL standards together with Apple, AMD, IBM and Intel.

The *Photoshop* Liquify filter is great for adapting the shapes of subjects to fit your own personal ideals. It takes just a few clicks to produce a willowy *Photoshop* beauty.

In contrast, AMD offers good OpenCL support in all its products and documents both its OpenGL and OpenCL support online. Following its disastrous attempted adoption of the proprietary Stream standard (the main opposition to CUDA), AMD is more or less obliged to stick to open standards now and in the future. Nevertheless, even open standards can be implemented in more or less advantageous ways, depending on each manufacturer's particular market policies.

AMD and the Promotion of Open Standards

AMD will have to stimulate and promote graphics acceleration technology if it wants to continue to compete successfully with Intel. It has had its work cut out since the introduction of the Sandy Bridge chipsets, although it is still (but only just) market leader in the field of integrated GPUs. The more general interest these can generate for applications that rely on hardware acceleration, the better it will be for AMD. This is especially true for mobile devices with onboard GPUs, such as the Radeon HD 7660D 'Trinity' series. When used with applications that are designed to make the most of this particular architecture, the more powerful graphics these chipsets provide can easily make up for their less powerful main processors. AMD's considerable efforts to persuade programmers to adopt this approach have included an offer of direct financial support to the programmer responsible for implementing the OpenCL-accelerated GEGL filters in GIMP. Amongst our test candidates (see opposite), Musemage and Corel are known to cooperate closely with AMD.

NVIDIA products do not officially support OpenCL. The online specifications for the high-end GTX 680 graphics card don't mention OpenCL support, even though it is included in the product.

Specifications

Note: The below specifications represent this GPU as incorporated into NVIDIA's reference graphics card design. Graphics card specifications may vary by Add-in-card manufacturer. Please refer to the Add-in-card manufacturers' website for actual shipping specifications.

GTX 680 GPU Engine Specs:	
CUDA Cores	1536
Base Clock (MHz)	1006
Boost Clock (MHz)	1058
Texture Fill Rate (billion/sec)	128.8
GTX 680 Memory Specs:	
Memory Speed	6.0 Gbps
Standard Memory Config	2048MB
Memory Interface Width	256-bit GDDR5
Memory Bandwidth (GB/sec)	192.2
GTX 680 Support:	
OpenGL	4.2
Bus Support	PCI Express 3.0*
Certified for Windows 7	Yes
Supported Technologies[1]	3D Vision, 3D Vision Surround, CUDA, DirectX 11, PhysX, SLI, TXAA, Adaptive VSync, GPU Boost, FXAA
SLI Options[2]	3-way
Display Support:	
Multi Monitor	4 displays
Maximum Digital Resolution*	2560x1600
Maximum VGA Resolution	2048x1536
HDCP	Yes
HDMI[3]	Yes
Standard Display Connectors	One Dual Link DVI-I, One Dual Link DVI-D, One HDMI, One DisplayPort
Audio Input for HDMI	Internal
GTX 680 Graphics Card Dimensions:	
Length	10.0 inches
Height	4.376 inches
Width	Dual-slot
Thermal and Power Specs:	
Maximum GPU Tempurature (in C)	98 C
Maximum Graphics Card Power (W)	195 W
Minimum System Power Requirement (W)[5]	550 W
Supplementary Power Connectors	Two 6-pin

We were unable to establish whether this kind of sponsorship directly affects the performance of the competition, although we did note that the NVIDIA GeForce GTX 680 (the most expensive of our test candidates) was one of the poorer performers in most categories. The slightly cheaper AMD Radeon HD 7970 generally produced better results and, on average, AMD products mostly performed better than NVIDIA products in the lower price categories too. It is difficult to determine whether these results are due to NVIDIA's negative attitude to open standards or AMD's targeted application sponsorship. At the end of the day, customers base their decisions on the performance that a product delivers in real-world situations, and that is precisely what we set out to test.

Image: NVIDIA

The NVIDIA GeForce GTX 680 was the best looking and most expensive graphics card in our test, but rarely produced the best benchmark values

How We Tested

It is simply impossible to test every single combination of hard- and software, so we restricted ourselves to three onboard GPUs, eight graphics cards and five software packages.

Our test system was based on a fast quad-core i7-2600K processor. With their fast main processor and middling onboard graphics, Sandy Bridge systems are prime candidates for a graphics card upgrade. We also lined up a dual-core i3-2120 system and one with the i7-3770K successor to the i7-2600K, which represents the current pinnacle of the Intel desktop CPU range. In accordance with Intel's 'tick-tock' product strategy, the newer Ivy Bridge processors have only a few percentage points of additional base computing power.

Onboard GPUs

For this test, the performance of the integrated GPUs was of much more interest than pure CPU power ratings. The i3-2120's Intel HD Graphics 2000 is the less powerful of the two onboard chipsets, while the HD Graphics 3000 unit built into the i7-2600K is the top of the previous-generation range of GPUs. Neither supports OpenCL. The i7-3770K has built-in HD Graphics 4000 with OpenCL support and is the best desktop graphics solution currently on offer from Intel.

Graphics Cards

Despite recent advances in onboard graphics power, a dedicated graphics card is still the best choice for top-notch visuals. We tested AMD and NVIDIA devices in a range from US$40-550 (see the box below). These cover the entire spectrum, from a simple office-grade card right up to a high-end gaming monster. The chipsets that these cards are based on can also be found under other labels such as Gigabyte, Sapphire and Asus, often with slightly different memory specifications, clock speeds and other features, but still from the same factory as the ones we tested. Whatever other components are built around it, the graphics chip itself is still the cornerstone of all visual performance.

Applicability of Test Results to Other Platforms

Intel remains the undisputed market leader for desktop processors, while AMD has cemented its place as king of the budget computer market. We combined an Intel Core i7 CPU with the NVIDIA GTX680 and the AMD HD 7970 to see just how good GPGPU can be when the CPU and the GPU have power to spare. All our tests were performed in a 64-bit Windows 8 environment.

Most home computers are not as well equipped as this, which is why we also tested the dual-core i3-2120 as a comparison. The results produced by this system are equally applicable to mobile computers in which mid-range CPUs are combined with better-than-average graphics – an AMD specialty. In all cases, in spite of their lack of CPU power, the AMD onboard GPUs (whether in laptop or desktop configuration) generally provided better performance than their Intel rivals.

Test Software

PhaseOne Capture One Pro 7	US$299
Corel AfterShot Pro	US$100
Gimp 2.8	Free
Photoshop CS6	US$700
Musemage 1.9.5	US$50

Synthetic Benchmarks for OpenGL and OpenCL

We used synthetic benchmarks to test the potential software-independent performance of each piece of kit in pure graphics mode. **Luxmark** determines the OpenCL performance of the CPU, the GPU or combinations of both, while **Furmark** measures OpenGL performance. Our image processing test involved combined CPU and GPU performance, so the results can deviate from the benchmarks. In several cases, overall performance was poor because the CPUs couldn't provide the GPUs with data at a sufficient rate.

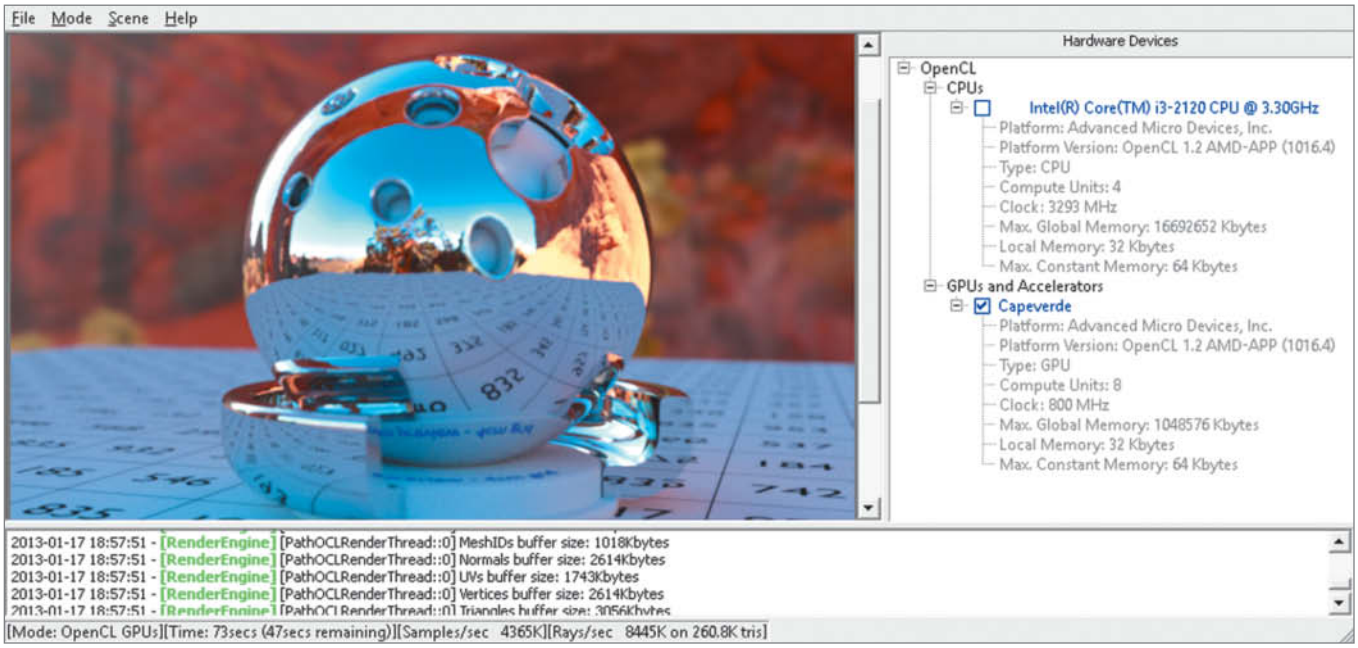
Image Processing Test with GPU Acceleration

While the range of current image processing software packages that explicitly take advantage of hardware acceleration is fairly narrow, it does include most types of

OUR TEST SYSTEMS

GPU	Price (approx.)	CPU	GPU Clock Speed	Memory Speed	Bus Width	Driver Version	OpenGL Version	OpenCL Version
Intel HD Graphics 2000	Onboard	Intel i3-2120	nd	nd	nd	15.28.8.64.2875	OpenGL 3.1	–
AMD Radeon HD 7750	US$115	Intel i3-2120	nd	nd	nd	12.10	OpenGL 4.2	OpenCL 1.2
Intel HD Graphics 3000	Onboard	Intel i7-2600K	850 MHz (1350 MHz)	667 MHz	128-bit	9.17.10.2875	OpenGL 3.1	–
AMD Radeon HD 6450	US$45	Intel i7-2600K	625 MHz	800 MHz	64-bit	12.10	OpenGL 4.1	OpenCL 1.1
NVIDIA GeForce 210	US$40	Intel i7-2600K	589 MHz (Shader 1402 MHz)	400 MHz	64-bit	306.97	OpenGL 3.1	–
AMD Radeon HD 7750	US$115	Intel i7-2600K	800 MHz	1125 MHz	128-bit	12.10	OpenGL 4.2	OpenCL 1.2
NVIDIA GeForce GTX 650 Ti	US$175	Intel i7-2600K	928 MHz	1350 MHz	128-bit	306.97	OpenGL 4.3	OpenCL 1.2
AMD Radeon HD 7870	US$295	Intel i7-2600K	1000 MHz	1200 MHz	256-bit	12.10	OpenGL 4.2	OpenCL 1.2
NVIDIA GeForce GTX 660	US$230	Intel i7-2600K	993 MHz	1502 MHz	192-bit	306.97	OpenGL 4.3	OpenCL 1.2
AMD Radeon HD 7970	US$490	Intel i7-2600K	1000 MHz	1375 MHz	384-bit	12.10	OpenGL 4.2	OpenCL 1.2
NVIDIA GeForce GTX 680	US$550	Intel i7-2600K	1006 MHz	1502 MHz	256-bit	306.97	OpenGL 4.3	OpenCL 1.2
Intel HD Graphics 4000	Onboard	Intel i7-3770K	nd	nd	nd	15.28.8.64.2875	OpenGL 4.0	OpenCL 1.1
AMD Radeon HD 7750	US$115	Intel i7-3770K	800 MHz	1125 MHz	128 Bit	12.10	OpenGL 4.2	OpenCL 1.2

– not applicable nd = no data available



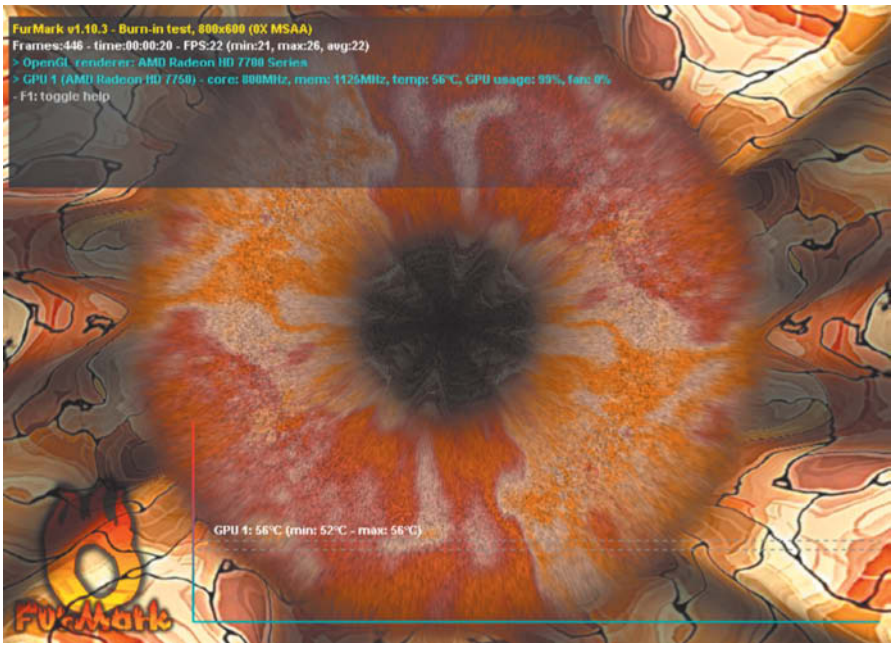
***Luxmark* is a free open source OpenCL benchmark that is great for determining synthetic OpenCL performance in GPUs, CPUs and combinations of both**

application, from RAW converters to traditional image editors. *Photoshop CS6* is one of these, although many of its features – including most filters – were not designed specifically with hardware acceleration in mind. *Adobe Camera Raw* (ACR) is not yet capable of benefiting from GPGPU.

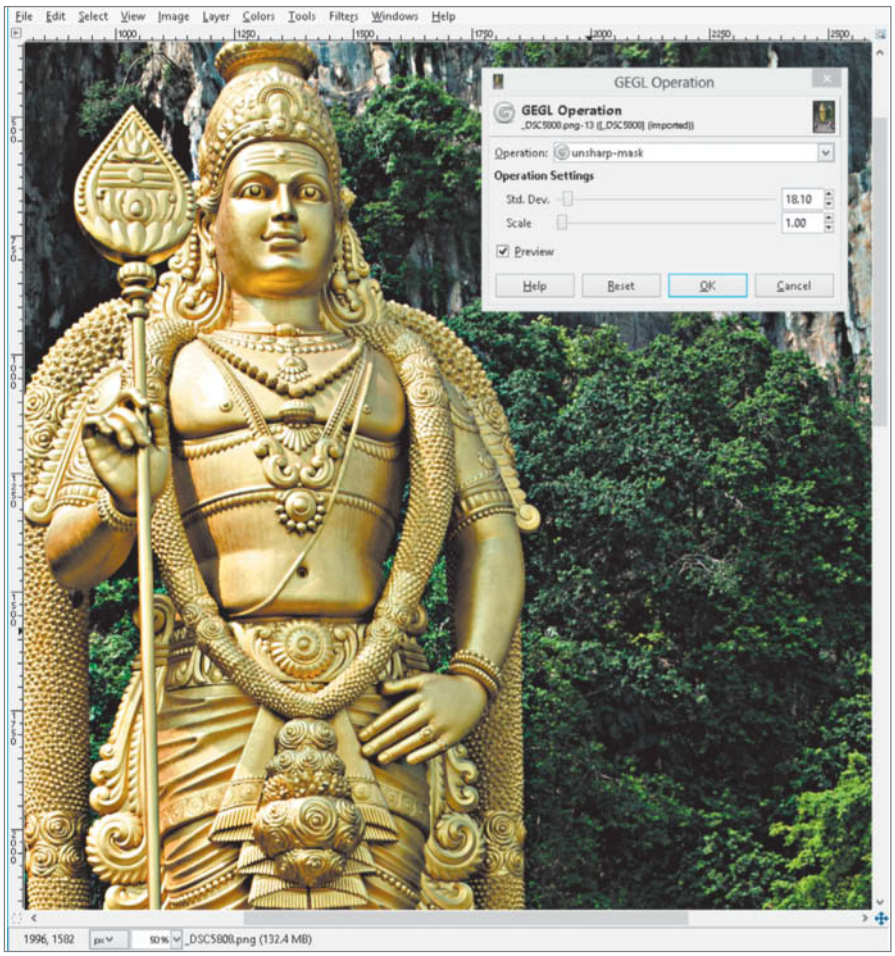
Adobe *Lightroom* does not support GPU-accelerated image processing at all and only uses OpenGL-based acceleration for video playback.

This means that a fast graphics card doesn't offer any benefits if you process your images using *Lightroom* or ACR. Other software manufacturers have scented a gap in the market and offer alternatives to Adobe's time-consuming non-accelerated RAW conversion process. Musemage, Corel and Phase One all offer products capable of accelerated processing. The Musemage programmers are in the happy position of being able to design their software to be GPU powered from the ground up and claim that all of their filters are GPU accelerated. Apart from the program's HDR functionality, which is based on OpenCL, all its filters run in OpenGL mode. Corel's *AfterShot Pro* and Phase One's *Capture One* both use GPGPU to shorten processing times. We converted a batch of 100 NEF RAW files to 8-bit TIFF to find out how well it works.

For our *Photoshop* filter test, we used a batch of uncompressed 140-megapixel 16-bit TIFF files that took up 800 megabytes of disk space. This enabled us to analyze performance precisely and mirrored the current trend toward huge image files. With cameras such as the 36-megapixel Nikon D800 becoming the norm, such enormous files are a realistic test basis, especially in the case of panorama images composed from multiple source files. Some of the filters we tested require so much processing power that we noticed obvious lag, even when processing relatively small (14-megapixel) images. They also proved that *Photoshop CS6* is still along way off providing true real-time processing.



***Furmark* is a synthetic 3D benchmark for OpenGL**



The OpenCL-accelerated GEGL filters have been added to GIMP 2.8.2 as an option. GIMP's developers are promising full GEGL integration in future versions of the program.

GIMP

The 2.8 release of GIMP, with its built-in GEGL filters, offers genuine GPGPU functionality. However, unlike the other programs we tested, GIMP's GPU acceleration is switched off by default. For example, if you want to apply an Unsharp Mask filter, you can choose between the familiar version from the Filters menu or a different version that includes an optional GEGL operation. But be warned: if your system has problems accessing the OpenCL interface, GEGL operations are extremely slow. To activate OpenCL, GIMP has to be started either using an environment variable or via the command line using the *GEGL_USE_OPENCL=yes* option. This non-user-friendly setup is sure to put many users off.

Right from the start, we had problems running GIMP on our test system. After a whole day's fruitless fiddling about, we decided to banish GIMP/GEGL entirely from our test field. The idea of integrating GEGL in GIMP is a good one, but is still at the experimental stage. The upcoming 2.10 version of GIMP will apparently be completely GEGL based, so we will just have to wait and see if it really comes up with the goods. In addition to GPU acceleration, the GEGL version is also said to support higher bit depths than GIMP's current standard 8-bit RGB mode.

The acceleration functionality built into *Capture One* really comes into its own when performing time-consuming tasks like batch RAW conversions

Test Results and Comments

The pure performance results we obtained from our AMD graphics cards using the Luxmark benchmark brought no real surprises. The measured values increase consistently according to each model's power and even the cheaper Radeon HD 7750 delivered better figures than any of the onboard GPUs we tested. As an example, the US$295 Radeon HD 7870 scored more than twice as many points as the US$115 HD 7750. Only the top-of-the-range HD 7970 failed to follow the same performance curve, producing a proportionally smaller increase in performance than the next model down the scale.

Compared with the AMD results, the *Luxmark* results we obtained from our NVIDIA test cards were almost laughable: the US$115 AMD card flatly beat even the US$550 GeForce GTX 680 on points. However, these results probably have a lot to do with the poor OpenCL driver provided by NVIDIA. The application benchmark tests tell a different story, with NVIDIA turning in much better performance. Unlike *Luxmark,* application benchmarks don't test GPUs fully loaded. The bottom line here is that synthetic benchmarks can be a useful tool but you have to know how to interpret the results they deliver.

In the case of our less powerful i3-2120 test system, the combined GPU/CPU test delivered worse results than the graphics processor on its own. This is because the CPU simply isn't powerful enough to provide the GPU with data at a sufficient rate. We observed the same phenomenon for the i7 processor when it was used with the faster Radeon HD 7850 and HD 7970 graphics cards. Both cards produce top-notch scores when used alone and slow down significantly when used together with the CPU. Logically enough, the same syndrome is not apparent using slower graphics cards with a more powerful CPU. The conclusion we can draw here, because only a fast CPU can deliver data rapidly enough, is that a powerful CPU is a prerequisite for fast GPU-based processing.

AMD and NVIDIA performed equally well in our *Furmark* OpenGL benchmark test, and even Intel's onboard HD Graphics 4000 produced relatively good results. Measured against a supposed usable minimum of 30 fps, the HD 4000 system is hopelessly overstretched by the synthetic benchmark test, producing just 5 fps. Under the same conditions, the AMD Radeon HD 7750 produced similar results. Generally speaking, you need to spend at least US$300 to get a card that can produce really smooth movement effects. Admittedly, this is not strictly relevant for most 2D image processing situations, but it does provide a useful yardstick when comparing the performance of various graphics systems.

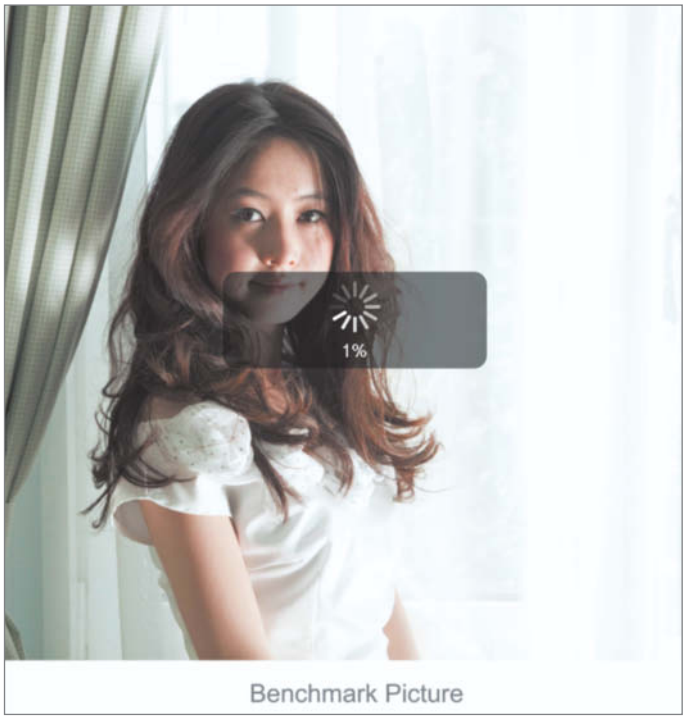
OpenGL Performance in Musemage and Photoshop

Musemage is the only program we tested that has its own built-in benchmark. To produce results, it applies a sequence of OpenGL-based filters to a test image, providing pure filter performance results – i.e., situations in which GPU acceleration makes good sense. In our tables, the less time the program takes to 'finish the course' the better. Faced with this test, the Intel HD Graphics 3000 GPU applies the filters one after another at a leisurely pace and finishes 83 seconds later. A graphics card added to the system works like a turbo charger – for example the Radeon HD 7970 finished the same task in just five seconds. In real-life situations, a dedicated graphics card should provide significantly better results when used with *Musemage*.

We tested *Photoshop*'s OpenGL performance using the Liquify, Adaptive Wide Angle and Oil Paint filters. Here too, we measured pure filter speed when applied to an open image.

The Liquify filter provided a surprise, performing best with the otherwise terribly slow NVIDIA GeForce 210, followed by the equally lethargic AMD Radeon HD 6450. In other words, the graphics cards were no faster than the onboard graphics. Using increasingly powerful graphics cards did not provide any discernible increase in performance for the Adaptive Wide Angle filter, and we achieved our best results at the bottom of the scale with the Radeon HD 7750 and the GeForce GTX 650. Our US$500+ gaming cards didn't improve things either. *Photoshop* obviously has difficulty allocating GPU and CPU resources and offers only limited graphics configuration options. OpenGL can be switched on or off.

The Oil Paint filter at least provided us with some kind of performance differential. With the onboard graphics, processing time was 66 seconds. The Radeon HD 7750 reduced that to 12 seconds and the Radeon HD 7970 was top of the heap at 9 seconds. In this case, the NVIDIA cards produced significantly poorer performance, with the cheapest AMD product squarely beating the most expensive from NVIDIA. Obviously, the real-world usefulness of OpenGL performance enhancement depends very much on the particular filter you are using. As ever, the exception proves the rule, and the Radeon HD 7750 appears to deliver the



The built-in benchmark in *Musemage* tests batch performance for OpenGL filters. Using a high-end graphics card significantly reduced the time required to apply filters.

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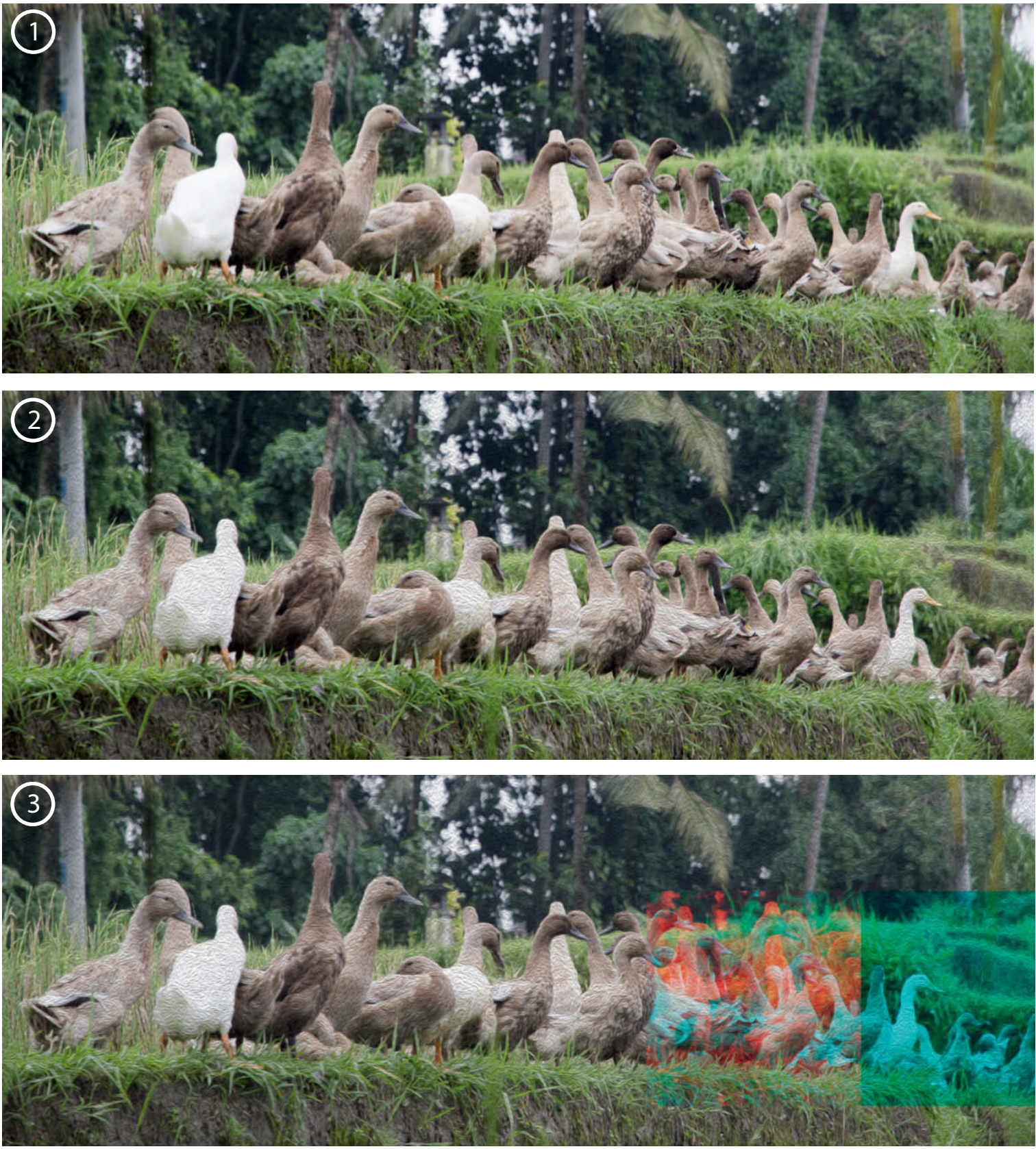


The *Photoshop* Oil Paint filter transforms standard digital images (1) into versions that, with a little imagination, look like oil paintings (2). Some of our test runs using the filter produced obvious processing artifacts (3).

best combination of value and measurably better performance.

Photoshop's OpenCL-based Filters

Photoshop's resource allocation works much better with its OpenCL filters. We performed our tests using the Field Blur, Iris Blur and Tilt-Shift filters. In this portion of the test, the most expensive AMD and NVIDIA cards occupied the top spots, and this was the only discipline in which the GeForce GTX 680 was able to win out twice in a row. Even the GeForce GTX 660 beat the HD 7870 with a processing time of 27 seconds. The conclusion here is: if you switch from Intel HD Graphics 3000 to a Radeon HD 7750, you will achieve a worthwhile blur filter performance increase. Field Blur was more than three times as fast (27 seconds instead of 91). Used to apply Iris Blur and Tilt-Shift effects, HD Graphics 4000 kept up well with the Radeon HD 7750, and Field Blur was the only filter to be discernibly accelerated by a dedicated graphics card.

RAW Conversion with AfterShot Pro and Capture One

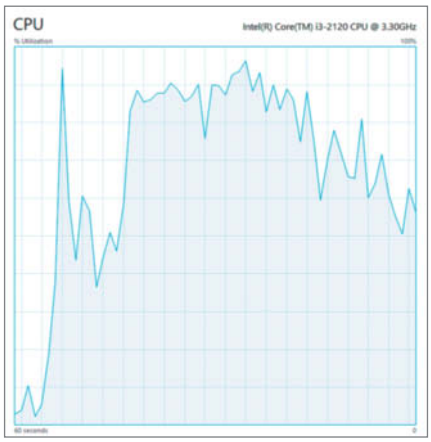
Converting large numbers of RAW files takes a lot of time, even if you use a powerful system. For example, on our i7-2600K system, *Lightroom* took 192 seconds to convert 100 16.2-megapixel NEF files (shot using a Nikon D7000) to 8-bit TIFF. Corel's *AfterShot Pro* is based on the defunct *Bibble*, which never won any prizes for functionality but was the fastest RAW converter on the market during its lifetime. Corel has continued to develop the program and has further improved its already speedy OpenCL-based RAW conversion functionality. Hardware acceleration can be set to one of four levels in the program's preferences. Unless you adjust the setting manually, it is automatically set to an average value that works with most systems.

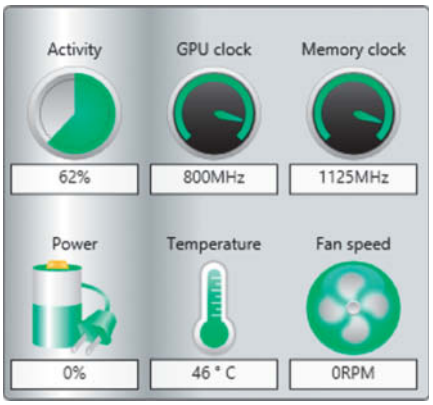
AfterShot Pro uses CPU and GPU capacity extremely efficiently when performing OpenCL-assisted RAW conversions. It was the fastest of our test programs.

The default value worked well with most of our test setups, and manual adjustments didn't produce any noticeable improvements. It failed only with the cheapest cards, so we had to fiddle about a bit to find the best setting.

AfterShot Pro is faster than *Lightroom*, even on our HD Graphics 3000 system, taking just 58 seconds to perform our test conversion. Using a HD 7750 reduces that to 30 seconds – i.e., a third of a second per image. The Corel software is close to becoming a genuine real-time RAW converter, although using it with ever-more-expensive cards doesn't produce any further increase in performance. All of our high-end AMD cards took exactly 30 seconds to perform the task. The NVIDIA results were generally not quite as good, but still acceptable across the board.

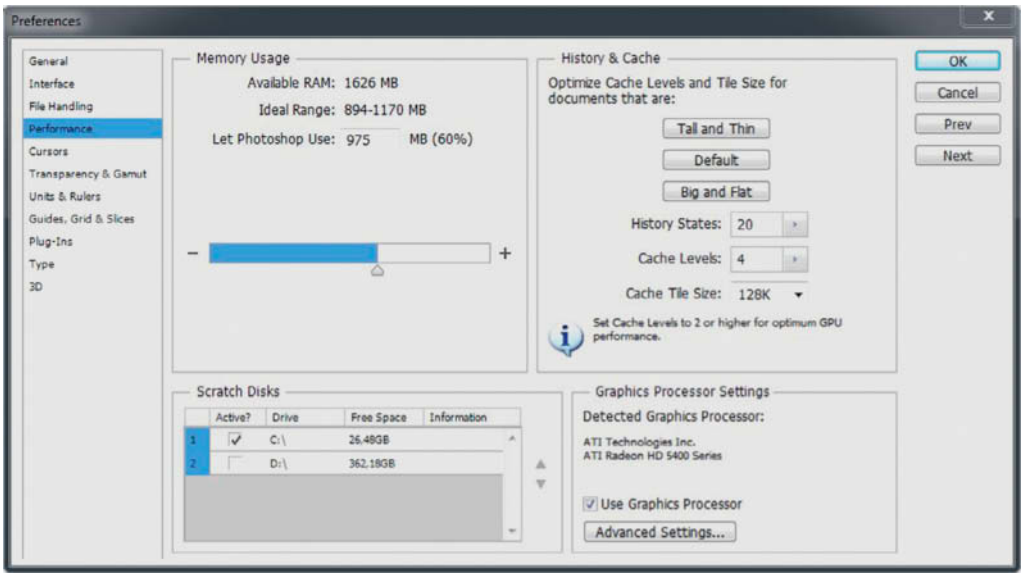
Capture One behaves in a more linear fashion, upping its performance as the graphics card become more powerful. Conversion nevertheless took longer than it did with *AfterShot Pro*, whichever hardware we used. *Capture One*'s results ranged from 523 seconds using the onboard HD Graphics 3000 to 134 seconds using the Radeon HD 7970. The mid-range GeForce GTX 650Ti clocked 216 seconds and the Radeon HD 7750 turned in a performance of 207 seconds. Here too, the NVIDIA products lagged slightly behind their AMD counterparts.





Conclusions

Our tests showed that even the fastest CPUs only deliver satisfactory GPGPU performance if coupled with suitably powerful graphics hardware. This is especially true of less



Photoshop's preferences offer various graphics processor configuration options. It makes sense to deactivate OpenCL if you want to troubleshoot a non-functioning process.

powerful solutions such as the HD Graphics 2000 and 3000 units built into Sandy Bridge systems. Not even the most powerful onboard graphics can even compete with cheaper graphics cards such as the Radeon HD 7750. But note that really cheap graphics cards for US$50 or less are simply a waste of money and rarely perform as well as most onboard GPUs.

The difference in performance between US$100 and US$300 cards is immense when measured using synthetic benchmarks, but is hardly worth mentioning in real-world application-based situations. The Radeon HD 7970 (for US$490) came out top in our tests, but only rarely beat the cheaper HD 7750 on real performance. The 7750's asking price of around US$115 is a worthwhile investment that can be amortized in no time if you earn your living processing images. In 2D processing situations, spending more is rarely worth it.

Our slower i3-based system often slowed down the GPUs we tested, but an upgrade is nevertheless worth considering. The cheaper combination of an i3 CPU and a Radeon HD 7750 was usually faster than the i7-3770K system with its onboard HD Graphics 4000.

If you are looking to purchase a computer specifically for image processing purposes, you don't necessarily need to go for the most powerful CPU on offer. A mid-range CPU with a low- to mid-range graphics card (starting at US$100) costs the same as a top-notch CPU with onboard graphics and delivers better performance for GPU-accelerated applications.

The endless duel between AMD and NVIDIA produced a clear winner in our particular scenario (see the results listed in the tables below). Whether you are looking for the best possible performance or simply the best value for money, AMD takes the 2D image processing prize in nearly all categories.

If you are considering a laptop, a Mac Mini or some other all-in-one computer that is not designed with hardware upgrades in mind, you will have to make sure that the model you are looking at has sufficient built-in graphics power before making a purchase. The right combination of CPU and GPU power is the key to successful, hitch-free image processing.

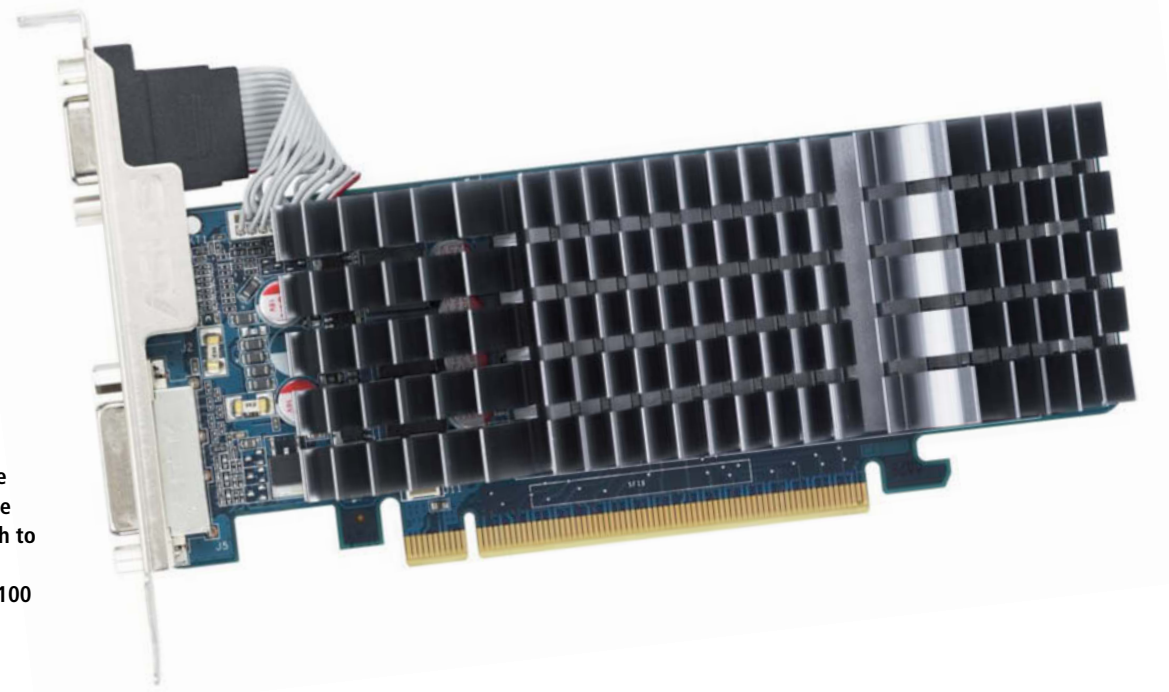
Hardware acceleration is not a standard feature in most image processing software, although our test shows that it is an aspect of software design that has serious potential. If you want to get the most out of *Photoshop*, getting hold of a mid-range or high-end graphics card is still the best route to take. Although this approach only accelerates the performance of a limited number of filters, the difference is still considerable. Corel *AfterShot Pro* converts RAW files extremely quickly, and Phase One's *Capture One* benefits enormously from its use of acceleration technology. On the open source side of the coin, GIMP has a lot of catching up to do. (jr)

GRAPHICS HARDWARE PERFORMANCE TEST – REAL-LIFE BENCHMARKS

		OpenGL			
		Musemage Benchmark		Adobe Photoshop CS6	
GPU	**CPU**	**Points scored** better ▶	**Required time** (seconds) ◀ better	**Liquify** 140-megapixel file (seconds) ◀ better	**Adaptive Wide Angle** 35-megapixel file (seconds) ◀ better
Intel HD Graphics 2000	Intel i3-2120	738	135	115	69
AMD Radeon HD 7750	Intel i3-2120	9143	11	95	50
Intel HD Graphics 3000	Intel i7-2600K	1195	83	109	72
AMD Radeon HD 6450	Intel i7-2600K	1738	57	73	60
NVIDIA GeForce 210	Intel i7-2600K	1015	98	47	75
AMD Radeon HD 7750	Intel i7-2600K	9435	10	93	57
NVIDIA GeForce GTX 650 Ti	Intel i7-2600K	9090	11	101	70
AMD Radeon HD 7870	Intel i7-2600K	18716	5	94	58
NVIDIA GeForce GTX 660	Intel i7-2600K	9770	8	106	70
AMD Radeon HD 7970	Intel i7-2600K	19872	5	90	57
NVIDIA GeForce GTX 680	Intel i7-2600K	12674	7	102	70
Intel HD Graphics 4000	Intel i7-3770K	2003	49	99	64
AMD Radeon HD 7750	Intel i7-3770K	9248	10	93	46

GRAPHICS HARDWARE PERFORMANCE TEST – SYNTHETIC BENCHMARKS

		Luxmark / OpenCL	
GPU	**CPU**	**LuxBall HDR CPU only** (262 Triangles, Default) better ▶	**LuxBall HDR GPU only** (262 Triangles, Default) better ▶
Intel HD Graphics 2000	Intel i3-2120	1335	–
AMD Radeon HD 7750	Intel i3-2120	1330	4339
7Intel HD Graphics 3000	Intel i7-2600K	2256	–
AMD Radeon HD 6450	Intel i7-2600K	3728	693
NVIDIA GeForce 210	Intel i7-2600K	2256	180
AMD Radeon HD 7750	Intel i7-2600K	3728	4260
NVIDIA GeForce GTX 650 Ti	Intel i7-2600K	2256	1747
AMD Radeon HD 7870	Intel i7-2600K	3728	9786
NVIDIA GeForce GTX 660	Intel i7-2600K	2256	2666
AMD Radeon HD 7970	Intel i7-2600K	3728	13229
NVIDIA GeForce GTX 680	Intel i7-2600K	2256	3984
Intel HD Graphics 4000	Intel i7-3770K	2414	1951
AMD Radeon HD 7750	Intel i7-3770K	3839	4228



Low-end graphics cards like this Asus EN210 (US$35) are simply not powerful enough to perform GPGPU tasks. You have to spend at least US$100 to get an appreciable performance boost.

	OpenCL					
	Adobe Photoshop CS6				Corel AfterShot Pro	PhaseOne Capture One
Oil Paint 140-megapixel file (seconds) ◀better	**Field Blur** 140-megapixel file (seconds) ◀better	**Iris Blur** 140-megapixel file (seconds) ◀better	**Tilt/Shift** 140-megapixel file (seconds) ◀better		**100 NEF files to 8-bit TIFF** (seconds) ◀better	**100 NEF files to 8-bit TIFF** (seconds) ◀better
109	89	65	49		117	809
12	38	44	40		40	223
66	91	66	50		58	523
41	93	67	50		44	525
100	90	65	50		53	533
12	27	33	29		30	207
12	24	29	24		37	216
11	27	34	30		30	150
18	24	29	24		35	170
9	28	27	27		30	134
17	22	28	23		33	156
40	39	30	25		50	530
11	22	29	23		28	206

	Luxmark / OpenGL	
LuxBall HDR CPU+GPU (262 Triangles, Default) better▶	**Benchmark Preset:1080** (1920 × 1080, AA off): Points better▶	**Benchmark Preset:1080** (1920 × 1080, AA off): FPS better▶
–	70	1
2521	529	8
–	164	2
4288	162	2
2196	74	1
7004	528	8
3774	1126	18
7314	1943	32
4680	1833	30
9805	3009	50
5954	2703	45
4027	314	5
7521	529	8

Book Reviews

Imperial Pomp

Frank Herfort
Published by Kerber
176 pages, 100 color photos
12.9 × 9.8 inches
Hard cover
US$48
ISBN 978-3-86678-798-8

Glitter and Glory

Imperial Pomp: Post-Soviet High-rise

Dreams of nationalist power and greatness belong to times long gone in most western countries, although some nations obviously have more trouble than others coming to terms with the past. Countries often have their own distinctive and enduring ideas concerning their own importance and the destiny that awaits them. To many Westerners, these concepts may be nothing more than harmless folklore, but they take on a whole new meaning in the hands of authoritarian regimes.

The photos of recent Russian architecture that Frank Herfort has collected for *Imperial Pomp* provoke just such conflicting feelings. The book showcases a selection of remarkable and sometimes bizarre buildings that convey extremely mixed messages about the direction that post-Soviet society is taking. It is certainly possible to imagine that some of these edifices could exist in western European cities, although probably not surrounded by rickety 19th-century wooden huts.

Such juxtaposition of the trappings of modern capitalism and the poverty of the past is a recurring theme in the book, but Herfort's clever choices of perspective and excellent technique ensure that the images offer more than just a simple photojournalistic statement.

Many of these images were captured using a large-format analog Cambo Wide that Herfort has been using with a digital back since 2011, and his accomplished photography is complemented by the high-quality printing and immaculate layout.

Three essays, contributed by photographer Matthias Schepp, architect Dmitrij Chmelnizki and the head of the Moscow Architectural Museum, Irina Korobina, round out the book. All three authors are scathingly critical of the brutality and arrogance of an architecture that is almost completely decoupled from the everyday life that surrounds it – a criticism that is just as relevant in other places too.

The hunger for power evident in many of these images all too clearly reflects the situation in today's autocratically led Russia and also holds a mirror to many similar buildings that exist beyond its borders.

Often standing alone with no real relation to their surroundings, the buildings in Frank Herfort's images are little more than randomly located foreign bodies

Image: Frank Herfort, 2013 (Kerber)

Old-school Art

Stern Portfolio: Yousuf Karsh

Much is constantly being written about the winds of change, and the enormous speed at which our lifestyles and attitudes are changing provides infinite additional reasons to do so. Sometimes though, very few words are required to make one or other central aspect of these complex cataclysms tangible.

This latest *Stern Portfolio* is dedicated to the work of the portrait photographer Yousuf Karsh and demonstrates particularly clearly just how much some basic social and artistic mores have changed in the past few decades.

Karsh was born in 1908 in Armenia and emigrated to Canada in 1925. During his career, he photographed many of the most famous and powerful personalities of his time, and many of his photos have long been seen as icons of an age – the famous shot of Winston Churchill without his cigar and the three-quarter portrait of Audrey Hepburn that graces the cover of this book are just two examples.

Some of the strengths of these images are obvious from the first moment you set eyes on them. The photographer's use of a large-format plate camera and his mastery of lighting technique give these images a depth of detail and a sense of three-dimensionality that is difficult to beat even today. In places, tiny details appear to almost leap off the page.

Besides his masterful technique, the real strength of Karsh's work lies in the way he handles his subjects. Rather than 'dissecting' them, he instead gives them an unusual amount of freedom to express themselves.

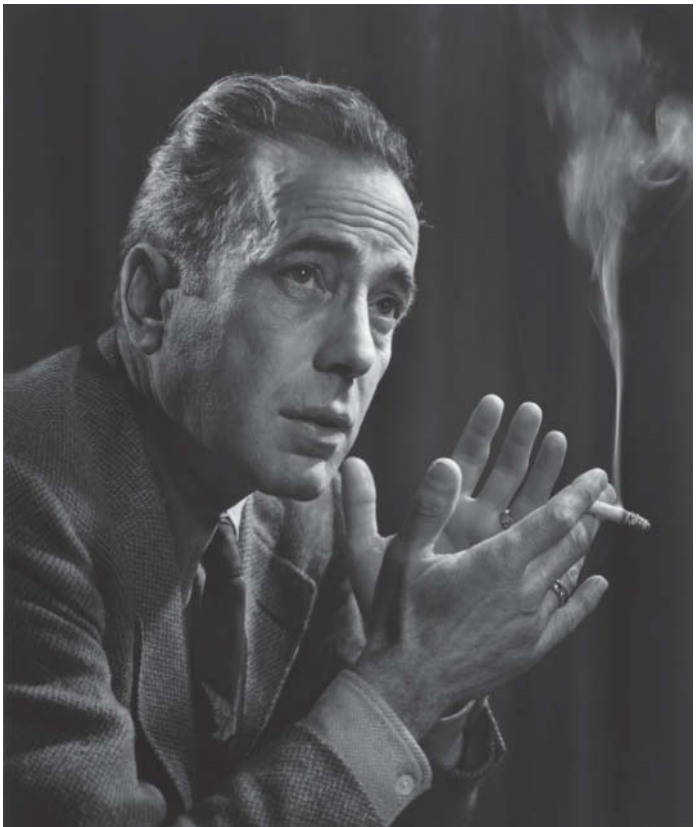
In contrast to the way today's celebrities are routinely taken apart in public, Karsh allowed his sitters to retain their dignity and appear to the viewer almost as a kind of ideal or archetype.

This is where one of the central dilemmas of our time becomes particularly manifest. In any open-minded society, it is essential to question and challenge the motives of the famous and powerful. The problem here is that everyone is fallible, and our investigations often lead to disorientation.

Karsh's photos may be anachronistic, but the sheer power and inspiration they radiate has lost none of its significance or meaning, even in this day and age. (Robert Seetzen/tho)

Stern Portfolio: Yousuf Karsh

Yousuf Karsh
Published by Stern Portfolios
176 pages, 67 monochrome and 7 color photos
10.6 × 14.2 inches
Hard cover
US$45
ISBN 978-3-652-00155-7



Yousuf Karsh combines top-class technique with an intelligent and sympathetic view of his subjects

Image: Yousuf Karsh, 2013 (Stern)

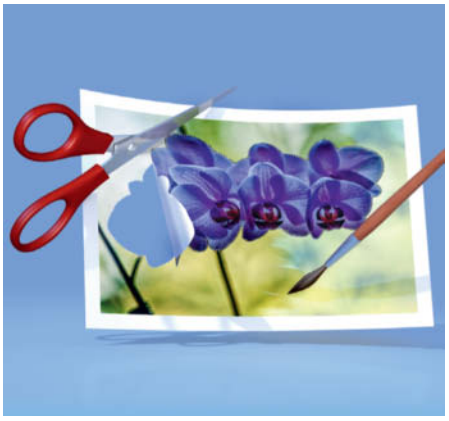
Coming up in Issue 14

Lens Test

Most DSLR and system cameras come with a kit lens that most users quickly outgrow. Most photographers' technical requirements grow with increasing experience, and acquiring a higher-quality or more capable lens is the next logical step. This in-depth test compares a range of replacement standard zooms and provides useful tips on how to choose your next lens.

GIMP 2.8 Workshop

Since Adobe announced its intention to sell its high-end image processing tools as part of an exclusively cloud-based rental model, many photographers have intensified their search for alternative software. The open source GIMP package is under constant development and offers a comprehensive suite of image processing tools combined with simple handling. This workshop gives the you the know-how you need to get productive with the latest version of the program.



Portrait Photography

Whether of celebrities or family members, effective portraits are some of the hardest photos to shoot. The real challenge in portrait photography lies in capturing an image that accurately reflects the subject's character, and the key to success lies in choosing the right combination of background, lighting and pose and then releasing the shutter at just the right moment. This workshop tells you all about how to shoot your own top-notch 'people pictures'.

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Issue 13

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DVD Production: Klaus Ditze, Nicole Tiemann

Published by

Heise Zeitschriften Verlag GmbH & Co. KG
P.O. Box 61 04 07, 30604 Hannover
Germany

In cooperation with

Rocky Nook, Inc.
802 East Cota St., 3rd Floor
Santa Barbara, CA 93103
U.S.A.

Publishers: Christian Heise, Ansgar Heise, Christian Persson
Managing Directors: Ansgar Heise, Dr. Alfons Schraeder
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Retail Sales outside of the U.S. and Canada
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Putzbrunner Str. 71
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Subscription Service: For orders and all other issues please contact CTDCS@magserv.com

Subscription Price (one year/two years)

USA	US$49.95/US$94.90	Australia	US$40.95/US$77.50
Canada	US$49.95/US$94.90	New Zealand	US$44.95/US$84.10
UK	US$41.95/US$78.90	Other	US$52.95/US$99.60

Delivery is free worldwide.

Suggested Retail Price (single issue):

UK	£7.99	Australia	AU$12.99
USA	US$14.99	New Zealand	NZ$16.90
Canada	CAN$14.99		

Printed in Germany
by Dierichs Druck + Media GmbH & Co. KG, Kassel

Distributed in the USA and Canada by CMG,
155 Village Blvd., 3rd Floor, Princeton, NJ 08540

Distributed outside of the U.S.A. and Canada
by COMAG Specialist, Tavistock Road, West Drayton, Middlesex UB7 7QE, UK

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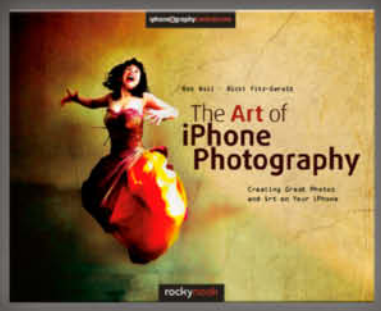

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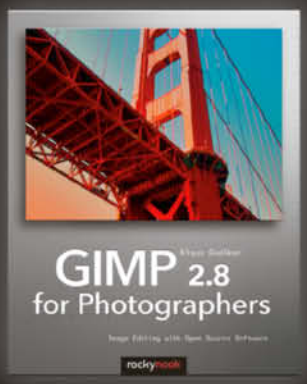

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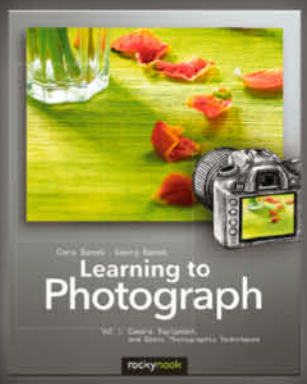

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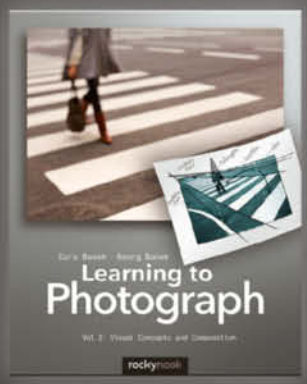

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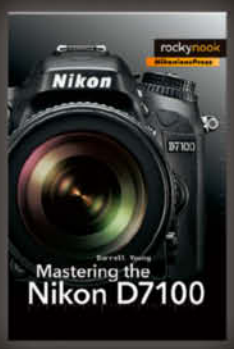

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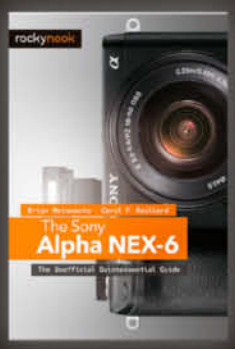

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