PC & TECH AUTHORITY

26 DRIVES TESTED
SSD, HDD BUYER'S GUIDE

NEW NVIDIA GTX 960
MID-RANGE MUSCLE
TOP CARDS TESTED

WINDOWS ANNOYANCES
SOLVED!

Infuriating quirks be gone!
Top tips from a Microsoft insider

REVIEWS

LENOVO CARBON X1, ASUS
PB279Q & MX27AQ MONITORS,
RASPBERRY PI 2, ASUS Z97-A
USB3.1, AUDIO TECHNICA ATH-
ADG1, GIGABYTE FORCE H1,
WINDOWS 10 AND MORE!

HOW TO:

· CONVERT A
SPREADSHEET
TO A DATABASE

· VIDEO EDITING
WITH CYBERLINK

AUSTRALIA TAX
SPECIAL REPORT

SAMSUNG GEAR VR REVIEWED
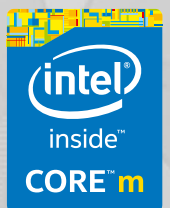### VR HITS THE MAINSTREAM

WIN-WIN

Nice move, Microsoft

So Windows 10 will be free. Sure, there are token restrictions on eligibility and the validity period, but for almost all corners of the PC world it's a free gift. This was mooted by a few bloggers through the second half of 2014, but it all seemed so unlikely, despite the logic behind such a suggestion. I would very much like to think that Microsoft CEO Satya Nadella was instrumental in this decision – which as CEO of course he was – but think back to the Ballmer era and it all seems all the more remarkable. Ballmer would make all the big calls, while what we hear of Nadella is a levelling of management, a breaking down of the separated cells of power within the company, and an agreed common goal to promote all relevant software and hardware within the company to be interlinked with Windows.

There's no denying that Windows 8 has been a disaster for the desktop PC. Uptake in the enterprise sector is abysmal – even factoring in its traditionally slow move to a new OS. Sure, it's nice on tablets, and yes absolutely it was a brave move to turf the aging icons on a desktop environment.

But it was all too much. When you have an operating system that confounds even advanced users, including IT professionals who struggle for many long minutes to figure out how to perform the most basic tasks, as I have witnessed, and experienced – then it's a disaster. When PC users are snubbed in favour of tablet users, throwing away decades of (relative) goodwill, and forcing them to unnecessarily learn an all new way of doing things, which they reject en masse, then it's a disaster.

When your company ignored the rise of the two most important developments in computing – and some would say society – in the last 30 years, being the internet and mobile computing, and has to claw its way back from a miserable single digit percentage of the user base (for mobile), or resort to tactics that earned it record-breaking antitrust fines (for Internet Explorer) – and then with Windows 8 tells all desktop and laptop users they're less important than tablet users via the heavily biased Windows 8, then it's a disaster for all of us.

It is stunningly impressive that Microsoft did the right thing, making a decision that puts us first. By refocussing on the desktop environment, by including a function in the installer that optimises it for that particular platform, and by giving it away... well, Microsoft will win, too, because that's what happens when such a remarkable act of customer-first awareness takes place.

We've got a hands-on look at Windows 10 on page 38, and for Windows 8/8.1 and most previous versions, there's a tweak guide (our cover story) starting on page 24 to help you get by in the meantime.

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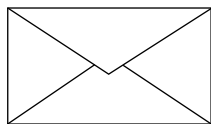
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INBOX
Readers write

LETTER OF THE MONTH
THE RURAL PIPE DREAM
I note with interest the comments in the March 2015 editorial regarding the redundancy of the cover DVD on the basis that "everyone just downloads what they need online". It's a wonderfully urban centric view but if you live outside of the metropolitan areas, it's not now, nor will likely ever be the case.

We enjoy limited internet speeds which enable web browsing and email. Much more than that is beyond the capabilities of the technology that the only provider in the area, Telstra, has chosen to provide. The idea of online gaming or downloading a movie is a dream that will likely never be realised for us as we just don't have enough people to justify the infrastructure provision and while we'd love capital city high speed broadband, we also know that realistically, we'll never see it in our lifetimes.

So, for those of us that live beyond the boundaries of the capital cities, please feel free to keep the cover DVD. There aren't alternatives for many of us. Thanks.
Charles de Joux

Ben Mansill replies: *It's always sad to be reminded that many Aussies must still endure sub-par internet service, but we're glad to hear you're getting good use from the DVD, Charles.*
Let's not forget that the DVD also has several full registered versions of good apps each month, which everyone benefits from.

THE GREAT WINDOWS 10 HOPE
Hearing the rumours about Windows 10 as a first time builder, I was exciting and I thought that if Windows 10 was good, not to different from Windows 7 with a start menu and a few extra bells and whistles that it would be a good buy.

I am really excited about the multiple desktops strategy and the 'an OS across all devices' goal. Since Windows Vista and 8, if the muck-up windows 10 it would be a disaster and Microsoft lovers would start using OS X (!).

Microsoft were lucky that Vista only lasted a short time . If Microsoft merged Windows 7 and 8.1 that to make windows 10 that would be great. I hope Windows 10 isn't too expensive.
Tobias Hall, age 11

Ben Mansill replies: *It's always very cool to get a letter from one of our younger readers.*

RETURN OF THE DVD SLIP
Towards the end of last year you stopped providing a cutout of a cover for the DVD. In order to not have to mutilate the mag

I would photo copy and then cut out the photo copy for the DVD's case, as I found being able to view the contents without having to go to the mag was much quicker for finding the information I required.
John Baldwin

Ben Mansill replies: *Thanks John, don't know how we let the slip slip, it has now returned!*

THANKS DAVE!
I just thought that I would let you know how much I appreciate your mag. It is always filled with great info and ideas to keep up with the latest technology and fads.

I especially enjoy the info that is contained in the Techdesk and the Mark Williams sections.
It's a good quality mag. Many thanks and keep up the good work.
Dave

CRAP BE GONE!
Just wanted to thank you for the tips on how to delete Crapware.

And what a simple and great name to describe this on going PC hassle.
It was great to read that if I get rid of stuff my PC will still boot up. That was a relief.

So I tried it and now i don't have to have an long afternoon tea break before my PC is ready to go. Bye Crapware and thank you.
Mitchell Hall

SOUND'S EXPENSIVE
Reading your magazine on a recent – interminable- plane trip I reached the article headline "the most important upgrade of 2015 could be to your ears". It caught my eye.

The article was about streaming music but made me think of another tech issue which undoubtedly will eventually be of interest to your readers, blasting their ears through their earphones with music or gaming noise; hearing aids.

Forgotten in the world of tech analysis, these objects are as necessary to many Australians as their mobile phone, five times as expensive as the most expensive phablet, twice the price of the equivalent item sold offshore in the US or UK, and if you need two of them, think nothing of forking out $10k.

Yes it's a rip off, of course, but so many of us are ashamed of our hearing loss that it is not until one's partner or kids say "for goodness sake take a hearing test" that you enter into the world of this rip off.

It is inconceivable that your testing equipment can't be adapted to giving the multinationals the once over.

Please; after all smart cigarette lighters are not as nearly important!
Peter Dowding

LOTM WINNER
This month's comment of the month will receive a SanDisk iXpand Flash Drive (our review is on page 51).
www.sandisk.com

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EMAIL: inbox@pcand techauthority.com.au Please limit letters to 200 words, where possible. Letters may be edited for style and to a more suitable length.

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TECH NEWS

The latest trends and products in the world of technology

24 WINDOWS ANNOYANCES SOLVED

WTop tweaking tips from one of Microsoft's MVP gurus, for Win 7 and 8

61 SSD, HDD and hybrid drives

The Labs team hits the data this month, rounding up 26 drives and testing for performance. We also look at the best value

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REGULARS

TECH NEWS

The latest trends and products in the world of technology

WINDOWS 10: A FRESH START FOR
EXISTING CUSTOMERS – AND IT'S FREE

Microsoft has unveiled its OS, which includes a new browser and a virtual-reality headset. Perhaps most significant, however, is the company's move to rolling updates. **Nicole Kobie** *takes a closer look*

Microsoft has revealed more details of Windows 10, including the Spartan browser and the HoloLens headset (see opposite).

Windows 10 will be a free upgrade for users of Windows 7 and 8 – news that may cheer those unhappy with Windows 8. But will the changes and new features (see p38 for our preview) be enough to convince customers to stick with Windows?

FRESH START

At a press conference at the end of January, Microsoft confirmed that, during its first year of release, Windows 10 will be free for those upgrading from Windows 7, 8 or 8.1 – but not Vista. Plus, the updates will keep coming. "This is more than a one-time upgrade: once a Windows device is upgraded to Windows 10, we will continue to keep it current for its supported lifetime – at no cost," executive vice president of operating systems Terry Myerson announced. "The experience will evolve and get better over time. We'll deliver new features when they're ready, not waiting for the next major release. And just like any internet service, the idea of asking 'What version are you on?' will cease to make sense."

This confirmed Microsoft's intention to move to rolling updates, a switch that "makes sense in today's consumer-device

> **"***The native browser in Windows 10 will not be Internet Explorer, but rather a new one, Project Spartan***"**

world," according to IDC analyst Al Gillen. The idea may not appeal to enterprises, but Myerson promised to "continue to support the way many of them work today".

A number of the features in Windows 10 are already well known. However, Microsoft showed off one upgrade that is sure to please: the Start menu features a scrolling area for Live Tiles, with the option to expand to full-screen to suit tablet-style hardware. Put simply: "It's much, much improved on what we had before," said Gillen.

THIS IS SPARTAN

The native browser in Windows 10 will no longer be Internet Explorer, but rather a new one codenamed Project Spartan. Sporting a cleaner look and a new rendering engine, Spartan features some intriguing new tools. On touchscreen devices, you'll be able to take notes with a stylus on top of web pages and save them to OneDrive. Microsoft's voice assistant Cortana will integrate with the new browser, too.

But this doesn't spell the end of Internet Explorer. "For some users … there will be good justification for using either Spartan or IE, and, in rare cases, both products," said Gillen.

WINNING BACK CUSTOMERS

Microsoft has work to do to regain goodwill, but Gillen is "encouraged" by the firm's approach. Aside from smart headwear and big-screen devices, Microsoft also showed Lumia phones running Windows 10.

"Challenges will come in the mobile arena," noted Forrester analyst Frank Gillett. "The new OS will provide an unprecedented ability to make apps that work on PCs, tablets and smartphones with a single application development effort. However, Windows 10 doesn't show enough potential for a differentiated mobile experience that will draw both developers and consumers away from iOS and Android."

FOUR STORIES NOT TO MISS

1 OFFICE 2016 TO ARRIVE IN 2015
Alongside its Windows announcements, Microsoft said Office 2016 will arrive in the second half of this year. The firm said it will be the "experience you're long familiar with" and will work best with a mouse and keyboard. Meanwhile, "universal" Office apps for touch and mobile are also being prepared for general release later this year, and will be available in upcoming versions of the Windows 10 technical preview.

2 GOOGLE STOPS GLASS SALES
Google has stopped selling its augmented-reality headset Glass. It said it wasn't the end of the technology, with future versions to be launched "when they're ready". The glasses hit the US market in 2013, with controversy almost immediately ensuing over the forward facing camera and privacy concerns spreading quickly.

3 SILK ROAD TRIAL STARTS IN US
The trial of the alleged mastermind of the Silk Road has started in the US, with Ross Ulbricht accused of running the dark-web site that became infamous for selling drugs and cybercrime services. Ulbricht maintains his innocence claiming that, although he developed the website, he'd passed it over to new owners before illegal activity began.

4 MICROSOFT AND GOOGLE DUKE IT OUT OVER BUGS
Google researchers uncovered a bug in Windows 8.1 and gave Microsoft 90 days to fix it before going public – and then released the details just before the company patched it, raising accusations of irresponsible disclosure. Google said the deadline was in place to maintain pressure on firms to patch, while Microsoft said it was merely "gotcha" tactics that ultimately hurt customers.

INTERNET OF THINGS:
DREAM OR REALITY?

*The tech industry is rushing headlong into a world full of connected "things". **Tim Danton** attempts to separate the smart thinking from the hype at CES 2015*

Sometimes tech companies have brilliant ideas, produce perfect products, and still can't convince consumers to buy them. Back in 2010, CES pushed 3D TVs as the next big thing. Trouble is, no-one bought them.

This year, the monstrous Vegas technology show was full of the Internet of Things (IoT) – but will firms be able to convince consumers to connect every aspect of their lives?

Make no mistake, tech companies' vision of the future is that nigh-on everything will be connected. At Samsung's CES keynote, co-CEO Boo-Keun Yoon claimed that 90% of the company's products would be able to connect to the internet by 2017. And that includes fridges and washing machines.

"In the five-year view, it's about a connected experience," Charlene Marini, vice president of marketing for ARM's embedded devices, told us at CES. "That is, the increasing merger of our physical and digital worlds – that's what we see IoT as being about. Our ability to understand context from the physical world – such as temperature, motion, humidity – and also to be able to control our physical world to some extent."

THE HUB OF THE HOME
The key to all this connectivity is the so-called hub, a box of some description that will sit in your home and, like the puppet master, control all those connected devices: the heating, your fridge, your security systems and so on. Samsung likes this idea so much it bought home-automation specialists SmartThings back in August 2014.

Broadcom, which specialises in system-on-a-chip solutions, was meanwhile pushing a vision of set-top boxes as the hub at CES. That has a logic to it: after all, your set-top box is connected to your internal network and your broadband, and offers a payment system through your service provider. It also offers a handy display. "When you're ready to retire in the evening, you might want to see what's going on in your house," said Stephen Palm, senior technical director at Broadcom. "We have the [wireless protocol] ZigBee in the set-top box, so you could design a whole new security system with ZigBee motion detectors and sensors like that."

Home security may well be the first industry to quickly see a shift from the traditional model: why pay a separate monthly fee for a service that can be handled by your ISP as part of the bundle? "In the US, people are paying $30 per month for these services – it basically dials out if there's an alarm and it has someone call the police," said Palm. "They're charging $300 per year to do that. The video-service providers could certainly provide that service through their broadband connection, and a much nicer user interface, and connect to video cameras." When you factor in support for presence through NFC and Bluetooth in people's phones, it's a smarter solution than today's dumb on/off security alarms.

Such a setup seems a far more compelling argument for connected homes than a smart fridge that tells you to buy some eggs.

"There are applications that make sense, and ones that don't make sense," said Marini. "If we're talking about consumers, psychology has a lot to do with it, culture has a lot to do with it, so there are going to be things that just don't work. This can't be a push. It has to be something consumers want."

HOT...
OR NOT

AMD RADEON 280X
It's faster in many games that Nvidia's all-new GTX 960 card, and can be found for a few dollars less, too. Usually the parry between AMD and Nvidia sees each one leapfrog the other with a new product release, but it appears AMD has held the high ground this time around in the all-important battle of entry-level/mid-range graphics cards.

NOT

USB 3.1
Yes, in a couple of years you'll probably find USB 3.1 up there in the Hot box when things are right with the new plug, but for today, after our initial testing of the supposedly revolutionary new connectivity standard, performance is a startling 40 percent lower than what was promised. Stay tuned, though, this story is far from over.

WHAT IS... HOLOLENS?

Microsoft surprised everyone by revealing the new HoloLens headset only days after Google announced that it was to stop making Glass. The timing couldn't have been better, especially with awareness of Augmented Reality on the up – but what exactly is HoloLens?

Is this Microsoft's version of Google Glass?
Not quite. As one analyst cheerfully pointed out to us, the only real similarity between the two is that both are worn on your head. Glass overlays a small box of information into your vision, whereas HoloLens projects entire 3D objects into the real world, allowing you to play Minecraft on your coffee table or follow maintenance instructions overlaid on a problematic appliance.

What's more, you can interact with these 3D virtual models via gestures and voice commands – and via Windows Holographic, Microsoft's interface for the virtual world.

Does this mean Windows is going holographic?
We have enough trouble with touch spreadsheets – imagine spreadsheets projected anywhere! Windows Holographic will project controls for you to work with – think of a miniature Start menu hovering in the air in front of you, from which you can tap to start up Netflix or Spartan. Rather than popping up phone notifications like Glass, HoloLens wants to give you access to your entire PC.
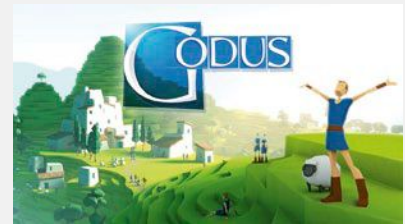
GAMING NEWS

The hot game news and opinion with **Daniel Wilks**

Asteroids: Outpost
ANNOUNCED

Atari has revealed that it will be releasing a 'reimagined' version of the classic arcade game, Asteroids to be developed Salty Games, a new LA-based studio reportedly made up of industry veterans with substantial AAA development experience. Billed as something of a homage to the arcade game, Asteroids: Outpost doesn't focus on a small vector graphics ship shooting down wave upon wave of space rocks but rather on an open world sandbox experience in which players explore and mine asteroids for resources that can be used to build better equipment and bases. In a nod to the original Asteroids, the game will also feature smaller asteroid showers as a constant threat to players and must be blasted from the sky.

Asteroids: Outpost will also focus on both cooperative and competitive multiplayer, with players forming alliances or battling other gamers for resources and territory. According to Fred Chesnais, CEO of Atari, "We're paying homage to the original Asteroids by incorporating classic features such as asteroid blasting capabilities, while introducing a completely new premise and gameplay. Asteroids: Outpost will appeal to both fans of the classic Asteroids as well as enthusiasts of immersive survival games and expansive MMOs."

MASS EFFECT 4 MULTIPLAYER REVEALED IN JOB LISTING

Thanks to a job listing tweeted by BioWare Senior Development Director, Chris Wynn it has been revealed that Mass Effect 4 will feature a strong multiplayer component. Amongst the key responsibilities for the newly created Online Producer position, "Create and champion the vision of the multi-player, connected experiences and online features of the game which respects the project leadership goals and be accountable for the quality targets and the results achieved" is paramount. The listing also states that Online Producer will also be responsible for providing and delivering context for the multiplayer component, hinting that it may be more thoroughly integrated into the overall story than the multiplayer in Mass Effect 3.

Little else is known about Mass Effect 4 at the moment aside from the fact that BioWare has stated that the game will be focussed on exploration and that the Mako, the all-terrain vehicle used for transport and exploration of planets in Mass Effect 1 and 2 will make a comeback.

SHADOWRUN: HONG KONG
BLASTS WELL PAST ITS
KICKSTARTER GOAL

Harebrained Schemes, the indie developer responsible for the commercially and critically successful Shadowrun Returns and Shadowrun: Dragonfall crowdfunded PC RPGs, recently took to the increasingly popular Kickstarter as a fund raising vehicle to raise money the next iteration of its successful franchise.

Initially asking for just $100,000 USD to complete the new game, Shadowrun: Hong Kong, the campaign blew through the goal in hours and fans continued to pledge money up until the campaign ended, eventually netting Harebrained Schemes $1.2 million USD in funding.

Through specifically stated stretch goals, Harebrained has promised a number of extra features will be included in the finished product, with two extra characters, animatics, enhanced player controls and a whole new five to six hour long mini-campaign being chief amongst those listed.

PETER MOLYNEUX UNDER ATTACK

Legendary game designer Peter Molyneux has come under fire from press and fans for delays and design decisions relating to his much hyped Kickstarter project, Godus. A spiritual successor to the developer's hugely influential and beloved 1989 god game, Populous, Godus received a little over $1 million AUD from the Kickstarter campaign, with an estimated delivery date of seven months. Molyneux also ran an enigmatic online competition named 'Curiosity', in which players tapped on a cube until someone eventually unlocked the centre.

Molyneux, known from making big promises, said that the winner of Curiosity would have their life changed as they would become the first 'God of Gods' in Godus and would receive a small percentage of game profits for as long as they held the position. The position of God of Gods, originally touted by Molyneux to potentially be for five to 10 years has been revised down to six months. The multiplayer and combat portions of the PC game, two elements essential for God of Gods haven't been implemented and Molyneux recently admitted in a scathing interview with Rock Paper Shotgun that he didn't ask for enough money to finish the project during the Kickstarter campaign. To add insult to injury, for the last two years, Bryan Henderson, the winner of Curiosity, has received little to no contact from Molyneux and Godus developer 22Cans, despite life changing promises.

CHIP NEWS

Mark Williams asks if Intel is planning Skylake to stab Broadwell-K in the back? Then sees why Nvidia is left red faced as it sips a cup of stormy tea. Then discovers that putting a Steamroller on a diet nets you an Excavator!

CPU

BROADWELL-K, A WARNING

Word has spread that Intel will unveil its new Skylake architectured CPU offerings on the 15th of August, days before the annual IDF conference. The Skylake-S (desktop) and Skylake-U (mobility) versions are said to be what will be shown off.

With Broadwell-K (Intel's first 14nm desktop part) not even out the door yet due to the 14nm ramp up delays, it has the expected launch window of mid-2015. Giving Broadwell-K possibly just two months before becoming obsolete. This has given rise to the belief by some in the industry that Intel will simply skip Broadwell-K altogether and push for Skylake's launch instead.

Intel have been stalwart in their communications however that both will launch as scheduled. If this turns out to be true, beware of buying an Intel powered system around June, you might be better off waiting a couple of months for the better, newer CPUs that'll arrive soon after.

∧ The Carrizo laid bare. AMD continues to win size and efficiency gains, but can it win in the market?

MORE CARRIZO DETAILS

AMD has revealed further details about Carrizo's 40% more power efficient claims while remaining on the 28nm process node.

The majority of the power savings come by AMD's switch in design philosophy, from Steamroller's high performance library implementation which takes up a lot of die space, to the new Excavator high density library that has been put into Carrizo. This achieves a 23% area reduction in total for the CPU cores with smaller sub components like the floating point scheduler, FMAC and I-cache control seeing about 35% reductions.

All those space savings has allowed AMD to cram in 33% more transistors (thus likely performance) for the IGP whose leakage has also been improved by 18% allowing AMD to either push for 10% higher frequencies at the same power cost or retain current frequencies at a 20% power saving.

Further performance is recovered thanks to a new 'Voltage Adaptive' feature that allows the CPU to operate closer to the voltage regulation limit meaning power isn't wasted by being too cautious about down clocking as voltages fluctuate under load.
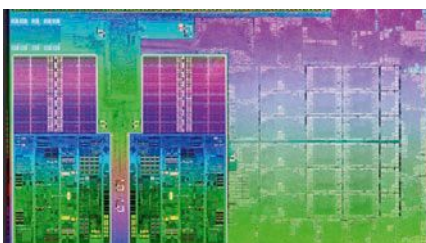
Ten AVFS sensor modules around the chip will now also provide voltage and frequency readings along with the typical temperature and power readings allowing the chip to more accurately reduce power for any given activity state of the chip.

GPU

GTX970 SPECS REVISED

Controversy hit Nvidia recently after users started reporting issues with their GTX 970 cards hitting a VRAM limit of 3.5GB instead of the full 4GB installed on the cards, with GTX 980 owners seeing no such issues.

Nvidia came out with an answer that shocked many. Due to a miscommunication the specs given by Nvidia initially for everyone's shiny new GTX 970 was wrong, and that the behaviour users were seeing was to be expected and even normal.

Essentially, the original specs had the same memory configuration as the GTX 980. 4GB of VRAM sitting on a 256bit wide bus connected to 64 ROPs with 2MB L2 cache. The problem is that the GTX 970 actually has one of its four ROP/memory controller partitions partially disabled, resulting in it having only 56 ROPs and 1.75MB of L2 cache.

Due to the die harvested nature of the GTX 970, we already knew that three SMM's were disabled from faulty GTX 980 chips, but we now know 256KB of L2 cache and 8 ROPs are missing too. 4GB of VRAM can still be attached to the GPU, as Nvidia has inbuilt a redundant link between the two memory controllers of each ROP/controller partition allowing them to disable a defective L2 cache block but still allow access to the associated memory controller that otherwise would've been disabled too, removing total VRAM available.

Due to a performance hit (at 1/7th the speed) in accessing that resurrected memory controller and its attached 512MB of VRAM, Nvidia split the memory into two segments -- the fully functioning 3.5GB fast segment and a 512MB slow segment. The card's drivers are designed to use the 3.5GB fast segment preferentially and when full start putting low priority data into the slow segment.

The 3.5GB wall users were seeing was just a bug with the drivers (since patched in Nvidia's latest drivers) preventing access to the final 512MB slow segment. While a minor issue, many owners were upset by

∧ The GTX 970 memory crossbar configuration. Along with the already known three disabled SM units shown in the top left, the newly discovered disabled L2 cache and the redundant memory controller link can be seen in the bottom right area

these revelations with some even returning perfectly working cards for refunds. If you're a GTX 970 owner all is not lost, it is still a fantastic performer, and thanks to Nvidia's driver trickery only a 3 percent performance deficit can be contributed to this unique memory configuration.

MOST WANTED

Groovy gear

Asus ROG Enthusiast SLI bridges

If you view the task of building your PC as some kind of metaphorical ascent up Mt Bling, you may think you have conquered this shiny, glowy challenge. But, you have not. No, not while your multi-GPU rig has plain old SLI bridges sitting atop your otherwise fabulous PC. What, with a plain circuit board showing? Ha! You're not even half way up – and if you're only running a single video card you're not even in the game.

As should be apparent, to ice the cake with intent means adding in one of these lovelies. They're milled from a single piece of aluminium and look terrific, and, they do glow.

It's not a surprise that these come in under Asus' Republic of Gamers label – or 'pride identity' as we like to see this. ROG gear is pretty splendid, and they don't cut corners.

There are a couple of notable provisos. First, the illumination only activates if a reference Nvidia card is being used, which is the 'Nvidia LED Visualiser'. Or at least that's the by-the-book theory. For non-reference cards Asus provide a Molex power cable that bypasses this restriction, letting the glow run free from its dark shackles to light up your case.

You'll need a Nvidia 600-series card or higher to make it all work, but again, if your card is as old as than that then you only bring shame upon yourself even thinking your rig worthy of such magnificent shine.

www.taochair.com

< Asus ROG Enthusiast SLI bridges 2- and 3-way $65, 4-way $79

< Lowepro Protactic 450AW RRP $299

∨ Lowepro Transit Backpack 350AW RRP $159

Proper bags for laptops, tablets and camera gear

There's piffling laptop and tablet bags, which are fine if all you ever carry are laptops and tablets. But if you're all about your camera gear then you'll need a proper bag to protect your goodies, and make carrying it all around more delightful.

LOWEPRO TRANSIT BACKPACK 350AW

The smaller of the two we tested, it manages to stuff an Tardisesque amount of gear in. We managed two DSLR bodies, a large zoom lens, flash, a regular lens and a small lens, with room to spare for chargers, external drives and a pack of Tic Tacs. The padded rear compartment can take a laptop up to about 15 inches in size.

There's a hidden rain cover as well as stomach and hip straps. We especially liked the quick access side opening, making it easy to reach in and grab gear without taking the bag off your shoulders.

LOWEPRO PROTACTIC 450AW

The bigger bag is serious photography kit, and still has a dedicated laptop/tablet compartment. It has the features of the 350AW, and more. We packed in two camera bodies, two zooms, at least four primes plus flashes and accessories. Despite the hefty weight of all this gear the bag remained comfortable to use.

www.lowepro.com

The BIPAC 7800NXL, Keeping You Connected

It is easy to see why the BiPAC 7800NXL all-in-one modem, continues to be a favourite amoungst Billion fans. With Gigabit Ethernet and 300Mbps Wireless-N, plus support for 3G/4G networks and Network Attached Storage (NAS), the 7800NXL offers maximum connectivity with minimum interruptions.

The 7800NXL's impressive list of features include:

- NBN ready ADSL2+
- IPv6-capable
- Gigabit Ethernet WAN (EWAN) port
- 4 Gigabit LAN ports
- Triple-WAN ports for 3G/4G LTE

For more information on the Billion BiPAC 7800NXL or for a full list of Billion stockists Australia-wide, head to **billion.com.au**.

BILLCOM2-15 PCTA NXL Print Ad

BILLION

CLOUDY WITH A CHANCE OF DISASTER

Anthony Caruana examines the dangers of too many eggs in one cloud

Almost every business and individual is using some sort of cloud service. Sometimes we don't even think of what we're using as a cloud service. Many of us rely on a webmail service such as Gmail, Yahoo! or Windows Mail. Storage services such as Dropbox are very popular and there are all the SaaS, or Software as a Service, applications such as Salesforce, SugarCRM, Saasu and others that businesses rely on.

If you use a fitness tracker then your data is being stored on a remote server somewhere. While you think you're buying some hardware, it's just one part of a bigger service.

But what happens when the services go belly up or you decide you want to change provider?

START AT THE END

Most of the time, when we choose a product or service, we start by working out what we want to do. We then evaluate the different options, maybe try one or two and then choose a winner.

In principle, that sounds smart but we're actually going to suggest a different approach.

Rather than working out what you need and how you're going to engage the service, look at how you can get out if you change your mind or something changes with the service or it's discontinued.

It's tempting to commit to a service when the functionality is solid and the cost is low or free. But what happens if the provider suddenly needs to charge a fee to keep it running or, worse, decides to terminate the service?

When evaluating a cloud service look at how your data is stored. Is it locked into some sort of database? Can you export the data is a usable format such as a spreadsheet or CSV file? Are you even allowed to export

the data?

Before committing to any cloud service, it's so very important to work out your exit strategy, before you take the plunge.

LOOK AT THE COSTS

There's no such thing as a free lunch. Many cloud services offer a no-cost entry. A good example is Apple's iCloud. Everyone with an account gets 5GB of free storage space.

There was a time when 1GB was more capacity than anyone could fathom – it was about the time the Spice Girl's were popular. To really use all that iCloud offers you need to spend a few dollars.

> **"It's tempting to commit to a service when the functionality is solid and the cost is low or free"**

And that might be money you didn't plan on spending in the first place.

Similarly, commercial services such as AWS and Azure can have a very low cost entry point but once you start using storage, memory and CPU cycles the costs can escalate quickly.

Examine pricing models, think about how your behaviour will impact those costs and plan accordingly.

SERVICE GUARANTEES

One other thing – a service that you pay for is more likely to have some level of service level guarantee. Free services are typically delivered with no promise of minimum uptime. The vendors usually rely on their past record to convince you of their reliability.

However, if you're paying, it's reasonable to expect a promise of service reliability and performance with some sort of penalty on the provider if they don't meet the obligation.

Anthony Caruana *has worked for almost every major masthead in the Australian IT press. As an experienced IT professional – having worked as the lead IT executive in several businesses, he brings a unique insight to his reporting of IT for both businesses and consumers.*

EGGS AND BASKETS

That old saying about putting all your eggs in one basket applies to cloud providers. It might be tempting to put all your trust in one vendor. After all, if one provider can deliver your email, productivity software and storage so that all the pieces are neatly integrated then your life will be made much easier.

The trouble is, if the provider decides to change the terms of the service or, worse yet, withdraw the service then you'll potentially lose access or be hit hard in the hip pocket.

THE PRIORITY GRID

We're big fans of taking a traditional risk management approach. Draw yourself a 5-by-5 grid. One axis will represent impact and the other will represent likelihood. Then plot the impact and likelihood of losing each of your current or potential cloud service providers. If anything lands in the high impact and high likelihood box, you need to take immediate action. Use the grid to evaluate and prioritise which risks you need to address most urgently.

Cloud services can deliver you great personal and business benefits. But it's important to take a cautious approach and not jump in without thinking choices through carefully.

NEED HELP? EVER HAD AN ISSUE AS A CONSUMER? INVESTIGATOR CAN HELP.

If you've had an issue or had something happen and you think investigator could help, email your problem to *investigator@pcandtechauthority.com.au*

The Great Austr RIP-

Australia was once known as the land of the tech rip off. Now, after years of growing awareness and frustration, is the Australia Tax finally banished?

Nicole Kobie investigates

alian
_OFF?

A US tech giant launches a new device, and we release a collective sigh. Not only will we have to wait months for it to arrive on these shores - when it does, it will invariably be at a jacked-up price.

Well, that's how it feels - but is rip-off Australia still a problem? On these pages, we'll dig into the prices of hardware, software and cloud services to see whether Aussies really are being charged over the odds when it comes to technology.

The answer might surprise you.

SETTING A PRICE

How do companies decide what to charge for goods and services? When it comes to physical products, items can be divided into two types: commodities that can be freely substituted for one another, and unique goods where only the desired item will do. Many technology products fall into the latter camp - or, at least, manufacturers such as Apple try to convince us they do. Why? Well, because it gives suppliers a free hand to charge whatever they think consumers will be willing to pay for an item.

Editor's note: All currency conversions made for the purposes of comparing foreign product and service prices to the Australian equivalent were done on 2/2/15, at the following exchange rates: USD 0.780, EU 0.688, pounds 0.5188

"In industries where there are a number of substitutes available, prices are tied to the cost of producing the goods," Dr Amalavoyal Chari, an economics lecturer, told us. "If you were to charge significantly above the cost of production, someone else could easily undercut your price and take over your market share, so firms don't have much leeway in setting prices.

"For many products, though, it's easy to develop some degree of market power by differentiating your product from that of others," Chari continued. "For example, some consumers may have a preference for large screens, others for high camera quality. So, if you were Sony, you'd want to conduct some market research to figure out how much consumers are willing to pay for an extra-large screen."

A similar situation arises with services tied to a particular location or situation. "Products that can't be easily traded tend to have quite different prices in different locations," said Chari. "The prototypical example of such products would be a service such as a haircut. Similarly, it's hard to imagine how one could sell one's electricity or broadband connection to someone in another country. So geography creates separate markets, and price variation between these markets is partly cost-driven and partly demand-driven.

"Barring a dramatic technological breakthrough – such as a way to costlessly teleport yourself from Sydney to Melbourne to get a haircut there instead – these price variations won't be eliminated any time soon."

HARDWARE

Whether it's Amazon launching a new Kindle, Apple unveiling its next iPad or another tech giant with a new gadget, it's widely assumed that Aussies pay more than those in the US. To see whether this is true, we compared the retail price of three devices – an Amazon Kindle Paperwhite ebook reader, an Apple iPad Air 2 tablet and a Dell Inspiron 15 laptop (the basic, non-touchscreen specification)– across four major markets.

At first glance, the results seem mixed: buying a Paperwhite directly from Amazon costs $179 in Australia, whereas the advertised US price works out to only $117.42 when converted. But this isn't an apples-to-apples comparison. The Australian price includes the standard GST of 10%, whereas – because US sales tax varies from state to state – US prices are conventionally stated exclusive of taxes. If we were to adopt the same pricing convention, the Kindle Paperwhite would be listed in Australia at $162.73– which is still quite above the $117.42 paid by US customers.

The story isn't quite the same with respect to Apple hardware: subtract the

tax and Aussies pay $562 for an iPad Air 2. That's around $79 less than the US price. But Aussies seem to lose out again with the Dell laptop: $899 inc GST in Australia equates to $817.27 before tax - around $433 more than the price paid by our American cousins.

Aussies do end up paying more than Americans for computer hardware, and many other things. The GST accounts for some of this price mark up, but not all of that extra money goes to the public purse.

SOFTWARE

Software pricing is more artificial than hardware. There are of course development and other overhead costs to recoup but, as Chari points out, this is a type of product for which "the cost of producing an extra unit is virtually zero". A seller's imperative is to maximise their returns - a goal they may pursue by "discriminating a good deal between users, based on their willingness to pay, or proxies for these," noted Professor Michael Waterson, a specialist in industrial economics at the University of Warwick.

Our survey didn't reveal huge variations in the price of software between major Western nations: Microsoft's Office Home & Student, for example, costs almost the same in Australia ($169) as it does in the US ($180); Australia's price falls even lower once you knock out the GST.

Head to less robust economies, however, and prices vary significantly. In India, the

same Office package costs the equivalent of $107, and in Russia that falls to $95.

A Microsoft spokesperson confirmed that "pricing varies by region and is dependent on a variety of factors – including, but not limited to, exchange rates, local taxes, duties, local market conditions and retailer pricing decisions."

This type of price discrimination is understandable, to a point: if Microsoft sets prices that aren't widely affordable within a given region, those markets are more likely to use free alternatives (or simply pirate the software).

When companies try to segment their pricing more finely, however, it can leave a sour taste in the mouth. Recently, the Creative Bloq blog caught Adobe charging would-be customers different prices based on the browser they used: visitors to the company's website using Chrome on a Mac were invited to pay the equivalent of $89 per month for a Creative Cloud subscription, while those using Safari and Firefox saw a lower $74 price.

Adobe brushed the experience off, saying it was simply a pricing test, but the company has been the subject of anger in Australia before. In 2013, a government report found that it was among a group of companies charging Australian customers an average of 50% more than in the US, with one Australian MP criticising tech firms for "charging what you can get away with in any market".

HARDWARE

Stacked bar chart titled HARDWARE. Y-axis from 0 to 1680.

- US: $1,142 total — Amazon Kindle Paperwhite $117, Apple iPad Air 2 $641, Dell Inspiron 15 $384
- Australia: $1,640 total — Amazon Kindle Paperwhite $179, Apple iPad Air 2 $562, Dell Inspiron 15 $899
- Germany: $1,332 total — Amazon Kindle Paperwhite $144, Apple iPad Air 2 $710, Dell Inspiron 15 $478
- UK: $1,641 total — Amazon Kindle Paperwhite $211, Apple iPad Air 2 $773, Dell Inspiron 15 $656

Legend: AMAZON KINDLE PAPERWHITE · APPLE IPAD AIR 2 · DELL INSPIRON 15

US prices exclude sales tax

> **"In 2013, a government report found that it was charging Australian customers an average of 50% more than in the US"**

∧ The Spotify streaming music service is cheaper for Australians than for Americans or Europeans

Adobe subsequently slashed its Australian prices, bringing them into line with the US – but full price parity is still elusive. Now, a full year of Adobe's Creative Cloud Photography plan costs Aussies $120, while they pay the equivalent of $204 in Germany and $199 in the UK.

Professor Waterson isn't surprised by this. "There's no reason why they'd charge the same price in different countries," he told us. "Costs are often essentially the same across markets, especially in the case of software, so pricing is based entirely on demand characteristics."

CLOUD SERVICES

Like software, pricing for cloud services can raise tricky questions. With no straightforward bill of materials, how can anyone determine a fair price for cloud products?

Jagdish Rebello, senior director at IHS iSuppli, notes that cloud services are generally priced, "with an intention of creating long-term stickiness". In other words, the vendors are "basically trying to lock you in for the long term" by keeping prices low enough that you're not motivated to look elsewhere.

Because of that, whichever service is the leader in a given space gets to set the terms, which again may have little to do with the costs of the service. Spotify is a great example: in Australia, its premium service costs $12 per month, whereas in the US it's closer to $13 – and in Eurozone countries it's $14.55. These sums aren't equivalent at all – in each currency, Spotify has simply targeted a convenient number (10) that's low enough to tempt users to sign up.

Nevertheless, as other streaming services have launched, they've tended to pick a similar price point, since Spotify has set the bar. "You're quite likely to see a price of €10 in Europe, and that same service being offered for $10 in the US, just because that's a psychological price barrier that consumers in that country have," Rebello added.

In principle, it's possible to save money on an online service by signing up from a different region – or using a proxy to pretend you're abroad when you're really not. However customer support may prove an issue, not to mention the fact that your stored personal data may be subjected to more relaxed privacy laws than what we have at home . Still, if you're determined to save money, there's nothing to stop you subscribing to the Russian version of Office 365 – as long as you're fluent enough in the language to sign up and pay the bills.

BROADBAND

It's no surprise that broadband prices vary significantly between different regions. Each country's market is different, with variations in infrastructure, public investment and regulation, and consumers don't have the option of going elsewhere.

As it happens, in this case there's no need: Australia has some of the best prices in the world. For broadband up to 30Mbits/sec, Australians pay $70-$80 per month including a land line, while in the UK they pay $62 for a similar deal. Interestingly, our charging structure differs from that used in the UK.

In the UK the differentiating factor between contracts is headline speed, whereas Australia's Telstra offers only two levels of service – basic broadband and superfast – and otherwise prices its packages according to a monthly data allowance.

The big losers in this market are the Americans, who pay more than $82 per month for a 30Mbits/sec service.

In 2013, a think-tank called the New America Foundation undertook a study of US broadband offerings, comparing them to services in other countries, and ranked the US as the most expensive country in the world for broadband.

SOFTWARE

Australia $525
- $153 — OFFICE HOME & STUDENT
- $108 — OFFICE 365 HOME
- $120 — ADOBE CC PHOTO
- $144 — SPOTIFY

US $607
- $180 — OFFICE HOME & STUDENT
- $128 — OFFICE 365 HOME
- $143 — ADOBE CC PHOTO
- $156 — SPOTIFY

Germany $724
- $202 — OFFICE HOME & STUDENT
- $144 — OFFICE 365 HOME
- $204 — ADOBE CC PHOTO
- $174 — SPOTIFY

UK $725
- $170 — OFFICE HOME & STUDENT
- $124 — OFFICE 365 HOME
- $199 — ADOBE CC PHOTO
- $232 — SPOTIFY

(Y-axis: 0, 110, 220, 330, 440, 550, 660, 770)

■ OFFICE HOME & STUDENT ■ OFFICE 365 HOME ■ ADOBE CC PHOTO ■ SPOTIFY

US prices exclude sales tax

US

Apple iPad Air 2	$642
Microsoft Office Home & Student	$180
Microsoft Office 365 Home	$127
TOTAL	**$949**

US prices exclude sales tax

UK

Apple iPad Air 2	$782
Microsoft Office Home & Student	$216
Microsoft Office 365 Home	$157
TOTAL	**$1,151**

GERMANY

Apple iPad Air 2	$711
Microsoft Office Home & Student	$202
Microsoft Office 365 Home	$144
TOTAL	**$1,057**

BRAZIL

Apple iPad Air 2	$943
Microsoft Office Home & Student	$117
Microsoft Office 365 Home	$95
TOTAL	**$1,155**

SOUTH AFRICA

Apple iPad Air 2	$735
Microsoft Office Home & Student	$132
Microsoft Office 365 Home	$104
TOTAL	**$971**

Technology prices worldwide

AUSTRALIA PAYS LESS FOR PRODUCTS AND SERVICES THAN MOST MAJOR MARKETS AROUND THE WORLD, ALTHOUGH BRAZIL NUDGES AHEAD OVERALL, OWING TO HIGH HARDWARE PRICES

RUSSIA

Apple iPad Air 2	$726
Microsoft Office Home & Student	$68
Microsoft Office 365 Home	$48
TOTAL	**$842**

CHINA

Apple iPad Air 2	$739
Microsoft Office Home & Student	$144
Microsoft Office 365 Home	$82
TOTAL	**$965**

INDIA

Apple iPad Air 2	$740
Microsoft Office Home & Student	$113
Microsoft Office 365 Home	$87
TOTAL	**$940**

AUSTRALIA

Apple iPad Air 2	$619
Microsoft Office Home & Student	$169
Microsoft Office 365 Home	$119
TOTAL	**$907**

WINDOWS
ANNOYANCES
SOLVED

WINDOWS IS A POWERFUL OS, BUT IT HAS SOME INFURIATING QUIRKS AND GOTCHAS. **DARIEN GRAHAM-SMITH** AND MICROSOFT MVP MIKE HALSEY SHOW YOU HOW TO MAKE IT BEHAVE

How do I make Windows Search find the files I'm actually looking for?

Windows stores a database of files and folders on your hard disk, so that when you search for something, the results can be returned instantaneously. However, for speed and efficiency, only the most common file types and personal folders are included by default.

There are two ways to get Windows to search outside of your user folders: one is to open the target volume or folder in Explorer and use the search box to search directly from there. This will prompt Windows to ask if you want to add this location to its index. Alternatively, open Indexing Options from the control panel, and click the Modify button in the dialog that appears. This will bring up a list of all searchable locations, which you can tick to add to the index.

Another challenge you might face is finding files by a property other than filenames (for example, if you want to see all images created on a certain day). You can do this by directly specifying file properties, such as "size:>250mb –" or, in our example to the left, you might type "datecreated: 14/1/2015". In many cases, as you type, Windows will pop up a requester to help you select the values you want. The set of phrases that can be used to search for specific files is called the Advanced Query Syntax, and you can read more about it at http://tinyurl.com/7gd5sun

I want to reinstall Windows without losing all my data

Microsoft is paranoid about people pirating Windows, so your new PC almost certainly didn't come with a disc for installing the OS. It probably came with a recovery tool, which you can use to restore the system to its fresh-from-the-box state – but this includes wiping all your personal data, so isn't a convenient solution if you simply want to declutter your system.

If you're using Windows 8, there's a simple answer. The new Refresh My PC feature restores the OS to its "naked" state without touching your data files (although you'll still need to reinstall your desktop applications). You'll find it in the Metro-style PC Settings app, under Update And Recovery.

If you're using an earlier version of Windows, the official line is to make a backup of all your data, use the manufacturer's recovery tool, then simply copy your files back afterwards. We suggest this, too, as cloud storage is now so cheap there really is no reason not to.

It is, however, possible to reinstall Windows "in place". To do it, you'll need to somehow get your hands on an official installation DVD, and you'll also need to find your product key (see above right). When you open the disc within Windows and select Upgrade, the installer will try to reinstall the operating system while leaving your programs and files intact; if you're trying to fix a corrupted installation, this may be all you need. If you'd rather start from a clean slate, boot from the DVD and choose the "Custom (advanced)" installation option. Follow the prompts, and install Windows on the same disk as your old OS, but do not format the disk. Once the installation is complete, your old data files will be found in a folder called C:\Windows.old.

I can't write to my USB drives on a Mac or in Linux

When you format a USB drive of more than 32GB, the default option is to use NTFS, which is Windows' "native" file system. Unfortunately, while NTFS drives can be read by all major computing platforms, OS X and Linux systems can't write to these volumes without third-party software.

The simplest solution is to use the FAT32 format, which is supported across all three major platforms. If your disk is larger than 32GB, the Wind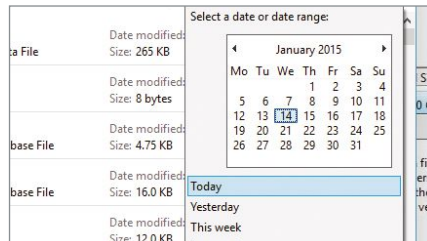ows Format requester won't show FAT32 as an option, but you can format a disk with this files system from the command prompt by typing "format d: /fs:fat32 /q" – where d: is the letter of your removable drive. The /q parameter specifies a quick format, which means Windows won't spend time checking the drive for errors.

FAT32 has one limitation: individual files can't exceed 4GB, which could be a problem if – for example – you're planning to move huge videos or database files around. In this case, you should choose the exFAT file system: this raises the maximum file size to 16 billion gigabytes. exFAT is only supported on Windows Vista and later, and on OS X 10.6.5 or later.

My PC takes forever to shut down and restart

This shouldn't be a problem for Windows 8 users, however, those on older versions of Windows have to wait for all programs and services to shut down before the computer switches off, which can be a slow process. By default, Windows 7 gives programs that are running 12 seconds to close down cleanly before attempting to force them to shut down.

There are two ways to speed up this process: one is simply to close programs yourself as you finish using them, so that there's less waiting around when the time comes to shut down the PC. This also saves resources, so you might see a performance benefit too.

If this still isn't fast enough, you can edit the Registry to shorten the 12-second timeout. Open the Registry editor – and make a backup of your Registry just in case – then navigate to HKEY_CURRENT_USER\Control Panel\Desktop, create a new DWORD value called "AutoEndTasks" and set its value to "1". Then, find HKEY_CURRENT_USER\Control Panel\Desktop\WaitToKillAppTimeout and give it a value of "2000". This is in milliseconds, so this setting will cause programs to be automatically closed after two seconds. Remember that forcing programs to close early can result in lost data, as files might not be saved.

What about the other side of the equation – making Windows start up more quickly? Defragmenting your hard disk may help, but it's unlikely to save you more than a few seconds; on an SSD, it won't have any effect at all, since all flash cells take the same time to access, regardless of their physical location.

Instead, try running the third-party BootRacer tool (greatis.com/bootracer), which is free for non-commercial use. This tool tracks Windows activity during startup, and can tell you which programs and processes are taking the most time, so you can identify what you may want to remove or prevent from running automatically.

Can I mute my PC when idle so it doesn't keep making noises while I'm in the other room?

There isn't a simple setting for this in Windows, but it can be done with third-party software. NirCmd lets you mute and unmute Windows audio from the command line (tinyurl.com/rzcqh); you can use the Windows Task Scheduler to call this automatically at times when the computer is idle. In Windows 8, you can also silence notifications for up to eight hours by opening the Settings charm and clicking Notifications – or set up recurrent Quiet Hours within PC Settings | Search & Apps | Notifications.

I can't install Windows 8.1 with my Windows 8 product key

For some reason, Windows 8.1 uses different product keys to Windows 8, so if you want to reinstall, the official recommendation is to use the Windows 8 installer, then upgrade to Windows 8.1 through Windows Update and the Store. However, it is possible to trick the installer into installing Windows 8.1 with a Windows 8 key: see tinyurl.com/m9ksqgh for a step-by-step guide.

My music library is full of files with names such as "ALBUMART_{E6043 A1C-BBEB-49C5-B3F0-5259B6312 C34}_ LARGE.JPG" – how do I get rid of them?

These are the thumbnail art files for your music tracks; they're downloaded by Windows Media Player on all recent versions of Windows, and they're usually hidden, so there isn't normally a need to get rid of them. The bad news is that, at present, there's no way to stop Windows Media Player from creating these files (disabling "Retrieve additional information from the internet" ought to do it, but doesn't). Pending a new version of the software, the best course of action would be to

I'm seeing an "Unknown device" in Device Manager. How do I work out what it is?

First, make sure you've downloaded and installed all the drivers available from the manufacturers of your PC, components and peripherals. If the device still can't be identified, open its Properties panel, select the Details tab and select Hardware IDs from the dropdown menu. You should see a string similar to "PCI\VEN_10EC&DEV_8168&CC_0200". A web search for the vendor code ("VEN_10EC" in this case) should tell you the manufacturer, and searching for the device code ("DEV_8168") may well lead you to the specific device.

Are you sure that you want to move this system file?

It's maddening when you're trying to move a folder from one place to another – or delete it – and Windows stops mid-action to pop up a requester asking you to confirm that you want to move one particular file. It's even more annoying if you've gone off to do something else, and come back to find that Windows has been sitting idle for an hour, rather than getting on with the task at hand.

Files are generally flagged as "system files" for a reason, and moving them around can cause OS and application failure when they can no longer find the resources they need.

Often, though, the file in question is something perfectly innocuous – such as the thumbs.db file that stores previews of the images in a folder, or the folder.ini file that contains various view settings. It's safe to move these files, or to delete them in the course of removing an unwanted folder. Unfortunately, there's no way to disable the warnings that will pop up when you try to do so.

If you want to rid yourself of this annoyance, you'll need to resort to a third-party trick. If you're adept with scripting hosts such as AutoHotKey or AutoIt, you could write a script that looks out for this particular requester, and automatically hits the "Yes" button whenever it pops up. Alternatively, check out a program called PTFB Pro (ptfbpro.com), which lets you set up all sorts of automatic behaviours and shortcuts such as this – the name stands for "Push The Freakin' Button". Of course, when setting up a system that's deliberately intended to defeat Windows' built-in protections, you should be extremely careful, as a misstep could have disastrous results!

Group Policy Editor seems to be missing from my PC

Only the Professional and Enterprise editions of Windows include the Group Policy Editor; there's no officially supported way to install it on Home editions. However, if there's a particular template you want to apply, you may be able to achieve the same thing by editing the Registry directly: see tinyurl.com/oerm3l7 for a long table of Group Policy objects and the Registry keys they control.

Help! My screen has turned upside down!

Press Ctrl+Alt+Up Arrow to restore the regular orientation. If that doesn't work, look for rotation options in your graphics driver.

I can't connect to my PC remotely because it keeps going to sleep or hibernating

You can disable sleep and hibernation from within the Power Options in the control panel. Alternatively, many systems can be configured to wake automatically when an incoming network connection is detected: to check this is enabled, open Device Manager, then open the Properties page for your network controller, click on the Power Management tab and enable "Allow this device to wake the computer".

Can I automatically switch my default printer when I move between home and the office?

Open Devices And Printers from the control panel and click on any printer. Then select Manage Default Printers from the toolbar; from here you can set up different default printers for different networks.

I did something and now Windows 8 won't start. How do I get into Safe Mode?

Can you create a Recovery Drive on another Windows 8 PC, or boot from your install DVD? If so, you should be able to get to the Advanced Repair Options: from here, click Troubleshoot, then Advanced Options, then Windows Startup Settings to find Safe Mode.

The action can't be completed, as the folder/file is open in another program

When a file is in use by a program or process on your PC, Windows locks it so that no other process can modify it. You may be able to open multiple instances of the file, but actions such as moving or deleting won't be permitted, as this may result in a crash or in data loss.

Unfortunately, sometimes Windows Explorer, or some invisible background process, fails to release its handle on a file after it's been accessed. In this case, even though you're no longer actively using the file, it still can't be moved, deleted or renamed.

The simplest way round this is to restart the PC, which will clear all locks. If that's too drastic, you can also try opening the Task Manager and restarting Windows Explorer.

For a more targeted approach, try out the freeware Unlocker tool from emptyloop.com/unlocker – this adds a right-click menu option to Windows Explorer that will attempt to release any locks on that are present on the selected file.

If you want to know more about what's locking your files in the first place, download Process Explorer from sysinternals.com; run the software, then select File | Show Details For All Processes. Next, open the Find menu and click "Find handle or DLL". Search for the name of the locked file and select it in the search results. You'll then see it appear in the details box at the bottom of the Process Explorer window; you can release the lock by right-clicking and selecting Close Handle.

Docking or waking my PC causes icons and windows to rearrange

This is an issue we've faced ourselves, on a PC connected to a 4K display by a DisplayPort cable. In our case, when the screen wakes up from sleep, it takes a moment for Windows to correctly re-identify the monitor resolution. While that's happening the OS momentarily falls back to the default 1,024 x 768 resolution, so all open windows are shuffled up to fit the smaller desktop. Once the proper resolution is detected, the desktop switches back to the correct resolution – but now everything is left bunched up at the top-left corner of the screen.

The likely cause is an issue with the graphics driver, so if you're having similar problems, the first step is to check whether an updated driver is available that might fix the problem. If you have a graphics driver utility such as the AMD Catalyst Control Center or Nvidia Control Panel, it's also worth checking the settings here, as something could be misconfigured. If you have multiple monitors connected, running both screens at the same resolution may help.

When I'm copying files, the "time remaining…" indicator keeps switching from two minutes to a couple of days and then back again

In fairness, Windows is doing its best. To provide any sort of estimate, the operating system has to extrapolate from the observed transfer speed. At first, it has to rely on the speeds achieved during the first few seconds of the copy operation.

This speed can easily change, however. If, while copying, you're also performing another action – such as loading a program or watching a video – your copy operation might briefly stall, causing Windows to drastically revise its timing estimate.

Even if the computer is otherwise idle, there are plenty of factors that can affect copying speed. For example, writing lots

66% complete

Copying 16,080 items from Dropbox to Data backup
66% complete

Speed: 28.2 MB/s

Name: RQ Business card.indd
Time remaining: About 2 minutes and 15 seconds
Items remaining: 3,799 (7.56 GB)

Fewer details

of small files tends to be much slower than one big one. If a mechanical disk is becoming full, fragmentation could cause the second half of a large file to write more slowly than the first half. If you're copying files over a network,

interference could have a similar effect. And so on.

There's no true reliable way to get better estimates: a cynic might suspect that the reason Microsoft added the speed graph to the Windows 8 file-copy progress window was so that you could see for yourself just how unpredictable data rates are.

If you want your copy operations to complete as quickly as possible, your best bet is simply to minimise the number of other things going on. You can also use software such as TeraCopy (codesector. com/teracopy), which uses memory buffers to speed up file copying where possible.

Why do I have to log in every time I turn on my PC?

The obvious answer is for security – and if you're at work, or on a laptop containing personal or confidential information, we suggest you leave these password prompts enabled. Data theft is a growing threat, so requiring re-authentication whenever your PC wakes up is a good thing. If you have young children who might be tempted to meddle, a wake-up password can help there too.

For a home PC, however, you might understandably want to skip the password. To disable the password request when Windows wakes up from sleep, right-click on the desktop and select Personalise. Next, click the Screen Saver link and you'll see a tickbox labelled "On resume, display log-on screen". Untick this and in future your PC will spring straight back into the desktop.

If you don't want to be asked for a password even when you start up Windows, this too can be

User Accounts

Users Advanced

Use the list below to grant or deny users access to your computer and
to change passwords and other settings.

Users for this computer:

Username   Group
darienge@gmail.com   Administrators

Add...   Remove   Properties

Password for darienge@gmail.com

To change your password, go to PC settings and select Users.

Reset Password...

OK   Cancel   Apply

configured, although the option is slightly more hidden away. Search for netplwiz at the Start menu or Start screen, and open the applet that appears. This will show a selection of master settings for all user accounts on the PC, one of which is "Users must enter a username and password to use this computer". Untick this option – and enter your password one last time to authenticate – and the selected user will henceforth be automatically logged on whenever Windows starts up.

Mike Halsey is a Microsoft MVP and the author of *Troubleshooting Windows 7 Inside Out* **and** *Troubleshoot and Optimize Windows 8 Inside Out* **from Microsoft Press. He's also the author of** *Windows 10 Troubleshooting* **and a new series of short guides to subjects such as the Registry and software compatibility, to be released this spring from Apress. Find him on Facebook and Twitter as PCSupportTV.**

Where has all my hard disk space gone?
Installing OS and application updates can result in large caches of backed up files you don't need. Applications can also leave temporary files on your disk in places that aren't obvious. Run Windows' built-in Disk Clean-Up tool and you may be surprised at how much can be safely junked. If you still can't account for all your hard disk space, try WinDirStat (**windirstat.info**), a graphical tool that scans your hard disk and shows you the heaviest files and folders at a glance.

Windows Update keeps turning itself back on!

It goes without saying that, in most cases, Windows Update should be left on. And to be precise, it isn't normally Windows Update itself that causes frustration, but the way it insists on restarting your PC at inconvenient times. The simplest solution to this is to open Windows Update from the control panel, click "Change settings" in the left of the window and change the dropdown option to "Download updates, but let me choose when to install them". You'll still be nagged when updates are available, but you'll be able to install them and reboot at your own convenience.

If you want to prevent Windows Update from restarting your PC altogether, open Regedit and navigate to HKEY_LOCAL_MACHINE\SOFTWARE\Policies\Microsoft\ Windows\WindowsUpdate\AU. If this key doesn't exist, you can create it. Create a DWORD called "NoAutoReboot WithLoggedOnUsers" and give it the value "1". This will tell Windows to stop automatically restarting your PC: updates will now only be installed when you restart the PC yourself.

If you never want to download updates – for example, if you're a developer testing against a specific OS component – you can disable Windows Update from the control panel, but be warned: you'll still have to keep an eye on your settings, as Microsoft has a sneaky habit of re-enabling Windows Update whenever it gets a chance, such as when you install new software or change settings for Office or Internet Explorer.

from IDEA to CHART-TOPPER

The truth behind *app* development

WHAT DIFFERENTIATES AN ALSO-RAN APP FROM AN ALL-TIME GREAT? **STUART ANDREWS** SPEAKS TO THE PROFESSIONAL APP DEVELOPERS TO FIND OUT

Is developing an app still a route to riches? Done right, and with luck, the answer remains a resounding yes. Annual app sales now account for roughly $20 billion of revenue across the Apple and Google app stores, and Gartner predicts cumulative revenue will hit US$77 billion by 2017.

Meanwhile, both Facebook and Google are hungry when it comes to acquisitions: in the past few months, we've seen Facebook buy WhatsApp for $19 billion, while Google has gobbled up travel-app developer Jetpac and translation specialist Quest Visual for undisclosed sums. Undisclosed, but undoubtedly a very high dollar amount.

Yet the majority of app developers aren't raking it in. A 2014 Gartner report claimed that less than 1% of apps were financially successful, while Midia Research found that only 50 companies were responsible for 81% of sales. It's a market for superstars.

This doesn't mean a new app can't be a raging success, but it takes expertise, market knowledge, great ideas and hard graft. We spoke to a range of app developers, from freelance contractors to studios working with major brands. They told us how app development works in the real world, and what differentiates a success from another poor little orphan app.

SUCCESS VS FAILURE

So, what differentiates a successful app from one that never makes it off the starting block? For one, the original idea plays a big part. Ben Paterson is creative producer at Figure Digital, developer of the virtual pet app, Animin. "Ideas for apps are ten a penny," he said. "Everyone and their iDog down the pub has an idea for an app, and 99% of them are either rubbish, insane or completely undevelopable."

It's a view shared by Kevin King, founder of the App studio Createanet, which has a roster of successful apps that includes Temphis Availability Manager and the FA Coach's App. "You get so many 'sad birds' instead of 'angry birds' floating around," he told us. "Because they didn't have

the creativity to start with, they don't go anywhere." It's also no good trying to ape existing success stories: "We get two or three ideas a week where, once you drill down, they really just want to do Facebook. You can't take on people like that."

Successful apps are about satisfying needs, not inventing them. It doesn't matter whether that need is a way to control a hot tub from a smartphone or enable property developers to keep on top of ongoing projects; as long as the app does something users want, and does it well, it has a chance of succeeding.

PRACTICAL HURDLES

A great idea also needs to be backed up by a business case. As Chris Williams, managing director of app studio B60, puts it: "The first key step is to understand the business need and requirements. This is fundamental. Many apps fail because they have no real need, or the plan to make money from it isn't thought through."

Usability is just as crucial. Rob Hayward, a successful freelance app developer who has worked with Formula One and The Comedy Store, says you need to make it "effortlessly easy". "You've got someone's attention for a fraction of time, often a few spare seconds while they're doing something else. They want a couple of taps and everything is done."

"They want a couple of taps and everything is done"

Williams thinks that a successful app "provides the features the end user needs while keeping the interface as clear, simple and easy to use as possible". B60 pulls this off by understanding user habits mainly through a combination of in-house expertise, workflow analysis and client consultation, although it also sees value in focus groups and end-user research.

Mobile-development studio and marketing agency Rokk Media also spends a lengthy research phase looking at potential users, sorting them into personas and following those personas on a journey through the app. "We look at what they want to achieve and what their hopes and fears might be – particularly the fears, since understanding the concerns users might have can help you point them in the right direction," said Martin Dainton, Rokk Media's chief creative officer. When developing an app for internal use by the non-technical sales team of a car dealership, for example, Rokk ensured built-in guidance and simple instructions were provided at every stage.

For Createanet, it's a question of careful prototyping, so that the key interactions are in place before a single line of code is written – and then putting usability at the core of the design. "The beauty of apps is that they're simplistic. You have to come up with an interface you can use with your thumb," explained King. "They're quite fickle. If you find something and it engages you then you're on board – and that's all about

∨ Virtual pet app Animin is the product of thousands in investment

∧ Getting to the featured pages of the iOS and Google app stores is the holy grail for developers, with a huge impact on visibility and sales

THE PROCESS

All apps begin with an idea, whether it's promoting a brand or something truly groundbreaking. If you have technical skills, you might be able to develop that idea for yourself, but in most cases there'll be a need to find investment and partner with a professional developer or studio.

The development process tends to take a standard shape. First, there's a pre-production phase, which may take in conceptualisation, user research and profiling, prototyping with wireframes or mock-ups, and the nailing down of a set of features, functions, specifications and requirements. The app then goes through a design phase, where those concepts are transformed into screens, buttons, menus and displays.

At this point, development begins in earnest, as servers are set up to support any back-end functions, and the different elements and features are coded. As with most software projects, there'll be milestones, where limited alpha or beta releases or slices of the app are released internally and to the client for feedback. Bugs, issues and feedback will be spun back into development, hopefully producing a more polished and stable version 1 release.

When ready, the app is submitted to the relevant app stores. With Android, launch may be merely a few hours away. On iOS, however, you could be looking at a wait of up to two weeks as Apple vets the app. Only when Apple's gatekeepers are happy is it released, appearing on the App Store's "Featured" pages if you're lucky, or joining the endless ranks if not.

MY FAVOURITE APP

Kevin King, Createanet: "I'm proud of our work on the FA Coach's App. The customer was a nice guy who had a vision and stuck to it – and he's done well from it. Otherwise, apps are more utilities to me. I like the Spotify app, however. They had a big brief in terms of the information and features they had to deliver, but they did a great job in terms of usability."

Martin Dainton, Rokk Media: "Our Make It Yours app had a unique interface, taking the concept of a visual success map and presenting it in a form with which people could interact. I'm quite impressed by Google's Inbox at the moment. It isn't the flashiest of apps, but it makes dealing with mail so much easier. One of the nicest-looking apps I've used recently was Taasky. It flows very well. It has a great UI and it's easy to use."

Nick Kuh, independent developer: "Wordsy is a multiplayer speed Scrabble-style game I conceived about a year ago. I built the game alongside client work throughout 2014 and have enjoyed watching my family and friends become hooked. I'd also list apps that I use daily: Google Maps and Apple's Calendar app make my life easier. Instagram is a really fun way to share raucous pics with mates."

Ben Paterson, Figure Digital: "I'm immensely proud of Animin, our next-gen digital pet. As for my favourite apps, it changes weekly, as I imagine it does for most mobile power users." lucky, or joining the endless ranks if not.

∨ Like many independent developers, Nick Kuh works as a gun for hire, but he also develops his own apps, including Scrabble-style game Wordsy

be around in a couple of months' time to support you."

In other words, apps need a budget, which may be anywhere between a few thousand pounds and hundreds of thousands. Even freelance app developers will look at the budget as a means of separating serious prospects from those without a realistic idea of what's involved. "I get lots of enquiries," said Jason Kneen, who develops iOS and Android apps through his studio, BouncingFish. "A lot of them are rubbish, to be honest. They want to do the next WhatsApp or Instagram and usually have no clue about how the whole process works or the costs involved."

Having worked with the likes of English Heritage and Friends of the Earth, Kneen takes the ideas that interest him and sketches out the work involved, then uses that to form a ballpark budget. It's at this point that those without a solid business plan back out.

Many would-be app tycoons also underestimate the costs of the back-end infrastructure that supports the app. "People look sites such as Instagram and Yo, and are unaware that alongside the front-end there's back-end infrastructure in place," said Kneen. "This needs to be paid for somehow. There are cloud services that will do this for free, up to a point, but when they start charging you - when you hit a million users - you might suddenly receive a bill for $10,000."

In addition there are design and technical challenges, from the difficulties inherent in building an app to work across multiple devices, resolutions and screen sizes, to issues concerning mobile connectivity and data flow.

Perhaps the biggest challenge in app development is time. App projects often run on short two- or three-month cycles, with immovable deadlines such as Christmas or sporting events with which to contend. "Anything is possible, within reason," said Rob Hayward. "It's just figuring out what you can achieve in the given amount of time." While there's always a temptation to add more features, app developers learn to resist. "If there weren't a limited amount of time, there wouldn't be any restrictions," Hayward said, "but when you're delivering a product in three months, then extras need to do something vital – or at least tick a box with an investor."

In a world where the changing of a single button can often result in hours of work, testing can be a major time sink, one that benefits from someone dedicated to the job, according to Hayward. This will not only cut down on lead times when adding new features, but could also uncover issues

"as long as the app does something users want, it has a chance of succeeding"

that developers and designers fail to spot. "You could be focused on how the design works, with different screen resolutions or languages, then a tester comes along, presses all the buttons in a different order, and finds something that you wouldn't normally find."

THE PROCESS

The submission process can also lead to delays. Kneen told us how agencies often expect an app finished on Friday to go live on Monday. "I have to say that we can submit it on Monday, but it may be ten to 15 days before it can go live." Apple sometimes rejects apps for peculiar reasons, and you may need to resubmit several times before this reason becomes clear.

One way to work with the time issue is to forget about cramming every last feature into version 1, and focus instead on producing a good, stable version that you can update. "You might get to a point where you have a fully functioning app, but with two missing features that the client wants

to add," said Jason Kneen. "If they hold out they could miss a deadline, and there's no shame in having a version 1 app that does the job, then updating it two days later."

Nick Kuh agrees this can be a viable approach, with developers "creating an MVP (minimum viable product), then iterating frequent app updates as they learn from their users and improve their product over time". However, he also sounded a note of caution: "If you're launching a brand-new app based on a great idea then you want your initial offering to be polished at launch."

Why? Because it's at launch that the app might benefit from press coverage and establish a long-term position in search results, while initial reviews will be more prominent and, in Kuh's words, "more likely to sway new users". "The better you make your app for launch," he argued, "the more chance you have of long-term success. Also, submitting a great first version to the App Store gives you your best shot at getting featured by Apple – the holy grail."

THE BOTTOM LINE

Is all this effort worth it? Well, few app developers end up selling up to Facebook for several billion dollars, but all those we spoke to were sustaining a successful business. "There's plenty of work out there," said Jason Kneen, who became a full-time freelance app developer in 2011 and has been busy ever since.

"It's definitely possible to make a good living from app development if you combine the development of good indie apps with work-for-hire," agreed Nick Kuh. "I've been developing solely for iOS since 2009, and five years on I'm still inundated with iOS projects and opportunities. I pride myself on the fact that every one of my own apps has earned enough through App Store sales to pay me back for the development time that I originally invested."

What's more, there are major opportunities in the enterprise sphere. "From our point of view, the biggest growth has been in business applications," said Rokk Media's Dainton. "People are starting to see that these devices are really useful on a business level. If they have satellite teams or those going into different areas and different departments, then apps really help with productivity." It's a market Createanet is also chasing in earnest. "You might not make the next Angry Birds, but you could sell a lot of product into a 2,000-seat business," said Kevin King.

In short, the gold rush might be over, but it's still possible to make a good living from app development, and keep your hopes of building a breakthrough app alive. It won't be quick or easy, but then building a successful business rarely is. ●

WHICH PLATFORM?

According to the latest figures from app-market analyst App Annie, there are 60% more downloads from Google Play than the Apple App Store – yet the App Store makes 60% more revenue. Does that make iOS development a safer bet?

It depends. For some apps, the core purpose is to support the brand, increase online sales or support a product, in which case ignoring Android is risky. "Android has definitely caught up," said Rokk Media's Martin Dainton, "so the requirement tends to be that your app must work across the board. For some clients, this means we need to consider a framework that allows us to publish to different platforms, or they may need simply to develop different apps for those platforms."

However, as Createanet's Kevin King explains: "if you're trialling something new – a new concept or a new idea – then my recommendation would always be to build iOS first. Make sure you're completely happy with it, go through the first two or three months of development and get the bugs and usability issues ironed out. You'll then have a stable platform from which you can build in Android."

The ease with which you can go cross-platform boils down to your approach. You can code natively using Apple or Google's development tools, then port the finished app to the other platform; or you can build within a framework such as PhoneGap or Appcelerator's Titanium, so that you can compile apps that run across both.

The first approach has some key advantages. "If you're building something

∨ Android is catching up with iOS fast – there are now 60% more app downloads from Google Play than from the Apple App Store

∧ Despite many big-name apps now being available for Windows Phone, interest in developing for the platform is very low

as a native app, then you definitely have more access to the device and its functionality," said Dainton. "If you're using a framework – such as PhoneGap, for example – then there'll be limitations."

The upside of using a framework is that it speeds up development and makes supporting other platforms far quicker and easier. As Titanium user Jason Kneen explained, "90% of the work that has to be done will be applicable to both platforms, and the other 10% covers whatever I have to do to get it working on the other platform, which is usually UI-related."

And what about Windows? Well, what about it? Most of the developers we spoke to said there was little to no interest in developing apps for Windows or Windows Phone. "There's just no demand," said King. "It's chicken and egg. A few top apps are now on Windows, but there's an app culture around Apple that just doesn't exist in Windows."

"Clients don't seem to be that worried about Windows," said Dainton. "We ask them if they'd like to consider it, but it often isn't on their radar." B60's Chris Williams agrees. "We have targeted Windows Phone devices, but it's rare for this to be a viable prospect due to the relatively small userbase."

Will Microsoft's unified Windows platform change this situation? Possibly – as might the growth in business-app development across tablets, phones and the desktop. At the moment, however, iOS and Android remain the focus of the app-development scene, even for those building business-focused apps.

IN THE LABS

What's on the bench, this month?

FAT PIPES

BEN MANSILL ON THE EVOLUTION OF BANDWIDTH

We have a review in this issue, on page 49, of the first USB 3.1 motherboard. It's an Asus, and the company was good enough to provide a USB 3.1 device to test the connection with (as such things are virtually non-existent at this point).

Is this a big deal? Yes, it will be... a few months down the road, for most of us, at least. Before then it will be important to certain professionals, like video editors wanting to transfer large amounts of data from one device to another.

For some perspective from the manufacturer's side, I'm reminded of a conversation I had with the Asia Pacific Marketing Manager of a very large Taiwanese company a few years ago. I was involved in the production of a talk show at the time, and that week's episode was all about 'future technology'. One of our guests was Mark Pesce, a well known futurist. Another guest was of a similarly visionary calibre. And so was our motherboard man, who we'd invited on.

I explained the theme of that week's

show, and what the other guests were likely to be discussing. Then, I asked him what he'd like to cover? "USB 3.0!" was his emphatic reply. But but... I tried to guide him towards, say, optical interconnects, or computers that needed no cables whatsoever. "You want to talk about USB 3.0? Really?"

In his world, it was huge. And so is USB 3.1, now. Double the bandwidth as well as backwards compatibility is one of those leaps than we tangibly experience day to day. According to sources within motherboard manufacturers we've spoken to, you can expect to see some existing motherboards refreshed with USB 3.1 connections built-in (like our review unit this month), while others will have an add-in USB 3.1 card bundled in the box. Purchasing stand-alone USB 3.1 cards, will of course, be popular.

You might be reminded of the early days of USB 3.0. While, initially, motherboards appeared with one or two

USB 3.0 connections, the majority were 2.0. In the case of motherboards that's due to the capabilities of the supporting chipset, as well as how the USB controller was integrated. But don't forget that there's a considerable cost for the USB controller – and that's why, even today, many devices still only feature a USB 2.0 port. Keyboards, for example, almost all carry USB 2.0 as an extra port. As for USB 3.0, my sources are still guarded about the unit cost, but expect that the controller itself will add around $30-$40 to the cost of a device. When you stack that on top of a commodity-level device fighting to be competitive you can see why the old standards persevere in non-critical integrations.

SAMSUNG
GEAR VR
44

RASPBERRY PI 2
MODEL B
45

HP ENVY
X2 13
42

WHAT OUR A-LIST MEANS

Our A-List award is reserved for the best products in each category we review. With a winner and an alternative pick in each, that's 92 products you know are first class.

WHAT OUR AWARDS MEAN

PC & Tech Authority's comprehensive Real World testing sorts out the best products from the pack. Any product recommended by *PC & Tech Authority* is well above average for features, value for money and performance.

WHAT OUR RATINGS MEAN

VERY POOR
POOR
ORDINARY
VERY GOOD
OUTSTANDING

0 1 2 3 4 5

HOW WE TEST

The science behind the numbers

While all manner of products come through our labs, as much as possible we run standardised tests for specific product categories. This allows you to compare products we may have reviewed in an earlier issue with something newer. However, at times we'll deviate if we feel a certain test is more appropriate to a certain type of product or group test.

GRAPHICS CARDS

To put today's GPUs under the most pressure, we use two real-world games with excellent built-in benchmark routines, in the form of Grid Autosport and Thief. These were selected as they don't favour Nvidia or AMD, instead taxing both equally, and their scores are in frames per second, where higher is better. Finally we run the synthetic 3DMark benchmark to get a holistic view of each GPU's performance. 3DMark's Fire Strike Ultra benchmark is used to push high-end GPUs to the limit, while the Sky Diver benchmark is used to test gaming laptops and mid to low-end GPUs. Both of these tests give an overall score, and once again higher is better.

LAPTOPS, CPUS AND MOTHERBOARDS

Futuremark's brilliant PCMark 8 Home benchmark is designed to see what today's Windows 8.1 PCs can do. We run the Home sub-benchmark as this most accurately replicates the average home user's workload, testing across five different synthetic benchmarks: Web Browsing, Writing, Casual Gaming, Photo Editing and Video Chat. Readers can download this benchmark for free to see how their system compares.

MEMORY

In the rare instance we're reviewing a new type of memory, or an exceptionally different memory kit, we use the SiSoft Sandra memory benchmark, which has been used by memory makers for over two decades.

STORAGE

We use Anvil's Storage Utilities to storage, as this synthetic benchmark was built specifically to test the performance of today's hard drives under a wide range of conditions. When necessary, we'll also use the PCMark 8 Home benchmark to provide extra information.

BATTERY LIFE							HOURS:MINUTES
HEAVY USE			2:30				
LIGHT USE						5:30	
0	1	2	3	4	5	6	

LAPTOP BATTERY LIFE

We subject laptops to two battery tests. In the light-use test, we optimise the system settings for the greatest power efficiency. We then disconnect the mains and run a script scrolling a selection of web pages until the system shuts down, giving you a realistic idea of the surfing time each laptop offers.

For the heavy-use test, we engage Windows' High Performance power profile, set the display brightness to maximum, and allow the taxing Cinebench 3D renderer to push the processor load to the limit. This gives a worst-case figure, revealing how long you can expect the battery to last under the most demanding conditions.

REVIEWS

SSD, HDD AND HYBRID DRIVES
61

Windows 10: the next chapter

MICROSOFT'S NEW OS IS TAKING SHAPE NICELY, AND THE
LATEST BUILD IS PACKED WITH NEW THINGS TO PLAY WITH

Microsoft's Next Chapter event brought a new preview build of Windows 10, allowing members of the Insider Programme to see how the OS is taking shape. The Project Spartan browser is notably absent – evidently it isn't ready for a public debut yet – but there's plenty else to see in terms of tweaks and new features.

CLEANER LOOKS

On installing Build 9926, you'll spot a few visual changes. The taskbar icons have shrunk, making it easier to see the underline effect that shows which applications are open. Explorer windows gain a cleaner look, with simpler minimise, maximise and close icons, as well as more minimal back and forward buttons.

Tablet-style apps and PC Settings (now just called Settings) pick up on the same theme, as does a new beta release of the

Store app. Both sport tasteful redesigns that make use of familiar elements such as tabs and icons; writing on the Windows blog, Insider boss Gabe Aul described this as "a new visual design, which will be common across PCs, tablets, phones and the web", and it's definitely a step forward from the unstructured look of Windows 8.

Not all the aesthetic changes are a success, however. The new folder icons in Explorer are ugly, and while it's clever that recently accessed folders now add themselves to the quick-access list in the Navigation pane automatically, the big, grey icons that indicate pinned items here are hardly elegant.

One more major upgrade to the front-end comes in the shape of the Notifications panel. Previously, this was a bare box listing recent pop-ups, but it's grown into a proper sidebar, with entries neatly shown in either grey or black to indicate with which you can interact. At the bottom sit quick-access buttons for various settings, switching into tablet mode or quickly connecting to Bluetooth audio devices and Miracast displays. It's a coherent replacement for the multiple sidebars of Windows 8.

At first glance, the Start menu looks much like that of previous builds, with application icons at the left and tiles at the right. However, rather than expanding

> The Start menu now scrolls, and optionally expands
  into a full-screen interface

sideways as you pin tiles and apps, the menu now keeps a consistent width and scrolls up and down – a far more manageable arrangement.

Search behaviour has become a bit muddled, however. You can still hit the Windows key and type to locate applications, documents or online resources – but to reflect the idea that all searches now go through Cortana (see Hey, Cortana, right), your results now pop up from the search field and sit awkwardly over the top of the Start menu. For a neater experience, you can press Windows+S to access the search box directly, but we preferred the way Start and search used to work together seamlessly.

WINDOWS 10 ON A TABLET
One final update to the Start menu is a new toggle that expands the tile-based interface into full-screen mode. This view replaces the old Start screen: rather than switching between two different launchers, you now get only one menu that scales up and down to suit either desktop or tablet use. It's an eminently sensible way to accommodate different usages: the only question is why Windows 8 didn't do this in the first place.

The other big change for tablet users is the quiet removal of the charms bar: swipe in from the right and you now get the Notifications sidebar instead. Frankly, we're happy about this – the charms were never a particularly quick or intuitive way to get things done. Similarly, Modern apps – as Windows 10 still calls them – now offer a streamlined set of controls in windowed mode, with a proddable button to switch to full-screen view at any time.

Once again, the only letdown is search. In tablet mode, the onscreen keyboard squeezes the results box into a tiny space,

HEY, CORTANA

The latest build of Windows 10 includes the desktop debut of Microsoft's "personal digital assistant", Cortana. Officially the feature is, for now, US-only, but you can enable it in the Australia by changing your region and keyboard settings. Without the Spartan browser – which Cortana uses to learn about you and make browsing suggestions – there's a limit to her usefulness, but you can still get a taster of the idea.

You can access Cortana by typing queries into the taskbar search field, but the real focus is on voice commands, which you can issue by clicking the microphone icon – or, in the optional always-listening mode, by using the key phrase "Hey, Cortana". You can carry out web searches, search for documents (using the somewhat unintuitive "show me" phrase), ask about a variety of topics – from the weather forecast to facts such as "What's the longest bridge in the world?" – and set reminders. At present, however, you can't use voice to create appointments or take notes.

Unfortunately, the speech interface is patchy. The "Hey, Cortana" key phrase isn't

always registered, and when it is, Cortana sometimes doesn't listen for long enough, resulting in half-recognised questions. Another problem is the quality of Cortana's voice recognition, which simply isn't as accurate or reliable as Apple's or Google's. It's particularly weak at recognising names and other non-dictionary words, which can make searching the web infuriating. Overall, we can see Cortana's potential as a rival to Google Now and Siri, but there's a lot of work to be done if it's to become a really useful and usable part of Windows.

restricting the number of visible results and making them fiddly to select. We hope Microsoft keeps working on this aspect of things ahead of the final release. Windows 10 isn't just about PCs and tablets. It's coming for smartphones too, with a new look and feel to match the desktop OS, and support for the new universal app framework, which allows Modern apps to run on both phone and desktop devices. As with the desktop platform, Microsoft plans to release a preview smartphone build to the public in the coming months – suggesting that the final release might come as an upgrade for current Windows Phone 8.1 users.

Interestingly, Windows 10 also integrates

with the Xbox One console: a bundled app lets you access your Xbox friends list, achievements, activities and so forth, and in the final release it will also be possible to stream games from the console to any Windows 10 device. The console itself, meanwhile, will be able to run universal apps – part of a clever joined-up strategy to attract developers to the Windows Store by growing the potential market.

VERDICT
This latest build shows Windows 10 starting to develop a personality of its own. Not everything is fully realised, but the new OS no longer feels like an iteration of Windows 8 – at this point it's more like the antidote to that OS, pulling off a genuinely harmonious marriage of desktop and touch-operation modes, while managing to remain fluid and intuitive in both modes.

Which is just as well, since this latest build of Windows 10 carries particular significance: it's the first to emerge since Microsoft announced that upgrades within the first year of the official launch will be free for users of Windows 7 and 8 (excluding Enterprise versions). That means a lot of previously ambivalent customers will suddenly be eyeing up Windows 10 as their next OS. To an extent, Microsoft's fate hinges on whether or not they like what they see. Happily, the signs are that development is continuing down the right track to win back those hearts and minds.
Darien Graham-Smith

∨ Pressing Windows and then typing to search results in an ugly collision of interfaces

∨ The updated Settings app provides another look at Microsoft's ideas for a cleaner aesthetic

Dell Venue 11 Pro 7000

DELL SPRUCES UP ITS SUPERB 10.8IN BUSINESS TABLET WITH INTEL'S CORE M TO CREATE THE BEST BUSINESS TABLET YET

The Venue 11 Pro 7000 won't win any awards for groundbreaking design. Dell has barely deviated from the format of previous Venue 11 Pro models, save for moving a few ports around the tablet's edges, and it's fair to say the look remains more "functional business tool" than "funky Windows hybrid"; between this and the Microsoft Surface Pro 3, there's no contest in terms of looks.

It's well built, though. At 757g, it's light enough to wield in one hand, and the rubberised plastic rear stops it slipping. It feels like a quality device, and, if our Venue 11 Pro from last year is anything to go by, it should be more than capable of surviving day-to-day knocks and scrapes.

As ever, the Venue 11 Pro's high point is its Full HD display, which gives the Surface Pro 3 a run for its money. Maximum brightness is down on last year's model, but 398cd/m^2 is still bright enough for outdoor use, and a contrast ratio of 886:1 ensures images have plenty of pop. Colour is good, too: the Dell's IPS panel covers 91.7% of the sRGB colour gamut with a decent level of accuracy. The only sticking point is that greyscales are tinted with a slight greenish cast.

Behind the display, a dual-core Intel Core M processor now takes pride of place. Gone are the ultra-low-voltage Y-class Core i3 and Core i5 Haswell chips of previous models: instead the device is

∨ The Haswell chips of old have been replaced with Core M processors

equipped with a 800MHz Core M-5Y10 CPU. That speed may sound fairly slow, but the Core M-5Y10 boosts up to 2GHz when required.

As a result, the Venue 11 Pro delivers nippy performance. Our review unit partnered the Core M-5Y10 with 4GB of RAM and a 128GB M.2 SanDisk SSD, achieving a respectable 0.56 in our Real World Benchmarks. That's a little behind the 0.59 scored by the HP Envy x2 13 (**see p42**), but the trade-off is a smaller, thinner chassis.

Battery life is good too, besting even last year's Atom-based model. With the screen set to 75cd/m^2 and Wi-Fi turned off, the Venue 11 Pro's 38Wh battery lasted 11hrs 21mins in our light-use browser test – almost an hour longer than its predecessor.

We remain impressed by the Venue 11 Pro's connectivity options, too. On the wireless front, it has dual-band 802.11ac, Bluetooth 4, Miracast and an optional 4G module. There's also video output via a micro-HDMI port, plus a single full-sized USB 3 port and micro-USB for charging.

A final nice touch – and one that IT departments in particular will appreciate – is that you can lever off the Venue 11 Pro's plastic rear to access and replace both the internal battery and the SSD. There's also an optional tablet keyboard with a secondary 28Wh battery; in our tests, this almost doubled the Venue 11 Pro's battery life.

The Dell doesn't get everything right. The Surface Pro's 3:2-ratio screen feels more comfortable in both landscape and portrait orientations, and it offers a higher resolution, too. In addition, the Venue 11 Pro provides nowhere to stash the stylus and, while the tablet keyboard

∧ Great performance, complemented by a top-quality screen and excellent flexibility. Awkward to use comfortably in portrait mode though

provides a comfy, usable keyboard and touchpad, it's annoying that you can't tilt back the display very far.

On the other hand, the Venue 11 Pro not only serves as a very likeable tablet, but it can also transform into a pleasingly compact ultraportable, and even a desktop PC replacement. Of course, the requisite accessories come as optional extras, so you'll have to shell out $109 for the tablet keyboard, while prices for the stylus and dock weren't available at review time, but it will be an additional cost overall.

Thankfully, the tablet itself isn't too pricey, especially if you can make do with a 64GB SSD.

The entry-level model throws in a slim, clip-on keyboard for $999 – comparing very favourably with the Surface Pro 3. If you're after a nippy, long lasting and multitalented Windows tablet, the Venue 11 Pro hits the mark.

Sasha Muller

BATTERY LIFE

Looping video 11hrs 21min

KEY SPECS

$999 · www.dell.com.au
Dual-core 800MHz Intel Core M-5Y10 · 4GB RAM · 128GB SSD · 10.8in 1,920 x 1,080 display · 2MP/8MP front/rear cameras · 802.11ac Wi-Fi · Bluetooth 4 · Windows 8.1 64-bit · 1yr C&R warranty · 279 x 177 x 11mm (WDH) · 757g

OVERALL

| 0 | 1 | 2 | 3 | 4 | 5 |

Toshiba Portege Z20t

SILENT, LONG-LASTING AND WITH DESIGN GEARED TOWARDS RELIABLE USEABILITY

Another Core M-based device lets us see further evidence of its advantages – and cons. Toshiba is pitching the Portege Z20t as a business device, but also hopes to sell them into schools, so it's a sturdily built device with thoughtful features.

The fanless Core M CPU allows this transformer to operate silently, and with impressive battery life. Indeed, the battery function is its most impressive feature. Both the keyboard unit and tablet section pack a battery. When running with the keyboard attached (and not connected to the mains), it draws power first from the keyboard battery, then the tablet battery

when that's drained. Conversely, when connected to the mains the tablet battery is charged first. This, so you always have the maximum possible charge for tableting. On the tablet battery alone 9 hours of operation is possible, and an impressive 17.5 hours with the keyboard.

On the downside, the Core-M's fanless design creates a lot of heat, a trend we've seen in all Core M devices so far. The hotspot is on the right rear of the tablet – exactly where your right hand falls. In gaming, spreadsheet and video tests it became very warm indeed. Never painful, but still distractingly warm.

The tablet-to-keyboard connector allows the tablet screen to be positioned facing backwards or forwards. Two large and sturdy-looking metal lugs keep it in place. It's not as discrete as other connectors, but looks to be the goods for maximum durability and strength.

A big thumbs-up for the matte screen, which shows up clearly even with bright overhead office lights.

It's available in three models (4 or 8GB

RAM, 128 or 256GB RAM), all with the same Core M-5Y71 CPU, which scaled between 800MHz and 2.86GHz (of a 2.90GHz maximum) in our testing. The dual-core Core M can't compete with an i5 or i7, and for a similar price many i5 or i7 ultrabooks beckon for your dollar. However, if a sturdy and flexible design plus silence and battery life are the priorities, it's a very impressive piece of kit.

Ben Mansill

KEY SPECS
$1672 - $2310 · www.toshiba.com.au
Intel Core M-5Y71 CPU · 4 or 8GB DDR3L RAM · 128 or 256GB SSD · 12.5in 1920x1080 touch screen · active digitiser stylus · HDMI, 2xUSB 3, 10/100/1000 LAN · Kensington lock

OVERALL

0	1	2	3	4	5

Lenovo Carbon X1

IT'S THE PORSCHE 911 GT3 OF THE LAPTOP WORLD

The review unit as supplied is the full-spec job, and in this guise it truly is a supreme business machine. There's an all-encompassing aura of luxury about the Carbon X1, which, in a world of nice looking ultrabooks, sets the Carbon X1 above the rest. Like all ThinkPads (past and present), there's a wonderful fusion of raw utility and premium styling.

There are four models available in the all-new Carbon X1 range, from a 2.2GHz non-touch 128GB version, to the full pack of meat we're testing today.

The $2669 pricetag is ballpark-average for an ultrabook of this specification, and that buys you a Core i7-5500U CPU (up to 3GHz), 8GB RAM and a 256GB SSD which is also Opal 2.0 compatible

(for better encryption). The only serious disappointment is that 8GB is the maximum memory configuration. Aside from the beautiful matt black finish, the 14inch IPS screen is the star. It's razor sharp and its maximum brightness is just right. Visibility is pretty much perfect even from almost side-on, and its boardroom or coffee table party trick is being able to fold all the way flat, so everyone can see.

It's very thin, with a tapered design that comes to a fine edge at the front (but notably not a razor sharp wrist-cutter like some) feels great to touch (not warm, but not cold like most metal-cased ultrabooks), almost silent – even under load, and the keyboard has the best feel of any I've tried in a year or more. Each key has a soft and grippy surface, not too grippy, mind you, but just right for extended accurate typing. Matching it is just about the best trackpad I've ever used. It's large, almost frictionless (a glass surface, but somehow not hard and cold) and the extra large buttons have an action

that's just plain sexy, with a lush and perfectly weighted movement.

If you want an ultrabook that's going to dazzle you every time you use it, and those around you who set eyes upon it, but has the performance and features to match its fine appearance, then this is your new ride.

Ben Mansill

KEY SPECS
$2699 · www.lenovo.com/au/x1
Intel Core i7-5500U · 8GB DDR3L RAM · 256GB Opal 2.0 SSD · 14in 2560x1440 IPS touch screen · 2 x USB 3.0 (1 x AlwaysOn), mic/headphone combo, ethernet extension connector, Lenovo OneLink connector, HDMI, mDP

OVERALL

0	1	2	3	4	5

HP Envy x2 13

HP TAKES ON THE SURFACE PRO 3 WITH ITS CORE M-POWERED TABLET, BUT CAN IT COMPETE WITH MICROSOFT'S DESIGN?

If you can't beat them, join them. That appears to be the mantra for HP with its new Envy x2 13. Where the previous Envy x2 partnered an 11.6in tablet with a keyboard dock, 2015 sees it grow into a larger 13.3in model replete with a built-in kickstand and a thin, clip-on keyboard; a design clearly inspired by the Microsoft Surface Pro 3.

If you're hoping to be bowled over by a futuristic, super-svelte hybrid, however, we suggest you look away now – this simply isn't what you've been waiting for. The main problem is that it's far too big, especially given that it's powered by one of Intel's latest Core M processors, purpose-built for thin-and-light devices.

In fairness, the Envy x2 isn't a horribly ugly thing, but HP has made some truly baffling decisions in the design department. For starters, the pair of Beats-branded speakers take up a couple of centimetres at each side of the display, and the thick bezels at the top and bottom mean that with the keyboard attached the Envy x2 is as wide and tall as most 15.6in laptops. It positively dwarfs the Surface Pro 3 and, at 14mm thick, it's

never going to win the award for slimmest Windows tablet, either.

It's difficult to handle, too. The tablet alone weighs 1.27kg, and the only real plus point of this is that the silver metal body feels pleasingly solid in the hand. But the build is too hefty for a tablet: unless you're a regular at the World's Strongest Man (or Woman) competition, this isn't a device you can hold comfortably in one hand. The presence of a sturdy, fold-out kickstand at the rear does help a little, though: it's easy to prop up the HP on a flat surface, and since it folds right back to almost flat, it's comfortable to use in tablet mode whether on a lap or a desk.

Thanks to the layer of fetching grey fabric on its underside, the clip-on Bluetooth keyboard looks smart. This clasps magnetically to the tablet and folds against the display when you need to pop it in a bag, with strong, hidden magnets holding it firmly in place. A loop along the keyboard's edge hints at stylus support. Sadly, the keyboard doesn't have a reserve battery for keeping the tablet topped up – instead, it draws its power from the tablet.

The keyboard itself is pretty good. We're not fans of the vertical strip of Page Up, Page Down, Home and End

∧ Bright display, good performance and keen pricing but middling battery life, annoying touchpad and heacy weight bring it down

buttons on the far-right edge – the arrangement makes it far too easy to press these buttons by mistake – but the widely spaced backlit keys provide just the right amount of feedback, and the soft-leather wristrest makes for comfy typing. The touchpad, however, made us thankful of the touchscreen; it's far too sensitive to taps, yet feels oddly laggy and unresponsive to cursor movements, and it often registered left-clicks when we were simply trying to scroll the mouse cursor across the screen. We can only hope that a driver update improves matters.

Otherwise, the Envy x2 suffers from several of the same usability issues as Microsoft's Surface Pro tablets. The x2 is fine on a desk: the kickstand provides an excellent range of movement, and the large keyboard and screen make for a workable substitute to a laptop. However, things go downhill rapidly once you try to use the Envy x2 elsewhere. The heavy tablet and lightweight keyboard make for an unstable combination on your lap, and the sheer size of the Envy x2 makes it a

∨ The fold-out kickstand provides a good range of movement

∨ With the keyboard attached, the Envy x2 is as wide and tall as a 15.6in laptop
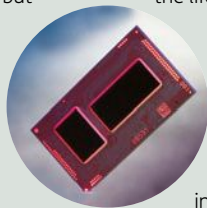
BROADWELL: NEED TO KNOW

The Core M processor inside the Envy x2 is one of the first chips we've seen based on Intel's new Broadwell microarchitecture – but it will soon be joined by a new family of fifth-generation mobile Core i3, i5 and i7 processors. Broadwell desktop chips aren't due until this summer, but anyone using a Haswell laptop right now is about to find themselves running last-generation hardware.

Does this mean your current laptop is obsolete? Absolutely not. According to Intel's "Tick-Tock" model, Broadwell is a "Tick" – a scaling down of a previous architecture, rather than a new one. Specifically, Broadwell uses the same CPU core as Haswell, but shrunk from a 22nm manufacturing process to 14nm. This brings a minor performance benefit: smaller chips generate less heat, so they can spend more time running at "Turbo Boost" frequencies before they need to slow down and cool off. But the practical effect is small: Intel's own marketing material anticipates only a 4% improvement in productivity performance over last-generation chips.

Another benefit of smaller die size is increased electrical efficiency, and that's helped in Broadwell by a new low-power audio subsystem. Intel claims its latest chips consume around half as much power as their Haswell equivalents when idle, and around 40% less power while playing video. This isn't quite as significant as it sounds, since the CPU accounts for only a fraction of a system's total power consumption. Once you factor the screen and the rest of the components into the calculation, the overall difference between Haswell and Broadwell laptops is less than 5% when idle, and a little more than 13% when watching a film.

One area where Broadwell does score significantly over Haswell is graphics. As with the previous "Tick" (2012's Ivy Bridge architecture), while shrinking the die Intel has also taken the opportunity to upgrade the GPU. In this case, a 22% increase in performance is promised – not something to be sniffed at, especially if there's a chance you might be investing in a 4K display within the lifetime of your next PC.

All the same, we'd advise against buying a new laptop purely to get your hands on the latest CPU. Even if your current PC is on its last legs, keep an eye out for deals on Haswell systems, which may well be discounted as Broadwell filters into the mainstream.

And then there's the question of what's around the corner. Broadwell was originally intended to launch last year, but was held up by the technical challenges of the new 14nm manufacturing process. Now that the process is up and running, Intel plans to get back on track by switching production to Broadwell's successor – codenamed Skylake – in the second half of this year. Since Skylake is a brand-new architecture (a "Tock"), it's likely to bring significant new features and improvements, making it a more interesting upgrade than Broadwell.

poor travelling companion.

There are glimmers of quality here and there. The Envy x2's display is great. This stretches a Full HD resolution across a 13in IPS panel, and it bursts with dynamic, punchy images. Brightness tops out at 392cd/m2, contrast reaches 1,095:1, and the panel covers a respectable 93% of the sRGB colour gamut. It's by far the HP's strongest suit.

Behind the scenes, Intel's Core M-5Y10 CPU provides the Envy x2's processing power, a chip that sounds rather frugal on paper. It runs at a base frequency of only 800MHz, boosts up to 2GHz and has a TDP of a mere 4.5W. In truth, we were primed for disappointment, after the faster-clocked Core M-5Y70 in the Lenovo Yoga 3 Pro turned in some very mediocre numbers.

Happily, the x2 confounded our expectations. In our Real World Benchmarks, the combination of the Core M, 4GB of memory and 128GB SSD turned in an Overall score of 0.59, which is well ahead of the Yoga 3 Pro's 0.45, and not far off the performance of Ultrabooks and rival hybrids with Core i5 Haswell hardware. It's clear that, with the right hardware design, Intel's Core M has a surprisingly healthy performance kick. What's more, the fanless design means there isn't a whisper of noise, even when the Envy x2 is working flat out.

Battery life is limited more by the demands of the Envy x2's display than the power-frugal CPU, but the HP acquitted itself reasonably well in our

> The heavy tablet and lightweight keyboard make for an unstable combination on your lap

tests. With the display brightness set to 120cd/m2, our looping-video test saw the Envy x2 chew through its capacity in a reasonable 6hrs 8mins. We had been hoping for more, however: given the Core M CPU, this is by no means a record-breaking performance.

The Envy x2 wants for little when it comes to connectivity. There are two full-sized USB 3 ports, one on either edge of the tablet, a full-sized HDMI output and a microSD slot. Speedy 802.11ac wireless networking is the order of the day, and Bluetooth 4 is included as well. The front-facing 2-megapixel webcam isn't stunning, but there's detail enough for video chats over Skype.

The final disappointment here is the Envy x2's speakers: although they take up a sizable chunk of space either side of the display, sound quality is middle of the road. There's plenty of volume, and enough energy to make music and movie soundtracks listenable, but there's a harsh quality to the sound that made several of our test tracks sound edgy and thin, and the lack of low-end and mid-range warmth sees basslines almost disappear. We expected far better.

After a few days with the Envy x2, we kept returning to one question: what is it actually good at? It's too big and unwieldy for a tablet we'd want to use with any regularity, and the clip-on keyboard is borderline impossible to use on your lap, or in most situations when you're travelling. The Envy x2 is most at home when it's sitting on a desk, but even in this scenario we found the touchpad to be a regular aggravation.

It's a shame, because the excellent display and solid performance tick two important boxes, but the $1349 price doesn't help against the Surface Pro 3, which costs $1209 for the i5/128GB model, although that's without the keyboard. Overlooking the pricing, though, the HP's flaws make it impossible to recommend; for a device that promises the best of both worlds, the Envy x2 delivers neither.

Sasha Muller

BATTERY LIFE

Looping video
9hrs 12min

KEY SPECS

$1349 · www.hp.com
800MHz Intel Core M-5Y10 · 4GB RAM · 128GB SSD · 13.3in 1,920 x 1,080 touchscreen · 2 x USB 3 · HDMI · 802.11ac Wi-Fi · Bluetooth 4 · Windows 8.1 64-bit · 1yr RTB warranty · 355 x 216 x 14mm (WDH) · 1.27kg (1.83kg with keyboard)

OVERALL

| 0 | 1 | 2 | 3 | 4 | 5 |

Samsung Gear VR

A REAL EYE-OPENER, BUT IT'S STILL EARLY DAYS
FOR CONSUMER-GRADE VIRTUAL REALITY

The concept of virtual reality has arguably been around for as long as computers themselves – but a really persuasive implementation has always seemed frustratingly out of reach. Now, though, a host of companies are introducing new technologies that promise to immerse you into the digital world, and the Gear VR is the first fully realised product of this new generation.

For such a pioneering product, the Gear VR makes an unassuming first impression. It's made entirely of white plastic, and has the appearance of a rather bulky pair of ski goggles. You may also be surprised to find that the Gear VR lacks a display of its own: similarly to Google's Cardboard concept, it works in conjunction with a Galaxy Note 4 smartphone, which clips on at the front of the headset. Internal lenses then focus your vision onto specific areas of the screen.

Controls are minimal: a wheel on top of the headset adjusts the focus, and there's a pair of volume buttons on the right, alongside a capacitive touchpad and a back button. A sensor inside the goggles detects when you've removed them and turns off the screen.

HOW IT WORKS

While the Gear VR looks fairly basic from the outside, as soon as you don the headset you'll realise a lot of clever work has gone into it. Using a series of gyroscopes – technology licensed from Oculus VR, the Facebook-owned organisation behind the much-hyped Oculus Rift headset – the Gear VR tracks your head movements in real-time, providing a seamless and completely immersive VR experience.

To see just how good it is, you only have to play with one of the supplied 360-degree apps. Our first try was with The Blu VR, an educational "video" that flies you through a seascape, allowing you to look around freely as you go. The experience of following a killer whale as it drifts along, or a shark as it swims past, is enough to convince us this technology is here to stay. Anything that can cause normally articulate editor-in-chief Ben Mansill to blurt out "that's amazing" like a hormonal teenager has to be pretty good.

This isn't where the Gear VR's talents end, either. It's possible to play games, view static (but immersive) 360-degree photographs, and even watch standard 3D and 2D movies via the Oculus Cinema app. The latter isn't as daft as it sounds: the app places you in a virtual seat in a virtual cinema, allowing you to watch the movie as comfortably as you'd expect. Since the screen doesn't follow your gaze as you glance around, it's completely convincing, and the viewing experience feels remarkably natural.

Some of this content is supplied on a microSD card, which comes with the headset, and you can download further apps, games, photos and videos from the Gear VR's store app. Not all of it is inspiring, though: Milk VR's 360-degree videos are effective but rather boring, while the games are mostly lightweight "look, shoot and explore" affairs. One of the more developed offerings is Temple Run VR: this looks great, but after five minutes of running and jumping through its virtual world we were reaching for the sick bucket. Perhaps not all games are suitable for the full VR treatment.

Such issues aside, there's enough here to provide a tantalising insight into what future VR content might look like. A more developed version of The Blu VR, for instance, would be a revelation in an educational environment. With the ability to pause the action, zoom in on a particular creature and launch a floating information panel, it could create a new genre of immersive pedagogic tools.

The cinema is another taster of things to come: why sully your minimalist designer living room with a huge 100in telly, when all you really need for the home-theatre experience is a Gear VR strapped to your noggin and a pair of decent headphones?

Our only caveat here is that, for now, the image isn't sharp enough. The Note 4's 2,560 x 1,440 screen resolution is exceptionally high by smartphone standards, but split it into two and stare at it from an inch away and grain is clearly visible, especially around the edges of text, buttons and graphics.

Still, in time, as the pixel density of LCD panels rises inexorably, we can see VR becoming a genuine alternative to static TVs and projectors for big-screen viewing.

VERDICT

It's clear that the Gear VR is an early-adopter device. The fact that it can only be used with one type of smartphone inevitably limits its appeal, and any consumer VR system hoping to win over the mass market will need a more developed content library than what's currently on offer – not to mention a sharper resolution.

We must also mention some specific niggly problems with the Samsung hardware. Sometimes we struggled to position the headset so our eyes could focus comfortably on the display (mounting the goggles high up on your face seems to provide the best results), and since there's little ventilation, the lenses tend to fog up in use, rather ruining the effect.

Overall, though, the Samsung Gear VR is a fabulous piece of kit. It's a truly impressive technical achievement, good enough to convince us that within a couple of generations virtual reality will be a true mainstream technology.

And for now, it's an exciting glimpse of the future – one that, if you're curious, and happen to own the right phone, can be yours for a mere $249.

Jonathan Bray

KEY SPECS
$249 · www.samsung.com.au

OVERALL

| 0 | 1 | 2 | 3 | 4 | 5 |

Raspberry Pi 2 Model B

THE NEW SLICE OF RASPBERRY PI IS THE SWEETEST YET

Packing a shiny new quad-core powerplant, the little Raspberry Pi 2 is ready to do big things. The Raspberry Pi is a palm-sized computer with the bare essentials. It's dirt cheap but you need to supply your own keyboard, monitor, mouse and 5V power supply, along with a microSD card to store the operating system. This barebones PC is aimed at those who like to tinker – what it lacks in accessories it makes up for in potential.

We've seen several hardware revisions, but the Raspberry Pi 2 Model B is the biggest leap yet. It packs 1GB of RAM, double that of its predecessor the Raspberry Pi Model B+, but the most significant upgrade is the new quad-core 900MHz ARMv7 processor. All for the same price as the very first Pi.

Not only does the new Pi deliver more grunt, but the move from ARMv6 to ARMv7 architecture allows it to run a wider range of Linux operating systems and applications, with better Ubuntu support. It's even getting a free version of Windows 10 from Microsoft.

The Pi 2 features the same connectors as the B+, meaning you can use existing cases and accessories. Unfortunately the ARMv7 processor upgrade has fragmented the software ecosystem.

Linux distros designed for previous models won't run on the Pi 2 without modification. In many cases it's as simple as downloading the ARMv7 kernel and modules via the command line, but you're still using the ARMv6 "userland" – the applications and other things which aren't part of the kernel. The Pi 2 can handle this but to get the most from the new hardware we'll need new distros with a userland compiled for ARMv7.

Raspbian Linux, an optimised version of Debian, has been upgraded for the Pi 2 but – as we went to print – it still relied on the ARMv6 userland. You'll also find upgrades to some purpose-built Linux distros like the OpenELEC media centre.

There are niggling issues which will take a while to iron out. For example, when the Pi 2 was released the RPi.GPIO Python Library hadn't been upgraded – which was a problem if you relied on the GPIO pins to support joysticks for a retro arcade distro like Raspicade. Raspicade's two-player version of Adafruit's Retrogame joystick utility also required tweaking, plus you needed to disable the startup splash screen or the Pi 2 wouldn't boot. These problems should be sorted by the time you read this, but you might run into similar issues if you rely on other specialist distros.

The wait for updates to your favourite distros isn't too high a price to pay when you look at the performance boost over last year's Raspberry Pi B+, which packed a single-core 700MHz processor and 500MB of RAM. Fire up Raspbian's Epiphany web browser and the Pi 2 is 3.4 times faster than the old Pi B+ when pitted against the SunSpider JavaScript benchmark.

This shellacking comes from just one of the Pi 2's four processor cores. Turn to benchmarks which unleash multi-core architecture and the Pi 2 is around six times faster than the B+. You can see the performance boost with the naked eye; it boots Raspbian in around half the time and it's a similar story when launching desktop applications. We should see a further boost from new distros built on both the ARMv7 kernel and userland.

Of course one of the Raspberry Pi's great strengths is overclocking support, letting you push it to the limit. Bump up the old Pi B+ from 700MHz to 1000MHz, with a few other performance tweaks, and SunSpider says it's still only half as fast as the stock-standard 900MHz Pi 2. Overclock the Pi 2 to 1100MHz and you'll see a 20 percent performance gain.

So what's the benefit of that extra grunt? If you're running arcade/console emulators you can play more demanding games, perhaps tweaking the CPU/GPU memory split to support the graphics. Media centre software with a graphics-heavy interface will also lap up extra RAM. Meanwhile servers always appreciate extra grunt, whether they're streaming multimedia, serving files or driving Minecraft.

The performance jump also makes the Raspberry Pi 2 more feasible as a basic Linux desktop PC. We'll have to wait and see with Windows 10, but it's likely to be a stripped-down ARM-friendly version following in the footsteps of Windows RT.

All up you get a lot of bang for your forty bucks. After several incremental upgrades, the Raspberry Pi 2 is a big leap forward which certainly broadens its horizons.
Adam Turner

KEY SPECS
$41 · au.element14.com
Quad-core 900MHz ARM Cortex-A7 · 250MHz Broadcom VideoCore IV · RAM: 1GB (shared with GPU) · microSDHC · four USB2.0, 10/100 Ethernet, 40-pin GPIO · Audio in: I2S digital (via GPIO) · 3.5mm audio/video jack, HDMI, I2S digital (via GPIO) · Video in: 15-pin camera interface · HDMI, composite (via audio/video jack), 15-pin display interface

OVERALL

| 0 | 1 | 2 | 3 | 4 | 5 |

3D SPEED ■MINIMUM ■AVERAGE

GRID (2880X1620)	49FPS	59FPS
GRID (1920X1080)	60FPS	74FPS
THEIF (2880X1620)	29FPS	39FPS
THEIF (1920X1080)	38FPS	58FPS

0   25   50   75   100   125

Gigabyte P35v3

PURE GAMING POWER FROM GIGABYTE

Times have changed for gaming laptops. As one of the strongest growing segments of mobile computers, we've seen the back-breaking, battery-devouring, plastic-encrusted beasts of the past evolve over the last couple of years into thinner, lighter, faster creatures that could easily be mistaken for the tool of a businessperson. Gigabyte's P35v3 is the perfect example of how far gaming laptops have come, though the powerful hardware within means it's not the kind of machine that can roam all day without a power plug in sight.

Measuring just 21mm at its thickest, and tipping the scales at 2.3kg, it's dramatically skinnier and lighter than the heavyweight bruisers of the past. It's still relatively large thanks to the 15.6 inch display, which crams in a seriously high resolution of 2880 x 1620, but this is an optional extra; a more affordable version uses a 1920 x 1080 display instead. While we love the crisp image provided by this display at the desktop, it's problematic when it comes to games. The P35v3 packs some serious mobile GPU power, but even twin desktop GTX 980s will struggle with such a high resolution. This makes the 1080p option arguably the better buy for those who plan to spend more time playing Call of Duty than answering emails in Outlook.

The chassis is built primarily from aluminium, with a plastic base, and feels reassuringly solid. It does tend to get a little warm while gaming, but that's to be expected when you're packing top of the line hardware in such a slim package. The keyboard feels nice and stiff, and has backlighting for use in dim gaming dens, while the touchpad is accurate and responsive.

A huge range of I/O ports adorn each side, with twin USB 3.0 ports backed up by another two USB 2.0 ports. Three video options are provided in the form of HDMI, D-sub and a Mini-DisplayPort, allowing this thing to power basically any external display imaginable. An SD card reader is also included, along with headphone and microphone ports. Finally, Gigabit Ethernet is supplied via the single RJ-45 port.

Heading into the guts of the machine reveals why it can command such a premium price. At the heart is Intel's i7-4710HQ CPU, a quad-cored, HyperThreaded brute that ramps up to 3.5GHz when the going gets tough. This is paired with 16GB of DDR3 memory running at a brisk 1866MHz, more than enough for even the most demanding applications. Long term storage is similarly impressive, with the base model including twin 128GB SSDs in RAID 0 mode, backed up by a sizeable 1TB mechanical drive spinning at 7200RPM. There's even a DVD burner that can easily be removed to install other devices in its bay; just unlock the locking mechanism and it slides right out.

So far so good, but it's this laptop's GPU that is of most interest. Nvidia's shiny new GTX 980M GPU is tasked with driving the behemoth of a display, and it's based on the latest Maxwell architecture. This comes with 1536 CUDA cores along with 64 ROPS, fed by a 256-bit memory bus. This places it somewhere between a GTX 960 and GTX 970 desktop part, more closely to the latter.

As we know from the desktop piece, this is a powerful piece of hardware, as borne out by our benchmarks. Due to the sheer power on offer, we ran our usual gaming benchmarks with desktop settings instead of the usual lower-detail laptop options, as this machine has the grunt to handle it. We also ran them at the native resolution of 2880 x 1620, which showed that this machine doesn't have quite the muscle to deliver a stable 60fps with all settings maxed at such a ludicrously high resolution, hence our recommendation to go with a 1080p display.

There is a price for this performance, with relatively loud fan noise whenever games were played. Gigabyte's software allows this to be tamed, but doing so will decrease performance. Battery life is also not this machine's strongest point, measuring just 165 minutes. It's the price to be paid for having so much power on tap.

Despite the low battery life, this laptop really is hard to fault. The inclusion of a cutting edge GPU is backed up by equally impressive specs across the board, all presented in a slim, subtle case.

Bennett Ring

KEY SPECS
$2799 · www.gigabyte.com.au
i7-4710HQ CPU (to 3.5GHz) · 16GB DDR3 · 2 x 128GB SSDs · 1TB 7200rpm HDD · GTX 980M GPU · 2.3kg · 15.6inch 2880x1620 display

PCMARK 8
Home Accelerated Benchmark: **3429**
Home Accelerated Battery Benchmark: **165 minutes**

OVERALL

0   1   2   3   4   5

Asus MX27AQ 27" WQHD Monitor

THIN AND MODERN LOOKING MONITOR, WITH A QUALITY PANEL TO MATCH

There's a plethora of 27inch monitors on the market and Asus has thrown another one into the mix with the MX27AQ. This model is part of Asus's Designo MX series of monitors, bringing a 27inch WQHD unit to replace the MX279H, a 27inch HD display.

The MX27AQ is a strikingly good looking monitor. Even when turned off, thanks to a narrow bezel, brushed metal chin and thin panel, it has a modern appearance. The thin bezel would be fantastic for those wanting to use it in a multi-monitor setup, but unfortunately there is no VESA mount. The included stand only allows the monitor to tilt forwards and backwards, there's no height adjustment.

Luckily when on, the display is top notch. 100% sRGB colour reproduction, excellent 178 degree viewing angles and a lovely high resolution of 2560x1440. Be sure to turn off the VividPixel feature, which over sharpens text to the point of illegibility.

There's one DisplayPort connector and 3x HDMI ports. One of those HDMI ports supports MHL, so your mobile devices can enjoy the big screen too. No USB ports or a card reader on the MX27AQ. That's the price you pay for such a 6mm bezel.

Asus includes a weird feature called QuickFit on this monitor. Using the monitor's on screen display, it provides a grid which aligns to traditional paper sizes (A4, 6"x4" photos, etc.) so that you can resize your windows or images to be at this size. I'm not sure how useful it is, but it's there for you to use if need be.

The Asus marketing material touts that the built in speakers were co-developed by Bang and Olufsen, but there's no real evidence of that when using the speaker. It's no better than the usual audio quality built in monitor speakers put out.

This is a smart looking monitor with a great quality panel to match. The lack of VESA mounting will bother a few people, but if you need your monitor to look good on the desk as well as display a quality image, the MX27AQ might be for you.

Anthony Agius

Asus PB279Q 27inch 4K UHD Monitor

3840X2160 PIXELS, IPS PANEL AND 100% SRGB COLOUR ACCURACY - FOR A PRICE

Asus was one of the first manufacturers to release affordable 4K UHD monitors and the PB279Q is the latest, measuring 27inches diagonally and packing a resolution of 3840x2160 pixels. The IPS panel in the PB279Q is LED backlit, capable of 10-bit colour and has 100% sRGB coverage.

No surprises then, that it looks wonderful. Colours are rich and deep, with no banding. Text is crisp with no jagged edges. Great viewing angles too thanks to the IPS panel. Whilst it has a slightly glossy display, it is not glass, so reflections are kept to a minimum. 100% sRGB coverage will be of interest to photographers and others doing colour accurate work.

The PB279Q has a pivot stand that allows you to place the screen in portrait mode. It also swivels left and right -- handy for showing your display to others.

For taller people, this monitor extends high, helping keep your back straight.

Inputs galore on the rear: 4x HDMI 1.4 ports, supporting MHL. The four HDMI ports let you take advantage of the Picture-in-Picture and Picture-by-Picture features, placing up to 4 HDMI inputs on screen simultaneously. Oddly, there are no USB ports.

As with all 4K monitors, there are caveats. First, your computer needs support 3840x2160 @ 60Hz over DisplayPort. The HDMI ports on the PB279Q only do 30Hz at 4K – even if your computer has HDMI 2.0, you still need to use DisplayPort 1.2. The second gotcha is using this monitor with Windows. The native 3840x2160 resolution is tear-inducing, as text becomes microscopic on the 27inch panel. You can scale text in Windows, but not all applications support it and it's generally a frustrating experience.

With a street price of around $1000, it is more expensive than other 4K UHD monitors, even with its IPS panel and 100% sRGB colour reproduction, it looks great, but it's hard to justify over the Dell P2715Q which is cheaper and has very similar specs, better warranty and more features.

Anthony Agius

Asus Z97-A USB 3.1

SUPERSPEED+ LANDS AT LAST

It seems like only yesterday that USB 3.0 became a standard feature on Intel motherboards. It's actually been a year and a half since Intel introduced it to the Z87 chipset, but the specification was actually created much earlier, back in 2008; Intel simply took its sweet time to integrate it into its chipsets. This is probably why the introduction of the new USB 3.1 standard feels a little premature, yet the standard has actually been around since 2013. We've just received the first motherboard to include the new USB format in the form of the Asus Z97-A USB 3.1. Let's see just how fast the new connection is, and determine whether or not its time has really come.

USB 3.0 drives are referred to as SuperSpeed drives, while the newer 3.1 devices are labelled as SuperSpeed+ products. Its theoretical maximum speed is 10Gbit/sec, which puts it on par with the Thunderbolt specification. We all know how popular that format turned out to be; introduced back in 2011, Thunderbolt is still a very niche standard that hasn't found its way outside of video editing suites or image designer dens. At this speed it has twice the theoretical performance of USB 3.0, which is nothing to sneeze at. Backwards compatible with both USB 3.0 and 2.0, the existing implementation on the Asus board has a Type A port that looks identical to the usual USB 3.0 and 2.0 ports found on today's boards. However, a new Type C USB connector is due in the near future that will be half the size of today's Type A USB ports and which can be inserted in any orientation. The fact that there is a new connection type due for USB 3.1 in the near future is worrying for the Asus Z97-A USB 3.1 board, as its older Type A USB port connections won't be of the sexy new variety. Having said that, adaptor cables will be available that allow the ports on this motherboard to function with external drives packing Type C connectors.

One caveat of USB 3.1 is that it's powered by two PCIe 2.0 lanes, worth noting if you're going to be packing several devices that require the use of PCIe lanes. For example, a PC armed with twin GPUs and an m.2 SSD along with several add-on cards might not have enough PCIe lanes to go around. Although this is a rather extreme example, it's definitely a consideration for prospective buyers.

ASMedia has long been the driving force behind new USB standards, so it's no surprise to see that USB 3.1 is delivered here courtesy of the ASMedia ASM1142 host controller. The rest of the board appears identical to the Asus Z97-A, so we're only going to focus on its USB 3.1 performance. ASMedia's marketing material claims real world performance of around 800MB/sec, so we were very keen to see what the port could do.

To test the USB 3.1 ports requires the use of an external drive also packing a USB 3.1 connection, which arrived in the form of a prototype external drive supplied by Asus. To deliver the high speeds required by USB 3.1, the drive includes twin mSATA drives connected in RAID 0 mode. Unfortunately pricing for this prototype wasn't available, but the fact that all external USB 3.1 devices are going to need similarly powerful hardware suggests that external USB 3.1 drives are going to be extremely expensive.

We used Crystal Disk Mark to test the performance of the drive, copying 4GB of data five times to reach an average overall speed. Sequential read performance measured in at a blistering peak of 691MB/sec, while sequential write was almost as fast, at 685MB/sec. To compare this with USB 3.0 performance, we then plugged the prototype drive into the Intel-powered USB 3.0 ports. Sequential read performance clocked in at 429MB/sec, while sequential write measured 430MB/sec. It's not quite the doubling in performance promised by the standard, with read speed 61% faster, while write speed was 59% faster.

There's no denying that USB 3.1 is a speedier connection type than USB 3.0, and for supported devices and requirements it's here now. But there's the issue of this board using older Type A connectors, which are set to be replaced by Type C in the near future. There's also the fact that this board will retail for around $70 to $100 more than the identically specced Z97-A. Asus informs us this price difference is a result of having to import the newer boards on a weaker Aussie dollar. While the motherboard overall is a top shelf product – with or without USB 3.1 – you may want to stick with the regular Z97-A and purchase a USB 3.1 add-on card if the economics make that the cheaper option at purchase time.

Bennett Ring

KEY SPECS
$299 · www.asus.com.au
Intel Z97 chipset · 4 x DDR3 3200MHz · 2 x PCIe 3.0 x16 slots · 1 x SATA Express · 1 x M.2 Socket · 4 x SATA3

CRYSTAL DISK MARK
4GB file copy on USB 3.1: **Sequential Read = 691MBs/sec**
4GB file copy on USB 3.1: **Sequential Write = 685MBs/sec**

OVERALL

| 0 | 1 | 2 | 3 | 4 | 5 |

Labs Briefs

Cougar 500K

www.cougar-world.com - $89

This keyboard is the work of the Devil and I don't like it at all. Lifting the new Cougar from its box for the first time, one of the keys fell off. The plastic attachment bits weren't broken, but it won't stay put no matter how hard I fiddle to get it back in its place. Factory QC fail, right there. Next infuriation is the apparently clever split space bar. Being a gaming keyboard, and with WASD use in mind, half the spacebar is a macro key. But its function can't be restored as a regular space bar, so heaven help you if you use your right thumb when typing for space, becauseallitwilldoisthis.

The keys feel loose and clacky, though they are nicely raised. But it's a $90 membrane keyboard. For just $20 more even the mechanical Razer Blackwidow Stealth is vastly superior in all respects.

Ben Mansill

OVERALL

0   1   2   3   4   5

Corsair K65

www.corsair.com - $99

Corsair went keyboard crazy through last year, with a great many variations on its K-series mechanical product. At the opposite end of the maniacal full-bling K95, replete with millions of cycling disco colours, is the wee K65, and I really like it.

It has the same super sexy black brushed aluminium top plate, three levels of brightness – all of which are too bright, but you get used to that, I've found, plus a mute music button, volume and a Windows key lockout selector.

But, as you can see, it's little, and that's no small thing. 10 keyless keyboards, as they're inelegantly called, give you back some desk space at the cost of a little versatility. You know your computing habits – if you never use the numpad then you may as well save money and a fistful of desk space. The K65 uses only Cherry Red switches, so that means a mildly clacky and slightly spongy feel.

Ben Mansill

OVERALL

0   1   2   3   4   5

Gigabyte Force H1

www.gigabyte.com.au - $139

While initially pitched to us as 'mobile gaming headphones', which the product website also reinforces, these wireless Bluetooth cans offer a lot more versatility. Indeed, the packaging, when it arrived, has barely a mention of gaming. But of course, if you game hard on your mobile or PSP...

For $139 or so they're quite good value, regardless of how you'll use them. They're unusually comfortable for an over-ear model, but I couldn't go for longer than an hour or so before discomfort took hold.

Bluetooth pairing was effortless, as it should be. What shines is the audio quality, which is a fairly neutral sound and nicely detailed. A bit bass-heavy, but only barely. These would be a good choice for media consumption on a mobile device.

Ben Mansill

OVERALL

0   1   2   3   4   5

audio technica ATH-ADG1 and ATH-AG1

www.audio-technica.com - $319

These two lovelies are audio-technica's (currently available) top of the range gaming headphones. They're technically identical, both with 53mm drivers, but the ADG1 is an open-back design, and the AG1's are a closed design. This makes the ADG1's better, in my opinion, sound is less boomy, you can hear yourself talk over game comms, and the ADG1's also have a soft material cushion cover where the AG1's have a sweat-inducing soft plastic.

Sonically they're both extremely good, delivering a clear and crisp sound for music and gaming. Thing is, they're only marginally better than the audio-technica PDG1's (reviewed last issue), which are $140 cheaper. Still, better is better, and it's fair to say that the ADG1's are among the very best gaming headphones available, period.

The only negative is the spring-loaded head clips, which just don't hold it in position so they slip down. A rubber band fixes

PC &TECH AUTHORITY RECOMMENDED

OVERALL

0   1   2   3   4   5

Minitar Wireless AC repeater/AP router

www.minitar.com - $69.95

Functioning in both 5GHz and 2.4GHz bands, this 802.11ac/b/g/n device scans your network for any and all Wi-Fi signals, and once you have entered your network password, it's up and running.

The Minitar Wireless AC repeater/AP router is intended for areas where the Wi-Fi reception fades before you'd like it to. This could be a large open space or a home, and the power plug design should be a real space saver. With no line of sight obstacles, a range of around 300m should be possible, and about a third that for most indoor areas.

Because it's a modem, too, LAN and WAN/LAN ports are included plus a WPS button and a reset switch. Using 802.11ac, speeds of up to 433Mbps are claimed. That drops to around 300Mbps using 802.11n.

Ben Mansill

OVERALL

0 1 2 3 4 5

Sandisk iXpand Flash Drive

www.sandisk.com.au - $129 (32GB), $179 (64GB)

This is a little more than a simple USB 3.0/Lightening data transfer and storage device. Its first trick is packing a small battery into the unit, so extended use via Lightening won't need the iPhone or iPad's battery.

The main draw card, though, is its media playing capabilities. When used in conjunction with the SanDisk iXpand Sync app it will play media stored on the device, which is its primary function. File types not commonly supported on an iDevice such as MKV and FLAC are perfectly playable via the iXpand.

Another wee plus is the flexible rubber arm housing the Lightening connector. There's no chance any accidental bending will break this and damage the device or your iPad/Phone. On the downside, a small battery LED gives no indication of power remaining, only that it's operable, or not.

Available in 32 and 64GB capacities, this is just the thing for password protected and encrypted media files you want to carry anywhere.

Ben Mansill

OVERALL

0 1 2 3 4 5

Thecus W4000

www.thecus.com - $649

If this new NAS had arrived in time for our storage group test last month it would have ranked near the top. Inside an uncommonly tough (and heavy) steel case lies a motherboard running a 2.13GHz dual core Atom CPU, 2GB of RAM attached to an included SSD boot drive.

Upon that drive is Windows Storage Server 2012 R2 Essentials, an OS only available through OEM hardware, like this. It offers business grade NAS that's designed to integrate in an office environment with other cloud based services like Office 365 and Windows Azure.

This is a durable and low-risk NAS solution that should keep to a minimum the fuss involved with integration into your network. The 4-bay device is extremely well built and well worth the reasonable $649 RRP, less if you shop around.

Ben Mansill

OVERALL

0 1 2 3 4 5

EpicGear GeKKota

www.epicgear.com - $TBA

It's increasingly rare that we see an ambidextrous mouse arrive in the Labs. Especially so, when it doesn't compromise itself into uselessness through being a mostly formless lump. No, the Gekkota manages to have a sculptured shape that provides a nice thumb indent that's rubberised, and of course on the other side the same indent works to tuck your pinky finger away, all resulting in a very comfortable and stable hold.

We received a gloss white unit as well as the black, and the white by far looks fantastic. But just one gaming session showed up the drawback – it tends to encourage sweat, and when that's flowing, the grip suffers, at least in terms of the top and rear-side areas – the rubber inlays on the side still do their job well.

Ben Mansill

OVERALL

0 1 2 3 4 5

Nvidia GTX 960 Roundup:
Maxwell goes Mainstream

CAN NVIDIA'S NEW MID-RANGE CARD STACK UP AGAINST THE OPPOSITION FROM AMD – AND ITS OWN HIGHER-SPEC GPUS? BENNETT RING RUNS THE NUMBERS

Nvidia's Maxwell architecture set the premium market alight with its blistering performance at ice-cool temperatures. The fully-fleshed version of Maxwell found in the GeForce GTX 980 was fast enough to push AMD's steamy R9 290X off the top of the performance pile, yet had a Thermal Design Power (TDP) of just over half that of the R9 290X, measuring 165W vs the estimated top TDP of the AMD product of 300W.

No wonder Nvidia felt it could charge a premium for these products, with the cheapest GTX 980 now retailing for around $200 more than the cheapest R9 290X. It's a price leap that is hard to justify considering it's only around 10 percent faster. Nvidia then released a cut-back version of the GTX 980 in the form of the GTX 970, which now retails for between $400 and $500, with more expensive versions offering better cooling

and overclocking potential. This left the Maxwell architecture with one price point left to occupy – the $250 to $350 mainstream range.

Enter the GTX 960, which pares Maxwell back even further than the GTX 970 to deliver a product that is the most wallet-friendly of Nvidia's performance-oriented products. At this price it's going head to head with AMD's R9 280; does it have the grunt to put AMD's mainstream model back in its box?

THE GM206 GPU

Nvidia's GTX 460, 660 and 760 products were some of its most popular, offering true gaming performance at affordable prices. While serious enthusiasts were happy to pay the $700+ for the premium 680 and 780 products, with performance gamers shelling out $500+ for 670 and 770 cards, the vast majority of gamers are

more comfortable spending $300 on their GPU. This is the niche that the GTX 960 is targeted at, but things have changed since the prior generations. AMD's GPUs are far more competitive in 2015, and their prices have been slashed and burned. Before we strap the GTX 960 to the testbench to see if it can outpace AMD's bargain-priced offerings, let's take a look at what makes Nvidia's latest product tick.

Maxwell products aim to deliver twice the performance per Watt of the previous generation, in this case the GTX 760 (Nvidia decided to skip the 8XX series for some reason, outside of a few laptop chipsets). Yet looking at the TDP of the GTX 760 compared to the new product doesn't seem to indicate such an efficiency increase. The GTX 760 had a TDP of 170 Watts, while the GTX 960 will cause power meters to top out at 120W, which is only a 30% drop. However, the

GTX 960 is a faster product than the 760 which helps to explain why the TDP drop isn't exactly half, but it's unlikely to be double the speed.

CORE ARCHITECTURE

The chip at the heart of the GTX 960 is the GM206, which is basically a cut-down version of the chip that resides in the GTX 970 and GTX 980, the GM204. The first drop is the number of CUDA cores, the units within the Maxwell architecture that do most of the hard work. The GTX 960 has 1024 of these cores, compared to 1664 in the GTX 970. Interestingly, the older GTX 760 actually had more CUDA cores, with a total of 1152. However, Nvidia reworked the design of these cores when moving to Maxwell, and the end result is that each core is a much higher performer than the previous generation.

The total number of texture units has also been decreased, down from 104 in the GTX 970 to a total of 64 in the GTX 960. The total number of Render Output Units has suffered the biggest drop, down from 64 in the GTX 970 to 32 in the new card. Likewise with the memory bus, which has dropped from the 256-bit version found in the GTX 960's bigger brother, to just 128-bit. Thankfully it runs at the same high speed of the higher end products, with the GDDR5 memory purring along at a very fast 7GHz. However, the onboard memory

has also been cut in half, dropping to just 2GB, which could be an issue for many of today's RAM-hungry games. It's common to see especially pretty games chewing up 2.5GB to 3GB of memory when running at 1080p and high levels of anti-aliasing. Like its faster siblings, the GTX 960 takes

> ## "One of the key benefits of owning an Nvidia product is the range of added features"

advantage of Nvidia's new delta colour compression engine, which shaves off 25% less bytes per frame than the prior generation. This goes some way to making the 128-bit memory bus bearable.

HEAT, SPEEDS AND GAMES

As a result of these changes, the transistor count of the GM206 chip is just 2.9 billion, compared to the 5.2 billion found in the GTX 970's GPU. These transistors are manufactured on the same 28 nanometre process of its bigger brothers, but the reduction in number gives the card a lower TDP of just 120W, compared to the GTX 970's 145W. As overclockers know, a lower TDP can lead to faster clock speeds, which is why the base clock speed of the GTX has increased to 1126MHz compared to the GTX 970's 1050MHz. However,

Boost Clock speed is what really matters, as this is the maximum speed the chip will run at during the most demanding games, and this is equal between the GTX 970 and 960, at 1178MHz. Note that this is the Nvidia reference speed; it seems this GPU has plenty of headroom for tweaking, but more about that later.

The net result of these changes is a product that is designed to run at 1920 x 1080, whereas Nvidia's higher end products target the 1440p and 4K markets. That's the marketing spiel anyway; real world gamers will know that even the GTX 980 struggles to run certain games at 1080p with all of the graphic details maxed out, let alone 4K resolution. The latest example is Evolve, a graphically taxing game that sees Nvidia's GTX 980 delivering 40 to 50ps when running at Ultra detail with a 1080p resolution. Given this, we don't think Nvidia's claims of the GTX 960 being able to handle basically any game at 1080p at 60 frames per second is very realistic.

NVIDIA'S EXTRA GOODIES

One of the key benefits of owning an Nvidia product is the range of added features that are unique to its products. While AMD also has certain proprietary benefits, such as Mantle, overall we'd say that Nvidia's tend to be more useful across a wider range of products. The GTX 960 comes with every new feature offered by the other GTX 9XX products,

"We wouldn't recommend enabling PhysX on a product of this calibre"

and it's worth covering them to see why we favour Nvidia's features.

Tweakers have been downsampling for several years already, a process where the game is rendered at a higher resolution than that offered by the user's display. For example, it's possible to render a game at 2560 x 1440 but then display this on a 1080p display, and the end result looks like a jaggie-free image, similar to anti-aliasing. In fact, downsampling works in a very similar manner to anti-aliasing, but can be applied to DX11 games that may not natively support anti-aliasing due to their deferred rendering engines (hence why so many games now only support SMAA or FXAA). There is a catch though, as downsamping requires plenty of grunt to deliver playable performance. Also, enabling downsampling requires the user to spend 30 or so minutes figuring out exactly which resolutions could be enabled on their display, but Nvidia has simplified this with its Maxwell products.

The feature is known as Dynamic Super Resolution, or DSR, and it's taken all the hard work out of downsampling. The user simply has to select which resolutions they'd like to use in the Nvidia control panel, and then hit apply. It's a fantastic feature, but we do question whether the GTX 960 has the horsepower to handle it. It should still deliver playable performance on older games, but forget running anything like Battlefield Hardline with DSR enabled. There's also a bug in the latest Nvidia drivers that has broken DSR for many users, including the author of this piece, but we're confident Nvidia will resolve it soon.

Current Nvidia owners will be pleased to hear that DSR is backwards compatible with older products, not just Maxwell, and the same is true of the next technology, G-Sync.

G-SYNC
Perhaps more relevant to the GTX 960 is support for Nvidia's new display technology, G-Sync. Without going into too much detail, this basically allows G-Sync compatible displays to run games at lower frame rates without any onscreen slowdown or stuttering. It's good down to about 40 frames per second; any lower and the user will start to notice each frame being drawn.

There's a slight catch with G-Sync though, in that monitors supporting it are few and far between. They're also rather expensive, with the cheapest G-Sync display in Australia selling for $545... and that's a mere 24 inch model, made by AOC. Still, if G-Sync display prices do drop, this could be a killer feature for GTX 960 owners, as they'll be able to play the latest games at sub-60 frame

v Gaming laptops are speed demons, and also have application for business power users

rates, without suffering any noticeable performance issues.

MFAA
The third and final new feature offered by Maxwell is support for Multi-Frame Anti-Aliasing, or MFAA for short, and this is exclusive to Maxwell products. It's basically a new form of anti-aliasing that promises to deliver close to 4xMSAA image quality, with a 20 to 30% performance increase. When this feature first launched late last year, it was limited to just 20 games; since then, Nvidia has opened support up to every DX10 and DX11 game that offers MSAA, with the exception of Dead Rising 3, Dragon Age 2, and Max Payne 3. We tested MFAA out and were hard pressed to find much of a difference between 4xMSAA and 4xMFAA, but we also only measured a 15 to 20% performance increase. Still, that's enough to up a game's frame rates from a stuttering 50fps to a smooth, v-sync locked 60fps.

The GTX 960 obviously offers support for Nvidia's PhysX technology, but we wouldn't recommend enabling it on a product of this calibre. Even high-end GPUs struggle with PhysX enabled, so something like the GTX 960 would feel the pinch in taxing situations. However, the GTX 960 would make a very capable secondary GPU to devote to PhysX; if only there were more than a handful of games that supported it.

PERFORMANCE TO SPARE
So the GTX 960 comes with all of the added extras unique to Nvidia products, but it's also got a hidden ace up its sleeve, one that prior X60 products have shared. Due to the lower TDP, the GPU has plenty of headroom to be pushed faster than the stock speeds. Most of the following products that we reviewed arrive pre-overclocked, so even if you don't want to get your hands dirty, you'll still see the benefits of this ability. Despite having a default Boost Clock speed of just 1178MHz, we were able to push these products to speeds in excess of 1450MHz, a healthy speed increase considering it's free. The memory wasn't quite as overclockable though, peaking around 7700MHz, which is still a 10% increase.

Now that you've seen what makes the GTX 960 tick, it's time to look at six of the latest incarnations of this product to hit the market.

MSI GeForce GTX 960 Gaming 2G

A REAL HEAD TURNER

I f you're looking for a graphics card to proudly display through your case's Perspex window, this could be just what your interior designer ordered. Where Gigabyte's huge coolers are all about function over form, MSI has delivered a real head turner of a cooler, with its striking red and black design.

The Twin Frozr V has three heatpipes wicking the heat away from the GPU, but they're much longer than those found in other cards, and they appear to do a damn fine job. Even under load, this cooler remained whisper quiet, recording the lowest operating volume in the roundup at just 44dB. Like several of the other products on test, the fans don't spin up until the GPU hits a certain temperature, resulting in total silence at the desktop. However, this was while running the card in "Gaming" mode – the user can set the card to run in "OC" mode via MSI's included software.

We should point out that we tested the card in Gaming mode as well, which is probably why it didn't score the fastest in the roundup. Despite this, we think most gamers would prefer a silent graphics card versus an extra frame or two, and we're confident that enabling OC mode would see this card match the fastest in the pack.

During gaming mode the Boost Clock starts at 1253MHz, but bump it up to OC mode and this increases to 1304MHz, equal to the fastest cards in the roundup.

MSI has kept the standard range of GTX 960 outputs, with triple DisplayPort 1.2, a single HDMI 2.0 and one DVI-I. However, they've increased the power supply from a single six pin to a single eight-pin, which should help with extreme overclocks.

Our only concern with this product is the price – at $349 it's a pricey graphics card. Still, the added benefit of near silent cooling, automated overclocking courtesy of OC mode and good looks makes for a compelling package.

KEY SPECS
$349 · www.msi.com

OVERALL

| 0 | 1 | 2 | 3 | 4 | 5 |

Palit GeForce GTX960 Super JetStream 2GB

THE PRICE IS RIGHT

N ow this is where we think most GTX 960s should be priced, at just under $300. Given time we think the rest of the market will have to come down to this level, but until then this is the most affordable GTX 960 that we've tested. It's arguably not that much more affordable than some of the other cards, but it breaks through the psychological barrier of the $300 price point. Given the low price, you'd be forgiven for thinking that this think might turn in bottom tier performance numbers with a howling cooler... but you'd be quite wrong there.

As our benchmarks illustrate, this budget number turned in framerates that even the most expensive products would be proud of, basically tying with the faster Gigabyte products. Whipping out the sound meter proved that it didn't rely on a buzzbox of a cooler to do so, with its twin fan setup recording just 45dB, the second quietest cooler in the roundup.

There have been a few compromises though, which help explain the pricing. It uses the standard GTX 960 PCB, and is fed juice via a single six pin power connector. As a result, we don't think it's going to break any world records for extreme overclocking. Thankfully Palit has done all the hard work for you, with the product shipping with the fastest Boost Clock frequency of any GTX 960, at 1342MHz. The range of outputs is rather quaint though, with twin DVI-I, a single HDMI 2.0 and single DisplayPort 1.2. Those packing three shiny new displays will probably find this a turn-off, as they'd rather use three DisplayPorts to easily set up a multi-monitor configuration.

But for the rest of us, this budget-priced product delivers the goods in spades. It's got performance without compromising on fan noise, and even looks half decent. It just goes to show that you needn't spend the big bucks for top tier performance, though overclockers will soon realise this is not the card for them.

KEY SPECS
$289 · www.palit.biz

OVERALL

| 0 | 1 | 2 | 3 | 4 | 5 |

Gigabyte GV-N960G1 Gaming-2GD

THE BIG KID ON THE BLOCK

Welcome to the most expensive, most audacious GTX 960 on the market, Gigabyte's G1 Gaming GTX 960. With a price tag that is getting close to GTX 970s, at just $80 less than the cheapest GTX 970 on the market, Gigabyte's uber GTX 960 had better pull off something special to justify the high price.

Let's start with the PCB, which is obviously not of the reference variety. Measuring 240mm, it's a much larger PCB than standard GTX 960s, and we're guessing Gigabyte borrowed stock from its GTX 970 line for this product. It's supported by an even longer backplate, which helps support the massive triple fan cooler, measuring 295mm, the overall length of the product. The triple fan cooler is surprisingly quiet, coming in around the middle of the pack at 47dB.

Instead of the single six pin power connector found on most GTX 960s, Gigabyte feeds this version via twin six pin plugs, which should deliver a more consistent power supply during extreme overclocks. Gigabyte claims that the GPUs used on this range have been binned based on their ability to overclock, which will likely make this the overclocker's GTX 960 of choice. It's already received a hefty factory overclock, with the Boost Clock increased to 1304MHz. However, in use it hits a whopping 1500MHz, making this one of the most ambitious factory overclocks of the lot.

It's no surprise then that this card topped our benchmark result, even it was only by a few percent.

And therein lies the problem – unless you're a serious overclocker, the added cost is hard to justify. If you're going to spend this much, you're better off saving up for a GTX 970, which will run rings around this product. However, if you are a serious tweaker, the range of extras on this card will make the extra $60 easy to afford. Also, the addition of Gigabyte's Flex monitor output, which makes running four displays with different connections a breeze, could be reason enough for multi-monitor users to consider this card.

Balancing value and performance, our overall score is 3/5, but if you're an overclocker seeking world records, this card is an easy 5/5.

KEY SPECS
$359 · www.gigabyte.com.au

OVERALL

| 0 | 1 | 2 | 3 | 4 | 5 |

Gigabyte GV-N960WF2-2GD

GIGABYTE FLEXES ITS MAINSTREAM MUSCLE

While it might not be quite as massive as its brother, this more affordable Gigabyte product shares many of the excellent features that Gigabyte has endowed its GTX 960s with. The first is the 0dB cooler, which is used to highlight the fact that the twin fans on this cooler don't spin up while on the desktop, only kicking into action once the GPU hits a certain temperature. This makes it a great product for HTPC owners, who need the ultimate in silence while watching films.

Having said that, like its brother, this is one of the larger GTX 960s around, as Gigabyte has once again used a larger PCB than the default, measuring 240mm. However, the cooler ends at the same length of the PCB, so it's not quite the case-devourer of the other Gigabyte GTX 960 in this group test.

Another noteworthy feature is the inclusion of six outputs, which is a record for GTX 960s, and is identical to the more expensive Gigabyte card. Twin DVI-I, triple DisplayPort 1.2 and a single HDMI 2.0 port provide plenty of output options. Gigabyte's Flex technology means you don't have to stick to DisplayPorts or shell out for expensive DisplayPort adaptors to output to four displays, allowing a mix and match of the various outputs.

It's all handled automatically, so there's no need to fiddle with any dipswitches.

Once again we see Gigabyte equipping this card with twin six-pin power inputs, which should deliver cleaner power for overclocks. Speaking of which, the factory overclock of this product is a little slower than its cousin, at 1279MHz. That's a mere 25MHz less, which is basically imperceptible during games, and it should easily hit 1400MHz with a little encouragement.

Doing so is made easy with Gigabyte's excellent overclocking software, but like all Nvidia products, we expect that most users will probably use EVGA's Precision software instead.

With one of the quieter coolers in the roundup, and a respectable price, this is the Gigabyte card we'd recommend for mainstream users. It's an impressively engineered job and ticks all of the important boxes.

KEY SPECS
$329 · www.gigabyte.com.au

OVERALL

| 0 | 1 | 2 | 3 | 4 | 5 |

Asus STRIX-GTX960 -DC2OC-2GD5

SMALL IN SIZE, LARGE IN PRICE

Asus' take on the GTX 960 might come in one of the smallest boxes, but it sits towards the upper end of the spectrum when it comes to pricing. What has Asus done to the GTX 960 to justify such a high price? Not quite as much as other companies it seems.

While we don't have a reference GTX 960 from Nvidia (such things don't appear to exist in the wild), it appears that Asus has gone with the standard PCB for its product. This measures 170mm exactly, making it relatively short, but the custom heatsink extends for another 42mm beyond this, giving the card an entire length of 212mm. Asus has strapped a backing plate to the PCB, which ensures the unit can handle the huge cooler without flexing, and apparently also helps with heat removal.

The cooler uses Asus' DirectCU II design, which uses four 10mm heatpipes to drag heat away from the copper heatspreader to the large aluminium cooling fins. Like many of the GTX 960s, the twin fans on this cooler only kick into action beyond a certain temperature. Asus doesn't advertise what that feature is, but the fans remain switched off and silent while on the desktop. ASUS claims they'll also remain switched off when playing Starcraft or League of Legends, but they spun up in all of our benchmarks. As a result of the extra cooling, Asus gives this card a factory overclock, with the Boost Clock frequency increased to 1317MHz.

It's fed via a single 6-pin power plug, and doesn't seem to be quite enough of an overclock to keep up with the competition. As our benchmarks show, this card was a few frames behind the fastest in the roundup. We should keep this in perspective though; while not being the fastest, the tiny difference across all GTX 960 products will be basically imperceptible during gaming. Still, with one of the highest price tags, we expected a little more out of Asus' take on the supposed sweet spot of GPU pricing.

KEY SPECS
$3359 · www.asus.com.au

OVERALL

0 1 2 3 4 5

Gainward GTX960 Phantom

NOT AS QUIET AS THE NAME SUGGESTS

Just take a look at that picture. Gainward's Phantom cooling system can't be mistaken for anything else, as it's a giant slab of cooling fins, chilled by twin fans. Despite the fans being located behind the cooling block, each fan can easily be removed, making for simple cleaning when the dust demons come to stay. Despite being built around the usual GTX 960 PCB, which measures 170mm, the Phantom cooler makes this one of the biggest cards in the roundup, stretching another 70mm to reach a total length of 240mm. It's definitely not the card for those with cramped cases.

Given the huge size of the cooler, we expected this product to be whisper quiet, but our sound meter test proved otherwise. The Phantom roared along at 51dB, which is a huge increase over the quietest card in the roundup, MSI's version which purred at just 44dB.

Given the loud cooling, we expected Gainward to have endowed this product with a speedy factory overclock, but it wasn't to be.

The Boost Clock has been increased to 1266MHz, which is one of the less ambitious overclocks in the roundup. A single six-pin power connector is used to supply power to the card, so it likely won't overclock quite as well as those with more extravagant power solutions. Gainward has also gone for a different output configuration than other GTX 960s, with twin DVI-I, one HDMI 2.0 and one DisplayPort 1.2. That's great for older displays, but users with newer monitors will prefer the additional DisplayPorts found on other products.

If the Phantom has one thing going for it, it's the price. At just $295, this is one of the more affordable products in the roundup. Manual overclocking should help to boost the performance slightly, so if you're looking for an affordable GTX 960, the output and fan noise compromises will probably be easy to swallow overall.

KEY SPECS
$295 · www.gainward.com

OVERALL

0 1 2 3 4 5

Conclusion

As you can see, manufacturers have delivered a wide variety of GTX 960 products, across a relatively large spread of prices. Yet performance across the bunch remained incredibly close, with even the slowest products just a couple of frames behind the leaders, a common occurrence when looking at competing graphics cards that are all built around the same GPU.

Our benchmarks indicate that the GTX 960 has the goods to deliver smooth average frame rates of 60 frames per second, but the minimum frame rates tell another story entirely.

REAL WORLD RESULTS

In Thief, this card bottomed out at 28 frames per second; even though the aver-age frame rate is solid, drops to such low frame rates will prove to be a jarring experience while gaming. As a result, it's not quite the 1080p at 60 frames per second product that NVIDIA claims it to be, and you can expect the performance to drop even more in demanding games like Battlefield 4 and Evolve.

THE RADEON PROBLEM

There's one other problem with the GTX 960 – and that's the existence of AMD's Radeon R9 280X graphics card. With the cheapest of these retailing for $320, our benchmarks show that it has a healthy lead over the GTX 960 in a variety of applications. It might be heavy and hot, but at this price point it's the card to buy.

CHOOSE YOUR CARD

Hopefully Nvidia will slash prices on the GTX 960 so that it can follow up on the success of earlier X60 products, but until then AMD gets the nod in the $300 range – a factor compounded by the maturity of the 280X cards available today.

If you do choose to buy a GTX 960, Palit's model is hard to pass up thanks to its excellent price and performance. Meanwhile extreme overclockers will have to spend a little extra for Gigabyte's G1 Gaming model, which we're sure will be topping world record charts in no time. as well as punching above its weight when it comes to the best a 960-series card can deliver at this point.

< The 960-series has proven to be a very competent gaming card, though just shy of our expectations

GTX 960 BENCHMARKS

GRID AUTOSPORT	MIN FPS	AVG FPS
GIGABYTE GV-N960WF2-2GD	71	91
GIGABYTE GV-N960G1 GAMING-2GD	70	91
PALIT GEFORCE GTX960 SUPER JETSTREAM 2GB	71	90
GAINWARD GTX960 PHANTOM	72	89
ASUS STRIX-GTX960-DC2OC-2GD5	67	88
MSI GEFORCE GTX 960 GAMING 2G	70	86
AMD RADEON R9 280X	66	88

THIEF	MIN FPS	AVG FPS
GIGABYTE GV-N960G1 GAMING-2GD	28	64
GIGABYTE GV-N960WF2-2GD	31	63
GAINWARD GTX960 PHANTOM	30	63
PALIT GEFORCE GTX960 SUPER JETSTREAM 2GB	34	63
ASUS STRIX-GTX960-DC2OC-2GD5	33	61
MSI GEFORCE GTX 960 GAMING 2G	30	61
AMD RADEON R9 280X	56	75

3D MARK	SCORE	GRAPHICS SCORE
GIGABYTE GV-N960G1 GAMING-2GD	7060	8084
PALIT GEFORCE GTX960 SUPER JETSTREAM 2GB	7010	7987
GIGABYTE GV-N960WF2-2GD	6987	7986
GAINWARD GTX960 PHANTOM	6946	7908
ASUS STRIX-GTX960-DC2OC-2GD5	6855	7813
MSI GEFORCE GTX 960 GAMING 2G	6830	7773
AMD RADEON R9 280X	7646	8518

PRICES	
GIGABYTE GV-N960WF2-2GD	$329
GIGABYTE GV-N960G1 GAMING-2GD	$359
ASUS STRIX-GTX960-DC2OC-2GD5	$335
GAINWARD GTX960 PHANTOM	$295
MSI GEFORCE GTX 960 GAMING 2G	$349
PALIT GEFORCE GTX960 SUPER JETSTREAM 2GB	$289

FAN NOISE	LOAD NOISE (DB)
MSI GEFORCE GTX 960 GAMING 2G	44
PALIT GEFORCE GTX960 SUPER JETSTREAM 2GB	45
GIGABYTE GV-N960WF2-2GD	47
GIGABYTE GV-N960G1 GAMING-2GD	47
ASUS STRIX-GTX960-DC2OC-2GD5	49
GAINWARD GTX960 PHANTOM	51

Hard Decisions
Storage devices

THIS MONTH WE'VE TESTED 26 SSDS, HARD DISKS AND HYBRIDS, SO WHETHER YOU NEED A PERFORMANCE BOOST OR MASSES OF STORAGE, WE'VE GOT A DRIVE FOR YOU

CONTENTS

Few things have a greater impact on the performance and usefulness of a PC or laptop than its internal disk drive. Not having enough storage is immensely frustrating, as you have to uninstall programs to make room for the latest game, for example, or move some of your files to an external storage device before you can download a rented film. A slow hard disk, on the other hand, can make your computer feel sluggish, as the operating system and applications take ages to load.

Both problems can be solved with a drive upgrade. Mechanical hard disks are astounding value, providing thousands of gigabytes of storage for less than 3p a gigabyte. Meanwhile, solid-state drives (SSDs) are incredibly fast and enable a PC to boot in seconds, while adding a welcome dose of responsiveness to the operating system. Hybrid drives try to offer the best of both worlds, combining the speed of an SSD with the capacity of a mechanical hard disk.

If you're fitting a disk in a desktop PC, you don't necessarily have to choose between a hard disk and SSD, as you could use a fast SSD as your system disk, and store your files and documents on the slower hard disk. Laptops usually have room for only one drive, though, so you'll

have to decide whether speed or capacity is more important – unless you fit a hybrid drive (see below). Bear in mind that some laptops don't have standard hard disk bays or won't let you upgrade the disk, so check before you buy.

THE HARD WAY

Hard disk drives have been around for an eternity in technology terms. These provide the highest storage capacities by far, as well as being much cheaper per gigabyte of capacity than SSDs, so if you have lots of media and documents to store, a hard disk is your best option. If you use a hard disk for your operating system and applications, don't expect the same fast loading times and snappy responsiveness you'd get with an SSD, as even the slowest SSD is over three times as fast as the fastest hard disk.

Hard disks are often referred to as mechanical drives due to the way they work. Fundamentally, a hard disk consists of a mechanical arm and, depending on its storage capacity, one or more platters. The arm holds the read/write heads, which move across the platter at extremely high speeds. The platters themselves rotate at anything up to 10,000rpm.

Data is stored on the surface of each platter, and the arm moves the heads over the surface to read and write data.

It's the mechanical nature of hard disks that makes them slower than SSDs, which use flash storage instead of moving parts. It's also why hard disks are more susceptible to damage – dropping a laptop with a hard disk is likely to result in data loss.

SOLID AS A ROCK

A solid-state drive (SSD) is one of the most effective upgrades you can make to your PC and is an excellent choice for a primary system disk. With their superior read and write speeds, they can instantly make your operating system more responsive. Boot up and shut down times are significantly shorter than with a mechanical disk, and applications will typically open much faster.

SSDs are able to achieve such blistering file transfer speeds due to the lack of any moving parts. Rather than the disk platters found in hard disks, SSDs use NAND flash memory. NAND comes in a number of varieties based on how much data each of its cells can contain. The increasingly rare Single-level Cell (SLC) type can store only one bit, Multi-level Cells (MLC) can store two bits and Triple-level Cell (TLC) can store three.

By using cells that store more than one bit, manufacturers can pack more storage capacity into a smaller space, allowing SSDs to reach ever-greater capacities while still fitting in existing drive bays. There's a balance to strike, however, as using more bits per cell can compromise speed and reliability.

Other innovations have also allowed SSDs to increase in capacity, such as Samsung's 3D V-NAND system, which stacks cells both vertically and horizontally. SSDs are still behind hard disks for capacity, however, and their cost per gigabyte is also a lot higher.

A separate controller acts as an interface between an SSD's NAND modules and the operating system, and this can affect performance. Marvell is a popular controller manufacturer, and its designs can be found in many SSDs from different manufacturers.

With no moving parts, SSDs are less susceptible to impact damage and resulting data loss, so if you're prone to dropping your laptop, an SSD might be a sensible upgrade for you. All SSDs come in the 2½in form factor but, as with laptop hard disks (see below), they vary in thickness, so check your laptop's drive bay before you upgrade.

HYBRID DRIVES

As we've mentioned, hard disk drives still provide the most storage for your money, but the read and write speeds of SSDs can't be beaten. The obvious solution, therefore, would be to combine the two. That's precisely what many manufacturers have done with their solid-state hybrid drives (SSHDs).

Many desktop PC manufacturers provide an SSD as a system disk for the operating system and software, and a secondary hard disk for media files, but this simply isn't possible in most laptops, which have a solitary drive bay. This is where an SSHD could be a good compromise.

SSHDs combine both types of storage technology in a single physical drive. Most have a large-capacity hard disk and a smaller SSD NAND cache, typically around 8GB in size. Caching algorithms then decide which data should reside on the SSD and which will go on the hard disk. Typically, the data you use most frequently, such as operating system files and software application data, will remain on the SSD cache for quick access. This means performance should improve over time as the caching algorithm learns your usage patterns. Our tests show that SSHDs make some difference to file transfers and can dramatically reduce boot times.

There are also other hybrid drive implementations, such as Western

Digital's Black2 Dual Drive. Instead of using an SSD as a cache, these drives package together a hard disk and an SSD in a single 2½in drive. This means you can use the smaller, faster SSD as your system disk and still have plenty of mechanical hard disk space for your files. It's an excellent solution for when you have only a single drive bay.

ANOTHER DIMENSION

Storage drives typically come in two form factors: 2½in and 3½in. All SSDs are 2½in but mechanical hard disks can come in either size. A typical PC case will be able to accommodate both sizes, but laptops use only 2½in drives.

This is complicated slightly by the fact that not all 2½in drives are the same thickness. Most are 7mm thick, but some are available in a thinner 5mm format for use in Ultrabooks and other slim laptops, and there's also a thicker 9.5mm format, which is often seen in large desktop replacement laptops. We note how thick each drive is in our reviews, but you'll need to check which size will fit your laptop before you buy.

Thankfully, many 7mm SSDs come with a spacer that makes an SSD fit into a 9.5mm drive bay. Some drives also come with data migration kits, such as a USB-to-SATA connector and accompanying software that allows you to transfer your operating system and data across from an existing drive.

ADATA Premier SP610

THE ADATA PREMIER SP610 IS AN INEXPENSIVE SSD BUT ITS PERFORMANCE IS ONLY AVERAGE

The ADATA Premier SP610 differs from other SSDs in that it uses a Silicon Motion controller instead of the more common type from Marvell. Silicon Motion has been around for a while, and other companies such as Corsair also use its controllers. The ADATA Premier SP610's SM2246EN controller supports the SATA3 (6Gbit/s) interface, and has a claimed read speed of 560MB/s and write speed of 290MB/s for the 256GB model we tested. The Premier SP610 is also available in 512GB and 1TB capacities, both of which have a higher rated write speed of 450MB/s. The cost per gigabyte is about average across the capacities, at between 52 and 55 cents.

Like many other mid-priced SSDs, the Premier SP610 uses 20nm MLC (Multi-level Cell) NAND with an Input/Output Operations Per Second (IOPS) rating of 73,000.

There isn't much in the way of included accessories, but you get a spacer to fit the 7.5mm-thick drive in a laptop with a 9.5mm drive bay. There's also a free download of Acronis True Image HD included, which will be useful for anyone who needs to migrate their Windows installation from an old disk.

The Premier SP610 did reasonably well in our benchmarks, managing 487.3MB/s in our large-file read test and 451.7MB/s in our large-file write test. This gives it an overall speed of 469.5MB/s, which is average large-file performance for the price. We sometimes saw faster large-file read speeds above 600MB/s but only occasionally.

The drive's small-file performance wasn't quite as impressive, but it was still respectable. We recorded small-file read speeds of 85.7MB/s and write speeds of 99.4MB/s for an overall small-file speed of 92.6MB/s. This isn't the fastest SSD available, but it's good value per gigabyte.

The ADATA Premier SP610 is a good proposition for those who don't need the absolute best performance, although it trails behind the Patriot Blaze and Crucial MX100 for overall performance. Our favourite low-cost SSD by far is the SanDisk Ultra II, however, which is only fractionally more expensive than Adata's model and provides far superior large-file performance.

256GB

Large files overall	469.5MB/S
Small files overall	92.6MB/S

0% -50 Reference +50 +100

KEY SPECS
$137 (256GB) $270 (512GB) $553 (1TB)
Costs per gigabyte - 0.53 (256GB) 0.52 (512GB), 0.55 (1TB)

OVERALL

0 1 2 3 4 5

Crucial MX100

THE CRUCIAL MX100 IS A FANTASTIC-VALUE AND FAST SSD

The MX100 IS part of Crucial's budget range of SSDs, and when it comes to performance at a low price, it's tough to beat. The MX100 is available in 256GB and 512GB capacities and has a low cost per gigabyte of around 54 cents.

The MX100 uses 16nm, 126Gbit/s, 2-bit MLC NAND flash from Crucial's parent company Micron. The smaller 16nm manufacturing process allows Crucial to pack more chips into a tighter area, lowering production costs and paving the way for even higher-capacity SSDs, which goes some way to explain how Crucial is able to price the MX100 so competitively. The MX100 uses a Marvell 88SS9189 controller with custom Micron firmware.

Although the MX100 isn't available as part of an upgrade kit, it comes with a couple of extras we wouldn't expect from a budget model. There's a spacer for fitting the 7.5mm-thick SSD in a laptop with a 9.5mm drive bay, as well as a free downloadable copy of Acronis True Image HD 2014. The only critical feature this software download lacks compared with the full retail version of Acronis TrueImage is the ability to back up only the files that have changed since the last backup, which reduces the time a backup takes. Even so, the included software is useful if you need to copy files from your old hard disk to the MX100.

Crucial's MX100 SSDs are all rated as having 550MB/s read speeds, but the write speed performance increases with each higher capacity. The 256GB drive is rated at 333MB/s and the 512GB model at 500MB/s.

We tested both models and found they performed excellently for the price. The 256GB model delivered a large-file read speed of 457MB/s and write speed of 454.4MB/s. The faster 512GB model produced a read speed of 467.5MB/s and write speed of 679.3MB/s. In our small-file tests, the 256GB disk managed a read speed of 81.9MB/s and a write speed of 98.9MB/s. The 512GB model's small-file performance was only marginally different.

The 512GB version of the MX100 is the best option if your budget allows, not only for its larger capacity but also its superior performance. Overall, the MX100 is astonishingly cheap for such a quick SSD, but it just loses out to the Sandisk Ultra II for a Best Buy award, thanks to the Ultra II's similar performance and lower cost per gigabyte.

256GB

Large files overall	625.7MB/s
Small files overall	90.5MB/s

0% -50 Reference +50 +100

KEY SPECS
$145 (256GB) $279(512GB)
Costs per gigabyte - 0.56 (256GB) 0.54 (512GB)

OVERALL

0 1 2 3 4 5

Patriot Blaze

THE PATRIOT BLAZE HAS QUICK LARGE-FILE TRANSFER SPEEDS BUT ITS SMALL-FILE PERFORMANCE IS DISAPPOINTING

Much like the Intel 730 Series of SSDs, the Patriot Blaze range has a maximum capacity of 480GB, so it isn't a great choice for those who need a lot of storage space. Lower-capacity options are available, including 60GB and 120GB models, but we wouldn't recommend that anyone buy an SSD with less than around 250GB of space.

The 240GB and 480GB models are the best choice for most people. These allow you to install an operating system as well as applications and games to benefit from the faster speeds of solid-state drives.

Both the 240GB and 480GB drives cost around 50 cents per gigabyte, which makes the Patriot Blaze a competitor to the keenly priced Crucial MX100. Like the MX100, the Patriot Blaze uses 16nm

MLC NAND, with smaller flash chips that allow more to be packed into a standard 2½in enclosure. The 16nm manufacturing process also reduces costs. The NAND is paired with a Phison PS3108-S8 controller – the same chip we've seen in other inexpensive SSDs.

Both the 240GB and 480GB drives are rated as having a 555MB/s read speed, but the 240GB model has a slightly faster rated write speed of 535MB/s compared with the 480GB model's 500MB/s. In our file transfer tests, the 240GB model delivered a relatively slow large-file write speed of 423.3MB/s but an excellent read speed of 540MB/s. Its small-file speeds were only average, however, and the read speed of just 75.9MB/s was a particular disappointment. The small-file write speed of 98.6MB/s was more respectable.

The Patriot Blaze comes without any accessories. We weren't expecting an upgrade kit to help you transfer your data, especially considering the Blaze's very reasonable price, but we'd have liked to see a spacer included to help fit

the 7mm-thick drive in laptops that have 9.5mm drive bays. You don't get any data migration software either, unlike the Crucial MX100, which comes with a copy of Acronis True Image HD 2014.

The Patriot Blaze is good value, but its slower small-file performance means it just loses out to the Crucial MX100 for a Recommended award. However, if you're looking for a budget SSD, the Best Buy-winning SanDisk Ultra II is better value than both drives.

KEY SPECS
$123 (240GB) $243 (480GB)
Costs per gigabyte – 0.51 (240GB) 0.50 (480GB)

OVERALL

240GB

Large files overall	481.7MBs
Small files overall	87.3MB/s

0%   -50   Reference   +50   +100

Samsung 850 Evo

SAMSUNG'S 3D V-NAND TECHNOLOGY MAKES THE 850 EVO A TOP PERFORMER

We were fans of Samsung's 840 Evo series of solid-state drives, as they were the first models we'd seen that came in capacities of up to 1TB. The 850 Evo is the follow-up, and uses Samsung's new 3D V-NAND technology.

This refers to the way the cells in the Evo 850's NAND flash chips are stacked vertically and horizontally, allowing Samsung to offer greater storage capacities without shrinking the manufacturing process, which is becoming increasingly difficult. These chips use a 40nm process rather than the 20nm process more commonly seen in other manufacturers' SSDs.

Although 3D V-NAND should pave the way for higher-capacity SSDs, the 850 Evo range still offers a maximum storage capacity of 1TB. Samsung claims that 3D V-NAND reduces cell-to-cell interference,

which will help the cells last longer, and the technology should lead to higher capacities in the future.

All the SSDs in the 850 Evo range use Samsung MGX controllers except for the 1TB model, which uses a Samsung MEX model. We tested the 250GB, 500GB and 1TB versions, and the performance was almost identically impressive.

The 250GB drive achieved an astonishing large-file write speed of 713.5MB/s in our tests. Its large-file read speed was less impressive but still above average at 473.5MB/s. The 1TB drive managed a similar write speed of 712.9MB/s, and 465.3MB/s in the large-file read test. In our small-file test the 1TB drive was the quickest model, with 99.8MB/s write and 91.2MB/s read speeds. Overall, the small-file speeds were about average for all three drive capacities.

None of the drives comes with an upgrade kit, and it's not available as an optional bundle either. Samsung doesn't even include a spacer to help fit the 7mm thick drive in a 9.5mm laptop drive bay, but at least it provides Samsung

Data Migration and Samsung Magician software. The former makes it easy to clone an existing drive, but you might have to use your own SATA-to-USB cable if you don't have a spare SATA cable. Samsung Magician provides a number of useful tools for optimising the disk drive, upgrading the firmware and monitoring the drive's health. The software is easy to use.

The 850 Evo's large-file write speeds are slower than the Crucial M550's. The disks in Crucial's range are generally cheaper per gigabyte and are also faster overall, making them our Best Buy performance SSDs.

KEY SPECS
$169 (250GB) $319 (500GB) $529 (1TB)
Costs per gigabyte – 0.67 (250GB) 0.64 (500GB) 0.53 (1TB)

OVERALL

250GB

Large files overall	593.5MB/s
Small files overall	92.8MB/s

0%   -50   Reference   +50   +100

VICTORIOUS

ARC 100 SOLID STATE DRIVE

OCZ

It takes a lot to be victorious. Disciplined practice, chasing perfection and an ultimate drive gets you there. And that's just what our SSDs have in store for you. A rich mix of real consistent performance, high quality Toshiba flash and a super reliable aluminum casing combined with the unique ShieldPlus warranty program and yet remain affordable. It's our everyday goal to bring you the winning SSD; the OCZ ARC 100 series. **Be victorious.**

Up to 490 MB/s · Up to 80,000 IOPS · OCZ Barefoot 3 M10 Controller
Toshiba 19nm Multi-Level Cell (MLC) NAND · Available in 120GB – 480GB

SHIELDPLUS
WARRANTY

OCZ
STORAGE SOLUTIONS
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Crucial M550

THE CRUCIAL M550 PROVIDES EXCEPTIONAL
PERFORMANCE FOR THE MONEY

The MX100 is Crucial's budget-friendly SSD, but the M550 is for those who would rather have extra performance. Unlike Crucial's cheaper model, the M550 is available with up to 1TB of storage. It's the successor to one of our favourite SSDs, the M500. As its name suggests, the M550 is a fairly minor update, but any drive that improves on the excellent M500 is bound to grab our attention.

As well as the 1TB drive, you can buy 256GB and 512GB versions. All but the 1TB model are available either as a standard 2½in SATA3 disk or as mSATA DIMM-style chips for use in an Ultrabook. We tested the 2½in SATA3 version of the drive, but there shouldn't be any performance differences between the two designs.

Like the MX100, the M550 isn't available as part of an upgrade kit with cloning software, a USB-to-SATA adapter or other accessories. All these parts are widely available elsewhere, though, and at least the drive comes with a bracket for mounting the 7mm-thick SSD in a 9.5mm disk bay.

Like the M500, the M550 uses 20nm Micron NAND flash, although it adds a new Marvell 88SS9189 controller with custom Micron firmware. All the different capacities of M550 performed comparably in our file transfer speed tests.

The 1TB model wrote large files at 617MB/s and read them at 618.2MB/s, both of which are very fast speeds. Small files were written at 100.1MB/s and read at 83.5MB/s, which is above average. The 256GB model wrote large files at 628.5MB/s and read them at 610MB/s, while in the small-file tests it produced 100MB/s write and 81MB/s read speeds, so there is little performance difference between the capacities.

The 512GB drive offers the best value, costing 78 cents per gigabyte, but $279 is a considerable amount of money to part with. The 256GB drive costs 54 cents per gigabyte and the 1TB model is 61 cents per gigabyte, making them both good value for such quick drives.

The M550 isn't the cheapest SSD but is still good value and has excellent file transfer performance. It wins a Best Buy award.

256GB

Large files overall	625.7MB/s
Small files overall	90.5MB/s

0%   -50   Reference   +50   +100

KEY SPECS
$149 (256GB) $279(512GB) $615 (1TB)
Costs per gigabyte - 0.58 (256GB) 0.54 (512GB), 0.61 (1TB)

OVERALL

0   1   2   3   4   5

Intel 730 Series

THE INTEL 730 SERIES SSD HAS STRONG
PERFORMANCE BUT IS EXPENSIVE

The price of SSDs has been consistently decreasing while capacities have been increasing, so we were surprised to see that Intel's 730 Series of SSDs still offers only 240GB and 480GB capacities, especially as many rivals now offer upwards of 1TB.

The 240GB model isn't particularly good value at 78 cents per gigabyte. The 480GB model is slightly more expensive at 83 cents per gigabyte, but that's still distinctly more expensive than SSDs from companies such as SanDisk and Crucial.

Intel claims that the 730 is exceptionally fast, as it's equipped with the company's own third-generation controller with optimised firmware and 20nm NAND flash, both of which have been overclocked. This specification is an improvement over previous Intel SSDs

such as the 520 series, which used older SandForce controllers. Intel also claims that the 240GB 730 Series SSD has a lifetime of around five years based on 50GB of writes per day, rising to 70GB per day for the 480GB version. This happens to coincide with Intel's limited five-year SSD warranty.

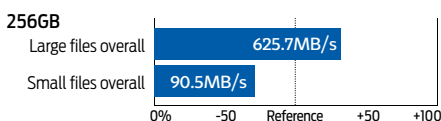Although we can't test Intel's longevity claims, we put the 480GB 730 through our demanding file transfer benchmarks. It wrote large files at a reasonable if unspectacular 546.2MB/s and read them at a respectable 487.4MB/s for a speed of 516.8MB/s overall – a slightly below-average result.

In the small-file tests the 730 achieved 100.4MB/s write and 81.4MB/s read speeds for an average read and write result of 90.9MB/s. Again, that's slap in the middle of the spectrum for the SSDs we've reviewed.

Disappointingly, the SSD comes without a spacer for fitting the 7mm-thick drive in a 9.5mm-thick drive bay, such as those found in many big desktop-replacement

laptops. This is something we'd normally expect to see, but the Intel 730 Series SSD will still fit happily in most normal-sized laptops. There are no other extras, either, such as the disk cloning software that comes with some other SSDs to make transferring your software to the new drive a little easier.

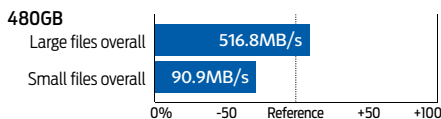The Intel 730 Series performs reasonably well but is outclassed by the Best Buy-winning Crucial M550, which is faster and cheaper than Intel's drive.

480GB

Large files overall	516.8MB/s
Small files overall	90.9MB/s

0%   -50   Reference   +50   +100

KEY SPECS
$189 (240GB) $399 (480GB)
Costs per gigabyte - 0.78 (240GB) 0.83 (480GB)

OVERALL

0   1   2   3   4   5

OCZ Vertex 460A

UNCOMPETITIVE PRICING AND LACKLUSTRE PERFORMANCE

The venerable OCZ Vertex 460 has long been a solid SSD performer, and the new 460A model uses a newer A19 MLC NAND flash from OCZ's parent company Toshiba. For Toshiba, the 19nm MLC NAND used in the Vertex 460A is its second generation of this type.

The 460A retains the Barefoot 3 controller which was used in the original 460A. The Vertex 460A comes bundled with a 3.5inch desktop adaptor, as well as a copy of Acronis True Image, which will come in handy if you're cloning from another drive when it's installed.

Claimed speeds for the 460A across available capacities are 530MB/s (120GB), 540MB/s (240GB) and 545MB/s (480GB), showing a slight increase in speed as capacity increases. Claimed sequential write speeds come in at 420MB/s (120GB),

525MB/s (240GB) and 525MB/s (480GB). The 240GB version was the only capacity tested as part of this group test.

During our testing, using our custom benchmarking process, the Vertex 460A performed at its best in the large file write test, coming in at 524.4MB/s. This places it near the middle of the field, though still below the drives which were able to reach 600MB/s or higher.

Large file read speeds were poor, coming in last in the group test, at 378MB/s, while small file read (90.1MB/s) and small file write (66.1MB/s) testing also put the Vertex 460A low in the rankings.

Stacking the Vertex 460A up against the competition based on price per gigabyte leaves it faring poorly. It is nearly 20 cents more expensive per gigabyte than Crucial's MX100, which is admittedly a budget drive, but the MX100 also out-performs the Vertex 460A in all but large write tests.

Because the 460A is a very new release in the Australian market, prices may drop quickly. Indeed, OCZ and its resellers will need to do just that to keep this drive

competitive. We suggest pricing this drive as you research a purchase because the market may move quickly, rendering the costs quoted here obsolete.

Should you locate a Vertex 460A in the capacity you want, at a competitive price and your only priority is large file write speeds, then it starts to look more attractive. The inclusion of a mounting bracket as well as Acronis True Image may also sway purchasers towards this drive if all other factors are equal.

240GB

Large files overall	451.4MBs
Small files overall	78.1MB/s

0%   -50   Reference   +50   +100

KEY SPECS
$90 (120GB) $179 (240GB) $316 (480GB)
Costs per gigabyte - 0.75 (120GB) 0.74 (240GB) 0.66 (480GB)

OVERALL

0   1   2   3   4   5

PNY XLR8 Pro

THE PNY XLR8 PRO ISN'T BRILLIANT VALUE AND ITS PERFORMANCE LEFT US COLD

The XLR8 Pro is marketed by PNY as a high-performance gaming device, but in practice it doesn't offer much to make it any better for gaming than other SSDs. It's available in 240GB and 480GB capacities, and both models use a SandForce 2281 controller. SandForce has been making SSD controllers for a long time, and is now owned by Seagate after an acquisition in mid-2014. The SandForce controller is paired with 25nm MLC NAND flash memory. At 66 cents per gigabyte for the 240GB drive and 53 cents per gigabyte for the highest-capacity 480GB drive, the XLR8 Pro range is reasonable value.

You don't get much in the way of bundled accessories or software, so you should factor this in if you need an application to help you transfer your

system and files from an old hard disk. It's also worth bearing in mind that the XLR8 Pro is 9.5mm thick, so it won't fit in a laptop that has a 7mm drive bay. PNY includes a very short SATA cable with the drive, which might not be long enough for your desktop PC, depending on how your motherboard is configured.

PNY rates all the drives in its XLR8 Pro SSD range as having read speeds of 550MB/s and write speeds of 520MB/s, with a high Input/Output Operations Per Second (IOPS) rating of 85,000, which indicates that the drive should have good response times. The performance of the drives in our benchmarks left us underwhelmed, however. The 240GB model managed 464.4MB/s in our large-file read test, which is about average, and a below-average 472.2MB/s in the large-file write test. This is only fractionally faster than cheaper drives such as Crucial's MX100 and is significantly slower than SanDisk's Ultra II.

The XLR8 Pro's small-file performance was more respectable, though. It wrote small files at a slower-than-average 97MB/s, but its small file read speed was quick at 84.6MB/s.

Despite its great small-file read speeds, the PNY XLR8 Pro isn't particularly quick overall or very good value. You're much better off with the faster, better-value SanDisk Ultra II.

240GB

Large files overall	468.3MB/s
Small files overall	90.8MB/s

0%   -50   Reference   +50   +100

KEY SPECS
$160 (240GB) $256 (480GB)
Costs per gigabyte - 0.66 (240GB) 0.53 (480GB)

OVERALL

0   1   2   3   4   5

SanDisk Ultra II

THE SANDISK ULTRA II IS A FAST AND GREAT-VALUE SSD

Few solid-state drives can rival Crucial's MX100 for value, but the SanDisk Ultra II range has managed just that. With prices that equate to 58 cents per gigabyte for the 240GB drive, 54 cents per gigabyte for the 480GB model and, again, a reasonable 54 cents per gigabyte for the 960GB version, the SSDs in the Ultra II range are very good value.

The 240GB version of the Ultra II uses a Marvell 88SS9190 controller, while the higher-capacity disks use a Marvell 88SS9189.

Crucial also uses the latter controller for its MX100 and M550 SSDs. All the Ultra II drives are built with SanDisk's 19nm TLC flash memory, which can store three bits of data per cell instead of the two in MLC NAND. This means more data can be stored in the same area, allowing for more capacious SSDs.

The Ultra II has a SATA3 connector and is 7.5mm thick, so it will fit in laptops with slim drive bays. A spacer is included for fitting the drive in laptops with 9.5mm drive bays.

No data migration software is bundled with these SSDs as such, but SanDisk's SSD Dashboard software is available as a free download. This helps you monitor and maintain your drive's health and performance as well as install any firmware upgrades.

SanDisk sent us the 240GB model to put through our benchmark tests. We found its data transfer speeds excellent for such an inexpensive drive. In our large-file test it read files at 454.4MB/s, which is about average, but it was able to write large files at an impressive 617.7MB/s, making the Ultra II a top performer for a budget drive. Its small-file performance was reasonable too, with a read speed of 77MB/s and a write speed of 97.5MB/s. That's not quite up to the standard of Crucial's MX100, but it's not far off.

For a long time, Crucial's MX100 was the obvious SSD to buy for those on a tight budget, but now the SanDisk Ultra II has stolen its crown.

The 240GB model is reasonably priced, but the 960GB version as well as the 480GB drive offers the best value at just 54 per gigabyte.

240GB

Large files overall	536.1MB/s
Small files overall	87.3MB/s

0%   -50   Reference   +50   +100

KEY SPECS
$140 (240GB) $260 (480GB) $520 (960GB)
Costs per gigabyte - 0.58 (480GB) 0.54 (480GB), 0.54 (960GB)

OVERALL

0   1   2   3   4   5

Seagate Desktop HDD

THE SEAGATE DESKTOP HDD ISN'T PARTICULARLY QUICK BUT IT'S GOOD VALUE FOR THE LARGEST CAPACITIES

The Seagate Desktop HDD range goes all the way up to 4TB, which should provide ample space for the even the largest media collections. It's also available in 2TB and 3TB capacities. Whichever capacity you choose you'll pay 3p per gigabyte, so you might as well opt for the largest capacity you can afford.

Our prices are for the OEM versions. Retail kits are slightly more expensive but include mounting screws, a SATA cable and a Molex-to-SATA power adaptor. Seagate also offers its Desktop HDD in smaller capacities, but we've excluded those as they're poor value in comparison.

These drives were formerly part of Seagate's Barracuda range but have since been rebranded as the Desktop HDD range. They are standard 3½in devices and have 64MB of cache and a SATA3 controller, although plugging a mechanical hard disk into a SATA2 port is unlikely to affect its speed. The 5,900rpm spindle speed of the 4TB drive is relatively slow, but Seagate says this means the drive runs cooler than faster models.

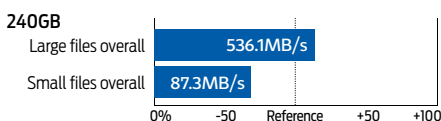Seagate sent us the 4TB disk to review. Its performance in our tests wasn't the best we've seen. We didn't expect this disk to rival the speed of an SSD or SSHD hybrid drive, but its performance was even short of other mechanical disks we've tested. In our large-file benchmark, the Desktop HDD wrote files at 168MB/s and read them at 157MB/s for an average score of 162.5MB/s, making this one of the slower mechanical hard disks we've seen. Small files were written at 73.9MB/s and read at 75.7MB/s for an average of 77.5MB/s, which still isn't amazing but is closer to the competition.

The drive is still more than quick enough as a secondary disk to store your documents and media files, but you'll notice its slow performance if you use it as a main disk for your operating system and programs.

The 4TB Seagate Desktop HDD was a below-average performer in our speed tests, which wasn't entirely surprising considering its relatively slow spindle speed. It's an inexpensive drive if you need a vast amount of space, so it would be a good choice as a secondary drive for storing your documents and media. However, Western Digital's 4TB Green 3½in drive is a similar price and has significantly better performance.

KEY SPECS
$105 (2TB) $139 (3TB) $199 (4TB)
Costs per gigabyte - 0.05 (2TB) 0.05 (3TB) 0.05 (4TB)

4TB
Large files overall	162.5MB/s
Small files overall	77.5MB/s

0%   -50   Reference   +50   +100

OVERALL

0   1   2   3   4   5

Seagate Desktop SSHD

A GREAT-VALUE HYBRID DRIVE, BUT ITS SPEEDS WEREN'T AS IMPRESSIVE AS WE'D HOPED

Seagate's Desktop SSHD was one of the first 3½in desktop hybrid drives. Hybrid drives are an attempt to combine the speed benefits of an SSD and the large capacity of a mechanical hard disk by adding a small amount of NAND flash memory to speed up access times for frequently used files.

Seagate's adaptive memory technology learns the user's data access patterns and adds the most frequently used data to the solid-state memory to speed up the system. The 4TB Seagate Desktop SSHD we tested is equipped with 8GB of MLC NAND and 64MB of cache, and spins at 5,900rpm.

The Desktop SSHD range also includes 1TB and 2TB versions, and these have faster spindle speeds of 7,200rmp. At 6 cents per gigabyte for 4TB, 7 cents for the 2TB disk and 11 cents for the 1TB model, the disks offer good value but cost a little more than Seagate's Desktop HDD and Western Digital's Green drives.

Seagate sent us the 4TB model to test, but the 2TB and 1TB models should be slightly quicker due to their faster spin speeds. In our tests the Desktop SSHD delivered respectable rather than spectacular performance. Its large file write speed of 193.9MB/s was good, and similar to that of Western Digital's Green 4TB disk, but its 175.7MB/s read speed was far behind WD's disk. Small file transfer speeds of 79.9MB/s write and 77.6MB/s read are fine, but nothing special.

To see if the cache made any difference to Windows boot times, we used the Bootracer utility. The first run with the SSHD took 42 seconds. However, the second run dropped to 29.5 seconds and the third fell to 22.9 seconds as the SSHD cached frequently used files.

Boot times aside, the Seagate Desktop SSHD's performance is no better than that of a standard 3½in drive such as one of Western Digital's Green range. A 3½in SSHD is a tricky compromise too, as most desktop PC cases have multiple drive bays, so a better combination would be to use an SSD for your operating system and software and a hard disk for your media. SSHDs make more sense for laptops, which are limited to one drive bay.

If you don't want the hassle of having your OS and files on different disks, and value fast boot times, the Seagate Desktop SSHD could be for you. For everyone else the Western Digital Green range is a better bet.

KEY SPECS
$109 (1TB) $135 (2TB) $239 (3TB)
Costs per gigabyte - 0.11 (1TB) 0.07 (3TB) 0.06 (4TB)

4TB
Large files overall	184.8MB/s
Small files overall	78.8MB/s

0%   -50   Reference   +50   +100

OVERALL

0   1   2   3   4   5

Seagate Laptop SSHD

SEAGATE HAS AN SSHD FOR EVERY SIZE OF LAPTOP

Seagate's Laptop SSHD hybrid drive combines a hard disk with 8GB of flash memory to combine the storage space of a mechanical disk with some of the speed of an SSD. The drives are available in a range of thicknesses. The 7mm size (ST500LM000) will support most laptops, but there's also a 9.5mm (ST1000LM014) drive for large desktop-replacement laptops and a super-slim 5mm drive (ST500LX012) for Ultrabooks.

The 7mm and 5mm drives are available in 500GB capacities, while the 9.5mm drive goes up to 1TB. This works out at 10 cents per gigabyte, which is good value. The 1TB drive has four heads and two platters, which explains its thickness. It operates at 5,400rpm, which is typical for most laptop disks. All Laptop SSHD models have an 8GB cache of MLC NAND flash memory. The

SSHD's controller uses an algorithm to learn which files you use most often and moves them to the NAND flash for faster access. It doesn't require any drivers, so it should work in Mac and Linux laptops as well as Windows.

Seagate sent us the 1TB model to review. Its performance overall in our benchmarks was excellent. The drive wrote large files at 132.1MB/s and read them at 133.9MB/s – the write speed in particular is one of the best we've seen from a laptop disk. Its small-file speeds were also good, with a 82.7MB/s write and a huge 92.7MB/s read speed, making an average of 87.7MB/s. This is the best small-file speed we've seen from any 2½in or 3½in disk.

Due to the way the cache works, we expected subsequent test runs to show even faster speeds, but even after four or five runs we saw no improvement. The technology came into its own when booting into Windows, though. When we first measured it using the Bootracer utility, the Laptop SSHD booted into Windows in 50.7 seconds. This dropped to 44 seconds for

the second run, and once we'd restarted six times the cache had reduced the boot time to just 28 seconds.

It may cost more than other laptop disks, such as the Western Digital Green Mobile, but the fast Seagate Laptop SSHD is a solid upgrade if your laptop's existing storage is a slow mechanical hard disk. Hybrid drives make a lot more sense in laptops, where you're limited to one storage disk, and are a good compromise if you need plenty of capacity and don't want to spend a lot more on a high-capacity SSD. With the added benefit of the faster boot times and general overall responsiveness, the Seagate Laptop SSHD is a fine upgrade choice.

KEY SPECS
$99 (1TB)
Costs per gigabyte - 0.10 (1TB)

OVERALL

1TB

Large files overall	133MB/s
Small files overall	87.7MB/s

0%   -50   Reference   +50   +100

Seagate Laptop Ultrathin

THE SEAGATE LAPTOP ULTRATHIN COULD GIVE YOUR ULTRABOOK PLENTY OF EXTRA CAPACITY, BUT ITS PERFORMANCE IS DISAPPOINTING

Ultra-thin laptops, such as Ultrabooks, can be difficult to upgrade. Many don't even let you upgrade the disk at all, and some of those that do have drive bays that are too shallow for a standard 7mm-thick 2½in disk. This is where ultra-thin 5mm hard disks such as Seagate's Laptop Ultrathin come in.

Although thin, the disk is a standard laptop model in terms of mounting points and interface, so you may be able to use it in 2½in drive bays that support 7mm and 9.5mm drives. In contrast, some ultra-thin drives from manufacturers such as Western Digital have proprietary connectors so are really only suitable for manufacturers to build into their laptops. Many thicker drives offer better value, though, so we'd only recommend getting this drive if you really can't use a thicker

one. The Ultrathin weighs 93g, too, which may be important if you want to keep your Ultrabook light.

With room for only a single disk platter, the Laptop Ultrathin range has a maximum capacity of 500GB. Larger capacities would require a second platter and would make the disk too thick. The 500GB version works out at 30 cents per gigabyte, which is quite expensive for a mechanical hard disk.

The Ultrathin has 16MB of cache and a spindle speed of 5,400rpm, which is standard for all but the fastest laptop drives. The Ultrathin's overall performance in our benchmarks was decidedly underwhelming. It wrote large files at 100.8MB/s and read them at 106.7MB/s, giving it an average transfer speed of just 103.8ms. That's one of the slowest results we've seen recently. The drive was also slow at writing small files, with a score of 66.9MB/s putting it near the bottom of the laptop hard disk pack. It was quicker at reading small files, managing 78.3MB/s, which led to a more respectable – if still

below-average – 72.6MB/s overall in the small-file transfer test.

There's little reason to buy the Ultrathin drive unless you explicitly need an ultra-slim model. Its performance is eclipsed by other larger drives, and its cost per gigabyte is far higher, making it poor value.

If your laptop is able to accommodate standard 7mm-thick 2½in drives, we'd recommend the Seagate Laptop SSHD instead, thanks to its faster overall performance and boot times.

KEY SPECS
$150 (500GB)
Costs per gigabyte - 0.30 (500GB)

OVERALL

500GB

Large files overall	103.8MB/s
Small files overall	72.6MB/s

0%   -50   Reference   +50   +100

Western Digital Black

STRONG PERFORMANCE FOR A MECHANICAL HARD DISK AND PLENTY OF STORAGE FOR NOT MUCH CASH

The Black range of 3½in desktop drives is Western Digital's performance series. Each drive has a 7,200rpm spindle speed and 64MB cache. Other hard disks, such as Seaga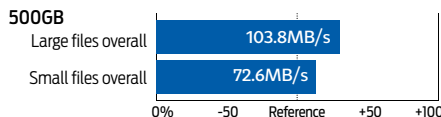te's Desktop HDD range, have slower speeds for their higher-capacity models, but although you pay a premium for the faster speeds, the Black range still provides good value. It's available with 500GB, 1TB, 2TB and 4TB and, as usual, the large capacities provide the best value. The 4TB drive works out at just seven cents per gigabyte, while the 500GB model is 17 cents. We feel the 500GB model isn't worth buying, as the 1TB model is only around $20 more.

Western Digital sent us the 1TB and 4TB models to test, and there was a fair difference between them in our tests. The 4TB model managed 237.2MB/s when writing and 326.7MB/s when reading large files, which is exceedingly quick for a mechanical drive. The 1TB drive was slightly slower, writing at 231.2MB/s and reading at 281.9MB/s, for an overall score of 256.6MB/s.

In the small-file test the standings were reversed. We measured a small-file write speed of 84.8MB/s and read speed of 68MB/s from the 4TB drive, but the 1TB drive performed better, with a 91MB/s write and 82MB/s read speed for an average of 86.5MB/s – 10MB/s faster than the 4TB drive.

The Western Digital Black is certainly good value considering its strong performance, but if you're looking for a secondary mechanical hard disk for your media, and are pairing it with an SSD, it might be overkill.

If you'll only use the Western Digital Black as a media drive to access movies and music, you won't feel the benefits of the additional speed. In that case it might be worth saving some money and opting for a cheaper hard disk such as one from Western Digital's Best Buy-winning Green range instead. The Green drives aren't far off for overall speed, and you could put the money you'd save towards an SSD to use as a system disk.

If, on the other hand, you need a secondary drive to store data such as 4K video files for editing, the Western Digital Black comes into its own, especially the 4TB model with its fast large file transfer speeds.

4TB

Large files overall	282MB/s
Small files overall	76.4MB/s

0%   -50   Reference   +50   +100

KEY SPECS
$85 (500GB) $105 (1TB) $179 (2TB) $299 (4TB)
Costs per gigabyte - 0.17 (500GB) 0.10 (1TB)
0.09 (2TB) 0.07 (4TB)

OVERALL
0   1   2   3   4   5

Western Digital Black2 Dual Drive

THE WESTERN DIGITAL BLACK2 IS A CLEVER COMBINATION OF A HARD DISK AND SSD ALL IN A SINGLE 2½IN FORM FACTOR

At first glance, the Black2 Dual Drive looks like a standard 2½in hard disk, but it's actually two disks in one, with both a 1TB hard disk and 120GB SSD in the same shell. Unlike other hybrid drives, the Black2 doesn't use the SSD as a cache. Its just two drives in a case with one SATA3 interface.

Conveniently, the Black2 comes with a couple of extras to help you install the drive in your computer. A USB3-to-SATA adaptor and a downloadable edition of Acronis True Image that only works with the Black2 will help you clone your PC's existing Windows installation to the SSD. At 9.5mm, the drive is deeper than most SSDs or laptop hard disks, so if you plan to fit it in a laptop, check that your drive bay is big enough.

You don't need Acronis True Image if you reinstall Windows from scratch, but the software driver is essential. Without it, only the 120GB SSD will be visible to Windows. The driver is compatible with Windows 8.1 and Windows versions as old as XP, and the drivers are included on a USB flash drive.

The Black2's SSD uses 20nm NAND flash and a JMicron JMF667H controller. The 1TB hard disk has a spindle speed of 5,400rpm and 64MB of cache. As the drives are separate, we ran each through our benchmarks. In our large files test, the 120GB SSD wrote files at 216.2MB/s and read them at 394.9MB/s, for an overall score of 305.6MB/s. These are very slow speeds for a modern SSD. Small-file performance was also average at 93.3MB/s for writing and 79.2MB/s for reading.

The 1TB hard disk was more impressive for a mechanical disk, with a large-file read speed of 196.6MB/s and a write speed of 112.3MB/s. That's great for a 2½in hard disk, but the small-file write speed of 37.9MB/s is poor. If you're using your disk mainly to store media files, however, this shouldn't be a problem. Small-file performance is more important for loading programs and the operating system.

Since its launch, the Black2 has fallen in price to the point where it costs 28 cents per gigabyte in total, which isn't cheap. If you want the speed of an SSD for your software and operating system, 120GB should be just enough space. That leaves you with a generous 1TB for your media, making the Black2 a good upgrade for a laptop's storage capacity. Just make sure its 9.5mm thickness will fit in your computer.

PC &TECH AUTHORITY RECOMMENDED

4TB

	HDD	SSD
Large files overall	154.5MB/s	305.6MB/s
Small files overall	52.3MB/s	86.3MB/s

0%   -50   Reference   +50   +100

KEY SPECS
$320 (1TB + 120GB SSD)
Costs per gigabyte - 0.28 (1TB + 120GB SSD)

OVERALL
0   1   2   3   4   5

Western Digital Green

GREAT PERFORMANCE FOR A BUDGET PRICE MAKES THE WESTERN DIGITAL GREEN HARD DISK RANGE A BEST BUY

Western Digital's Green series of 3½in desktop hard disks offers a great combination of low price and impressive performance. It's difficult to judge exactly what makes the drives perform so well, as Western Digital is secretive about some of the specifications. Rather than list a spindle speed, Western Digital describes its Green disks as using 'IntelliPower'. According to the company, this is a set of algorithms that manage spin speed, transfer rate and caching to deliver power savings and improve performance.

The Western Digital Green range is available in 500GB, 1TB, 2TB, 3TB and 4TB capacities, so there are plenty of options. The cost per gigabyte for the larger capacities is a very reasonable five

cents for 4TB, 3TB and 2TB versions and 4p for 1TB, making them close rivals to the Seagate Desktop range for price. The 500GB drive is only $10 less than the 1TB model, so isn't really worth buying.

We tested the 4TB and 1TB models and both performed remarkably well considering their low price. The 4TB version managed a read speed of 256.9MB/s and a write speed of 195.6MB/s in our large-file test. The 1TB model performed similarly, managing read speed of 255MB/s and a write speed of 201.1MB/s. These large-file scores are above average for mechanical hard disks.

In the small-files test the 1TB model wrote at a strong 85MB/s, but the 4TB drive managed a huge 92MB/s, which is the best we've seen from such a large drive. The 4TB drive read small files at 73.2MB/s, which again was quicker than the 1TB disk's 65.3MB/s. Considering the low price of the drives, we're seriously impressed with their performance.

If you're looking for a secondary drive

to store your media, the higher-capacity drives in Western Digital's Green range offer a great price per gigabyte, and they're quick enough to use as large system disks, too. Anyone who needs to work with a lot of large files, such as when editing video, should consider the Western Digital Black range instead with its superb large-file performance, but for most people the Western Digital Green series is the Best Buy.

KEY SPECS
$69 (500GB) $79 (1TB) $109 (2TB) $139 (3TB) $195 (4TB)
Costs per gigabyte - 0.14 (500GB) 0.08 (1TB) 0.05 (2TB) 0.05 (3TB) 0.05 (4TB)

OVERALL

4TB

Large files overall	226.3MB/s
Small files overall	82.6MB/s

Western Digital Green Mobile

THE WESTERN DIGITAL GREEN MOBILE HAS REASONABLE SPEEDS BUT IS LIMITED BY ITS FORM FACTOR

Although 2½in disk drives are commonly used for laptops, Western Digital's 2½in Green Mobile hard disk drive is not intended for such use. This is because, with a thickness of 15mm, it simply won't fit in laptop bays that typically accept 5mm, 7mm or 9.5mm drives.

Instead, despite its name, the Western Digital Green Mobile is designed for use in a desktop PC or custom enclosure. Its smaller 2½in form factor is more often seen in all-in-one desktop PCs, so if you need to upgrade your all-in-one's internal storage, it's worth checking whether yours takes 2½in or 3½in drives. Most regular PC cases will also accept the 2½in drive in any slots designed for SSDs. The Green Mobile is available in either 2TB or 1.5TB capacities, which cost 11 and 13 cents per gigabyte respectively.

The appeal of these thicker 2½in hard disks is that they typically generate less heat and are more power-efficient than typical 3½in hard disks. Like Western Digital's 3½in Green hard disk range, the 2½in Green disks use Western Digital's 'IntelliPower' and 'IntelliSeek' technologies, which help reduce the disk's power consumption and the level of vibration as the disk spins up and down.

The Green Mobile uses a conventional SATA3 connector and has 8MB of cache. If you need to transfer data from an existing drive, you'll be pleased to hear that Acronis True Image WD Edition is available as a free download from Western Digital's website and works with any Western Digital drive.

The 1.5TB and 2TB versions we tested performed similarly. In our large-file read test, the 1.5TB disk managed a speed of 135.6MB/s while the 2TB drive managed 144.2MB/s. Write speeds were 103.6MB/s for the 1.5TB and 113.3MB/s for the 2TB disk, meaning the 2TB drive was fractionally faster overall. In our small-files

test the 1.5TB disk read at 65MB/s and the 2TB drive at 65.9MB/s. Write speeds were 79.9MB/s for the 1.5TB disk and 83.7MB/s for the 2TB version, which are above average for a 2½in hard disk.

Western Digital's Green Mobile range performed very well overall, and the price per gigabyte is competitive. If you don't specifically need a 2½in disk, however, Western Digital's Green disks are better value and offer higher capacities and performance.

KEY SPECS
$192 (1.5TB) $230 (2TB)
Costs per gigabyte - 0.13 (1.5TB) 0.11 (2TB)

OVERALL

1.5TB

Large files overall	119.6MB/s
Small files overall	72.5MB/s

SSD Benchmarks

Large write (MB/s)

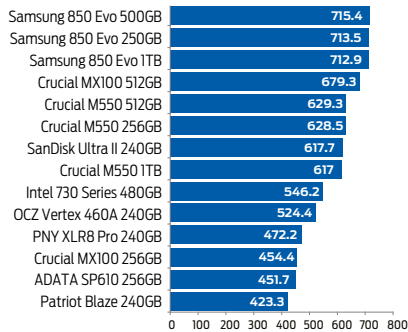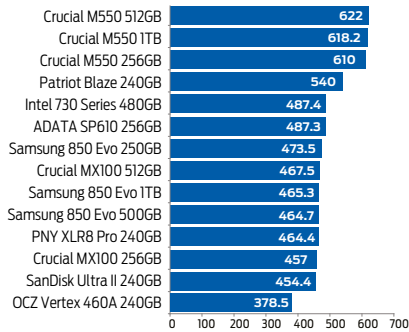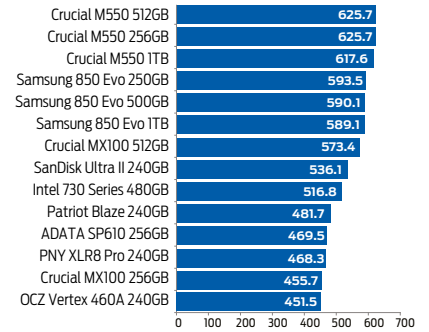|	
Samsung 850 Evo 500GB	715.4
Samsung 850 Evo 250GB	713.5
Samsung 850 Evo 1TB	712.9
Crucial MX100 512GB	679.3
Crucial M550 512GB	629.3
Crucial M550 256GB	628.5
SanDisk Ultra II 240GB	617.7
Crucial M550 1TB	617
Intel 730 Series 480GB	546.2
OCZ Vertex 460A 240GB	524.4
PNY XLR8 Pro 240GB	472.2
Crucial MX100 256GB	454.4
ADATA SP610 256GB	451.7
Patriot Blaze 240GB	423.3

Large read (MB/s)

Crucial M550 512GB	622
Crucial M550 1TB	618.2
Crucial M550 256GB	610
Patriot Blaze 240GB	540
Intel 730 Series 480GB	487.4
ADATA SP610 256GB	487.3
Samsung 850 Evo 250GB	473.5
Crucial MX100 512GB	467.5
Samsung 850 Evo 1TB	465.3
Samsung 850 Evo 500GB	464.7
PNY XLR8 Pro 240GB	464.4
Crucial MX100 256GB	457
SanDisk Ultra II 240GB	454.4
OCZ Vertex 460A 240GB	378.5

Large overall (MB/s)

Crucial M550 512GB	625.7
Crucial M550 256GB	625.7
Crucial M550 1TB	617.6
Samsung 850 Evo 250GB	593.5
Samsung 850 Evo 500GB	590.1
Samsung 850 Evo 1TB	589.1
Crucial MX100 512GB	573.4
SanDisk Ultra II 240GB	536.1
Intel 730 Series 480GB	516.8
Patriot Blaze 240GB	481.7
ADATA SP610 256GB	469.5
PNY XLR8 Pro 240GB	468.3
Crucial MX100 256GB	455.7
OCZ Vertex 460A 240GB	451.5

Small write (MB/s)

Crucial M550 512GB	101
Intel 730 Series 480GB	100.4
Crucial MX100 512GB	100.2
Crucial M550 1TB	100.1
Crucial M550 256GB	100
Samsung 850 Evo 1TB	99.8
ADATA SP610 256GB	99.4
Crucial MX100 256GB	98.9
Samsung 850 Evo 500GB	98.8
Samsung 850 Evo 250GB	98.8
Patriot Blaze 240GB	98.6
SanDisk Ultra II 240GB	97.5
PNY XLR8 Pro 240GB	97
OCZ Vertex 460A 240GB	90.1

Small read (MB/s)

Samsung 850 Evo 1TB	91.2
ADATA SP610 256GB	85.7
PNY XLR8 Pro 240GB	84.6
Crucial M550 1TB	83.5
Crucial M550 512GB	82.5
Crucial MX100 512GB	81.9
Crucial MX100 256GB	81.9
Samsung 850 Evo 500GB	81.4
Samsung 850 Evo 250GB	81.4
Intel 730 Series 480GB	81.4
Crucial M550 256GB	81.0
SanDisk Ultra II 240GB	77.0
Patriot Blaze 240GB	75.9
OCZ Vertex 460A 240GB	66.1

Small overall (MB/s)

Samsung 850 Evo 1TB	95.5
Samsung 850 Evo 250GB	92.8
ADATA SP610 256GB	92.6
Crucial M550 1TB	91.8
Crucial M550 512GB	91.8
Crucial MX100 512GB	91.1
Intel 730 Series 480GB	90.9
PNY XLR8 Pro 240GB	90.8
Crucial M550 256GB	90.5
Crucial MX100 256GB	90.3
Samsung 850 Evo 500GB	90.1
SanDisk Ultra II 240GB	87.3
Patriot Blaze 240GB	87.3
OCZ Vertex 460A 240GB	78.1

HDD Benchmarks

Large write (MB/s)

WD Black 4TB	237.2
WD Black 1TB	231.2
WD Black² SSD	216.2
WD Green 1TB	201.1
WD Green 4TB	195.6
Seagate Desktop SSHD 4TB	193.9
Seagate Desktop HDD 4TB	168
Seagate Laptop SSHD	132.1
WD Green Mobile 2TB	113.3
WD Black² HDD	112.3
WD Green Mobile 1.5TB	103.6
Seagate Ultrathin	100.8

Large read (MB/s)

WD Black² SSD	394.9
WD Black 4TB	326.7
WD Black 1TB	281.9
WD Green 4TB	256.9
WD Green 1TB	255
WD Black² HDD	196.6
Seagate Desktop SSHD 4TB	175.7
Seagate Desktop HDD 4TB	157
WD Green Mobile 2TB	144.2
WD Green Mobile 1.5TB	135.6
Seagate Laptop SSHD	133.9
Seagate Ultrathin	106.7

Large overall (MB/s)

WD Black² SSD	305.6
WD Black 4TB	282
WD Black 1TB	256.6
WD Green 1TB	228.1
WD Green 4TB	226.3
Seagate Desktop SSHD 4TB	184.8
Seagate Desktop HDD 4TB	162.5
WD Black² HDD	154.5
Seagate Laptop SSHD	133
WD Green Mobile 2TB	128.8
WD Green Mobile 1.5TB	119.6
Seagate Ultrathin	103.8

Small write (MB/s)

WD Black² SSD	93.3
WD Green 4TB	92
WD Black 1TB	91
WD Green 1TB	85
WD Black 4TB	84.8
WD Green Mobile 2TB	83.7
Seagate Laptop SSHD	82.7
WD Green Mobile 1.5TB	79.9
Seagate Desktop SSHD 4TB	79.9
Seagate Desktop HDD 4TB	73.9
Seagate Ultrathin	66.9
WD Black² HDD	37.9

Small read (MB/s)

Seagate Laptop SSHD	92.7
WD Black 1TB	82
WD Black² SSD	79.2
Seagate Ultrathin	78.3
Seagate Desktop SSHD 4TB	77.6
Seagate Desktop HDD 4TB	75.7
WD Green 4TB	73.2
WD Black 4TB	68
WD Black² HDD	66.7
WD Green Mobile 2TB	65.9
WD Green 1TB	65.3
WD Green Mobile 1.5TB	65

Small overall (MB/s)

Seagate Laptop SSHD	87.7
WD Black 1TB	86.5
WD Black² SSD	86.3
WD Green 4TB	82.6
Seagate Desktop SSHD 4TB	78.8
Seagate Desktop HDD 4TB	77.5
WD Black 4TB	76.4
WD Green 1TB	75.15
WD Green Mobile 2TB	74.8
Seagate Ultrathin	72.6
WD Green Mobile 1.5TB	72.5
WD Black² HDD	52.3

SSDs

	ADATA Premier SP610	Crucial MX100 **RECOMMENDED**	Crucial M550 **BEST BUY**	Intel 730 Series	Patriot Blaze	PNY XLR8 Pro	Samsung 850 Evo	Sandisk Ultra II **BEST BUY**	OCZ Vertex 460A
Rating	★★★☆☆	★★★★☆	★★★★★	★★★☆☆	★★★★☆	★★☆☆☆	★★★★☆	★★★★★	★★☆☆☆
HARDWARE									
Capacity	256GB/512GB/1TB	256GB/512GB	256GB/512GB/1TB	240GB/480GB	240GB/480GB	240GB/480GB	250GB/500GB /1TB	240GB/480GB/ 960GB	120GB/240GB/ 480GB
Cost per gigabyte	53c (256GB), 52c (512GB), $55c (1TB)	56c (256GB), 54c (512GB)	58c (256GB), 54c (512GB), 61c (1TB)	78c (240GB), 83c (480GB)	51c (240GB), 50c (480GB)	66c (240GB), 53c (480GB)	67c (250GB), 64 (500GB), 53 (1TB)	58c (240GB), 54c (480GB), 54c (960GB)	0.75 (120GB), 0.74 (240GB), 0.66 (480GB)
Interface	SATA3	SATA3	SATA3	SATA3	SATA3	SATA3	SATA3	SATA3	SATA3
Claimed read	560MB/s	550MB/s	550MB/s	550MB/s	555MB/s	550MB/s	540MB/s	550MB/s	540MB/s
Claimed write	290MB/s (256GB), 450MB/s (512GB, 1TB)	333MB/s (256GB), 500MB/s (512GB)	500MB/s	470MB/s (480GB), 270MB/s (240GB)	533MB/s (240GB), 500MB/s (480GB)	520MB/s	520MB/s	500MB/s	525MB/s
Controller	Silicon Motion SM2246EN	Marvell 88SS9189	Marvell 88SS9189	Intel third generation	Phison PS3108-S8	SandForce 2281	Samsung MGX Controller (250GB, 500GB), Samsung MEX Controller (1TB)	Marvell 88SS9190/ 88SS9189	Barefoot 3 M10
NAND flash type	20nm MLC	19nm MLC	20nm MLC	20nm MLC	16nm MLC	25nm MLC	40nm 3D V-NAND	19nm TLC	19nmMLC
Mounting kit	No	No	No	No	No	No	No	No	Yes
Part code	ASP610SS3-256GM-C, ASP610SS3-512GM-C, ASP610SS3-1TM-C	CT256MX100SSD1, CT512MX100SSD1	CT256M550SSD1, CT512M550SSD1, CT1024M550SSD1	SSDSC2BP240G4R5, SSDSC2BP480G4R5	PB240GS25SSDR, PB480GS25SSDR	SSD9SC240GCDA-RB, SSD9SC480GCDA-RB	MZ-75E250BW, MZ-75E500BW, MZ-75E1T0BW	SDSSDHII-240G-G25, SDSSDHII-480G-G25, SDSSDHII-960G-G25	VTX460A-25SAT3-120G, VTX460A-25SAT3-240G, VTX460A-25SAT3-480G

HARD DISKS

	Seagate Desktop HDD	Seagate Desktop SSHD	Seagate Laptop SSHD **RECOMMENDED**	Seagate Laptop Ultrathin	Western Digital Black	Western Digital Black[2] Dual Drive **RECOMMENDED**	Western Digital Green **BEST BUY**	Western Digital Green Mobile
Rating	★★★☆☆	★★★☆☆	★★★★☆	★★★☆☆	★★★★☆	★★★★☆	★★★★★	★★★☆☆
HARDWARE								
Form factor	3½in	3½in	2½in	2½in	3½in	2½in	3½in	2½in
Capacity	2TB/3TB/4TB	1TB/2TB/4TB	1TB	500GB	500GB/1TB/2TB/4TB	1TB + 120GB SSD	500GB/1TB/2TB/ 3TB/4TB	1.5TB/2TB
Cost per gigabyte	5c (2TB, 3TB, 4TB)	11c (1TB), 7c (2TB), 6c (4TB)	10c (1TB)	30c (500GB)	17c (500GB), 10c (1TB), 9c (2TB), 7c (4TB)	28c	14c (500GB), 8c (1TB), 5c (2TB, 3TB, 4TB)	13c (1.5TB), 11c (2TB)
Interface	SATA3	SATA3	SATA3	SATA3	SATA3	SATA3	SATA3	SATA3
Spindle speed	5,900rpm (4TB), 7,200rpm (other capacities)	5,900rpm (4TB), 7,200rpm (other capacities)	5,400rpm	5,400rpm	7,200rpm	5,400rpm	IntelliPower	IntelliPower
Cache	64MB	64MB/8GB SSD	64MB	16MB	64MB	64MB	64MB	8MB
Quoted seek time	12ms	12ms	8ms	13ms	IntelliSeek	21ms	IntelliSeek	IntelliSeek
Part code	ST2000DM001, ST3000DM001, ST4000DM000	ST1000DX001, ST2000DX001, ST4000DX001	ST1000LM014	ST500LT032	WD5003AZEX, WD1003FZEX, WD2003FZEX, WD4003FZEX	WD1001X06XDTL	WD5000AZRX, WD10EZRX, WD20EZRX, WD30EZRX, WD40EZRX	WD15NPVX, WD20NPVX

Prices correct at time of going to press

Welcome to **Upgrade Australia**

MINI PC AND MOBILE
DESKTOP SOLUTION

A closer look at how to combine the versatility of a desktop with the compact size, portability and energy efficiency of a notebook.

You're chasing a PC that's customisable, which usually means you're shopping for a desktop. But the option to move from study to lounge room, or home to office is also important, which usually means you want a laptop. This month's Upgrade Australia focuses on a solution that's the best of both worlds: a solution that lets you personalise a PC's innards to your specific needs. At the same time, you have the option of fewer cables and greater portability, should the need arise. You'll still need to plug this solution into the wall, but its compact design makes it a cinch to relocate.

FROM WORK TO ENTERTAINMENT

Intel's range of 5th generation Core i3 & Core i5 Next Unit of Computing Mini PCs house personalisation potential in a four-inch square design. You have a choice of a leading-edge Intel CPU, SSD and RAM, alongside any external display, USB devices and external speakers with support for 7.1 surround sound. Connect your NUC to a compatible TV with HDMI to use it as a home-theatre PC. With Linux Mint OS and the XBMC media centre app, you can use infrared support to access a library of locally stored video, music or images on as much as 2TB of internal storage, with a compatible remote.

On top of this, gigabit Ethernet and 802.11ac Wi-Fi mean users can reliably stream content from a local network or cloud storage. Built-in Bluetooth connectivity is there to connect your NUC with compatible speakers or headsets, with range of up to 30

feet. You can further reduce cable clutter by wirelessly pushing the image from a NUC to a WiDi-compatible display via Intel WiDi technology. This makes it easier to shift your NUC from lounge-room media hub to study-room work computer. On top of this, Intel HD Graphics 5500 and 6000 Graphics means a NUC is ready to connect to 4K Ultra HD displays.

BUILT TO WORK WITH YOU

A Core i5 processor-powered VPro NUC offers even greater versatility, stability and manageability. This 5th generation Intel CPU provides the necessary horsepower to streamline resource-intensive tasks, with Intel Turbo Boost Technology 2.0 for automated performance boosts. For instance, record and mix high-quality audio content at the office, and bring the NUC home to finalise at home. Additionally, the NUC is capable of editing and rendering HD videos in a similar respect.

Dual Mini-DisplayPort options on the back of the NUC allows triple-display 4K support for larger viewing efficiency, with the option to add Wi-Fi and WiDi. The 5th generation NUCs also include a charging-capable USB port that's ideal for quickly charging smartphones and tablets. If mobility isn't a prerequisite, you can also create your own fixed-screen All-in-One desktop solution by

way of included Video Electronics Standards Association (VESA) bracket.

VERSATILE GAMING PLATFORM

With a Core i5 processor inside a NUC, gamers can also take advantage of automated performance improvements by way of Intel Turbo Boost and games optimised for Intel Graphics. Intel HD Graphics 6000 has the power to handle casual, indie and mainstream games on a compatible TV, 4K display or across multiple HD monitors. Better yet, it's DirectX 12 ready. The new Intel Graphics offer enhanced gaming performance and video editing conversion performance with Quick Sync (over previous generation NUCs).

Combine an M.2 SSD with Intel Rapid Start Technology to load games faster and instantly resume where you left off. All of your gaming peripherals connect via Bluetooth or USB (3x USB 3.0 and 1x USB 2.0), which means there's room for keyboard, mouse, headset, steering wheel, gamepad or joystick. The gigabit Ethernet port equates to fast streaming of high-end games from a dedicated desktop to your NUC via Steam's Big Picture Mode. On top of this, the compact design makes it easier to transport between rooms or to LAN parties.

For more information, visit intel.com/nuc

THE ULTIMATE UPGRADE EVENT

On March 19th in Sydney a huge event takes place with a showcase of PC gear and star speakers from the leaders in technology. It's an insight into emerging technologies, plus a bit of fun, too. Food and drinks will be provided! Go to www.pcauthority.com.au/UpgradeAustralia/ to register your interest in attending, all are invited, but only a lucky few can attend, so register your interest now!

It's a wide open road

THE OPEN WORLD GENRE OF GAMES HAS ALWAYS BEEN WITH US, BUT WHAT IS SO APPEALING ABOUT IT, AND WHAT'S DRIVING THE CURRENT EXPANDING CROP OF TITLES? **DAVID HOLLINGWORTH** INVESTIGATES

There are many unique pleasures when it comes to gaming. There's the frenetic pace and feeling of achievement you can get from a good round of Battlefield 4, or the sense of scope and fine control of history that Civilization delivers. Speed junkies may get their kicks with racers as diverse as Asseto Corsa to GRID, while aviation nuts can enjoy the many commercial and combat sims. There are truly games for all occasions, but there's one gaming genre that has always offered something harder to pin down, and it's a game that's becoming more prominent.

We're talking about open world games. These days, in fact, the line between open world and many other genres is blurring pretty heavily, but expanding computing power has allowed the wide open worlds of games like Skyrim and Grand Theft Auto V to grow into ever larger, more photo-realistic vistas. And while large studios such as Bethesda and Rockstar do good work in the area, smaller developers are also opening up the genre, with titles as diverse as Stranded Deep and No Man's Sky.

But where has this growing love, and demand for ever more, open world games come from, and why does it seem that, all of a sudden, that more and more developers are making open world games? Well, pack a meal or two – we're going on a journey...

IN THE BEGINNING
Open worlds in games are nothing new – they in fact go all the way back to the first Ultima games, in the early 80s. They weren't nearly as interactive as the modern sandboxes we have today, but the one key feature – an open world to explore and discover, without a discrete and linear path to follow, was in place.

Fantasy games were almost certainly always going to head in this direction. It is after all a trope of the fantasy novels and roleplaying games these early titles were based upon. From the sprawling and detailed world of The Lord of the Rings Middle Earth, to the darker, more baroque Elric novels, readers have always

"What Elite brought that no other game quite had before, was the sense that it was a real, ongoing world, and that you could explore it at your pace"

wanted to step out of our world, and into theirs. The rise of tabletop game Dungeons & Dragons also helped shape the desire to explore fantastic realms. As D&D inspired many early dungeon-crawl computer RPGs, it's obvious – in hindsight – that those worlds were always going to expand, especially as computer power grew capable of representing ever larger, and more open, worlds.

Computer games have always provided a degree of distraction from the every-day – even Pong and Dig-Dug essentially transfer you into a different place – but open world games take that a step further. It's not just escapism, they offer, but true immersion. There is a reason that many gamers look back on titles like

Ultima with immense fondness; it was the first convergence of everything many computer gamers had been dreaming of.

There were a tonne of what we would now consider open world games that followed in Ultima's wake, including driving games like New York City, to action games like the sprawling Hunter, but possibly one of the most iconic games of this early period would have to be the space sim Elite.

Elite was... well, for many, it was the ultimate in science fiction games. It's also got quite a development history, coming out first on the BBC Micro, and eventually finding its way to the Commodore and Amiga, and then DOS in 1991. The game's premise was deceptively simple – you're pilot, with 100 credits and low-end space ship. The rest of the game, the missions you take, the way you play, the way you upgrade or improve your ship... it's all up to you. The game featured hundreds of procedurally generated planets, an alien race to avoid, and items to trade.

What Elite brought to the open world table that no other game quite had before, was the sense that it was a real, ongoing world, and that you could explore it at your pace. It was, in effect, a sandbox for players to explore however they saw fit.

However Elite also highlighted some of the limits of early experiments in expansive and open gameplay. While it had hundreds of worlds, a range of starships to own and tinker with, it was also presented in wireframe graphics, in simple black on white. There were limited

colours on some versions, but generally, this was the price you paid for wanting something non-linear. Even Ultima, which was 2D back then, was very basic in its graphics. Even into the 90s, games like Hunter – which was ground-breaking in its day – were blocky, polygonal affairs. It was technically 3D, but, again, to look back at, it really wasn't much.

Oddly, it would be a humble Italian plumber that really opened up the world of gaming.

IT'S-A MARIO!

Super Mario 64 is one of those moments in gaming that is truly pivotal. If you played it, back in 1996, I'm sure that you can re-member the feeling of awe, of jaw-drop-ping amazement, as you start to explore the 3D worlds on offer. But as great as the game looked, it brought together a whole raft of elements that gamers can now take for granted.

The game featured a truly fluid camera system that made the most of the 3D space, following Mario as he jumped, flew, dove, and bounced around a series

∧ It is absolutely true that Mario 64 was one of the first true open world games

of large, enclosed 'worlds'. Controlling Mario was similarly a breeze, thanks to the Nintendo 64's excellent analogue control stick, and the ways in which you could direct Mario around each world were truly groundbreaking, allowing you to combine jumps with control stick movements and the environment, so that you could wall-jump, double and triple-jump, and even swim underwater.

That latter ability brings to mind one of the most memorable levels of all in SM64, the underwater level, where you need to avoid a serpentine sea monster, and explore a sunken wreck, all while trying to manage a limited supply of oxygen. While the rest of the game was largely typical in its colourful and happy presentation of Mario, this level was brutal and pretty dark. Truly, one of the most impactful images many gamers will ever remember is Mario's lifeless, floating corpse after they spend too long between taking life-giving breaths.

Nintendo was also working on The Legend of Zelda: The Ocarina of Time during SM64's own development, and game's share many similarities. Indeed, The Ocarina of Time – when it came out two years later it was considered another massive leap forward for open world gaming. And if you're seeing a trend here, of console hardware edging ahead of PC hardware in terms of graphical power, you'd right – Nintendo, for instance, was able to leverage the fact that it owned the software (Super Mario 64) and hardware (the Nintendo 64 itself) side of the business, truly pushing the limits of what both could do.

Gaming on the PC was of course going strong, too, but on PC it was strategy titles, and more linear shooters and RPGs that were gaining prominence.

In fact, the 90s would close out with another groundbreaking open world game on console, though this was somewhat of a bittersweet accomplishment. Shenmue, on the Sega Dreamcast, featured a large city to explore, with NPCs, minigames, early Quick Time Events, and much more.

> Long before the extravagant worlds of GTA IV, the very first title in the series gifted gamers with exactly the same feeling of going anywhere, and the freedom to do anything

> *"Open world games are all things to all players. Most importantly, they offer truly unique experiences to players"*

The game that would come to define the entire genre launched in the new millennium. Grand Theft Auto III eschewed the top-down 2D of the previous series and delivered a truly sprawling 3D experience that borrowed a lot from Shenmue, but also added in the trademark Rockstar irreverence.

GTA III had a bit of everything. You were a criminal, for one thing, at a time when most games were religiously sticking to keeping people playing good-guys. If you could see a vehicle, you could drive it, and you could drive it pretty much everywhere. In fact, exploration was rewarding in game by finding money and other collectibles. Rooftops and alleyways alike were littered with ramps, again rewarding players with new and impressive ways to wreck motor-vehicles. And, of course, the games narrative was very non-linear. While there was a very definite, and strict, narrative series of quests, there were many side missions, and missions could be completed at any time. Future GTA games, and Rockstar's excellent Red Dead Redemption – would fill out the open world with more and more activities, from herding horses, to crafting, to treasure hunts, and numerous mini-games, from tennis to darts.

In many ways it was the blueprint for open world games to come. In fact, today, many open world games that borrow from this model – big city or similar space, open to explore, with a raft of player activities – are often called GTA clones. It's unfair, as it really is now just a genre of its own, but there's no denying the impact that Rockstar has had on the genre. In a very real sense, more modern games like Watch Dogs, Sleeping Dogs and Saints Row stand on the shoulders of Rockstar's work in the field.

Rockstar's continued to be one of the major drivers in the genre, and to many Grand Theft Auto V is its ultimate expression. Possessed of a truly vast open world, full to the brim with interesting characters and content, and instantly accessible no matter what kind of game you want to play, whether you want to stick to the story, go off and see how many cops you can kill before getting taken down, or simply to explore. Added to this is an online mode that delivers another

∧ While open world games are indeed, mostly, open, many, such as Fallout 3 steer the player a little via especially challenging enemies

illusive and often optional ingredient to open exploration – the ability to share that with others. GTA Online is pretty much the same game world, but with the ability to create your own individual characters and stories.

Which, in a way, brings us to massively multiplayer RPGs. By design, these worlds are similarly large – you can traverse entire continents without seeing a load screen in World of Warcraft, and it's possible to similarly travel from Hobbiton to the Grey Mountains in Lord of the Rings Online. Here, though, the emphasis is on the interaction; you can (and many have) spend happy hours just exploring, but it's impossible to travel in many areas of MMO worlds because of level restrictions that make such exploration rather perilous. Even Fallout 3 and New Vegas, very well respected open world games, and dedicated singleplayer titles, tend to channel players by the use of monsters.

Players being what they are, though, do see this as bit of a challenge. When World of Warcraft first released, there were entire stretches of road filled with player skeletons, as people tried to be the first to get to new areas ahead of their natural level progression.

WHAT'S OVER THAT HILL?
Obviously, open world games are popular, and amazingly, we're now seeing more and more of them being developed, and not just by AAA developers. And what draws people to these games is almost as varied as the games themselves. Some love the sense of that wider world, others the variety of quests and missions types these games represent; there are players who get addicted to crafting and exploration, or even contests to see how fast they can complete certain parts of the game.

But that depth of gameplay is perhaps this biggest attraction – open world games, especially the more modern ones, are all things to all players. Most importantly, they offer truly unique experiences to players. When Fallout 3 was published, three people in the office were playing the game, and each morning

we'd all compare stories – to an outsider, we could have been playing three different games. Events that had dominated one player's time had been missed or even avoided by another; locations and NPCs that one of us fell in love with may have been destroyed or killed by another.

Going a step further, it's even possible to bring in your own story. Take The Elder Scrolls V: Skyrim, for example. The game is now over three years old, but it still has legions of fans – some are well into their second 1000 hours of gameplay. And what a lot of them do is ignore the main plot in favour of their own smaller stories. This is where the PC has a big advantage over the console versions, as PC fans get to play with mods, and one mod offers not only a wealth of fresh character creation options, but also randomises where you start in the world. On top of this, it's entirely possible – and a lot of fun – to play the game in what's called 'Iron Man'

∨ The Elder Scrolls: Skyrim and Elite: Dangerous are both modern state of the art examples of the open world game

mode. Basically, you're allowed to save the game at the end of your session, but not go back to old saves, and if you die... that's it. Game over.

A lot of players – myself included – then like to add our own backstories. We could be a lost hunter, a studying mage, an Imperial spy... anything, really, and the game is open enough to support that style of personal, and yet emergent gameplay.

Though very different, zombie survival game DayZ is really not that different form playing Skyrim in that form. The game offers no plot other than your survival, and can be a real struggle, but the possibilities for exploration, interaction, and truly unique narrative experiences are nearly endless. It is emergent gameplay at its best, because the stories you make are yours, in a very personal way.

We're now seeing a lot of similar games come out, from publishers large and small. Games where it's not so much about the narrative, but for creating a rich enough environment where players can create their own. While many games

come complete with heavily structured missions and text-boxes to move you around, modern open world games, like DayZ, use systemic triggers to move you through the game world. You might discover that you are hungry, and so need to hunt; but to do that, you'll need a weapon, and so on.

The story emerges not from external plot devices, but from the most basic urges known to humanity. And that's what makes games like DayZ, and the more recent Stranded Deep so immersive. Stranded Deep is thankfully free of zombies (which are becoming more than a little overdone), but no less tense because of that. The game places you as the lone survivor of a plane crash, on procedurally generated island – your challenge is to survive, find food, build shelter, and maybe move from island to island without getting eaten by sharks.

Stranded Deep also highlights another modern phenomenon in the open world genre – these giant worlds used to be the purview of big developers and publishers, but now smaller dev houses are getting on board. Hello Games is the company behind another amazingly open, and largely procedural, game, No Man's Sky, which delivers thousands and thousands of worlds to explore. It's very sci-fi, but very much open to the player how those worlds are explored.

THE BEST OF TIMES

If you're fond of open games of narrative-free exploration, it's possible there were in quite the golden age. Our personal gaming systems, whether next-gen console or high-power desktop PC are more versatile than ever, a fact that developers are keen to take advantage of. At the same time, the tools to create these worlds are more accessible to devs than ever, meaning that this level of development is becoming widely democratised outside of the control of monolithic publishers. DayZ, for instance, started life as a one-person mod-project.

So we get to see richer games, with more unique mechanics; mechanics rich enough that they can drive a game without a narrative arc to propel players. Worlds not only get bigger, but they're presented in higher and higher definition, complete with destructible physics, high-res textures, and in-depth crafting systems.

In short, we're finally starting to see what all those early games promised so long ago – fantastic locations and thrilling challenges built on an ever more realistic framework. And those open worlds are only going to get bigger and better from here on. When it comes, Grand Theft Auto VI is going to be one hell of a thing.

The A-List

ONLY THE BEST OF THE BEST MAKE IT TO *PC & TECH AUTHORITY*'S A-LIST

L enovo's lovely Carbon X1 (reviewed this issue, page 41) came that close to bumping the Macbook Retina out of its long standing hold on the Professional Laptop category.

It's much lighter and thinner, can be configured to be as powerful – although the Carbon's memory can't go higher than 8GB, which ultimately is a fatal blow for a professional machine. We also really liked the more useable resolution of 2560x1440 vs the Retina's higher 2880x1800 – as there are still major issues with high DPI scaling across a great majority of websites and apps, but countering that is that the Retina's higher resolution fits its purpose as a professional machine. So, it stays.

However – if a Windows machine is what you need, then the Carbon X1 is an outstanding choice.

PC DESKTOP

ALL-IN-ONE
Apple iMac 27in
★★★★★

PRICE $2199

SUPPLIER www.apple.com/au

If you can afford it, the 27in iMac is the finest piece of all-in-one engineering on the market. A truly powerful beast with performance to match its looks..

SPECIFICATIONS 3.2GHz quad-core Intel Core i5; 8GB DDR3 RAM; 1TB Western Digital Caviar Black HDD; NVIDIA GeForce GT 755M 1GB; 27in 2560 x 1440 LCD.

PERIPHERALS

WIRELESS ROUTER Netgear Nighthawk X6 AC3200
★★★★☆

SUPPLIER www.netgear.com.au

Designed to keep pace with high-bandwidth content consumption, it is the router King.

SPECIFICATIONS 1GHz dual core processor with 3 offload processors, 6 High performance antennas, one 2.4GHz band and two 5GHz Wi-Fi bands

DESKTOP STORAGE CalDigit T3 with Thunderbolt 2
★★★★★

SUPPLIER www.amazon.com

The T3 is an expensive RAID device, but when you factor in the drives and the capacity included, it's good value.

SPECIFICATIONS 6/9/12/15TB external hard disk with RAID; Thunderbolt and Thunderbolt 2, 135 x 241 x 116mm 4.5kg.

NAS Synology Diskstation DS214play
★★★★★

SUPPLIER www.synology.com

The fastest NAS in our grouptest (*PC&TA 197*), with excellent media streaming capabilities.

SPECIFICATIONS 2.1GHz Intel Atom; 2GB RAM; 2 x USB 3 + 1 x USB 2; iOS and Android mobile apps; RAID 0, 1, 5, 10; JBOD .

ALL-IN-ONE PRINTER

Canon Pixma IP 8760
★★★★☆

SUPPLIER www.canon.com.au

This Canon can do it all, and at a reasonable price.

SPECIFICATIONS 9600 x 2400dpi print; 2400 x 4800ppi scan; USB 2; 802.11n WLAN; 150-sheet tray

LASER PRINTER Dell B1160w
★★★★★

SUPPLIER www.dell.com.au

The best all-rounder in our printer grouptest, with excellent text printing and decent costs.

SPECIFICATIONS 1800 x 600dpi resolution; USB 2; Wi-Fi; 150-sheet input trays; 331 x 215 x 178

LAPTOPS

VALUE
Asus TF103C
★★★★★
PRICE $429
SUPPLIER www.asus.com.au
While ostensibly a tablet with a removable keyboard, it also fits tidily into the value portable category thanks to it's immense usability and remarkably low price.
SPECIFICATIONS Quad-core 1.86GHz Intel Atom Z3745 · 1GB RAM · 8GB/16GB eMMC storage · 10.1in 1,280 x 800 IPS display · dual-band 802.11n Wi-Fi

PERFORMANCE
Aorus X7
★★★★☆
PRICE $2999
SUPPLIER www.aorus.com
Super-sleek, light, outrageously powerful and with a spec-list that outclasses many high end desktop systems.
SPECIFICATIONS Q4-3.4GHz i7-4700HQ · 4GB/8GB DDR3L 1600, 4 slots (Max 32GB) · 17.3" Full HD 1920x1080 · NVIDIA® GTX 765M SLI GDDR5 4GB · mSATA 128GB/256GB, 2slot 2.5"HDD 500GB/750GB/1TB 5400rpm

PROFESSIONAL
Apple Macbook Retina
★★★★★
PRICE $3199
SUPPLIER www.apple.com/au
The machine that does everything right, and looks the part, too. We've chosen the top-end 2.3GHz i7 model with 16GB of RAM and a 512GB SSD plus GT 750M graphics.
SPECIFICATIONS 2.3GHz Intel Core i7; 16GB RAM; 512GB SSD; 15in 2880 x 1800 LCD; 1 x USB 3; 2 x USB 3; 2 x Thunderbolt 2; dual-band 802.11abgn Wi-Fi; Bluetooth 4; 3G

ULTRA PORTABLE
Microsoft Surface Pro 3
★★★★☆
PRICE $1549
SUPPLIER www.microsoft.com.au
Attach the Type Cover 2 and it's as good, if not better, than any 'proper' ultra portable laptop. It took three versions, but Microsoft has nailed this format. At least an i5 is recommended.
SPECIFICATIONS 1.9GHz Intel Core i5-4300U; 12in touchscreen (2160 x 1440); 8GB RAM; 256GB SSD; 802.11ac/abgn; Bluetooth 4

HANDHELDS

SMARTPHONE
Sony Xperia Z3 Compact
★★★★★
PRICE $699
SUPPLIER www.sony.com.au
In short, no other smartphone offers the same level of performance and features at this price.
SPECIFICATIONS 2.5GHz Qualcomm Snapdragon 801 SoC · 2GB RAM · 16GB storage · Adreno 330 graphics · 4.6in 720 x 1,280 IPS display

TABLET
Apple iPad Air 2
★★★★★
PRICE $539
SUPPLIER www.apple.com/au
The iPad Air 2 is definitively the best tablet on the market right now, and rightfully replaces its predecessor on our A-List.
SPECIFICATIONS 1.5GHz Apple A8X SoC · 2GB RAM · 16/64/128GB storage · 9.7in 1,536 x 2,048 IPS display · 7,340mAh battery

EBOOK READER
Kindle
★★★★★
PRICE $109
SUPPLIER www.amazon.com
The new model is quicker, slimmer, lighter and cheaper than before. If all you want to do is read books, its simple design and performance are perfect.
SPECIFICATIONS 6in e-Ink screen, 170g weight, 114 × 8.7 × 166 mm, 2GB memory, 10-day battery life . WEB ID 279534

SOFTWARE

SECURITY Norton Security 2015
★★★★★
SUPPLIER www.norton.com/security
Great malware protection and equally good legitimate software recognition

BACK UP Acronis true image 2015
★★★★☆
SUPPLIER www.acronis.com.au
The 2015 version adds full-system backup and dual backup and unlimited cloud storage.

OFFICE SUITE Microsoft Office 365 Home Premium
★★★★☆
SUPPLIER www.microsoft.com.au
The easiest to use Office to date.

WEB DEV Adobe Dreamweaver CS6
★★★★☆
SUPPLIER www.adobe.com.au
This edition makes PHP and CMS its core focus.

AUDIO Cubase 7.5
★★★★☆
SUPPLIER www.steinberg.net
The addition of better filters solidifies this program's continued place on the A-List.

VIDEO Sony Vegas Movie Studio HD Platinum 11
★★★★☆
SUPPLIER www.sony.com.au
May not have the bells and whistles of other consumer editing packages, but its tools are efficient.

PHOTO Adobe Photoshop Lightroom 5
★★★★☆
SUPPLIER www.adobe.com.au
An excellent tool for photo management and light editing, as used by the pros and now available at a very reasonable price.

The Kitlog

DREAM BUILDS WITH REAL GEAR.

As you can see from our storage round up this issue, there's still a sizeable performance gap between the fastest and slowest SSD – with cost not really being a significant factor as the cost per GB is very similar from top to bottom.

However, the best of the best is what the Perfect PC is about, so the Samsung 850 stays – but it needs to be noted that the Crucial M550 is a whisker away, and better at some tasks. You won't be disappointed with either. We're leaving the Samsung in, too, for the Game Box for the same reasons.

As for the video cards, despite our thorough testing this month of Nvidia's new 960-series GPU across a suite of cards, its price and performance fall just short of our recommendation in the Game Box. The 970 is simply a better gaming card that's still at a price that fits the Game Box goals.

THE GAME BOX

CPU

INTEL CORE I5 4690K
PRICE $289
Ripping along at a stock speed of 3.5GHz, this 'K' model allows easy overclocking for even more performance.

MOTHERBOARD

ASUS ROG RANGER
PRICE $219
Fully featured, extremely well engineered. Alternatively, the MSI Gaming 7 or Gigabyte Z97X-UD5H are equally as good at the same price.

MEMORY

KINGSTON HYPERX BEAST 16GB
PRICE $240
Our roundup award winner, it's well-priced, fast and overclocks very well.

VIDEOCARD

NVIDIA GTX 970
PRICE $500
Quiet, sips power, but when the performance is needed this blazer eats up the frames.

THE PERFECT PC

CPU

INTEL CORE I7 4790K
PRICE $419
Out of the box at 4GHz and with a 4.4GHz Turbo speed, this CPU will eat anything thrown at it.

MOTHERBOARD

ASUS Z97 DELUXE
PRICE $339
Plenty of cutting-edge technology crammed into this package. It's for those who want it all in a LGA1150 system .

MEMORY

CORSAIR DOMINATOR PLATINUM CMD32GX3M4A2133C9 32GB
PRICE $615
These memory chips are hand selected and tested, and 32GB of fast RAM will keep things smooth and fast in intensive tasks.

VIDEOCARD

NVIDIA GTX 980
PRICE $700
It's a pure powerhpouse, with the fastest single-GPU performance available today, and with support for advanced lighting and VR.

TOTAL: $2691   RIG ONLY: $1793

COOLER

COOLERMASTER NEPTON 140XL
PRICE $120
Easy to install AIO CPU cooling, relative quiet and performance to rival twin-radiator units.

CASE

BITFENIX RONIN
PRICE $99
Bitfenix continues to deliver great budget cases that look terrific and are easy to build in.

SYSTEMDRIVES

SAMSUNG 850 PRO 500GB
PRICE $300
Samsung's newest SSD offers greatly improved durability. Supplement it with a hard drive of your choice if needed.

KEYBOARD

CORSAIR K70
PRICE $160
The glorious perfection of mechanical keys with well thought-out gamer design.

DISPLAY

LG IPS277L
PRICE $400
27 inches of IPS glory. The resolution isn't perfect, but the price is. The thin bezel makes this a very attractive screen.

MOUSE

TT SPORTS VOLOS
PRICE $79
The easy first choice at *PC&TA* HQ where we play hard and test every mouse. Also superb value.

AUDIO

TT ESPORTS CRONOS
PRICE $80
Fantastic set of headphones that delivers great 2.1 audio for gaming and music without swamping you with bass.

SOUND BLASTER X-FI XTREME
PRICE $80
The best positional game audio at this price and good music quality.

POWER SUPPLY

COOLER MASTER G750M
PRICE $125
Outstanding value for money, it's powerful enough for even performance PCs packing twin GPUs.

TOTAL: $4998   RIG ONLY: $3700

COOLER

CORSAIR H105 WATER COOLER
PRICE $160
Best-of-breed cooling plus nice and quiet equals a happy CPU.

CASE

COOLER MASTER COSMOS II
PRICE $400
The only case you'll ever need. Premium luxurious bliss.

SYSTEMDRIVES

SAMSUNG 850 PRO 1TB SSD
PRICE $749
Our Labs winner is fast and durable with a wide choice in capacities.

SEAGATE BARRACUDA 2TB
PRICE $100
Supplement the PRO with cheap HDD storage.

KEYBOARD

CORSAIR VENGEANCE K95
PRICE $179
The perfect keyboard. Lovely Cherry Red mechanical switches, a slick and attractive aluminium body and customisable backlighting make this The One.

DISPLAY

ASUS PB287Q
PRICE $719
A fully-featured 4K monitor with near-perfect colour accuracy for under $800.

MOUSE

NEW

CM STORM REAPER
PRICE $85
Very solid and feels fantastic under the hand with sweet on-screen movement.

AUDIO

CREATIVE SOUND BLASTER ZXR
PRICE $269
Superb music and general audio, with the versatility of a comprehensive set of connectivity options.

POWER SUPPLY

CORSAIR HX1000I
PRICE $349
Corsair's mighty HX1000i pumps out extremely reliable power, even when under full loads.

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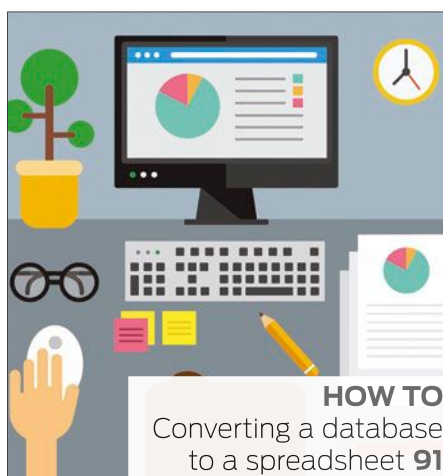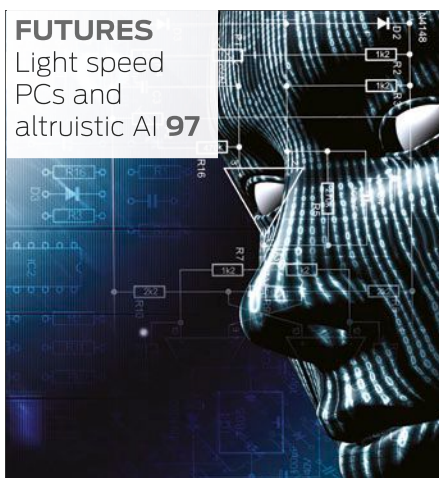
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THE BACK SECTION

It's the section where the real world experiences of our writers shines, and more than a few valuable lessons are to be learned.

CREATE PROFESSIONAL VIDEOS
WITH POWERDIRECTOR 11 LE

Darien Graham-Smith introduces the professional-grade video-editing suite that headlines this month's software downloads

Home-movie footage has an undeniable charm, but it doesn't take much effort to turn a piece of video that looks distinctly amateur into something more professional. The LE indicates this is a "light" edition, but fear not: this is still a fully featured video-editing tool, and an excellent way to create professional videos to share online. It just lacks some capabilities of the full version: in particular, the maximum output resolution is Full HD (1,920 x 1,080), so 4K rendering isn't supported, and direct transfer to DVD and Blu-ray isn't included either. MPEG-2 and AVCHD video files can't be imported, but this shouldn't pose a big problem; almost all modern smartphones and DSLRs capture MPEG-4 files in either MP4 or MOV format, both of which are fully supported via codecs already built into Windows.

This edition of the software also comes with a limited selection of video and transition effects – but such things are superfluous anyway. Professional film-makers don't distract the viewer with crazy colour filters and animated transitions, and neither should the rest of us.

Over the next three pages, we'll walk through the process of assembling a professional-looking video, and making it available for others to view. Although we'll focus on the PowerDirector interface, the workflow is similar in most major editing software, so if you want to get started with a different package, the same general principles will apply.

FIRST STEPS
Whether you're creating a ten-second video for friends or putting together a professional TV show, the video-editing workflow follows a standard sequence. You start, naturally, by shooting and collecting together all the footage you want to use. Next, in your editing software, arrange your clips into the desired order and trim away any extraneous footage, so the movie cuts cleanly from one scene to the next. At this point you can also apply any video corrections and effects where necessary – for example, you might want to

brighten up dark footage. You can also create transitions between scenes where appropriate, and finish the job by adding extra elements such as titles and music. When you're happy with the way it all plays through, you can finally render the project to a new video file, all ready to be shared.

DEVICE SETTINGS
Although PowerDirector has the capability to capture directly from a camera attached to your PC, most people are likely to shoot using a standalone camera. It's worth double-checking that your device is set to a supported format – Sony DSLRs, for example, can optionally capture video in AVCHD – and also how many frames per second you're capturing. Many devices default to 30fps, but in Australia it's better to choose 25fps, as otherwise you're likely to see a strobing effect from

fluorescent lights.

With these settings in place, you're ready to shoot your footage and move on to the editing stage. If you want to work with pre-existing video files in uncertain formats, don't panic – these can be converted, either within PowerDirector or using free conversion software. This can reduce quality and smoothness, however, so it's best avoided if possible.

GETTING YOUR CLIPS ONTO THE TIMELINE
When you first start up PowerDirector 11 LE, you'll be invited to choose either the Full Feature Editor or the Easy Editor. The Easy Editor is a simple way to turn a set of video files into a single movie, but it doesn't give you much scope for creativity. The Full Feature Editor isn't difficult to use, and offers far more room to experiment and learn – so we recommend you skip the Easy Editor and

"This is a fully featured video-editing tool and an excellent way to create professional videos to share online"

WORKING WITH AUDIO

As well as video clips, it's possible to drag audio files onto the timeline to add sound effects or background music to your video. By default you'll see an audio-only Track 3 available for this purpose.

Audio clips can be trimmed and dragged like regular video clips, and volume changes can be automated using envelopes. To set this up, click on the line along the middle of the audio clip to create a "node", then drag that node up or down to fade or boost the volume at that point. To make this easier, you can expand the track view by dragging the track-dividing line in the track list.

In the same way, you can also edit the volume envelopes of video clips – click the waveform in the lower half of each clip. To move, copy or trim a clip's audio independently of its video, right-click on the clip and select "Unlink Video and Audio".

dive right into the main program.

Once you enter the Full Feature Editor, you'll see the screen divided into three sections. The upper-left area shows, by default, the current library of video clips and still images that are available for use in your movie; a series of icons down the left-hand side of this pane lets you change what's shown here. When the time comes, this area is also where you'll find transitions and other effects.

In the upper right of the window, meanwhile, you can see a preview of the selected clip; and along the bottom half of the screen sits the timeline, which at present will be a stack of empty tracks.

You'll notice that a collection of clips and images comes pre-loaded into the library. These are fine to play with if you're just tinkering with the program, but if you have your own footage, it makes more sense to work with that. We'll start therefore by removing the default clips from the library; this won't delete them from the disk, only from this particular project. To do this, simply click anywhere in the library pane, then press Ctrl+A to select all clips, then press the Delete key to remove them.

IMPORTING MEDIA

Now it's time to import your own media, by clicking the yellow "from folder" icon at the top left of the library. You can import individual files or select an entire folder of media as needed. If your clips are in MOV format, you might need to select "All Files" in the file-import dialog to see them, since PowerDirector doesn't show such files by default.

Once all your clips are imported, you can start dragging them onto the top track of the timeline. Arrange them sequentially as needed: to zoom in and out of the timeline, use the zoom control at the bottom left, or drag left and right in the time-code area above the timeline. To check that you have the correct clips in the correct order, you can use the preview window at the upper right to play, pause and skip around the timeline.

"PowerDirector's Full Feature Editor isn't difficult to use and offers far more room to experiment and learn"

EDITS, EFFECTS AND TRANSITIONS

Once your clips are in order, the next step is to trim away any extraneous footage that comes before and after the action. If you hover over the edge of a clip, you can click and drag to make the clip start playing from a later point, or finish earlier.

After you change the length of a clip, you'll see a dropdown menu giving you the option to shunt all subsequent footage left or right accordingly – this is called ripple editing, and it can be useful to ensure you're not left with unwanted gaps (or overlapping clips).

If you're working with a long clip that contains multiple scenes, you might want to split it into two or more parts. This is also helpful if you want to cut away from a clip to a different one, then cut back to the first. To achieve this, position the timeline cursor at the point where you want to split the clip, then click the contextual Split button that appears above the timeline. PowerDirector also includes a tool that tries to detect different scenes in a video and split up clips automatically: to access this function, hover over a clip in the library, then click the "Detect scenes" button that appears at its lower left.

Once you start assembling scenes into sequences, you may notice that your clips aren't all lit in quite the same way – or perhaps that all your footage is too dark, or suffers from an unwanted colour cast. You can easily adjust the appearance of a clip by selecting it on the timeline and clicking the Fix/Enhance button above to open a new pane. Tick "Colour Adjustment" to reveal a series of sliders,

ᐯ CyberLink PowerDirector 11 LE has a friendly interface so should be easy to pick up

ᐯ A few clicks can correct colour casts and brighten up murky footage

allowing you to adjust the exposure, contrast, colour balance and so forth. If you wish, you can click "Apply to All" to correct all clips on the track in one go. Click the close icon at the top right of this pane to return to the library view.

APPLYING TRANSITIONS

The last stage is to apply any transitions as needed. We recommend that you do this sparingly: a simple jump-cut is normally less distracting than an animated transition. However, if you

> *"PowerDirector includes a tool that tries to detect different scenes in a video and split up clips automatically"*

feel a crossfade or a jazzy transition is needed, you can access the Transition Room by clicking the relevant icon at the upper left-hand side of the interface (it looks like a frame of film with a lightning bolt in front of it).

Here you'll see a selection of transition effects. Click on one to preview it, and drag it onto the timeline to apply it. If you place your chosen transition over the start or end of a clip, you'll see a transition from or to black – or, if you're assembling your video across multiple tracks, a transition from or to whatever is on the track behind it. (In PowerDirector, each track sits "in front of" the last, so if you have clips positioned simultaneously on two tracks, the video for Track 2 will hide the video on Track 1.)

TITLES AND CAPTIONS

Not all videos need an introduction: it's often best to jump straight into the action. And as it happens, PowerDirector 11 LE comes with only a handful of animated title cards – none of which meet our professional ambitions.

However, you can easily create your own titles and captions in any graphics program, such as the free Paint.NET (getpaint.net). Simply create a new document with a size of 1,920 x 1,080 pixels, then paint it with a suitable background colour and type your required text on top, alongside adding any graphical effects you may desire. Save this as a PNG file and import it onto the PowerDirector timeline. You can adjust its position and length, and apply transitions just as you would a normal video clip.

A similar approach can be used to create a text overlay. The difference is that this time you'll want to ensure that the background behind your text is transparent; in Paint.NET, this is represented as a grey-and-white chequered pattern behind the text. Again, save the image as a PNG file (the JPEG format doesn't support transparency), then import it into PowerDirector and place it onto Track 2 of the timeline. You'll see Track 1 show through the transparent areas of the image, with your text superimposed.

If you drag the transition to a point where two clips on the same track touch, the first clip will segue directly into the second, using your chosen effect: do this with the Fade transition effect to create a crossfade. Transitions appear as a cyan rectangle superimposed onto a clip; you can change the duration of a transition by simply dragging its edges.

RENDERING YOUR VIDEO

When you're ready to render the finished product, click the Produce button at the top of the screen to switch to the production interface. Here, under the Standard 2D tab, you can choose a format: MPEG-4 at 1,920 x 1,080 resolution will suit most purposes.

It's also possible to target specific devices, and if you click the Online tab you'll see the option to upload your video directly to Facebook or YouTube (you'll be prompted to fill in details and log in to the relevant service as appropriate).

Again, the Full HD template is probably a good choice, although if you're working with low-resolution footage, you might opt to save space and upload time by choosing a lower resolution.
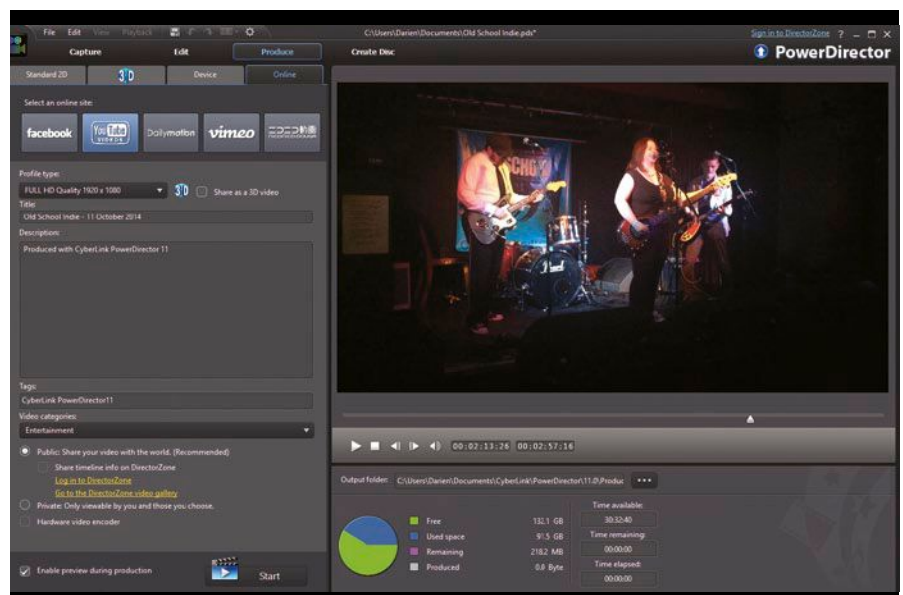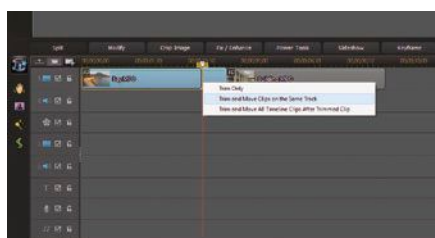
JOB DONE!

When you've selected suitable settings, hit the Start button towards the bottom left of the interface and PowerDirector will render your video.
Congratulations on a job well done. ●

> Your finished project can be shared online in minutes
∨ Ripple editing ensures you won't be left with gaps in your movie

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DITCH MESSY SPREADSHEETS
AND SWITCH TO A DATABASE

When it comes to storing business data, Excel isn't always the right tool. **Simon Jones** shows how to migrate a chaotic set of sheets into a structured database

Last month we looked at the pitfalls of using a spreadsheet application such as Excel to store lists of data. This approach may seem like the best solution at first, but you can run into problems sharing that data with multiple users, validating the content or even navigating your data. Why is that? Because you're using a tool that wasn't designed to do the job.

This month we'll consider an imaginary (but typical) case of a business using a spreadsheet-based list, and look at how this could be converted to a database application to overcome such problems.

HOW WORKBOOKS GET OUT OF HAND

Our list began as a simple record of projects undertaken for clients. As the company grew, so too did the number of clients, with names and contact details added to the workbook. Also, some way was needed of recording what various members of staff were doing on these projects, so even more data was added into this workbook.

At this point the spreadsheet approach became unworkable: there were far too many people trying to keep it up to date, often at the same time. The company tried instituting a rota, so that people took it in turns to update the workbook, but this meant that some tasks were forgotten about before they were recorded.

In the end, people set up their own workbooks to keep track of their tasks, sometimes remembering to copy the data into the main workbook at the end of the week. Employees developed their own shorthand for these books, and some changed the formatting and the order of the columns to suit their way of working. Copying this data into the main workbook resulted in a horrible mess.

This may be a made-up example, but I've actually seen all of these practices in real life. Let's take a closer look at some of the issues thrown up by this method of working.

PLENTY OF PROBLEMS

You can see the first sheet of our imaginary spreadsheet below. The first column details the name of the project to which

"At this point the spreadsheet approach became unworkable: there were far too many people trying to keep it up to date"

each entry refers. Some of these names are long, however, so staff may have been tempted to use abbreviations; as a result, typos have crept in. This makes it difficult to tie up which tasks belong to which project. The solution doesn't have to be difficult: you could choose a short name for each project that everyone agrees on, or give each project an ID number and translate this to the project name automatically.

There's a similar problem with the Started column. Some cells contain a date, but others record only a month – and one or two records just say "Yes". Excel does support data validation, so it's possible to ensure that particular cells always contain data of a particular type – but when a spreadsheet is developed in an ad hoc fashion, it's rarely used.

You won't have this problem in a database application, since the data type of the field will be fixed from the outset. If you don't know the exact date when work began, you can use the first of the month, or 1 January if you only know the year. If the project hasn't yet been started, you might leave the field blank – a NULL in database terms. If you knew the project had been started but didn't know when, you can use a date that would ordinarily be impossible for your data, such as 1/1/1900. Immediately it becomes easy to sort projects and gain a chronological overview of activity.

A more subtle challenge is presented by the column labelled Client. The entries in this column aren't linked to anything

∧ You can use the Table Design View to quickly set up your fields. The properties and lookup definitions of each field appear at the bottom

< The existing workbook exhibits many problems, most concerning a lack of consistency and concurrency

else in the workbook, but there's a list of Customers on Sheet 1, which is probably what it refers to. Storing multiple lists of the same items, referred to by different names, is confusing. You need to clarify the naming and settle on an unambiguous name for this entity: are they clients or customers?

The Status column is another one where there's been no validation, so people have again opted to write whatever they want. It would be better to establish a short list of all the permissible values.

The second sheet – Sheet 1 – is just as problematic. For a start, the sheet name isn't descriptive. What it actually contains is a list headed Customers, but this isn't formatted as a table in Excel: the address is in one field, which limits your ability to use Excel's built-in tools to search or sort it. You could, for example, filter for addresses that contain "Cardiff", but the results would also include those on Cardiff Road in Newport.

When it comes to addresses, the best approach is to use separate fields for the postcode, county, city, and street. Street should contain everything that isn't in the other parts of the address.

There's a Contact field, which presents problems too. Where we have several contacts within a single-client business, their names have all been lumped into this field, with their phone numbers and email addresses similarly placed into the other fields. Separating these out will be challenging – especially if there are three names in the Contact field but only two phone numbers.

The final column in this sheet is headed Last Contacted: employees are supposed to update this each time they make contact with a customer. Since this information is an extra thing for the employee to remember, and there's no guarantee they will – especially since it's

hidden out of the way on a second sheet– it's unreliable. This is really something the computer should be tracking automatically.

Finally we come to the Tasks sheets, which detail the tasks and comments for each worker. These aren't named consistently, and don't contain the same columns in the same order. While it makes sense for individual users to enter their data on their own sheets, the lack of coherence makes it difficult to collate and analyse the data. When a manager wants to see what work has been done on each project, for example, all the tasks have to be copied by hand from the individual

"While it makes sense for users to enter their data on their own sheets, the lack of coherence makes it difficult to analyse"

sheets into one list before they can be sorted and reported on.

BUILDING YOUR DATABASE
Sorting out these issues will take some work, possibly several days. Since users will probably have to continue to use the old system while we're building a new one, it's best to make a copy of the existing workbooks from which to work. This means we'll want to document every step in converting the data, so we can quickly do it again when the time comes to switch over to the new system.

The first thing you need to do is clean the data in your Excel workbook. Using Find & Replace can help, and you should delete any column or row that doesn't contain data (except for the column heading row, which must be kept). Add an ID column to each sheet, in column A, and populate it with incremental numbers by typing 1

in the first cell, selecting to the bottom of the data (Shift+End, Down) then using the Fill Down command (Ctrl+D). Create a master list of project names, and wherever a project name is recorded, use the VLookup() function to confirm its master ID number; if there's no number, then there's an inconsistency in your data.

Once your data is clean, it's time to design a new database to hold it. We'll use Access 2013, because in our theoretical example it's available to all our users through our Office 365 subscription. When you create a new Access database, you get a choice of creating it as an Access Web App or an Access Desktop Database. Web Apps have a simplified interface and can be used only if you have Office 365 with SharePoint Online or SharePoint Server 2013 with Access Services and SQL Server 2012. We'll use the traditional Desktop Database, since it offers more options and greater control over the user experience. Full details of the differences are given at tinyurl.com/loaxg2d

Select to create a new Desktop Database and name it: Access creates a new table called "Table 1", and places you into the Design View with one column, called "ID". Here you can design the tables you'll need in your database. Every table should have an ID field (an automatically incremental integer), but to avoid confusion it's best to give it a more descriptive name. In the Projects table it would be "ProjectID", "CustomerID" in the Customers table, and so on.

You can set the data type for every column created, and you need to give each column a name and set any other properties and formatting as appropriate for the field. As with the ID field, make sure the column names make it obvious

what data should go in the field – so, for example, use ProjectName rather than just Name, DueDate rather than Due. You can use the Name & Caption button on the ribbon to create an abbreviated caption as well as the explicit name. You can use spaces in column names, but you'll have to surround them with square brackets when writing queries and reports.

Set the formatting on columns such as PercentageComplete to be Percent and dates to be ShortDate, and also the maximum length of text fields to a sensible value, or they'll all be 255 characters long. Remember that some words (such as Date) are reserved, so you can't use them as column names: use TaskDate or something else more descriptive instead.

When it comes to columns where you want to look up a value in another table (such as the Customer column in the Projects table), define those other tables in Access before you add the lookup column. When it comes to Status, the simplest option is to just type the values to be shown in the dropdown list – but this makes it difficult to add or edit the list of possible values later. Unless you're dealing with a short list where possible values are unlikely to change – such as a field recording someone's sex – it's a better idea to create another table for entries such as ProjectStatus. This allows you to easily add extra options to the list in future without a programming change.

ENHANCEMENTS
While we're designing our database, we can implement improvements over the old spreadsheet-based way of doing things. One complaint our users had with their Excel workbooks was that each task contained only one cell for comments, and sometimes they needed to make more

than one comment on a task – or, the supervisor needed to make a comment about a task and then the user reply to this. Cramming everything into a single cell made it difficult to see when, and by whom, comments were made. We can do better by creating a separate table for comments, linked to the Tasks table. In this way, each task can have as many comments as necessary, with separate fields for the date, username and text of each one.

Another enhancement we can make is to set entries such as ProjectStatus to display in a particular order, rather than alphabetically – for example, you might want "Completed" to go at the bottom of the list. To do this, add a DisplayOrder column and use it to sort the lookup list. Don't be tempted to use the ID field; with this, any new records could only go on the end of the list.

To ensure our data remains clean, we

"Cramming everything into a single cell made it difficult to see when, and by whom, comments were made"

can mark fields that the user must fill in as "Required", and add validation to ensure that the data entered is in the correct form. You can make life easier by setting sensible default values: the CommentDate field on the Comments table could have its default value set to "=Date()", which will automatically set it to today's date whenever a new Comment is created. You can use validation along with a "Withdrawn" column in a table (a Boolean) to stop users adding new records with specific values. This allows you to keep historic values that used to be valid, but that aren't used any more. These features

can all be found on the Table Tools | Fields tab on the ribbon or in the Field Properties in Table Design View.
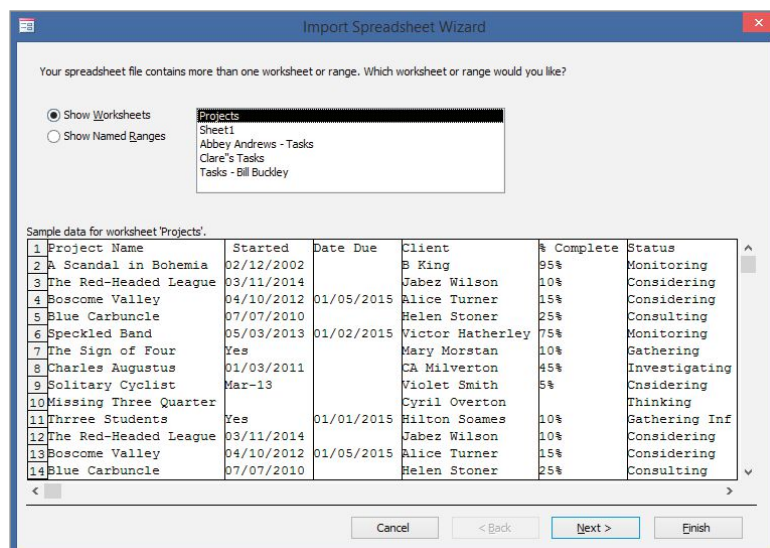
IMPORTING YOUR DATA
Once your tables are set up, you can use the External Data | Import & Link | Excel button on the ribbon to append the data from your Excel workbook to the tables in your Access database. Make a backup of your blank Access database before you start, in case anything goes wrong, and start by populating the small tables by hand if necessary. Take another backup once this is done, so you can get back to this point if anything goes wrong in the following steps.

Now import the main tables that don't rely on any other tables, such as Customers, before finishing with the tables that do have relationships, such as Projects and Tasks. If you rearrange and rename the columns in your Excel workbook to match the fields in your Access database as closely as possible, you shouldn't have any difficulty importing the data. Remember to make a note of everything you do so you can repeat it later if you need to convert the data again.
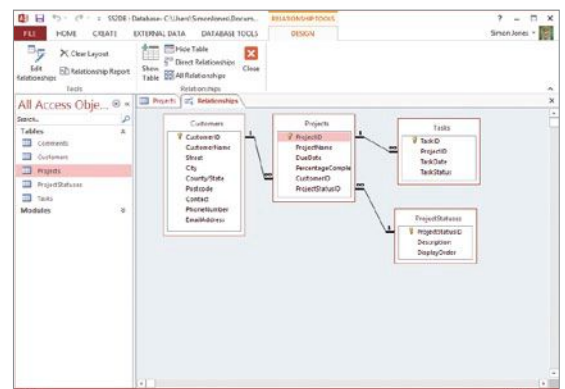
Once the data is imported, the tables in Datasheet View should work much as the Excel worksheets did – but with much better data validation, searching and sorting. If you wish, you can now start to design new forms and reports based on this data: for example, a Master/Detail form for Projects might show the data of one Project at the top of the form and a grid of the Tasks for that project at the bottom.

You could also set up a "My Tasks" form that lists all the outstanding tasks for the current user and an Overdue Tasks report that lists all the outstanding tasks for all users that are past their due date. ●

< The Import Spreadsheet wizard lets you bring your Excel data into Access one table at a time

∨ The Relationships View on the Database Tools tab shows how your tables are related to each other

SHAWN HARDING
SEO CONSULTANT

We look at jobs in IT and talk to someone in the field.

WHAT IS YOUR JOB?

I'm a search-engine optimisation (SEO) expert, and pay-per-click (PPC) specialist. Very simply, I help brands to be discovered online. I work in a creative marketing agency that handles promotions for clients of all sizes, and that might also include leaflet drops or magazine advertising – but my role is specifically online.

WHAT DOES YOUR DAY LOOK LIKE?

I spend a fair amount of time checking analytics, which enable me to stay on top of the trends among visitors to the sites we look after. There's a lot of work involved in maintaining a site's online presence: there are more than 200 factors that Google looks at to decide where you should rank for a given search phrase, the weighting of which is changed regularly, with bigger updates every so often. We need to respond to be able to respond to those movements.

WHAT TOOLS DO YOU USE?

I use a variety of tools to track website metrics. Google Analytics is the biggest one, and then there's SEOprofiler and the Moz tools. I like the Moz tools: everything you need is there, so it's easy to perform a basic audit of a site and see how it's performing. Google Webmaster Tools is useful as well – it's surprising how few developers use it.

I use a variety of website-editing packages too. Even if you have a dedicated in-house designer or developer, you don't want to be going to them every day and asking them to make tweaks, so I tend to do that myself as needed.

HOW DID YOU GET STARTED IN THE SEO BUSINESS?

A few years ago, I used to run my own YouTube channel, and while looking for ways to optimise it, I learnt a bit about SEO. At the same time, I was also running my own business; to promote it I needed to learn SEO principles and apply them to my own site. Through my own SEO and online promotion, my business was discovered and picked as a primary contractor for the London 2012 Olympics.

Along the way, I realised that there were a lot of SEO guys out there making promises, such as "we can make you the number-one hit on Google" – claiming stuff that simply wasn't true, or focusing on methods that weren't relevant any more, such as selling links to your site. I knew I could do better, so I started offering my own services on a freelance basis, and then ultimately ended up in a full-time position here.

WHAT ADVICE WOULD YOU GIVE TO SOMEONE INTERESTED IN THE CAREER?

You can start learning about SEO on forums such as Search Engine Watch and Search Engine Land. Moz.com will help you to understand what people are looking for, and what Google wants.

You don't necessarily need advanced technical skills – if you're comfortable in HTML and PHP, that's great, but if you're not then you can work alongside a web developer. You need copywriting ability, however. One mistake people often make is to create websites that appeal to search engines, rather than the visitor. If visitors don't find your site engaging, what's Google going to make of that?

IS SEO A CAREER WITH A FUTURE?

Already Google is looking at semantics and searcher context when ranking search results. This means old ideas such as keyword stuffing don't work any more. A more holistic approach is needed, and I think in time traditional SEO methods will become irrelevant. This doesn't mean the end of digital promotion as a whole, however: social media, for example, will be with us for a long time, so the focus will shift. If you want to get into this type of work, you'll need to be prepared for that change – you have to be ready to learn new skills and look at things in whole new ways.

WHAT'S THE WORST THING ABOUT THE JOB?

Sometimes it can take up to six months for a change to percolate through the system. So you'll make an improvement

"there's the risk that your clients will be hit out of the blue by a Google algorithm update"

to a site in January, say, and you may not see the benefit until July. That can be hard to explain to a client.

Google, meanwhile, can just change its algorithm without warning and suddenly you'll find your site has dropped off the first page of results. This too can be difficult to explain to a client: "Your traffic is down 80%; we're working to fix it, but it may be six months before we see an improvement."

WHAT'S THE PAY LIKE?

If you work for an agency, the pay isn't as high as if you're freelance, or employed in an enterprise-level business, but we have a range of skills on hand, such as in-house graphic designers. Plus I get paid at the end of every month. This isn't something that can be guaranteed if you're working freelance: if you take that route, there's always the risk that your clients will be hit out of the blue by a Google algorithm update and abruptly decide to take their business elsewhere. ●

WHERE TO START
- 58 resources to help you learn and master SEO (tinyurl.com/ppqjczp)
- Major Google algorithm updates (tinyurl.com/pgosuu7)
- Do you need an SEO? (tinyurl.com/kd4hu7r)

WHY THE WORLD NEEDS
LIGHT-SPEED COMPUTERS

University researchers are currently working on components that will allow them to make all-optical computers that can process at the speed of light. **Dr Richard Curry** reveals the science behind the breakthrough and what it means for computing

Data races over fibre broadband cables to your computer, only to slow to a comparative crawl as it's converted to electrical signals. This could be set to change, with researchers at the University of Surrey and University of Cambridge creating new materials to build the first all-optical computers.

The latest breakthrough sees the types of glass used in CDs and DVDs, know as amorphous chalcogenides, altered via a technique called ion doping, to form a material that can create, guide and detect light – and can therefore be used to build optical computing components.

Dr Richard Curry of the University of Surrey has been working to develop such materials for more than a decade. We spoke to him to find out what breakthroughs need to happen next, and how far into the future we can expect to see light-speed computers.

COMPUTERS CURRENTLY USE SILICON RATHER THAN GLASS. WHAT NEEDS TO CHANGE FOR OPTICAL COMPUTING?

Your computer works on silicon, and then at some point, we turn it into lights and optical fibres to send over broadband, but when it gets to the other end, it slows down again. It's slowly converted back to electrons, which crawl along in comparison to photons. What we're trying to achieve is to ultimately not have a conversion. I'd like to stop using [silicon] and electrons and use light instead, but the problem is we don't have materials that can use photons of light in the same way as electrons. We've been trying for years to do this.

YOU'VE RECENTLY MADE A BREAKTHROUGH WITH A NEW MATERIAL. WHAT KEY PROPERTIES DID IT NEED?

In this material, we needed to find a way in which we could actually control the light in the same way that in electronic materials we can switch electrons and send them to places or store information.

WHAT HAS TO HAPPEN NEXT FOR ALL-OPTICAL COMPUTERS TO BE BUILT?

There's a series of devices that we have to demonstrate going forward. When you get them all, we can put them all together, integrate them, and then we can start computing with it. Currently we've built one of those devices, which is like a detector, so it can identify that light is there. Thereafter you need a source of light, so we'll work on that next; then it becomes more and more complicated. These materials have an advantage in that we're already using them in our computers today for memory.

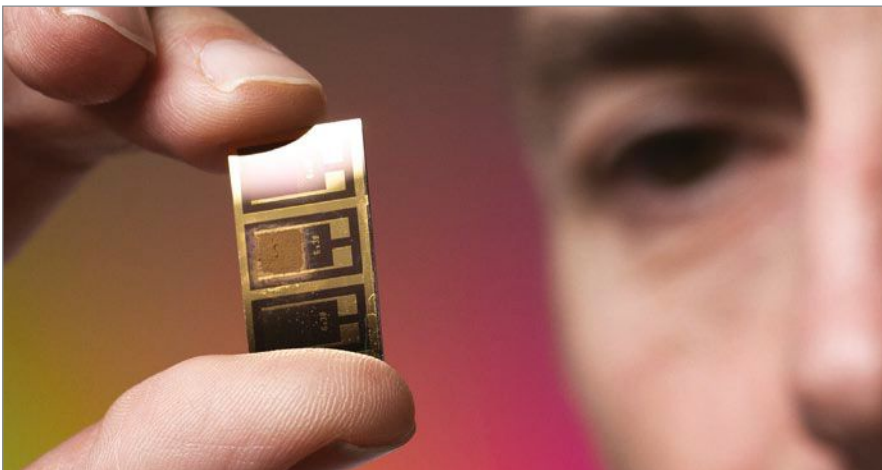∧ Researchers at the University of Surrey are developing materials that can create, guide and detect light

HOW LONG UNTIL THIS TECHNOLOGY IS IN COMPUTERS?

It's probably a ten-year path from here to getting an all-optical computer, but we'll see benefits before then because we can start by making a hybrid system, which is half light, half electronic. This will be better than what we have at present; there are gains to be had sooner, as well as the ultimate long-term goal.

WHAT WILL ALL-OPTICAL COMPUTERS OFFER IN TERMS OF PROCESSING POWER?

It will be the equivalent to, or better than the difference between, sending a letter via post and sending it via email. [It will be a] switch in capability: people developing drugs will have faster computers, way faster than what we have now, which will allow them to carry out far more complex calculations. The net benefits are huge.

What we need to consider is that all our devices are coming together – our phones, all the electronic gadgets that we have, even gadgets in the house are becoming more and more connected to the internet. This Internet of Things is going to require much greater ability to actually handle the data and process it, and this new technology will enable all of that to come to fruition. ●

∨ Glass used in CDs and DVDs is being altered to form a material that can form the basis of superfast chips

WHAT IS... MU-MIMO?

Multi-user MIMO is finally arriving en masse, promising faster speeds for multiple Wi-Fi users, with hardware on the way from D-Link and Netgear

W i-Fi is about to get more efficient – and therefore faster – for all those connected devices we have in our homes. D-Link and Netgear were among many companies at this year's CES to announce routers with support for MU-MIMO, part of the second wave of the 802.11ac specification. Here's how it works and what it means for you.

WHAT IS MU-MIMO, OTHER THAN AN ACRONYM THAT'S FUN TO REPEAT?

MU-MIMO not only sounds like a character from a children's television series, it's our favourite new tech term, thanks to its multiple use of the word "multiple": it stands for multi-user multiple input, multiple output. While plain MIMO time-slices the data if you need to send a signal to multiple devices – that is, it exchanges data with one device at any one time, alternating between them – MU-MIMO takes full advantage of the multiple antennas on connecting devices. So, if your router has three antennas and you're connecting a two-antenna laptop and a one-antenna phone, the signal will be sent at the maximum possible speed to both of the devices.
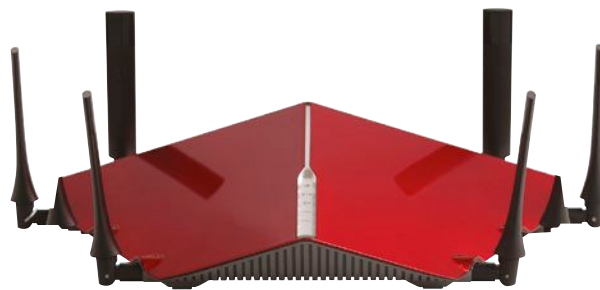
WHAT DOES THAT MEAN FOR USERS, OTHER THAN ADDING ANOTHER CONFUSING MARKETING TERM FOR ROUTERS?

If you're using a MIMO router, you may have noticed a slowdown as more devices have been added to the system. MU-MIMO is designed to get around this and make Wi-Fi more efficient for multiple users. You can also expect a boost in overall speed: D-Link's two new MU-MIMO routers offer up to 2.2Gbits/sec on the 5GHz band, the company said.

SOUNDS VERY WHOOSH. WHAT ARE THE LIMITATIONS?

Sadly, you're not going to get that 2.2Gbits/sec bandwidth on every device you connect, since it still has to be split. Also, because MU-MIMO requires separated antennas and signal processing, it isn't a two-way street: it works only downstream, from the router to your PC or other device, not upstream.

Don't place devices right next to each other, either: MU-MIMO uses a system called beamforming, which effectively focuses the signal on each client device. In short, two devices in the same direction will share the same stream of data, but those in opposite directions will get their own.

The final limitation? Your access devices – the laptops or phones you're using to hop onto Wi-Fi – will need to support MU-MIMO, so you may need to update their firmware.

WHEN WILL MU-MIMO GET HERE?

MU-MIMO was approved as part of the second wave of the 802.11ac specification at the end of 2013, and routers that support the technology are already hitting the shelves. D-Link's sci-fi-looking AC5300 (pictured above) and AC3100 were unveiled at CES, although prices and availability won't be confirmed until the second quarter of the year. Netgear used the show to demonstrate its Nighthawk X4 AC2350 Smart Wi-Fi router, which was first announced in September 2014; it's already available for $280 in the US. Both devices follow the Asus RT-AC87U, which costs around $300 and became the first router to support MU-MIMO when it arrived last summer.

HOW TO MAKE AI DO WHAT WE WANT

RESEARCHERS HAVE AGREED TO WORK TO ENSURE AI AND RELATED TECHNOLOGIES HELP HUMANITY

Artificial-intelligence experts have long warned that super-intelligent machines could – on purpose or inadvertently – pose a threat to human life. In an open letter signed by AI luminaries, including Stephen Hawking and Nick Bostrom, members of the research community have now pledged to ensure AI systems build in safeguards to ensure that our greatest invention benefits mankind, rather than wiping it out.
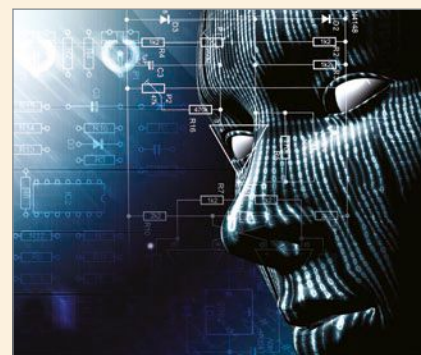
Dr Seán Ó hÉigeartaigh, an AI researcher who helps run the Cambridge Centre for the Study of Existential Risk, said such a pledge is necessary because recent progress in deep learning and statistical learning is increasingly

> Researcher Dr Seán Ó hÉigeartaigh believes now is the time to address the challenges thrown up by AI

raising troubling questions about machine intelligence. "It's no longer enough to ask 'can we build it?'," he told PC Pro. "Now that it looks like we can, we have to ask: 'How can we build it to provide most benefit? And how must we update our own systems – legal, economic, ethical – so that the transition is smooth?'"

Even positive results from AI could have "near-term challenges," he warned. For example, automation could affect jobs, robots could cause industrial or road accidents, and decisions must be made about the ethics of using autonomous weapons in war.

While Ó hÉigeartaigh sees "human-level" intelligence in machines as centuries away, he believes that it's necessary to build in controls now. "We need to start work on today's challenges – how to design AI so that we can understand it and control it, and how to change our societal systems so we gain the benefits AI has to offer," he said. "We can't assume we'll get it right by default."

"We have already seen unexpected behaviour from systems that weren't thought through enough – the role of algorithms in the 2010 financial flash crash, for example. It's essential that powerful artificial-intelligence systems don't become black boxes operating in ways that we can't entirely understand or predict," he added.

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· Once the installation has finished, launch ESET Smart Security
· Once launched, a prompt will appear asking you to activate your product (We're going to use log in details in this instance). Check your email for a set of log in details, use these details to activate and log into ESET.

Congratulations! You now have a 6 month trial version for ESET Smart Security!

For support of this software, please direct your queries to: http://www.eset.com/au/support/

Note: Please be advised that it is recommended that you remove other antivirus solutions, in fact, this installation will prompt you to.

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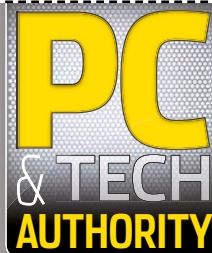
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GOETIA
Game demo – PC and Mac
Goetia is a point-and-click adventure game for PC and Mac – and, as in any adventure game, you'll be seeking out clues, finding objects, and figuring out how to use or combine them in order to progress through the different areas, puzzles and encounters.

However, there is one major difference compared to other adventure games that you might be used to. In Goetia, you play the part of Abigail, the ghost of a young lady. And as a ghost, you can walk through walls and fly through ceilings, you can explore everywhere as you see fit.

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JON HONEYBALL

"THESE COMPANIES ARE SHINING EXAMPLES OF THE WAY EUROPE IS STILL CREATING SOME OF THE BEST TECHNOLOGY IN THE WORLD"

Jon is impressed by some Buckingham-produced GPS equipment, which provides record-and-replay capabilities at a reasonable price

Last month I was talking about some of the technical innovations coming from the company Meridian, in Huntingdon, in the field of studio-quality encoding of music over a limited-data-rate pipe. This month I've decided to extend this theme by covering some more interesting technology from a pair of companies – one in the UK and one in the Netherlands – who are shining examples of the way we in Europe are still creating some of the very best technology in the world. The American hegemony in electronic innovation was an historical accident that's becoming less relevant: indeed, it's the lack of true global vision that will be the downfall of the big American companies.

Let's begin with GPS. There's a set of orbiting satellites that transmit the GPS signal: essentially a very accurate time clock that's synchronised between these satellites. If you can receive this signal from a number of the satellites, and because you know where they are and the time delays between their transmissions, you can triangulate your position in 3D space, relative to the satellites' orbits. That's right, 3D: it's easy to forget that GPS provides height information, because most of us are locked into a mindset of strictly 2D, in-car GPS from the likes of TomTom and Garmin.

However, give it some thought and you'll soon discover that information about absolute 3D positioning is terribly important if you're, say, the captain of a Boeing 747. (Incidentally, there's a world of pain concerning the way 2D maps can be projected onto the roughly

spherical surface of our planet, and how the inevitable distortions each different projection produces are to be compensated for – but I'll leave reading up on that to you, if you're sufficiently interested.)

So your current position is defined not only by where the satellites are, and which members of the global set they are, but also by the time at which you're taking the measurement – move the time by ten minutes and the satellites will have moved, as they aren't in geosynchronous orbit.

If you wanted to subject a GPS unit to exactly the same conditions – and I'm willing to confess this isn't something that will interest most people, but bear

"The American hegemony in electronic innovation was a historical accident that's becoming less relevant"

with me – it would be incredibly useful to be able to record these actual GPS signals (say, while going for a drive) and to then play them back at a later date. As far as the GPS unit was concerned, such playback would be as if it were travelling that exact same route again, at that date, and nothing would ever change, even run after run.

GPS record-and-replay equipment has been around for a while, but it's been prohibitively expensive, affordable only by the military, space agencies and similar. Now, Racelogic – a small but highly respected UK GPS engineering firm based in Buckingham – has changed all that, because its new LabSat 3 box can record real GPS and then play it back, at a reasonable cost.

Before we go any further, I need to explain something important. When you replay recorded GPS signals, you're creating an entirely time- and location-shifted space. So while it might strike

you as being hugely amusing to sit in a traffic jam on the M1 while transmitting a signal that tells everyone around you that you're all actually in Devon last Tuesday, it would also be highly illegal. And very dangerous too.

I flew into Incheon Airport in Seoul, South Korea, last year, a few days after North Korea had been making noises about disrupting the GPS signals – not what you want to hear just as your 747 is coming in to land. Handling signals of this kind clearly requires great care: you must operate it within a radio-screened environment (commonly called a Faraday cage) and measure the signal levels to ensure that there's no leakage whatsoever. That's a legal requirement, and if you do otherwise men in suits will arrive, knock on your door and cart you off to jail.

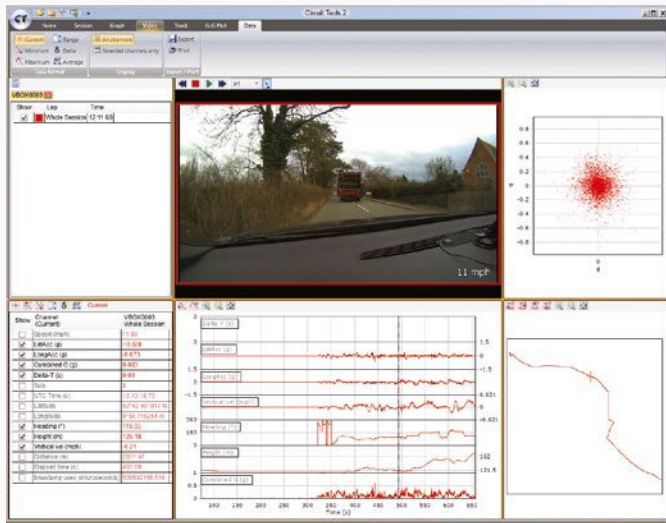Racelogic's software is stunning. Record a GPS scenario while driving around in your car, and replay it into a GPS device when you're back in the warmth of your lab (you do have a lab, don't you?). Then do exactly the same again tomorrow, to provide an entirely repeatable test environment. But that's not all – this software can import the simple recorded route information that any normal civilian GPS unit logs during a journey, then recreate the original GPS satellite signals that must have produced that information, so they can be played out again. This is a massively difficult computational geometry problem, and you can expect it to take up to ten times longer than real-time, so to regenerate the signals for a one-hour journey might take eight hours of processing time.

Or how about firing up Google Maps and just drawing in a route that you want to take, or synthesising a route entirely from numbers? In each case, Racelogic's software can then generate the appropriate GPS signals for you. Want to make a GPS unit think it's in the middle of
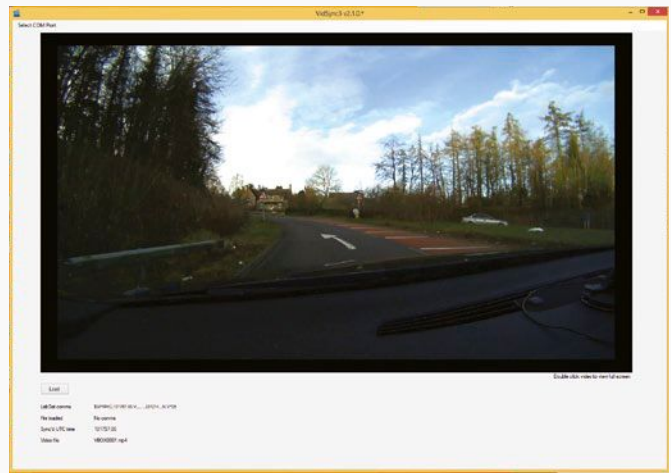
JON HONEYBALL
Jon is the MD of an IT consultancy that specialises in testing and deploying hardware
🐦 @jonhoneyball

∧ Playing back video enables you to calculate plenty of other data, allowing you to analyse race performance, for example

∧ Racelogic's LabSat 3 box can play back recorded GPS signals

Madrid on a Thursday afternoon, without leaving your desk? No problem.

The company has also designed a unit for video recording, called the Vbox, which takes the output from an HD-resolution bullet camera and a live GPS feed from a mag-mount GPS aerial, and records video of what the camera sees through your windscreen; along with all the synchronous GPS data too. When you play back this video on your Windows PC, it not only plays back the video but it can also calculate a whole range of data (**see screenshot above**) such as the acceleration, direction of travel, vertical height and so forth, which you can just read out as the video plays. You can see why that would be incredibly useful for car-development work or analysing race performance.

The power really starts once you connect the LabSat box to the PC running the playback of the Vbox video file. Now you can generate the "real" GPS signals to feed into a GPS device and receive a correctly synchronised view of exactly where the device was located at that point in time on the video feed. This makes it easy to see whether, for example, the GPS unit you're testing is suffering from lag when going around a roundabout (due to having to reacquire its signals repeatedly).

This is all powerful stuff, which would have been almost unthinkable even only a few years ago. It clearly shows the strength of the engineering base we have, and is therefore to be loudly applauded.

DAB HANDS
Now let's move on to a different transmission technology, namely Digital Audio Broadcasting (DAB). DAB is an antiquated, superseded and, frankly,

> *"DAB is an antiquated, superseded and, frankly, rather insulting piece of technology"*

rather insulting piece of technology. However, it has entranced various government departments for decades, so we're stuck with it, despite it being the wrong solution to the wrong problem at the wrong time.

The rest of Europe has moved on to DAB+, but we're stuck with the original. The core function of DAB is to take a low data rate – and hence low-quality – audio feed, crunch it down to the size of a postage stamp and then broadcast it over a digital carrier in around the 200MHz frequency range. As you can imagine, there's quite a small market for DAB generation and transmission hardware, since all the big broadcasters already have real-time solutions in place that once did cost vast sums of money, but which they've been able to amortise over several decades. The rest of us, who might someday need to generate a desktop DAB signal for test purposes, have to scrabble around with what's available.

Or maybe not. DekTec, from the Netherlands, has come up with a range of affordable, high-performance PCI Express cards, alongside hardware based on the USB bus, which can transmit DAB, DAB+, DVB-T (digital terrestrial TV) and so on.

Let's just walk through the process of making this work. We'll start with the audio file you want to work with, which should be WAV format at 48kHz sampling rate (that is, a sound quality akin to CD).

But the data rate for such quality is far too high for DAB transmission, so we need to reduce it. You may think this is simply a matter of choosing a different output from your audio-editing software, but this won't happen for two reasons: first, DAB doesn't use MP3 format, but rather MP2, its predecessor; and second, it isn't even normal MP2, which would have made things too simple. There are special data flags that have to be placed into the MP2 stream to support DAB.

But that's not all – next you have to think about the data rate that you'll be using over DAB. The best quality employed in the UK is for BBC Radio 3, which transmits at 192Kbits/sec, but most other stations are more compressed at 128Kbits/sec, while speech is right down at 64Kbits/sec. Just think that through. Take some content that was once akin to CD or FM at its best, encode it using an ancient codec at a ridiculously low data rate: does anyone really want to listen to 128Kbits/sec MP2? Does anyone really think this is quality?

The best tool for performing this feat of aural desecration is an open-source one called TooLAME, and the command line you'd use to take in a nice 48kHz WAV file and output a grotty MP2 is:

```
C:\toolame -s 48 -m s -b 192 -e -D
0 logicbouncenewmaterial2.wav
logicbouncenewmaterial2.mp2
```

You now have an MP2 file you can work on. Next you have to turn this into an ETI file, which stands for Ensemble Transport Interface. Without getting bogged down in complex details, DAB employs a transmission format called OFDM, or orthogonal frequency-division multiplexing. OFDM is also used for the
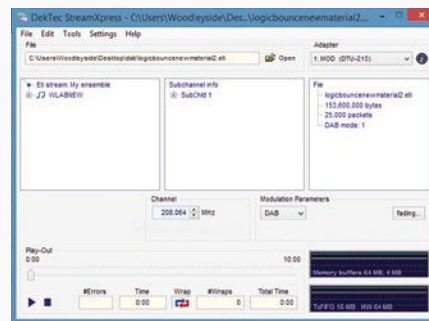
likes of 802.11n and 802.11ac Wi-Fi and even for terrestrial digital TV in the DVB format. ETI streams are effectively the bundled data that allow the transmitter to output them in OFDM format. You have to remember that DAB isn't just one station transmitting on one frequency: unlike FM radio, you can bundle together several DAB "radio stations" onto a single channel and transmit them all at the same time on the same frequency, which is all part of the idea called an "ensemble". To convert your newly minted MP2 file into an ETI file, you need to use a tool called DabMux, which is driven by a command line that looks like this:

```
C:\"program files (X86)"\dektec\
StreamXpress\dabmux  -f 25000 -o logic
bouncenew "material2.eti wlabmp2.xml
```

This tells DabMux to generate 25,000 frames of data (a data frame being about 2,500 per minute) and output the ETI file, but also to suck in a configuration file in XML format. Here's the XML file I used:

```
<ensemble transmode="1"
id="0x123" country="15"
ecc="0xE1" label="My
ensemble">
<service id="3" country="15"
label="WLABNEW">
<component primary="true"
ca="false" prot="UEP-3" bitrate="192" filen
ame="logicbouncenewmaterial2.mp2">
<mp2/>
</component>
</service>
</ensemble>
```

As you can see, there's some technical stuff in the first part, including a country code, and the name I'm going to use for my ensemble. Then we go to the service part; the "WLABNEW" is the name of my radio station. This is what you'll tune into on a DAB radio set. Then there's the component itself: it references the MP2 file just created and specifies the data rate to be 192Kbits/sec. There's an MP2 section to this XML file, but this isn't used. Now having this ETI file, I can fire up the DekTec software, load in the file, choose a broadcast frequency, and press Play. At this point, my new radio station will be broadcast out of the aerial socket of the DekTec unit, and I could attach a small aerial to it for reception by nearby DAB radios. Tune in the radio set and our new radio station is on air. Once again, just as with those GPS transmissions, you must do this inside a shielded Faraday cage to ensure that there's no possibility of

With DabMux from DekTec you can convert your MP2 file into an ETI file

leakage over even a few metres.

LESS THAN FRIENDLY

So what do these two hi-tech solutions have in common? Well, first, both would have been impossible only a few years ago. The power of modern PCs means that such specialist hardware can now be connected via USB and used to perform high-end work. General-

"With professional tools, there's a responsibility for providing a level of support that goes beyond call-centre staff asking: 'have you tried turning it off and on again?'""

purpose programming languages enable developers to write software solutions that can drive such hardware, and the prices are now affordable – in the context of professional lab equipment. Neither of these solutions is appropriate for a bedroom hobbyist, from a cost, complexity or broadcast responsibility perspective.

They're also similar in terms of the sheer complexity of their exposed capabilities. These aren't solutions that you can just fire up, fiddle with and press Go. Both require detailed knowledge and an understanding of what's going on; there's nothing wrong with that, of course, since they're professional tools.

However, both also have UIs that are, shall we say, "curiously cranky", and they provide a clear and fascinating reminder of just how far we've travelled in the business of delivering software to mainstream audiences. These tools are generally written by the engineers themselves, so poor error-handling and crashes when you ask them to do anything odd aren't unusual. They can be quite frustrating to work with.

At this point, you're probably expecting me to turn my flamethrower of hate onto

both firms for delivering fragile and cranky software, but I'm not going to do that, and here's why. These are bleeding-edge technologies and solutions; professional tools for professionals. And with that comes responsibility for providing a level of support that goes beyond call-centre staff asking: "have you tried turning it off and on again?". Both companies have excelled in this regard.

I uncovered a Windows 8.1 USB port bug in the Racelogic code, and the developer sent me a new version on Boxing Day, then several more versions over the subsequent days. I was doing battle with the DekTec DabMux software, PDF instructions for which were inducing a headache: it looked like English, it sounded like English, but I had no idea what it was saying. DekTec's developers worked tirelessly to explain what to do, how to make it work, and sent over scripts and example files.

Both companies actively seek suggestions on how to improve their products, but being such niche products they probably won't receive many. I'm more than happy to help (after all, I've invested a five-figure sum in their technologies) simply because I believe both are serious about what they're doing and clearly want to smooth out the few remaining rough edges.

Contrast this with a company that sells an expensive Thunderbolt-connected 4K video encode/decode box I bought last spring. I'll be polite and simply say the claims made by the company around the capabilities of its product didn't match my experience.

Only when I went nuclear over the phone at the product manager did he admit that some of those claims were a tad optimistic. I won't be doing business with the company ever again, because I don't need hassle like that.

Racelogic, on the other hand, even delivered some of its kit of parts in person, because it wanted to know what we were intending to do with it.

This sort of support is the lifeblood of serious engineering companies, and is a clear differentiator between the good and the ugly.

I hope this insight into some slightly unusual technology has been useful. It's a clear reminder that our desktop computing world – whether that be Windows, OS X or Linux – has a far broader reach than the million-selling but mundane Office applications – and that there's still world-leading work being done on our doorsteps. ●

PAUL OCKENDEN

"AFTER A FEW SECONDS, YOU COMPLETELY FORGET THAT YOU'RE STARING INTO A PHONE STRAPPED TO A CEREAL BOX"

Virtual reality may finally be hitting the mainstream – for less than $20, you can even turn your phone into a headset

Virtual reality (VR) is one of those strange areas of tech that's been knocking around for ages, perpetually about to explode into the mainstream but never quite managing to achieve it. The idea can be traced back to science fiction from the 1930s, while the first crude and clumsy devices appeared in the 1960s. One of these first VR incarnations, created by the influential computer scientist Ivan Sutherland, dangled above the user's head in such a precarious fashion that it was nicknamed the "Sword of Damocles".

At various times since then, mass-market adoption has seemed just around the corner but never actually happened. It was almost 25 years ago that Sega promised the Sega VR headset for its popular Mega Drive console. There was much hype, but it never arrived: the project proved too difficult for mass-market production and was shelved, although a version did appear in arcades a couple of years later. In the mid-1990s, Nintendo tried for the same market with its Virtual Boy, an innovative headset-based games console. Unfortunately, that was such a commercial flop that it never even reached Europe, and the whole project was cancelled within a year. (Even its product name would be considered a bit dodgy these days!)
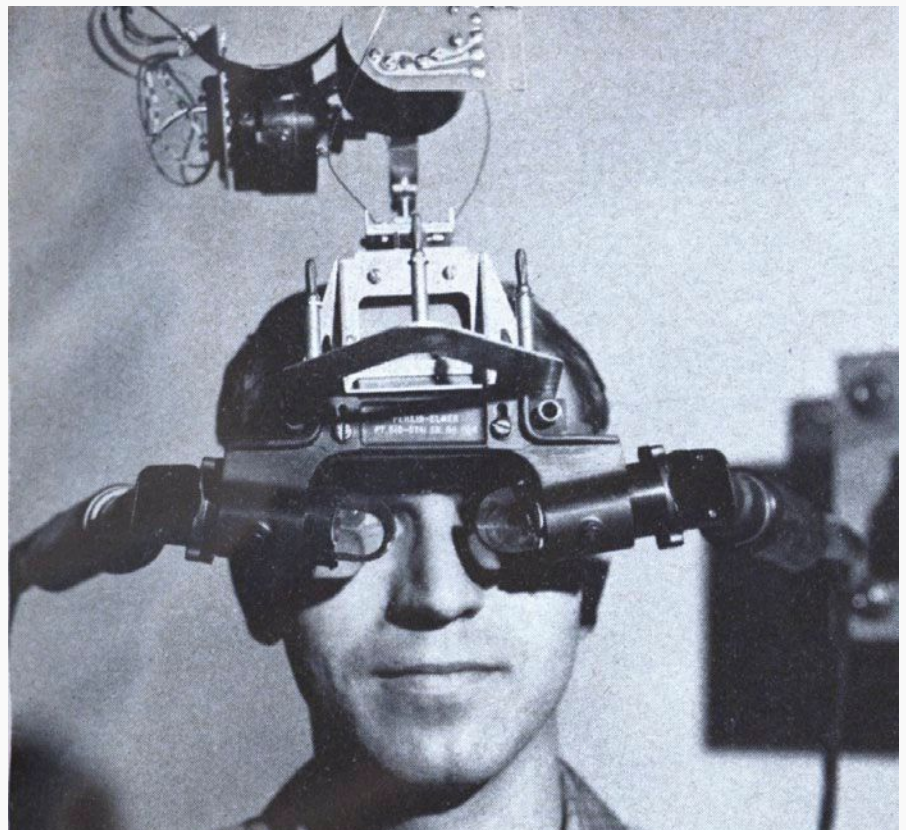
I ought to clarify something at this point, because the term "virtual reality" bears two meanings, one broad and one narrow. The term can encompass anything that simulates a real environment, and so may include those walk-in flight simulators on stilts that pilots use for training, and

their smaller cousins that you might find in theme parks. The second, far more specific meaning of virtual reality (especially when abbreviated to VR) is restricted to those headsets you strap over your eyes (and often ears) that give a stereoscopic view of an artificially generated world, the display of which is updated as you move around this environment. I'm talking here about this restricted sense of VR, and it's such VR headsets that over the past year have seemed about to go mainstream.

The best known is the Oculus Rift, which despite all the hype hasn't actually shipped yet. The kit you may have read about or seen on TV gadget programmes,

perhaps even played with at a demo or show, is all pre-release developer and SDK hardware. These developer headsets provide vision only, so the user has to supply headphones. They're also quite heavy, at around 379g, roughly the same as a can of Coke. Just try to imagine walking around with a can strapped to your face by a thick elastic band. Padding inside the headset helps, but it's still not the most comfortable of experiences. I hope when the consumer version arrives – promised later this year – it will be both lighter and wireless. All the versions to date have required an umbilical cord tethering them to a controller box, which uploads stereoscopic visuals to the

> Ivan Sutherland's "Sword of Damocles" was one of the first VR headsets

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"You probably have all of the components needed for a VR headset in your pocket right now"

headset and downloads six-axis motion-detection data to the host computer.

You may wonder why six axes of data have to be recorded, since many motion-tracking systems monitor only the X, Y and Z axes. However, a six-axis system (one with six degrees of freedom, or 6DoF) can monitor not only the estimated position in 3-space using accelerometers, but also **rotation** in any plane using gyroscopes. This is important for headset-based VR, as the display needs to scroll when you rotate your head. It's quite different from an Xbox Kinect camera monitoring your movements, with the display staying in a fixed position (although there are libraries available to extract estimated head-pose data from Kinect sensors).

I mentioned "gyroscopes", but don't imagine them as those spinning discs in use a decade or two ago: modern gyroscopic sensors are tiny solid-state chips with lithographically constructed components. Various kinds are available, but perhaps the easiest to understand is the "tuning fork", which has two moving arms continually oscillating in opposite directions. When a twisting motion is applied, the Coriolis force on each arm acts in opposite directions, changing the capacitance between them proportionally to the angular velocity of twist. It's mind-boggling to imagine this going on inside minute sensors inside each Oculus Rift (as well as many other everyday objects, such as optically stabilised camera lenses). These movement and positional sensors distinguish true VR headsets from first-person view (FPV) kit such as Fat Shark goggles – normally used for remote piloting of radio-controlled aircraft and drones – or home-cinema goggles (yet another technology that never really took off). Both these headsets are for display only and don't need to record head tilt or position.

Interestingly, Oculus Rift started life as a Kickstarter project with a US$250,000 goal, but ended up raising ten times that and subsequently being bought by Facebook for US$2 billion. All of this

happened long before the final product had shipped, which caused something of a backlash: many of the original backers demanded the return of their crowdfunding cash, as they weren't happy their investment in a niche product had ended up in the hands of an "evil empire".

Despite these complaints, the success of the crowdfunding venture meant many other rival VR systems soon started to appear on Kickstarter, Indiegogo and other funding sites. Some of them are obviously just flying a kite, and these are pretty easy to spot for making outlandish claims and/or merely using images of readily available hardware. Here's a tip: before investing in any crowdfunded project, always do a reverse search on the images shown in their listing. If you find them being used anywhere else – especially on one of the large Chinese marketing websites such as Alibaba or Banggood – then this project might not be what it seems...

A few of these projects do seem credible, though. One called Totem, from Vrvana (pronounced ver-vana, and yes, it sounds like something from **Shooting Stars**), looks particularly interesting: it has two front-facing cameras in addition to the individual display screens for each eye. This enables it to mix a VR feed with images from the real world, like a halfway

∨ The Carl Zeiss VR One is a low-cost headset
that should work with most phones

house between a full-on VR unit and an augmented-reality headset, such as Epson's wonderful Moverio BT-200.

Beyond these start-ups and crowdfunded projects, there are a few big-name players entering the VR arena. Sony has Project Morpheus, a five-year (and counting) R&D project, which is being continually updated. It should be ready to launch quickly whenever Sony feels market conditions are right. Certainly the demo versions Sony takes to various trade shows have a fairly finished feel to them, with nice, smoothly moulded plastics and a really solid build. This is no temporary, 3D-printed demo kit.

I'M IN THE PHONE...
There's a whole other angle to this market sector, too. Think for a moment about the components you need for a VR headset: a high-resolution display, accelerometers, gyroscopes, connectivity to the outside world, and CPU grunt to tie them all together. As a list of parts, does that sound vaguely familiar? You probably have all of it in your pocket right now. Yes, the main guts of a VR headset can already be found inside any smartphone, and a few vendors have already cottoned on to this fact.

For a start, there's Samsung with its Gear VR (see our full review on p44). Essentially this is an Oculus Rift–style housing, into the front of which you slip a Note 4 "phablet" (I'll never stop being embarrassed to type that word, hence the quotes). Strangely, this headset contains its own movement sensors rather than using those built into the phone. The Gear VR is not only confined to Samsung's Note 4 model, but the current development version is even further restricted to work

only with handsets locked to certain US carrier networks. No, don't ask me why – it seems crazy to me.

If you want a wider choice of phones, look no further than the Carl Zeiss VR One. The big selling point is that it contains "quality" Zeiss lenses, although I suspect for many the Zeiss brand has been tarnished by licensing the name to glass made by companies such as Sony and Microsoft/Nokia. The VR One not only supports a number of different handsets, but also exploits their internal gyroscopes and accelerometers. You need a special tray to hold your phone, but Zeiss is planning to release these for popular handsets, and to offer 3D-printing plans for more obscure phones.

Cheaper still, and even more flexible, are the Archos VR Glasses, a simple, black plastic affair designed to work with most smartphones with a 6in screen or smaller. It's a no-frills affair, but what do you expect for $20? Surely you won't find a VR headset any cheaper than that.

Or will you? Actually, the answer is yes! By far the cheapest option is the Google Cardboard, and you can probably guess what it's made from – the clue is in the name. It's essentially a folded piece of cardboard with two plastic lenses, a couple of magnets and some Velcro. The brilliant thing about it is the price: you can pick one up for less than $20. You can even cut one out yourself using a template, but I can't really see the point when the kits are so cheap. It's been somewhat cheekily nicknamed Oculus Thrift!

So, what can you do with Google Cardboard? Well, Google has a Demo app that provides a number of simple things such as 3D Google Earth views, 3D YouTube videos, and a natty VR tour of Versailles. You'll soon get bored with those, but head on over to the Play store on your phone and search for Cardboard. You'll find plenty of Cardboard-enabled apps there that let you ride a VR roller coaster or watch a 3D Paul McCartney gig (to be honest, I'm not sure which is scarier). There's much more to try, too. My favourites include Vanguard V, a third-person rail shooter game that delivers an immersive experience – after a few seconds, you completely forget that you're staring into a phone strapped to a cereal box. Sisters from Otherworld Interactive is a haunted-house story, and it's really very scary!

Most of these apps are free, but if you don't mind spending a small amount, I highly recommend Proton Pulse. If I tell you it's a 3D version of the old brick-busting Breakout game you'll probably roll your eyes, but it's far better than it sounds.

Incidentally, although Cardboard has its greatest support on Android, you can also use it with iPhones. Search for Google Cardboard in the App Store and you'll find some great apps, including the inevitable virtual roller coaster, along with a quaint duck-shooting game (quaint in the way

"Frankly, the possibilities for virtual reality are endless, and I'm very excited to be working in a field such as this right now"

it works, not in the way you kill virtual animals!).

Before you do, though, may I suggest you mark those panels and edges of the Google Cardboard that touch your face or hair, then unfold it and cover those edges with parcel tape or similar fabric. If you don't, you'll find the cardboard sucks grease from your face (especially if you pass it around among friends) and starts to resemble a used pizza box. It seems daft to go to all that trouble to protect something so cheap, but it's worth it.

I wanted to find out what a professional VR developer thought of Google Cardboard so I spoke to Iestyn Lloyd, one of the UK's leading VR developers, who has created games and apps for Oculus Rift and other high-end hardware. He told me: "It's great as a platform to keep kids entertained. Not only are the headsets very cheap, but they can be drawn on or otherwise customised. If you want more robust versions, some vendors are supplying them in aluminium."

Iestyn and I got chatting about possible applications for VR, particularly for low-end kit such as Cardboard. He explained how "for installations and expos, it's much cheaper to demo VR using Google Cardboard rather than expensive PCs running Oculus or other high-end headsets. Supervision is still important, though, because the headsets contain mobile phones, and you don't want those to go walkies. Google Cardboard also offers a great marketing opportunity:

> Google Cardboard can convert your smartphone into a VR headset for only $20

you can give away customised headsets (printed with your branding and logos) at events, including a QR code or NFC tag for the visitors to download and install your company's VR app. You can then use push notifications to keep these people engaged over a longer timeframe. For people such as myself who build VR games and apps for a living, we can use Cardboard to deliver cut-down or 'lite' versions of 'full' VR experiences, for a preview."

I also asked whether he could see any instances where low-end VR headsets had an advantage over higher-end kit. He explained: "It's important to realise app-based content produced for any of these low-end, phone-based headsets can be repurposed or built into a normal non-VR app. Imagine, for example, an app that showcases a stunning new office development.

We've seen so many false starts for VR, but with all these players currently developing both hardware and content, it will almost certainly break through to the mainstream this time. Right now, hardware and software remain fairly crude, but I'm sure we'll quickly evolve. I'm not sure we'll reach the point once envisaged by Ivan Sutherland, inventor of that original Sword of Damocles, when back in his 1965 paper The Ultimate Display he wrote: "The ultimate display would, of course, be a room within which the computer can control the existence of matter. A chair displayed in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be fatal." Now that's a scary game opportunity (and a strong incentive to pay your phone bill on time!). ●

NICK DALE

"TODAY IT'S FEASIBLE FOR SMALL TEAMS OF MOTIVATED ENGINEERS TO TACKLE PREVIOUSLY 'IMPOSSIBLE' PROBLEMS"

A background in aerodynamics and open-source software proves
enough to create a prototype car – with a little help from some friends

From time to time, we all find ourselves looking out of the window and daydreaming. Among the fast cars, holidays and lottery wins, there may be the occasional "Wouldn't it be great if...", quickly followed by, at least in my case, "How hard can it be?"

This is one such story. It's a tale of ambition, teamwork and talent (mostly other people's). And it's also the story of how modern PCs and largely open-source tools can solve problems that a generation ago weren't only difficult but, by all practical measures, impossible.

By personality and training, I'm an engineer. Many years ago, when BBC Micros were cutting-edge, a fascination with aircraft led me to study aerodynamics. On qualifying, my career quickly took me in other directions, but the fascination with all things aeronautic remained.

Two years ago, my brother, Jeremy Dale, asked if I knew anything about car aerodynamics. He and a business partner were building an ambitious tandem-seat hybrid car. While he could take on the complicated electronic tasks, he had no understanding of aerodynamics. They needed a body shell that wouldn't compromise performance.

Since I spend some of my spare time using the open-source surface-modelling package Blender, I had the means to draft such a shape. Google would surely provide the technical guidance on vehicle drag. "How hard could it be?"

Several things quickly became apparent. To do this properly would require multiple computational fluid mechanics (CFD) iterations, followed by validation in a wind tunnel. CFD tools typically cost thousands per licence and run on computers that could heat a small town. All of which were beyond our means.

Searching for a solution, I came across an open-source CFD toolset called OpenFOAM, which stands for open-source field operation and manipulation. It has the capacity to model a huge range

> *"The days where useful work can be undertaken only by large teams with huge IT budgets are over"*

of fluid-mechanics problems. The toolset comprises solvers for the equations of motion, turbulence models, mesh generators and analysis tools. Everything you could possibly want, apart from knowledge and understanding.

SO BEGINS THE JOURNEY
OpenFOAM runs only on Linux, so the first of many learning opportunities involved setting up a VirtualBox Ubuntu VM on my trusty Acer laptop (Intel Core 2 Duo processor, 4GB of RAM). To my surprise, with the settings more or less a stab in the dark, OpenFOAM ran successfully – albeit slowly. Clearly having good tools doesn't alter the fact that fluid mechanics calculations are computationally expensive. We quickly replaced my laptop with a Core i7-equipped Dell PC. It was easily the fastest computer I'd ever played with, earning the name Monster.

Porting the laptop's setup to Monster convinced us we might be able to do something useful with off-the-shelf hardware, particularly when we started to run OpenFOAM in parallel across eight threads. Everything subsequently represented refinement, streamlining or supercharging of this setup.

With Monster up and running, we had

a tool that could provide an insight into what was happening. I'd have felt less smug had I realised just how poorly I had configured the software. Important aspects of the solver, mesh and turbulence models were incorrect and, ultimately, had to be corrected. Fortunately, ignorance stopped us being daunted.

Having proved the concept, the project needed funding – and more effort than my work commitments allowed. My brother's business partner identified a potential source: the Niche Vehicle Network (NVN).

The NVN promotes the development and application of new technology by bringing together independent vehicle manufacturers, system suppliers, automotive technology companies and higher-education institutes, to collaborate on the innovative application of technology in low-volume vehicle production. Following discussions, NVN generously agreed to fund a programme of work, codenamed ASTAN, with the following scope:

1. To produce a practical tandem-seat small car body shell shape, with exceptional aerodynamic drag performance to enable a working car to deliver groundbreaking fuel efficiency and low emissions.

2. To deliver this challenging task to a high standard with limited resources of both time and budget, by using open-source CFD software and a low-cost multicore PC network.

3. To build and test a full-scale prototype body shell in a wind tunnel and assess the accuracy of the CFD model.

Of these very challenging objectives, the timescale was the most daunting. Approval came a month before ASTAN was due to start. We then had three months to complete the study before the tax year ended. My work commitments meant that the project-management load fell on my brother's shoulders. We had to identify specialist aerodynamic support,

NICK DALE
Nick initially worked as an aerodynamicist before moving into systems engineering. He's currently an engineering manager

establish a computing infrastructure, optimise the shell shape, find someone to build it, and then get it tested to confirm the CFD results.

SHEFFIELD UNITED

For specialist CFD support, we engaged Professor Ning Qin and Dr Jason Chen of the Aerodynamics Research Group at the University of Sheffield. They provided exceptional support. They scrapped much of my original setup and replaced it with a theoretically sound analysis environment. The only non-open-source component was the mesh generator, as the learning curve for the delightfully named OpenFOAM snappyHexMesh was not consistent with our timescales.

While Sheffield has a 120-core cluster computer with a lot of capability, access was an issue. Instead we decided to scale up the Monster setup. We bought four unbranded PCs, each toting a 3.5GHz Core i7-3770K CPU, with 16GB of RAM and a 1TB hard disk. Lacking the sophistication of the Dell box, and with fans that sounded like hairdryers, they nonetheless provided exceptional multithreaded performance. They ran intensively for four weeks over extended periods without issues… once we'd earthed the four PC cases together properly.

We used a cheap eight-port Gigabit switch to provide network connectivity. If anything, this was a bigger revelation than many of the other things we achieved. It shovelled all the data we needed reliably throughout.

Once my brother had worked out the intricacies of parallel computing across multiple nodes (one of many firsts for him), we had a standalone cluster of computers that could service 32 simultaneous parallel threads - quite a step up from a single T6400. Processing times tumbled from several days to a few hours. Our problems stopped being infrastructure and became design and manufacturing.

We ran a wholly digital workflow. Shapes were modified on my laptop in Blender and exchanged electronically with Sheffield. By the time we finished, we'd drawn, assessed and rejected almost 40 different shapes. Valuable confirmation that the shell should fit was achieved by generating full-sized cross-sections from Blender and comparing them with the car. The final shape was very different from my initial sketches. The bright guys at Sheffield were quietly optimistic that the figures would be excellent.

Our next challenge was to make a foam buck to use as a mould for the final shell and also as a full-sized wind-tunnel

∧ The team discarded 40 different shapes before finding the right one, here shown with pressures and velocities from the front

∧ The raw foam buck prior to surface prep

∧ The final sample in the Mira wind tunnel, complete with smoke to show the aerodynamic effect of the prototype model

model. Following design-freeze, the final shape was machined in foam. The result was excellent, apart from being made of polystyrene – one of our few mistakes. It turns out polystyrene collapses on contact with resin, becoming a gooey mess. We had to protect it with a hard coating, which added hugely to the time: this had to be applied and then smoothed. If we'd used polyurethane, which is insensitive to the resin, we'd have saved a lot of hassle. We were very lucky to find a mould builder who tirelessly worked to make us a shell and bore the brunt of the consequences of our decision to opt for polystyrene.

THE MISSING PIECE

The final piece of the jigsaw was Warwickshire-based Mira, which provides a variety of testing services to the automotive industry. For ASTAN, we wanted to use its wind tunnel, measuring

15 x 7.9 x 4.4m (WDH). It's as impressive as it sounds, with four 250kW fans, although it's pretty cold in March. Mira also provided a great deal of technical support, both in terms of how we might best use the wind tunnel and how to set up the CFD to reflect the wind-tunnel conditions and ensure a fair comparison.

Testing day was the first occasion on which the team had come together - another testament to the power of technology. Following installation and calibration, we started to gather real data. We collectively held our breath. Some of the features we'd introduced into the shape were fairly aggressive aerodynamically. The CFD said they'd work; the humans had doubts…

The computers were right. We'd achieved a shape with a drag coefficient of 0.18, a third less than that of a typical production car. Furthermore, the CFD results were within 5% of those of the wind tunnel. Outstanding under any circumstances; even more so given the complexity, novelty and time pressure of the ASTAN project.

LESSONS TO BE LEARNED

ASTAN taught us many things. For me, the most profound was what it said about my profession. Today it's feasible for small teams of motivated, vision-driven engineers to tackle previously "impossible" problems. The days where useful work can be undertaken only by large teams with huge IT budgets are over: the only limit is your vision, skill and drive.

ASTAN also highlights some brutal facts of CFD, which will always have the capacity to consume all available computing power. The ASTAN setup maxes out at 6 to 7 million cells per machine and relatively benign flow conditions with limited areas of flow separation. More complex geometries inexorably require more power. However, it also demonstrates the level of flexibility, modularity and extensibility of these tools.

CFD results will also always require validation for complex separated flows such as this one. Such validation requires physical models. Cost inevitably follows, but the value of testing at Mira was immense, and ASTAN demonstrated that a digital path to manufacture is readily achievable. Computer-driven analyses score in the 40 versions that don't need to be expensively built and discarded.

Whatever your field, the relevant high-quality tools are probably just a search away. The only prerequisite is to have the idea and to ask the question: "How hard can it be?" ●

DAVEY WINDER

"I DISCOVERED UNENCRYPTED DATA WAS BEING SENT TO CHINA BY A BATTERY-USAGE APP"

Do you really know what your apps are doing with your data?
A few tools can help you get a grip on your mobile security

Kofi Annan, former secretary general of the United Nations, once said "knowledge is power, information is liberating". This certainly applies to technology, even more so the technology in your hand. Are you aware of the permissions you've granted apps on your smartphone and tablet, and what they're doing with those permissions? Chances are, you don't – and liberating those apps to do what they like greatly diminishes the power you have over your privacy and data security.

What set me thinking about this was some advice that recently appeared on the PC Pro website, the aim of which was to help readers to better understand their data allowance under iOS 8. This isn't something that's of great concern to me, since I'm on true unlimited data plans for both my smartphone and tablet. What does bother me, however, (and should bother you) is what data those apps are shoving around and where they're shoving it to. For example, malware needs to communicate with its external server in order for its perpetrator to profit from the infection, whether that profit is paid in stolen data or resources.

So, here's how to determine what's using data (and much more besides) on your Android devices. If you dig into the Android system settings, there's plenty of information available to users about permissions granted and what data is being used by which apps, but making sense of it isn't always easy. More importantly, such raw system information doesn't provide enough knowledge with which to power your decisions about what apps to use. What you need, ironically, is yet more apps...

The first of these apps is NowSecure, which is best described as an application activity visibility monitor. Catchy, I know. Immediately following installation, it won't tell you much: it needs to sit in the background and watch for a while before it becomes useful (or displays any information at all, for that matter). After a week or so, it will begin to supply information about the security of your connections, the specifics of each app's communications, and even the geographic location of your data, in order for you to be better informed about your apps.

You'll first see a screen displaying a fairly arbitrary "security score" that's calculated from what proportion of your network traffic is secure; whether your device has been rooted; whether there are any

"Opening NowSecure reveals at a glance which apps aren't being as secure as you'd like"

unverified apps installed, and whether these can be debugged over USB; and if it's connected to any insecure Wi-Fi networks. As with many such score-based applications, I took the resulting number with a pinch of salt – and you should do the same – but feel free to drill down by tapping on the score itself and then on the various categories listed. Don't expect a great deal of detail at first: on my first glance at the security category, the app merely informed me that the majority of my network traffic is encrypted; it would have been more useful to see which parts of my traffic are unencrypted.
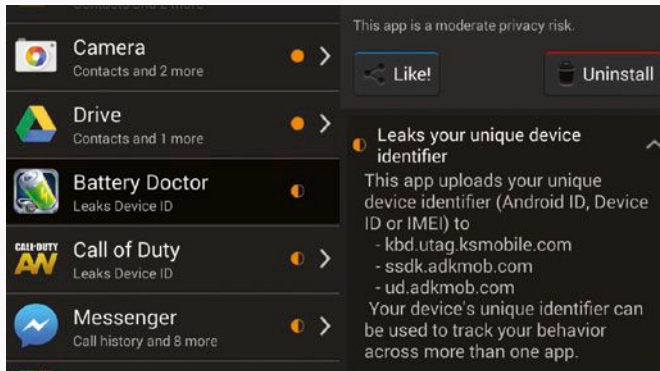
With this being so, you may be wondering why I'm recommending you install this

app. Well, it's because the useful detail comes from elsewhere. Not from the Security Feed section, which seems to merely be a vehicle for promotional news about the product, but in the Data Security section, where the power of NowSecure starts to reveal itself. It's here that I gained information on which of my data was being sent unencrypted. Opening it reveals at a glance which apps aren't being as secure as you'd like, and this app activity can be viewed as it's happened today, or over the course of the past week or month, to achieve a more meaningful portrait of risk.

I discovered that my data is 87% secure. Of the 13% that's unencrypted, Google Search was the biggest offender, responsible for 71% of unencrypted traffic on my test device. Second in the list was the operating system on 9%, followed by a battery-charging monitor on 7%, and then a bunch of other stuff on 1% or less, which includes Facebook, Chrome, Amazon and eBay.

The depth of detail also covers where my unencrypted data is being sent: not surprisingly, with Google as the main offender, some 47% of it ended up in the USA, but 14% went to the Netherlands and 6% to China. Heading back to the main menu and selecting "Countries" allowed me to drill down into this geolocation aspect of data usage, across all apps and in further detail. Destination countries are listed by the volume of data received, again on a daily/weekly/monthly basis at the click of a tab, which confirmed that the USA is where 71% of my data was ending up. Clicking on the country name reveals which apps are doing that particular talking: once again, as expected, Google proved responsible for 69% of traffic, although only 15% of the overall traffic was unsecured.

Taking a look at China enabled me to discover that not only was an alarming 100% of my data being sent there unencrypted, but that 95% of that traffic was as a result of a battery-usage app I'd

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< NowSecure tells me my data is 87% secure – is that secure enough?

< What data are your apps sending, and to where?

⌄ Antivirus has now become an essential install on all mobile devices

installed. This is information I'd never have known about without the NowSecure report, and while it doesn't necessarily indicate a security or privacy threat per se, it certainly presented me with food for thought.

The final option available through NowSecure is "organisations", which reveals exactly who your apps are talking to – expect this to be a mix of ISPs and advertising hosts. Once again, any unknown or unexpected names can be drilled down into to see which app is talking to them and whether or not the data being sent is secure. You can also then Google the organisation for more information.

NowSecure is a free download from Google Play, but that doesn't mean it comes without a cost. It's just a cost to your system resources; of all the apps installed on my Android device, NowSecure has become the biggest resource hog, responsible for running the battery down faster than any other app. Information at the cost of power is perhaps a good description. In fact, I uninstalled the app after a month of testing as a result – I'd recommend you use it as a report-building tool, leaving it for a week or so to gather data. Spend some time interrogating the results before uninstalling it again to save resources. Repeat this install-for-a week treatment once a quarter to keep on top of where your data is going.

GET A CLUE

The second app I installed to gain insight into what my other apps were up to comes from security vendor Bitdefender, in the shape of a free download called Clueful. Like NowSecure, Clueful hits you with an overall privacy score, which in my case was a less-than-comforting 57%, described as only "fair". This score is apparently calculated from the "danger level" of the apps I have installed, and Clueful warns that "the lower the score, the more dangerous are your applications and you should take the necessary steps". How does Clueful come to this conclusion? Actually, it's quite simple: it checks the permissions you've granted to each

app (those ones you should think about before clicking the Install button) against Bitdefender's cloud database, which holds data on what previously scanned apps are actually up to.

The idea is that you can then make an informed choice as to whether you believe the ratio of potential privacy risk to resource reward is sufficiently favourable on an app-by-app basis. Once again, I'll admit to treating this main-screen privacy score as arbitrary, feeling inclined to ignore it. It would be far more useful if I could inform Clueful that I do trust certain apps, based on my own assessment, and then have my privacy rating adjusted accordingly. However, if you scroll down past the big target that occupies most of the screen, you'll see a breakdown of the risks – my test device showed I had 39 low-risk apps installed, 22 moderate-risk ones, and none considered high-risk. This immediately suggests the situation isn't all that bad, but digging into the detail is obviously still required. I opted to take a look at all 69 apps installed on my device, and one click opened up a vertically split screen with my apps listed in order of apparent risk on the left, while details of the risk are displayed on the right. I could see that my calendar app had permission to read my contacts list and my calendar entries, which Clueful considers to be a moderate privacy risk, but that common sense says is clearly a requirement for any calendar app. I'd have expected that these would have been classified as low-risk "expected behaviour", in the same way Clueful understands that Messenger requires permission to send and

receive SMS messages.

This doesn't mean that Clueful is a complete waste of space, merely that you need to apply a little common sense when interpreting the results. Remember it isn't telling you which apps you ought to remove, but rather providing data about them to enable you to make an informed decision.

Where things become really interesting is when you use it in conjunction with NowSecure to build a broader image of your "privacy-scape". If we go back to that battery app NowSecure informed me was sending unencrypted data to China, Clueful shows only one concern with it, namely that it "leaks device ID". Clicking on this in the right-hand screen enabled me to delve deeper, revealing that the app uploads my Android ID, Device ID or IMEI to a number of specific servers registered to Chinese companies. A little extra research revealed one of these to be a mobile-tools provider, while another appears to be an ad-serving/tracking network. Neither would suggest much to worry about, but Clueful's advice that a unique identifier can be used to track your behaviour across more than one app is certainly useful.

I like the way Clueful displays its privacy information, and the fact that I can opt to uninstall any offending app without even leaving the app. I also like its filtering option, which quickly enables me to show only those apps that present a specific risk. These risk filter topics range from using intrusive ads through to tracking your location and gaining access to sensitive data. The number of apps, if any, which are found to match is displayed to the right of the filter category, saving you from wasting time looking into empty categories.

However, the number of apps not being analysed does concern me. You can see an Analyse button next to them, but pressing this just tells me that Bitdefender will try to analyse this app as soon as possible. Considering that some of the apps here are pretty popular , this strikes me as a weakness.

Overall, though, Clueful can fulfil that "information is liberating" brief. Keep in mind that neither is a security app in the usual sense of performing malware scans, so you should still install such software alongside them. That's right, I'm saying that common security sense nowadays dictates the need to install a complete mobile security suite on your device.

There are a huge number of such security apps out there, from the free to the hugely overpriced. Among the best value are those multi-device suites that allow you to install protection across device types and operating systems, offering you protection on a couple of laptops, your smartphone and tablet with a single licence. ●

STEVE CASSIDY

"I KNOW THAT EVERYBODY LOVES A RANT AND A DISASTER STORY, SO LET'S GET TO THAT PART FIRST"

Two traumatic recovery processes leave Steve unsure how
to feel about the state of the technology industry

I don't know whether to laugh or cry. Literally, such is the state of life in the information technology business at the start of year 2015. On one hand, I've just witnessed a classic story of hardware failure that's enough to make you despair for the whole industry. On the other, I've been able to use some clever software to get out of trouble – in ways that give me hope for the future, not only of our own business, but of the multitudes of businesses that have become painfully dependent on us (in ways that, even two years ago, nobody saw coming).

I know that everybody loves a rant and a disaster story, though, so let's start with that part. In what follows, I may perhaps be accused of navel-gazing, since my rant touches on product reviews, an area in which *PC & Tech Authority* itself has a certain interest. Really the story is about knowing how far you can trust your own hardware, and in this case I'm thinking specifically about storage devices. To a degree, reviews of such boxes all tend to ask and address a similar series of questions, based on the reasonable assumption that the list of factors relevant to your business remains fairly constant. We also accept that the manufacturer's representations of how you'll use the device, and how it will behave, align more or less with what's important to your operations.

When it comes to a buying decision, however, it's important to bear in mind that the parts of the review that seem most important may in fact be red herrings, while less sexy but crucial considerations might be understated. In a comparative review, there's a natural inclination to view performance as the key differentiator – an understandable instinct in an industry that has for

decades measured progress in terms of operations, frames or bits per second. Storage manufacturers themselves like to focus on performance claims as a means to distinguish their products.

These days, however, the raw speed of the chips in terms of bit-shovelling needs to be considered alongside relative power-efficiency. The good news is that the low-energy movement is already paying dividends: data-centre and server-room design is becoming easier, and ongoing per-unit running costs are falling. On that inevitable mid-summer day when the air conditioning dies, you'll be grateful for your VM management and your power-efficient post-Xeon 5500 Series servers.

This brings me to the real point of my rant: if you believe, as I do, that IT is only becoming more fundamental to businesses, then it's absolutely crucial to consider not only how a piece of kit performs when all is well, but also how it will cope with the grungiest of real-world operations and scenarios.

For a business, that's true of almost any type of product, but it applies particularly to storage. We're stowing away an unprecedented amount of data, and our interactions with these huge piles of data increasingly resemble needle-in-a-haystack exercises, such as picking out that vital seven-year-old, two-page document from the irrelevant terabytes of gossipy emails, holiday photos and backups of unused website designs (which may turn out to be tomorrow's vital document).

This kind of contingent usage pattern can result in performance that bears little resemblance to benchmark scores. Recently I've seen a bottom-end NAS device achieve impressive transfer speeds when given a few gigabytes by Windows Server 2012, reporting data rates of as much as 500MB/sec across a bonded Gigabit

"The majority of the storage failures I'm seeing recently are no different from those that happened back in the noughties""

Ethernet, using jumbo frames, flow control, iSCSI and separate LAN cards for the front-end and back-end traffic inside the server. Change the test data from a single file to a messy directory tree, however, and speed plummets. Another test on a single 100GB VHD showed a similar performance level: small, single files can zoom down the pipes, but once the workload starts to overwhelm the available memory cache, sploosh, into the swamp…

In this case, though, I'm not just

∨ Fast transfer speeds are great – but what happens when a drive fails?

STEVE CASSIDY
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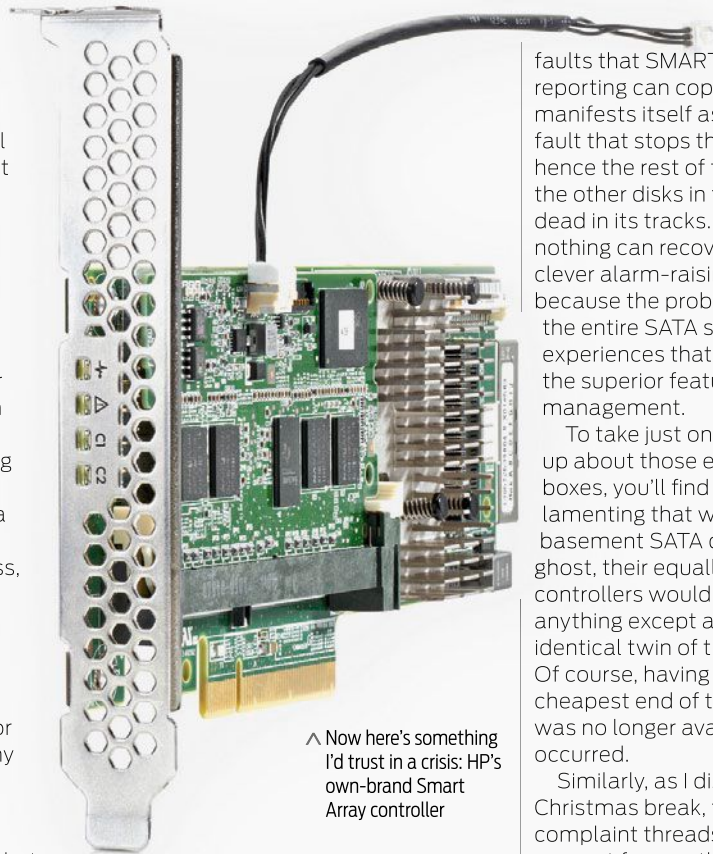
talking about how challenging usage patterns can destroy a device's advertised transfer rates. I'm writing in the aftermath of one of those awful horrors that leave senior management swearing never to use a particular platform again.

Here's how that came about: this month, one of my clients discovered to their horror that their main server didn't have a mirrored boot volume – and the controller was reporting that the surviving half of the original mirror was on its last legs. Their on-site tech specialist certainly wasn't going to ignore the predictive failure monitoring of the RAID card, but for some reason decided he didn't trust it to re-mirror a live boot partition.

I partly sympathise with his wariness, because the experiment to discover whether or not one has a trustworthy boot config is about as edgy as experiments get (short of those two blokes on MythBusters with some gunpowder). There are plenty of horror stories involving otherwise trustworthy server vendors who decide the best way to cut production costs is by skimping on the basic requirement to keep the customers safe, no matter what sort of fit the hardware may throw.

And it's the way of such horror stories that the long tail of bad reputation becomes a bit like the rear end of a brontosaurus: there's the real part, composed of plenty of red gristle and white bone, but then there's also the shadow it casts, which, although wholly insubstantial, appears far larger and more intimidating. Stories about a single version of Dell's PERC controllers and its broken boot-volume handling are of exactly this sort: with one prehistoric bad experience hanging in everyone's collective memory, all of Dell's RAID cards suddenly came to be treated as untrustworthy.

In fact, in my client's case, the techie's fear was focused on the least deserving suspect, because the server was an HP ProLiant of the almost-universal G5 generation. HP servers can be specified with own-brand Smart Array controllers, which have earned my almost complete trust. Just like those Dell PERCs you're likely to find in the wild nowadays, HP Smart Arrays can be tested by simply looking into the Array Configuration Utility (in case there's one dead member already), then yanking a member drive out of an array and plugging it back in again. The array controller will start to jump about like a cat chasing a laser pointer, and then the array will slow down a little as the controller quietly gets on with resyncing the drives.

∧ Now here's something I'd trust in a crisis: HP's own-brand Smart Array controller

That's all the upheaval you'll see, and this is how RAID is meant to work. And I don't mean only top-end storage controllers in big DAS deployments – the very essence of RAID is that all this stuff is supposed to work that way. Yet the very sad truth in 2015 is that almost nobody in our business acts as if this were a reasonable thing to be asking for!

Thus, my client's local techie didn't simply rip the cellophane from a brand-new 147GB SAS disk and let the controller get on with re-mirroring it. Instead he took down the server and set about cloning its partitions – agonisingly slowly, because HPs built with certain releases of SmartStart software have an unobvious partition layout on their boot disks. Then he created a whole new boot array to layer these partitions back over.

Since he hadn't built this server himself, nor done any torture testing on it with this specific setup, I can perhaps see why he chose this path. But really, must we persist in believing that the data integrity of RAID storage devices is something made up only to sound good in sales pitches?

It's perhaps noteworthy that the majority of the storage failures I'm seeing recently are no different from those that happened back in the noughties. Something goes bad inside a SATA disk, but rather than fitting neatly into those
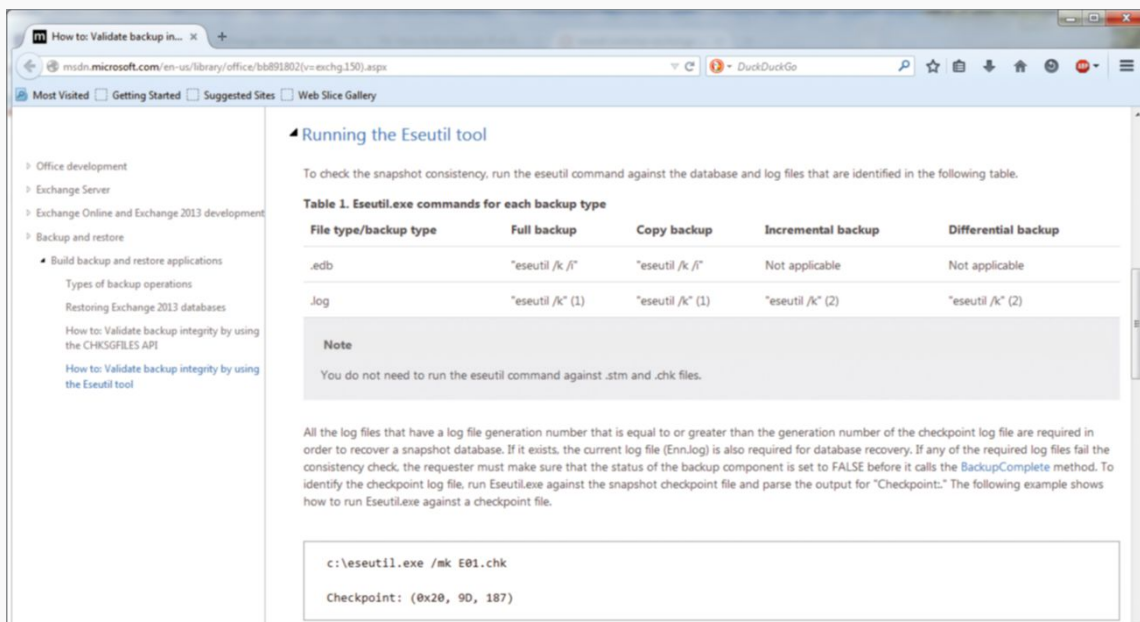
faults that SMART monitoring and reporting can cope with, this badness manifests itself as a low-level electrical fault that stops the power supply – and hence the rest of the device, including the other disks in the RAID array – stone dead in its tracks. Nothing is left running, nothing can recover automatically and no clever alarm-raising features can be used, because the problem is a shortcoming in the entire SATA specification. It's such experiences that teach us not to trust the superior feature sets in basic disk management.

To take just one example: if you read up about those early Iomega ix2 NAS boxes, you'll find numerous customers lamenting that when their bargain-basement SATA disks gave up the ghost, their equally simple-minded RAID controllers wouldn't rebuild the set with anything except an absolutely perfect identical twin of the dead member disk. Of course, having been bought at the very cheapest end of the market, such a twin was no longer available when the failure occurred.

Similarly, as I discovered over the Christmas break, there's a rich vein of complaint threads in the Netgear NAS support forums that all boil down to bottom-end devices failing to properly recover from a drive falling out of sync. Normally, if you have a dead NAS, and you suspect this problem – that one of the drives is holding the rest to ransom for purely electrical reasons – then your best course of action is to pull the drives out of their cages one after another, as I used to do with HP Smart Array RAIDs. However, Netgear's ReadyNAS OS responds to such attempts by declaring that it isn't only one that's drive dead, but in fact it's two! With a four-drive NAS, this can easily lead you to believe that all your files are history, because the OS doesn't consider whether the problem could simply be your having popped out the wrong drive. It tries to direct clients to a web UI, but says as little as possible on its small onboard status screen beyond a curt "restart failed".

In the case of the failure I attended to over Christmas, the device did end up recovering itself, but only after an epic volume reconstruction exercise following the reintroduction of that third crucial drive. It seems as though a SATA bus failure had caused the firmware to think that drive 4 was dead, when in fact the culprit was drive 3. As soon as drive 4 was taken out and put back with drive 3 removed, reconstruction could proceed – albeit in a somewhat bloody-minded way. Even though the 6TB of available space was less than 10% occupied, the RAID re-constructor whirred away for more than

an hour before remounting its volumes, as we discovered by refreshing the management interface every ten minutes or so. The recovery was eventually completed roughly nine hours later.

You can see why this might make a person want to cry. The combination of somewhat hopeful promises, minimal progress information, woefully scattered and inaccurate user-written "documentation" and colossal datasets makes for an unhappy recovery process.

This isn't the sort of scenario a review will necessarily focus on. Nor – perhaps understandably – is the RAID rebuild process often given prominence in vendors' claims for the capabilities of their hardware.

All the same, if you can, before investing in a NAS system, it's important to find out everything you can about array failure and recovery behaviour. You could even test it yourself: this needn't require sitting with stopwatches and sandwiches at unsocial hours. If you can get your hands on a test unit, simply yank out a drive, wait for it to spin down and then re-insert it, before logging in to its management pages to see what the machinery has to say. Drives fail, and there's nothing that can be done about that; good reporting of a bad situation is the ultimate recommendation.

YOU'RE LAUGHING, SQUIRE

That's enough of the crying. Now let's get onto the laughter, which actually arises from these same merry incidents over the Christmas break and just before.

If you're involved in network management at all, you'll be familiar with the great efforts that sales droids and

cloud architects regularly put into warning us about how fragile and awkward our poor old Windows servers are. And they may have a point – if you're misguidedly trying to wring the very last squeaks out of your creaking pre-recession hardware and software.

My own experience however has been that, in all my years of running around after apparently dead disks, and generating volumes of war stories concerning disk manager firmware in the process, the actual data saved on such drives has generally proved surprisingly robust.

At least one of the dramas I've recently

> _"This level of recoverability in a badly treated NAS gave me considerable hope"_

stage-managed to a happy conclusion concerned an Exchange 2013 message store, which – as the result of a penny-pinching decision to avoid investing in rack-mount hardware – had been kept and updated for several months on a cheap and cheerful external NAS with marginal iSCSI ability.

It was impressive, really, how well this setup endured the considerable abuse that was regularly meted out to it. People pulled out Ethernet leads; they yanked out the power connector by mistake; they ignored update requests; they thrashed the poor disks by copying huge volumes of messages around from private to public mailboxes. It added up to the worst torture test I could ever imagine for such a storage system.

Remarkably, though, this budget iSCSI

target device withstood everything they threw at it – right up to the point where it finally threw up its hands and dropped a RAID disk.

Exchange coped with this admirably. It reconnected on a reboot of the guest VM and undertook only an occasional bit of database repair, without the users being aware that anything had happened. I was sure, however, that if the RAID array needed rebuilding, it would be game over for the innermost layer of this pyramid of storage types – a ReadyNAS logical volume, containing a thin-provisioned iSCSI LUN, containing a Windows Hyper-V host NTFS drive, containing a Hyper-V guest logical disk, containing the Exchange message store itself.
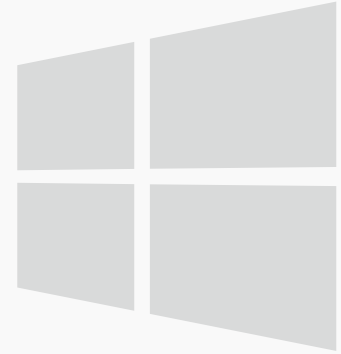
I was wrong! Once the array had been green-lighted, everything started back up with the barest of delays.

When I cast my memory back to the bad old days of bleeding-edge server management, such recoverability (on a network cobbled together with a minimum of clever tuning tricks) gives me considerable hope on two fronts.

First, I feel encouraged that Microsoft has evidently done the right kind of work in understanding where to expend its development efforts, so that a failure in one area of your systems doesn't necessarily mean everything else comes tumbling down. Second, I'm heartened to see that it's now possible to take advantage of technologies once reserved for heavy-metal data centres in the smallest of deskside deployments. That's the best possible kind of server and networking innovation: the kind that delivers peace of mind. ●

FIVE TALKING POINTS FOR
BUSINESS ON WINDOWS 10

Microsoft is preparing to launch a new version of its Windows operating system later this year, **Ry Crozier** lists the main attractions

Windows 10 - likely to be the last Windows to be given a version number - has already won plenty of attention for its technical features, including the return of the Start menu, a new browser and wider use of Cortana personal assistant software. However, questions remain on the costs and upgrade path. Analyst firms IBRS, Ovum, Gartner and Forrester have some answers.

1. WINDOWS 10 IS NOT FREE FOR ENTERPRISE (EVEN FOR A YEAR)

Microsoft won plenty of praise when it revealed upgrades to Windows 10 would be free for the first year. Speculation quickly turned to whether the kind offer would extend to the enterprise versions of Windows, not just the consumer editions. We now have an answer. "Windows 7 Enterprise and Windows 8/8.1 Enterprise are not included in the terms of [the] free Windows 10 upgrade offer," the vendor said. Software Assurance - the favoured volume licensing arrangement for enterprise customers - remains the best way to quickly get hold of Windows 10, according to the vendor and industry analysts.

2. EVEN IF IT WERE FREE, WOULD ENTERPRISE MOVE THAT FAST?

Unlikely, according to analysts. "One thing Vista did is show enterprises they could hold onto an operating system for two cycles," IBRS advisor Joseph Sweeney said, noting upgrade cycles were now "five or six years". Ovum's principal analyst Richard Edwards concurs that enterprises are unlikely to adopt Windows 10 in numbers immediately. "I don't see mainstream adoption of Windows 10 until we get towards the end of this decade," he said.

3. BUT IT'LL EVENTUALLY BE THE NEW ENTERPRISE STANDARD, RIGHT?

Forrester thinks so. Even before Microsoft's latest briefing on Windows 10, Forrester analyst Frank Gillett declared that "Windows 10 will become the new enterprise standard, the successor to Windows 7, a status that Windows 8 was unable to attain". After the event, Gillett said he believed Windows 10 would "persuade enterprises ... to upgrade from Windows 7 and be an easy upgrade from Windows 8". Others are more cautious. "It's far too soon to tell [if this will become the new enterprise standard]," Gartner's information management research VP Merv Adrian said. "They're not even shipping a production version yet. But, he added, "the indicators are all very positive."

4. MAYBE CONSUMERS CAN SPEED THINGS UP

Microsoft's 'free for a year' offer may not work for enterprises but it does apply to consumers. The vendor will undoubtedly hope they upgrade in large numbers, and pressure their workplaces to follow

> "Windows 10 will become the new enterprise standard"

suit. "Microsoft are saying, 'We must recapture the consumer market' because the consumer market is dictating what enterprises put on the desktop," IBRS' Joseph Sweeney said. "That's what this so-called free offer is about."

5. MICROSOFT WANTS TO QUICKEN THE CYCLE AGAIN

Microsoft first leaked its intention to create 'Windows as a service' in job postings in April and August last year. EVP of Microsoft's operating systems group, Terry Myerson, has now indicated the vendor will scrap version releases of Windows in favour of an as-a-service delivery model for updates. "Once a Windows device is upgraded to Windows 10, we will continue to keep it current for the supported lifetime of the device - at no cost," he said. "We'll deliver new features when they're ready, not waiting for the next major release."

Gartner's Merv Adrian sees the new delivery model as a positive. "They'll just update Windows the way people update other cloud-based software and not come out with Windows 11 four years from now and disrupt everything again," he said. "That's healthy, and it's useful for enterprises." However, Adrian is cognisant that a cultural shift in enterprise software delivery could pose some challenges. "When enterprises can and have to pay for the parts they will have to license, only time will tell how successful Microsoft will be with this approach," he said.

One issue that has already been raised is whether enterprises will be able to pay to delay the as-a-service cycle. Adrian said that enterprises can already invoke an option to move slowly on OS updates and that "it doesn't cost extra to do so". However, there remains little visibility on how such licensing options might operate in the new Windows 10 world.

This article was featured on ACS Information Age. For more visit: https://ia.acs.org.au/

CES IS BIG BUSINESS, SAYS JON HONEYBALL, AND IT'S TIME THE BIG PLAYERS SAT UP AND TOOK NOTICE

" It sounds idyllic: extend your Christmas holiday by popping over to Las Vegas for the first week in January. Yes, I'm talking about CES, that intense industry melting pot where anyone who is anyone in tech will be there. Well, if you exclude Apple. And Microsoft. And Google.

Each year, CES gets bigger, louder and, supposedly, better. But some are claiming this year's event was a letdown, referring to the lack of a "kaboom!" industry announcement by someone huge.

This follows last year's CES, which was mostly progression based upon existing work. That said, the sight of Michael Bay, Hollywood director of the Transformers franchise, stumbling off stage during the Samsung keynote, apparently due to an autocue failure, is something I will certainly remember for a long time.

This year, however, even the large-scale press conferences were boring, with little to show for the past 12 months. As always, there was a big push towards smaller, thinner and lighter devices with longer battery life and lower prices, all of which will appeal to the consumer. But there was little new in mobile, with most vendors holding off until Mobile World Congress in a few weeks' time.

You might think, therefore, that CES's time has come and gone. The reality couldn't be further from the truth. CES isn't merely a place to see new things, despite the huge cathedral-sized manufacturer stands and the dancing girls. It's a place to do business. My typical day runs from 7am through to midnight. Endless meetings, breakfasts, dinners, and then a flood of stand visits. I receive a triple-digit number of invitations to go and see some exciting new widget. Some PRs are quite pushy, insisting that I book my on-stand interview slot immediately because availability is scarce. Uh-uh, no it isn't – it's my time that's short.

One friend, a technical director, uses CES as the ideal opportunity to meet up with suppliers. He met with more than 40 of them in two days, which is the sort of workload that can bring a grown man to his knees. The younger manage to party on through the night, and innumerable stands are staffed by people in that post-zombie "I have been up for 36 hours" look.

My time at CES is a mix between wandering around the show floor, PR events and business meetings. And it's incredibly productive, if enough to flatten me for a few days once I return home. I simply couldn't get through that amount of work in that time frame anywhere else on the planet.

This year, I carried around a pocket-sized Garmin walking GPS system with me. The squiggle of walking, taxis and rental car looks like a child has frantically scribbled over Las Vegas Boulevard with a crayon, as my path goes back and forth between the major hotels and the Las Vegas Convention Center.

And it is somewhat intriguing that all of this manages to happen without some of the biggest names in the industry being visibly present. Apple is never there, but then it never talks about any of its products in advance of its own carefully orchestrated launches.

Microsoft wasn't really there, either, although there were discussions taking place behind closed doors. Other big industry companies weren't visible either. But then, it's CES – the Consumer Electronics Show. What does Microsoft make in that space? There's its range of Surface tablets, and maybe a new mouse or keyboard to show. That's hardly worth a full stand. There might have been some presence for Xbox but, like phones, gaming has dedicated events later in the year in E3.

And therein lies the problem. Far too much of this stuff is still too sandboxed, with product developments happening in contained spaces. Instead of a clear path forward, the whole industry seems to be groping around for a new direction, and in doing so is reaching out in several different directions simultaneously.

"We need a vendor to provide an open, free framework to make all this stuff relevant to the home user"

Yes, it mostly knows where it wants to go to, but the control, configuration and security aspects are making the public wary. We really need a vendor to step up to the plate and provide an open, free framework to make all of this stuff relevant and comprehensible to the home user. Niche vertical solutions won't work. We need a broader, more daring solution.

I'm hoping the big players were watching, and that at least one will have its act together for January 2016. It's time for someone to take the lead and make a bold push. Treading water does no-one any favours, especially those consumers the show aims to serve.

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