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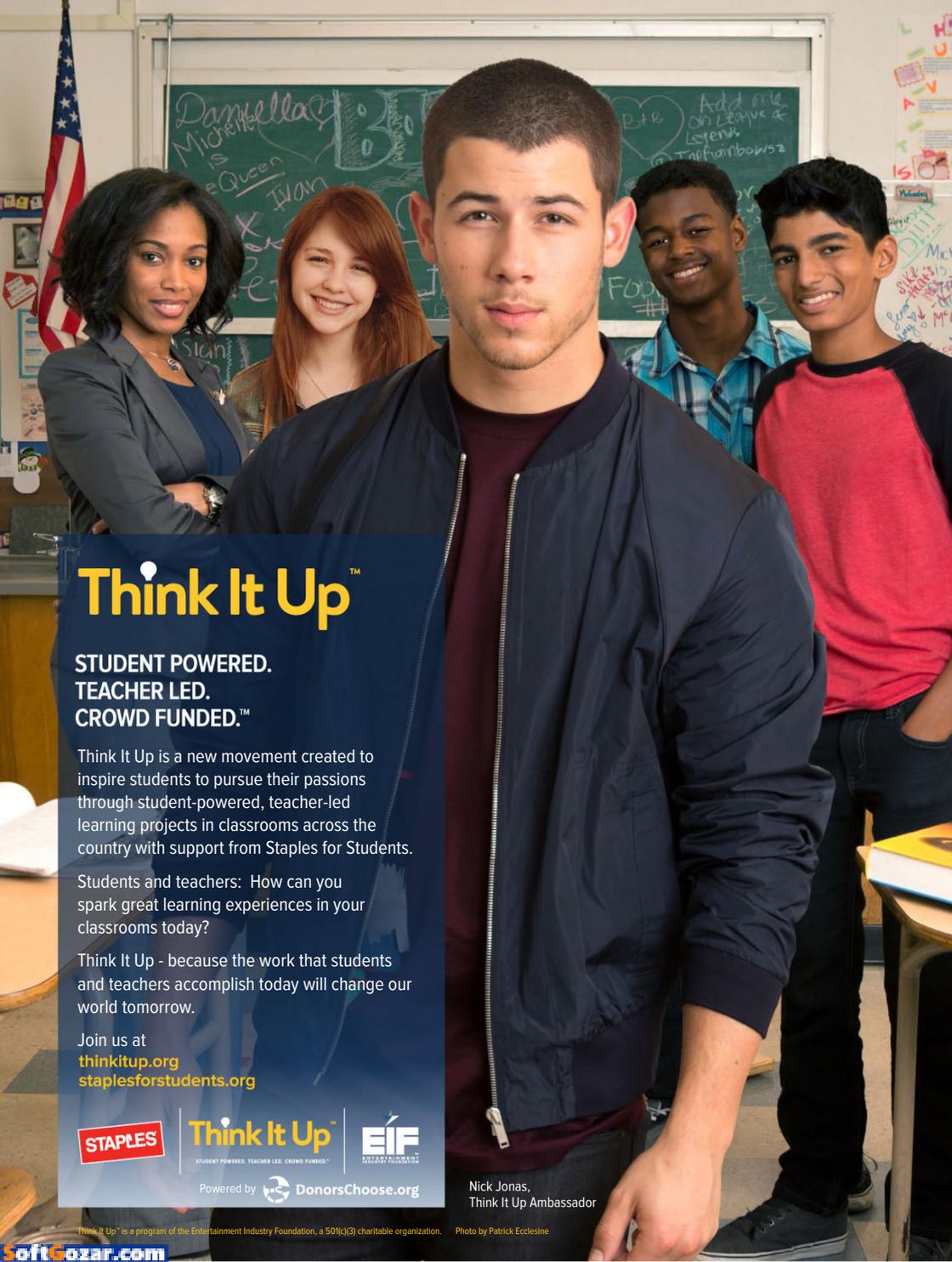
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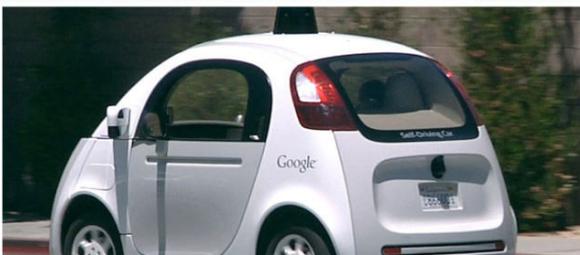


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reminds his friends (at least the
ones that have kids) that they all
have **big black letters on the box**
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Notebook hard drives are dead: How SSDs will dominate mobile PC storage by 2018

Trends in SSD pricing and laptop sales are all pointing in the same direction.

BY MARK HACHMAN

IF CURRENT PRICING trends continue, the conventional notebook hard drive could die by 2018, replaced with fast, slim, and increasingly cheaper SSDs.

SSDs can generally transfer data faster and with less latency than hard drives, running silently and consuming less power. But they've

traditionally been priced several orders of magnitude higher than a hard drive of the same capacity, limiting their use to higher-end PCs.

Quietly, however, that's changing. The flash vendors designing the chips used within SSDs have aggressively introduced technology that continues to lower their cost. Meanwhile, hard-drive vendors have spent the last 60 years whittling dollar after dollar from the cost of a hard drive, but face slowing price declines that should allow SSDs to catch up.

Hard drives certainly aren't going away—especially in desktop PCs, servers, and in devices like DVRs. But in notebook PCs? "Let's be honest," said Bob O'Donnell, principal at TECHanalysis Research. "[Hard drives] are obviously a technology that will have run its course at some point."

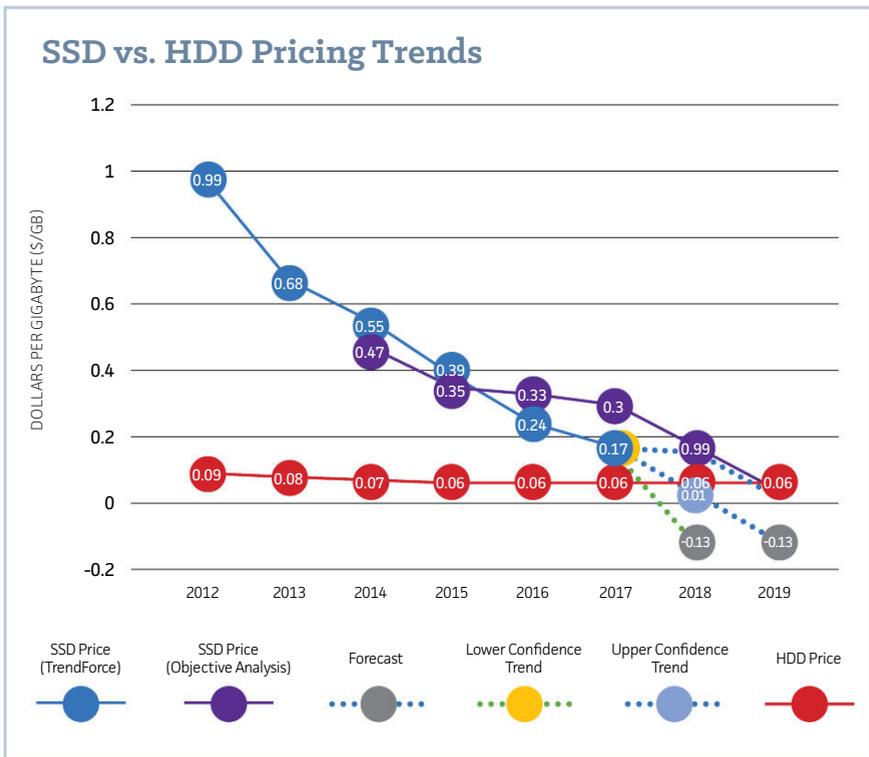
SSD price declines pressure hard drives, alter PCs

Right now, SSDs aren't anywhere close to the same price as a hard drive: On a dollars-per-gigabyte basis, SSDs are six times the price of a comparable hard drive, according to Taiwan's TrendForce. Over time, however, the firm's data predicts that SSD prices will plunge precipitously, putting SSD pricing on a level with hard drives—whose



We've long said that an SSD is the best upgrade you can buy for your PC.

SSD vs. HDD Pricing Trends



pricing has remained essentially unchanged. At that point, SSD's other advantages should give it the edge.

Alex Chen, the senior manager in the memory division for TrendForce, said in an email that he believes that the price per gigabyte for hard drives and SSDs will be "very close by 2018 to 2020."

Extrapolating the current price trend puts the crossing point at 6 cents per gigabyte. Variances in the forecast model could put that as early as mid-2017, or as late as early 2019.

Separate data compiled by Objective Analysis, which tracks the flash market, is more pessimistic, putting SSD prices at 6 cents per gigabyte barrier in 2019. (Note: the graphic includes forecasts from both

Two different estimates of SSD pricing, mapped against relatively static pricing for hard drives.

TrendForce as well as Objective Analysis; the dotted lines indicate *PCWorld's* own extension of that data, using Microsoft Excel's forecasting tool. The key is where the SSD pricing line intersects the hard-drive pricing trend.)

The rapid price declines have their roots in both technical as well as business causes.

Vendors designing flash memory, the building blocks of SSDs, have been busy developing denser multi-layer cell (MLC) flash. Intel and Micron also hope to increase that density further via 3D NAND flash (go.pcworld.com/3dnandflash), which promises yield capacities of 10TB inside a 2.5-inch form factor.

Competition also plays a role. With really only Western Digital and Seagate competing in the hard-drive market, price competition isn't necessarily as cutthroat as in flash. DRAMeXchange said (as reported by *Computerworld*) Samsung, Toshiba, SK Hynix, Intel, and Micron will maintain their aggressive pricing strategy into the first half of 2016.

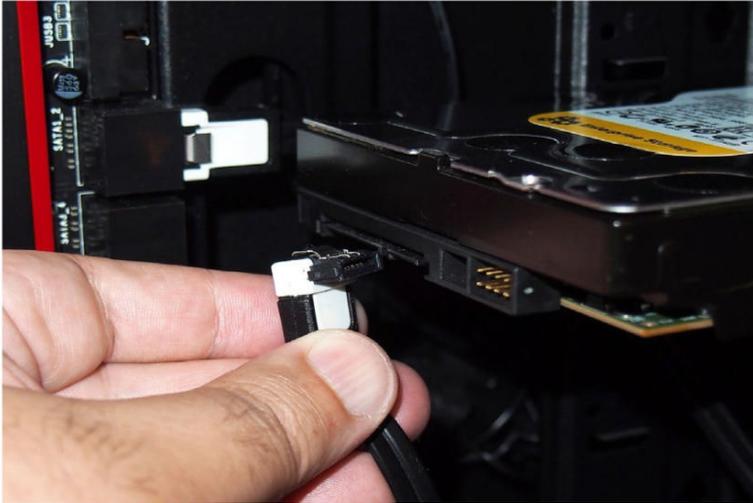
The lowered SSD prices should produce a cascade effect, not only spurring SSD adoption but also influencing the design of PCs.

Data originally compiled by *Computerworld* from TrendForce shows that SSDs were used in 21 percent of all notebooks worldwide in 2014. The firm's forecast calls for that number to rise to 42 percent in 2017. Hard drives, meanwhile, are expected to fall from 79 percent penetration in notebooks during 2014 to 59 percent in 2017.

In September, Gartner reported that 277 million "traditional" desktops and notebooks (typically using hard drives) were sold in 2014, compared to 263 million ultramobile (clamshell notebooks and tablets) devices, which use SSDs. By 2017, the firm says, that ratio will have flipped: 296 million ultramobile devices compared to 226 million

Device Type	2014	2015	2016	2017
Traditional PCs (Desk-Based and Notebook)	277	247	234	226
Ultramobiles (Premium)	37	44	57	78
Ultramobiles (Tablets and Clamshells)	226	199	208	218

Source: Gartner, Sept. 2015



Traditional hard drives aren't expected to vanish from desktops anytime soon.

traditional devices.

That, in turn, should influence the design of computers themselves. Apple was one of the first manufacturers to throw its weight behind SSDs with its redesigned 2010 13.3-inch MacBook Air. Since then, similar Windows-based ultrabooks have become more common. IDC also said recently that it expects shipments of 2-in-1 PCs, which dock SSD-powered tablets inside keyboards, to increase 75 percent next year.

If SSDs do become prevalent in the notebook market, expect a growing number of thinner, lighter PCs.

On the desktop, the hard drive isn't quite dead yet

Desktop users have an entirely different set of requirements. Analysts say that some users will indeed adopt SSDs as boot drives or as devices to quickly launch a few key apps. But consumers will still buy traditional hard drives, especially to store and edit digital video and games. External hard drives connected by high-speed USB 3.0 or USB-C cables will also remain as excellent backups for SSD-powered

systems. At some point, it's possible that mainstream desktops will include a single SSD drive and use external drives or the cloud for backup, but it's less certain than for the notebook PC.

"You can't store everything on your [desktop] PC inside flash; it's simply too expensive," storage analyst Tom Coughlin of Coughlin Associates said.

For that reason—the gobs and gobs of storage that traditional hard drives offer—we can't write off the hard drive entirely. Some SSD users may also be turned off by reports of slowdowns when transferring large files, or the risk of catastrophic failure. (Fortunately, current-generation SSDs have solved the latter problem.)

What the pricing argument also assumes is that consumers will instinctively recognize the advantages of an SSD, and gravitate toward notebooks that include them. Jim Handy of Objective Analysis thinks that won't always be necessarily true. "I'm thinking of doctors, lawyers, schoolteachers, and firefighters," he said, who buy on considerations like price, the processor speed, and the amount of storage—not the storage technology.

Offer a laptop with a 1TB hard drive for the same price as one with a 256GB SSD, and the average consumer will likely gravitate to the larger drive, Handy said. "These people are not even aware of the differences between a hard drive and an SSD," he said.

For now, hard-drive makers adhere to the "give 'em more" argument: For about \$100, you can currently buy a 3TB internal hard drive, far more than the 300GB worth of SSD storage \$100 currently buys.

Technologies like HAMR optically-assisted hard-drive technology could ship in volume next year, pushing hard-drive capacities to 30TB and disrupting the price-per-gigabyte of hard drives yet again. But traditional hard-drive vendors have also seen the writing on the wall:

For now, hard-drive makers adhere to the "give 'em more" argument: For about \$100, you can currently buy a 3TB internal hard drive, far more than the 300GB worth of SSD storage \$100 currently buys.



An SSD is the fastest way to get from a blank screen to here. Why wait for a hard drive to load?

Seagate bought LSI's flash business for \$450 million in 2014, and Western Digital has bought SSD makers STEC and Virident.

The “good-enough” argument

Extrapolating forecasts is always risky, and the data compiled by TrendForce and Objective Analysis differs somewhat. But the downward trend is clear: Unless the hard-drive industry can cut its manufacturing costs, it appears that eventually SSDs will become more cost-effective than traditional hard drives in the notebook space. At that point, then, we should expect those hard drives to disappear.

There will be exceptions, of course. It's not hard to believe that gaming notebooks will offer roomy hard drives as an option. Some movie services, such as Microsoft, allow you to download the film to your notebook's hard drive, and business travelers might cache a bunch of movies for a transoceanic flight. Still, these will probably prove to be the exception, rather than the rule.

For those of you who have used a laptop equipped with a hard drive, however—well, you already know how awesome SSDs are.

Rebooting a PC used to take enough time to get up and fetch a cup of coffee; today, it's barely enough time to pull out your phone and check your email.

But there's also the "good-enough" argument. You simply can't buy a peripheral that can enhance the performance of your laptop's CPU, or add more memory—so both of those components should weigh heavily in your buying decision. But if you want to add additional storage capacity, you have literally hundreds of external options to choose from, SD cards to add, or cloud storage like Microsoft's OneDrive. You don't need to buy a laptop with a 4TB hard drive inside, because you can always add that extra storage later. What you've got is good enough.

But increasing your laptop's boot speed? Loading a game in a matter of seconds? That kind of convenience comes from only one component: an SSD. And once you've experienced it, you don't want to go back. Lower prices may eventually kill the notebook hard drive in favor of the SSD. And what a great day that will be. 🖱

But increasing your laptop's boot speed? Loading a game in a matter of seconds? That kind of convenience comes from only one component: an SSD.

Microsoft will let you keep your free 15GB of OneDrive storage, if you claim it

BY MARK HACHMAN

MICROSOFT HAS GRUDGINGLY agreed to let current OneDrive users keep their 15GB of free cloud storage and 15GB of free Camera Roll “bonus” storage, rather than dropping you to 5GB as previously stated. Of course, there’s a catch: You have to be aware of the offer and willing to endure a bit of spam.

To take advantage of the offer, visit this Microsoft page (preview.onedrive.com/bonus). Microsoft representatives said the company does not have a supplementary explanatory blog post or statement to add at present, but interestingly the URL suggests the page is still in preview phase.

You’ve already navigated the first hurdle: Because users have to manually opt in to the offer, OneDrive users who are unaware of the deal won’t be able to take advantage of it. And there’s a small catch: By selecting the offer, you agree “to receive promotional emails from OneDrive.” Microsoft also says you may unsubscribe from them—how to do that, however, isn’t exactly clear.



Unchecking the box for promotional email, then clicking the Keep Your Free Storage button also appears to work. In response to a question from *PCWorld*, a Microsoft representative said the wording is being changed to “make it more clear.”

Why this matters:

Microsoft’s reputation has climbed of late, as it’s reached out and worked with customers on the development of Windows 10, Office, and even Solitaire. But the end of unlimited OneDrive storage was a real black eye for Microsoft’s outreach efforts, and even the latest offer feels a bit half-hearted. If you want your friends to be able to take advantage of the offer, you’ll need to share it with them.

What’s going on here?

Over 60,000 different users complained about Microsoft’s changes to its OneDrive policy, which also reneged on an earlier deal to supply Office 365 (go.pcworld.com/onedrivelimited) subscribers with unlimited OneDrive storage at a future date. But what users were really unhappy with was Microsoft’s decision to reduce the amount of free storage from 15GB to 5GB per account, as well as discontinuing the 15GB Camera Roll storage bonus for mobile users who uploaded their mobile photos to OneDrive. Microsoft’s new offer reverses the latter decision.

Microsoft has apparently maintained the 1TB limit on user accounts, however. In November, Microsoft said that it is also doing away with the 100GB and 200GB OneDrive paid plans priced at \$1.99 and \$3.99 per month, respectively. Instead, it will roll out 50GB of storage for \$1.99 per month in early 2016. Anyone needing more storage than that can get 1TB by signing up for Office 365 Personal (go.pcworld.com/o365personal) for \$6.99 per month. 

Over 60,000 different users complained about Microsoft’s changes to its OneDrive policy, which also reneged on an earlier deal to supply Office 365 subscribers with unlimited OneDrive storage at a future date.



Yes, you can overclock cheap Intel Skylake chips

BY GORDON MAH UNG

BUDGET PC BUILDERS are in for a treat: It's been officially confirmed that you can now heavily overclock Intel's cheap Skylake chips with a BIOS update.

Tech site TechSpot confirmed (go.pcworld.com/skylakeoverclock) it through hands-on tests. The team overclocked a Skylake Core i3-6100 from its default clockspeed of 3.7GHz to 4.7GHz, after motherboard maker Asrock provided the team with a beta BIOS that required switching off the integrated graphics.

Why this matters: Intel's last few generations of chips have limited overclocking to pricier K-series CPUs. With an apparent workaround

discovered, higher clock speeds and essentially “free performance” may become far more attainable for those who can’t afford a K chip.

An overview of overclocking

“Overclocking” is the term for running a CPU’s clockspeed above its rating from the factory. This may sound dangerous—and it can be if done improperly—but many CPUs are artificially limited to lower speeds by Intel at the factory to help meet prices.

Here’s a car analogy: It’s like if Ford sold a top-end Mustang that could hit 150 miles per hour, but then took the same car and set its computer to limit the top speed to 120mph. In this case, Intel’s cheapest K Skylake chip is the \$242 Core i5-6600K with a factory clock speed of 3.5GHz. The same chip has an equivalent Core i5-6500 for \$192 at 3.2GHz. If you could take that cheaper CPU and overclock it to the same speed, why buy the pricier part?

An architecture change within the sixth-generation chip that separates the chip’s “BCLK” (“base clock”) from other components appears

Locked Skylake CPUs can be overclocked, unlike Broadwell and Haswell chips.



to be the culprit behind the newly enabled overclocking. The base clock is one of the internal clocks that regulates the overall megahertz of the chip. With Haswell or Ivy Bridge, for example, the base clock was hooked up to other sections of the CPU, causing instability when the base clock was increased even in small amounts. That's no longer the case, and after months of speculation over whether or not base clock overclocking could work, we now know it could.

Maybe only dual-cores?

Something to note: TechSpot's overclocking confirmation was achieved only with the dual-core Core i3 chip. Anandtech's attempt at performing (go.pcworld.com/bclckoverclock) a base clock overclock of a quad-core Core i5-6500 hit a wall well before TechSpot's dual-core would. But it isn't known whether that's because of the motherboard Anandtech used or because board vendors are still tweaking their BIOSes to enable the overclocking.

Skylake is overclocking-friendly

Asked about the apparent overclocking "loophole" Intel officials said they didn't condone it saying only: "Intel does not recommend overclocking processors that have not been designed to do so. Intel does not warranty the operation of the processor beyond its specifications."

In other words, we only bless K chips for overclocking. What's not clear is how Intel will react to the overclocking loophole. When Skylake launched, the company pushed the chip as being friendlier to overclocking than previous K chips. Intel has condoned overclocking for a few generations of chips but in recent years seems to be pushing it even more heavily.

As mainstream desktop PC sales continue to decline, Intel has increasingly relied on sales to enthusiasts and gamers, who have no problem paying a premium for overclocking-friendly chips. If a groundswell of PC builders suddenly reached for the cheaper, overclock-ready chips to save a few bucks, that could impact sales of Intel's premium K chips.

Intel's premium K chips.

This wouldn't be the first time Intel had to squash such a trend. Intel's chipset for its Haswell series included the Z-series for overclockers alongside the cheaper H- and B-series chipsets. When motherboard vendors discovered a way to enable overclocking on the lower-cost H- and B-series, Intel stopped them by updating the microcode on its CPUs, forcing buyers to move back to the higher-margin motherboards with the Z-series chipset.

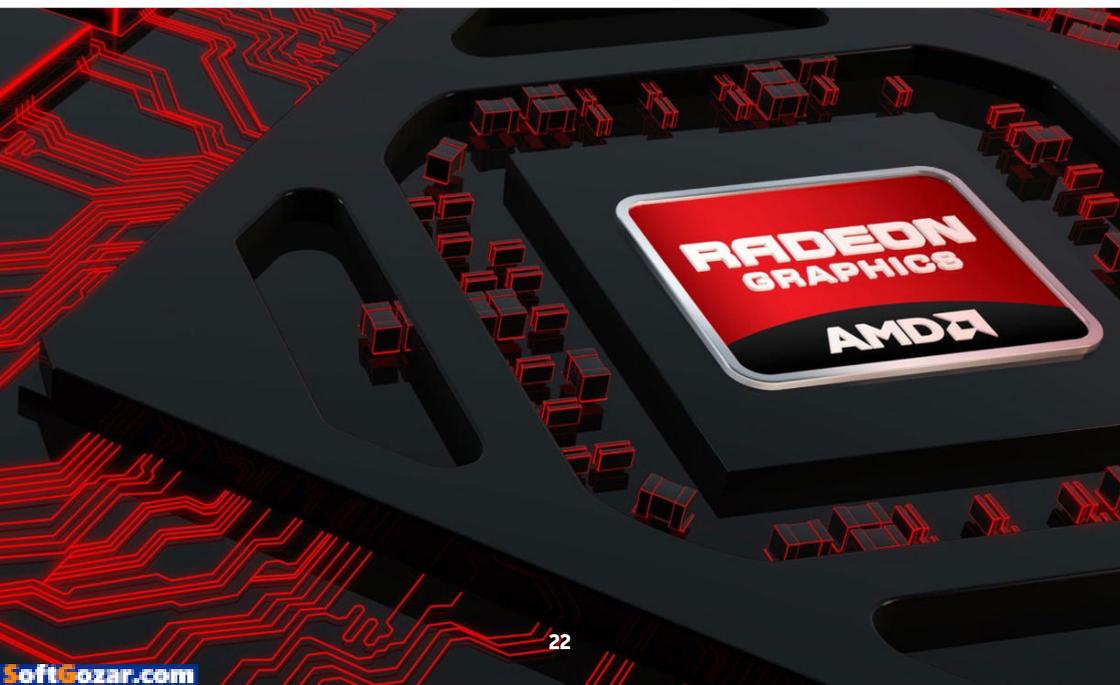
It's just as likely that Intel could look the other way. The company has truly been friendlier to overclocking. It has sponsored extreme overclocking contests using liquid nitrogen and liquid helium, and even threw a bone to budget builders with its \$72 Pentium G3258 "anniversary edition" in 2014 that was ready for overclocking. 🔌

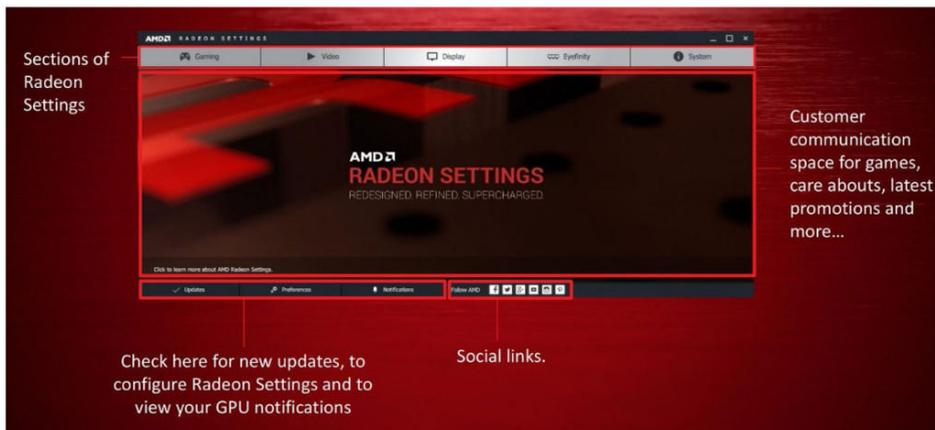
Intel has condoned overclocking for a few generations of chips but in recent years seems to be pushing it even more heavily.

Radeon Software Crimson is here: AMD loads next-gen drivers with killer features

BY BRAD CHACOS

WITH HIGH-BANDWIDTH memory (go.pcworld.com/hibandwidthmem) in the bag and cutting-edge processor technology finally appearing on the horizon for graphics cards—all GPUs have been stuck on 28nm since late 2011—AMD's gearing up for a major fight against Nvidia in 2016. But the nuts, bolts, and transistors are only part of the equation with modern-day graphics cards; the recently created Radeon Technologies Group (go.pcworld.com/radeongroup) is rolling out the rebuilt-from-the-ground-up software Radeon Software Crimson to





accompany the new breed of AMD hardware.

AMD's first tease of Crimson was a run-through of the slick new Radeon Settings hub (go.pcworld.com/radeonhubtour) designed to replace Catalyst Control Center. (R.I.P.) At the time, AMD revealed some of the overt new features in Radeon Settings, such as per-game OverDrive overclocking settings and one-click Eyefinity multi-monitor configuration. More recently, AMD's unwrapping the deeper-level goodies in Radeon Software Crimson—with handy features for new and old graphics cards alike—and pushing the drivers live so you can try them out for yourself.

Let's take a look at what's on tap. And remember: These new tricks build atop the features already introduced in Catalyst Omega (go.pcworld.com/catalystomega) and the Catalyst 15.7.1 (go.pcworld.com/catalyst157drivers) drivers released in the past year, so you'll still find goodies like Virtual Super Resolution and FullHD to UltraHD Video Scaling intact.

Gaming goodness

First up: Smoother, faster loading games. Radeon Software Crimson offers a new "Shader Cache" option that reduces stutter and can launch your games up to 33 percent faster than last year's Catalyst

An overview of the slick new Radeon Settings control hub that's replacing Catalyst.

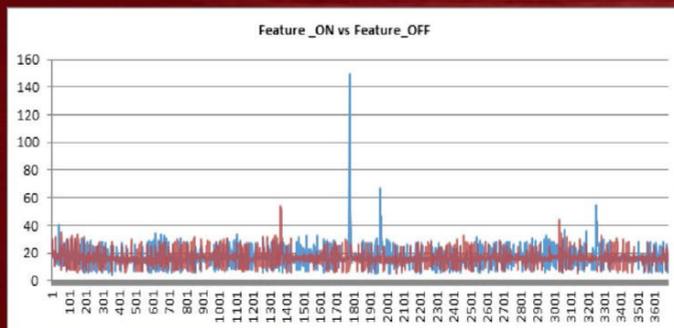
Omega drivers, AMD says. The feature can be enabled on a per-game basis inside the game-specific options in Radeon Settings' new Games hub. AMD claims that *Star Wars Battlefront* load times on a Windows 10 system with a Core i7-5960X, a Radeon R9 380, and 16GB of DDR4-2666MHz memory improved by 5.7 seconds with the Shader Cache enabled, while *Witcher 3* played smoother on another system with Shader Cache active.

Speaking of speed, AMD says that displays initialize up to three times faster with Radeon Software Crimson than they did with Catalyst Control Center. In case you missed our initial coverage, the Radeon Settings software itself launches up to 10 times faster than Catalyst Omega does, though that will vary depending on your system setup.

AMD's new software can also optimize the flip queue size—basically, how many frames are calculated in advance before being displayed—to reduce latency in games when every split second counts, most notably e-sports. Fewer precalculated frames means more responsive gameplay. Nvidia rolled something similar out with the GTX 950 (go.pcworld.com/gtx950), which is targeted toward players of Dota 2, League of Legends,

Reduced stutter and latency

The Witcher® 3 on AMD Radeon™ R9 390X graphics



AMD Catalyst™ 15.7.1

Radeon Software
Crimson Edition

Feature OFF vs Feature ON

Comparison Type	FPS		Std Dev / Avg Time	
	Feature OFF	Feature ON	Feature OFF	Feature ON
The Witcher 3	61.43	0.15%	22.77%	-12.23% / 10.54%

Core i7 4770K, 8GB DDR3-1600, AMD Radeon™ R9 390X, Windows® 7

A visual
representation
of optimized
flip queue size.



and the like. It's nice to see AMD offer something similar.

But what if you want to sacrifice speed for vastly increased power efficiency? AMD's Frame Rate Target Control lets you cap the maximum frame rate output of your GPU, so that it doesn't waste power rendering frames you won't notice anyway. (For example, when your graphics card can output 90fps in a game, but your monitor only supports 60fps.) FRTC proved wildly successful in our testing, and now AMD's bulking up the feature. Whereas before FRTC only worked with DirectX 10 and 11 games and was capable of limiting frames to between 55fps and 95fps, the new software embraces DX9 titles, and the frame rate limits are being expanded to between 30fps and 200fps. Awesome.

FreeSync, AMD's brand for game-smoothing variable refresh rate display technology, is spreading its wings too.

VRR gives you a super-smooth gameplay experience inside of predefined frame rate windows, such as 45fps to 75fps. If your frame rates fall outside those windows, the VRR isn't active, and the results can be particularly nasty below the minimum VRR refresh rate. Nvidia's proprietary G-Sync solution has long handled sub-optimal frame rates in a superior fashion, by doubling or tripling individual frames in order to maintain the smooth look without nasty flickering effects, leaning on the G-Sync module in the display for help.

AMD's striking back with its new "Low Frame Rate Compensation" technology, which uses an adaptive algorithm to keep your games as smooth and tear-free as possible under the minimum refresh window. This software-based solution probably won't work as smoothly as G-Sync's hardware-assisted fallback, but it's still sure to be a boon for Radeon gamers with FreeSync displays. (And really, it's best to tweak your games' graphics settings to stay inside your monitor's VRR window anyway.)

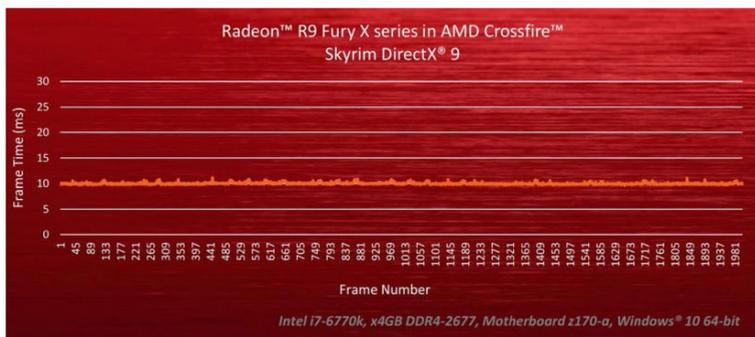
FreeSync support is also being extended to DX9 games, like the aforementioned e-sports titles and Skyrim. Speaking of DX9, Radeon Software Crimson also extends AMD's Frame Pacing for multi-GPU CrossFire setups to DX9 games. Multi-GPU setups are complex beasts, with each graphics card rendering every other frame in full. A few years back, that resulted in nasty stuttering on many CrossFire setups. Frame Pacing fixed that, and it's great to see it bring DX9 titles into the fold.

Wrapping up the gaming front, Radeon Software Crimson also includes performance improvements for the latest games and various

What happens both inside and outside FreeSync's VRR window. Note the new behavior with Low Frame Rate Compensation.

An example of the smooth frame pacing in Skyrim with CrossFire's R9 Fury X graphics cards now that Frame Pacing is supported in DX9 games.

FPS vs. REFRESH RATE	VSync	AMD FreeSync™ Without LFC	AMD FreeSync™ With LFC
FPS >= Max Refresh Rate	VSync ON	Smooth Motion, No Tearing	Same
FPS >= Max Refresh Rate	VSync OFF	Smooth Motion, Tearing, Uncapped Mouse Latency	Same
FPS Within Min/Max Refresh	VSync ON VSync OFF	Smooth Motion, No Tearing, Uncapped Mouse Latency	Same
FPS < Min Refresh	VSync ON	No Tearing, Motion Judder	*NEW* No Tearing, Smooth Motion
FPS < Min Refresh	VSync OFF	Tearing, Low Motion Judder	*NEW* Reduced Tearing, Lower Motion Judder



An example of scaling an image to 4K resolution without directional scaling (left) and with directional scaling enabled (right).



optimizations for the new DirectX 12 technology (go.pcworld.com/directx12faq) found in Windows 10. The first DX12 titles are just around the corner, folks. Linux driver performance has also been improved for many games. That's great to hear—though a bit weird, given that AMD's announced Crimson support only for Windows 7, 8.1, and 10. Linux performance is a glaring sore spot for AMD, though the new unified Linux driver architecture it's working on will hopefully alleviate the problem even further.

Beyond games

Radeon Software Crimson's new features and performance tweaks don't focus on games alone, however.

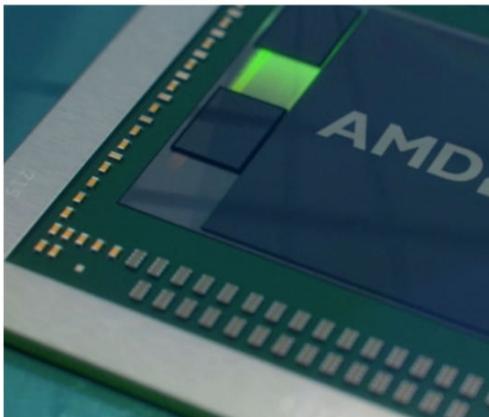
AMD's latest sixth-generation APUs gain some new video tricks. Not only will video look smoother, with less motion blur, AMD says new Advanced Detail Enhancement technology in the drivers will sharpen images further as well, building on the 1080p Detail Enhancement introduced in last year's Catalyst Omega drivers.

The AMD A8-8600P and higher APUs and Radeon R9 380 and higher

GPUs pick up an updated dynamic contrast ratio algorithm, while the Fiji GPU-based Radeon Fury, Fury X, and Nano graphics cards have a new directional scaling feature that more intelligently scales 1080p and 2K imagery to fit 4K screens. The goal: to eliminate the nasty “staircase effect” common when up-scaling images to higher resolutions.

Beyond new features, Radeon Software Crimson lets you deeply tinker with your displays: setting custom resolutions, timings, refresh rates, and pixel clocks for each screen in your setup.

AMD’s also investing in heavy quality assurance testing for Radeon Software Crimson. The company was already proud of the deep level of testing that went into last year’s Catalyst Omega driver. AMD says it conducted far more testing than that to help ensure Radeon Software Crimson’s stability, with 100 percent more automated testing and 25 percent more manual testing across 15 percent more system configurations.

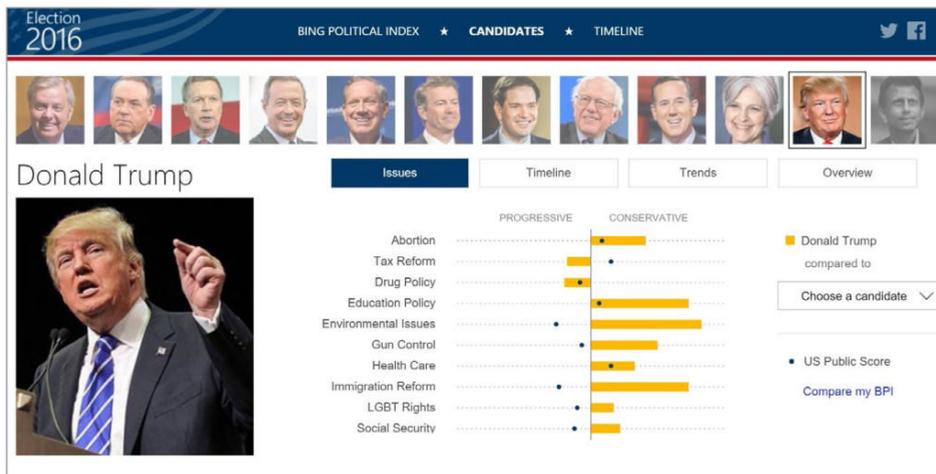


All in all, AMD’s doing everything it can to dispel the perception that its drivers are lacking in comparison to Nvidia’s GeForce drivers. New Radeon Technologies Group head Raja Koduri has been beating the drum about the importance of software as part of the overall Radeon experience.

“Software is the first thing people see on their screen, the first part of their experience,” AMD’s Sasa Marinkovic told *PCWorld* earlier this year. With Crimson, Marinkovic added, Radeon’s “software is as equally represented as the hardware.”

Now that you’re done reading up on the deep-level improvements, don’t forget to check out *PCWorld*’s [visual tour of AMD’s new Radeon Settings hub](http://go.pcworld.com/radeonhubtour) (go.pcworld.com/radeonhubtour), complete with talk about per-game overclocking and the company’s approach to new drivers going forward. 🛑

AMD’s HBM-bolstered Fiji GPU.



Microsoft's new Bing election site tracks candidates, will predict the next U.S. president

BY MARK HACHMAN

MICROSOFT'S BING HAS launched an election site for those who prefer their nuanced political positions boiled down into easy-to-read charts and graphs—and yes, Bing will try and predict the outcome at a later date.

Not long ago, Microsoft launched the Bing Political Index, an informational box that will appear when users access the site through a direct link, Bing.com/elections. But a candidate-specific box will also appear when users begin searching for that candidate's name, such as *Donald Trump*.

The site lists the candidates alphabetically by name in a horizontal

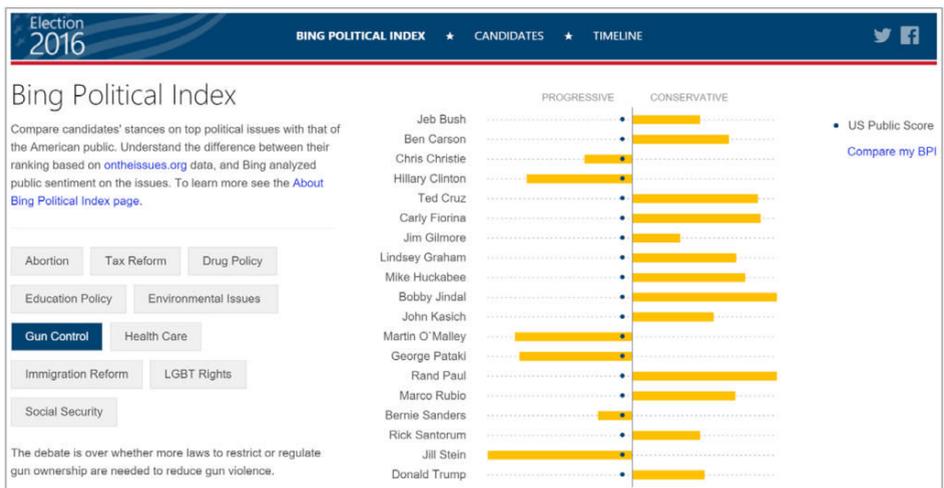
carousel, with candidates who have withdrawn from the race (Bobby Jindal, at press time) at the end. Bing breaks down each candidate by their position on the issues, a timeline of key quotes and events, how the candidate has fared on Twitter or Bing by number of queries, and, finally, a general biographical overview complete with funding numbers.

Why this matters: It seems a little condescending to boil each candidate’s viewpoint on a given issue down to a numerical score—though, if you try to follow the twists, turns, and quotes from each candidate on a daily basis, it begins to make a bit more sense. Voters start to tune in as the primaries draw closer, and the political winds can dramatically shift, and fast. One example: though Donald Trump is considered to be the de facto front-runner for the GOP nomination at this stage of the game, FiveThirtyEight.com considers him to be an absolute non-entity, considering his lack of endorsements (go.pcworld.com/primaryendorsements) from established politicians. Soon, we’ll know who was right.

Scoring the liberals, conservatives

Most of the site is devoted to what Bing calls the “Bing Political Index”

Bing breaks down how each candidate feels about an issue.



My BPI

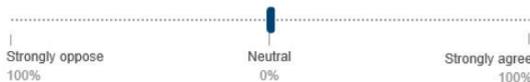
Calculate your Bing Political Index (BPI) score and compare your opinions on top political issues with the presidential candidates and the American public. For each statement, just drag the slider until it reflects your sentiment. When you view the candidates' BPI scores, your score will also appear. You can delete your score and calculate a new one any time you want.

While we recognize that political issues are more complex and nuanced than a single statement, we hope the results of this short survey are thought-provoking and encourage you to further research this election and the candidates.

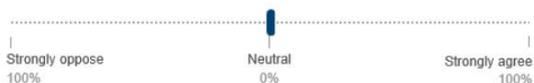
A note about your privacy

Only you can see this. Your BPI score isn't collected by Microsoft or hosted on Microsoft servers. Your score never leaves your computer. If you delete your responses, the data is completely removed from your computer.

1. Abortion should be a woman's unrestricted right.



2. There should be higher taxes on the wealthy.



(BPI), a relative position on abortion, tax reform, environmental policy, gun control, health care, and more. The comparison, according to Bing, relies on two scores—a “Candidate Score,” derived from issue analysis work done by OnTheIssues.org, and a “Public Score,” the public’s consensus on a given issue, using data collected by the Bing Predicts team and its predictive learning algorithms. Each BPI score will be updated on a monthly basis, reflecting the evolving positions of the public and each of the candidates.

By default, each candidate is compared against the Public Index across a variety of issues. Users can also compare each candidate to another. Alternatively, users can track a given issue, and see where each of them stands on it. And if you’d like, you can take a short quiz designed by OnTheIssues.org to determine how you lean on each

Bing’s BPI quiz can help you cement your stance on key issues, and then find a candidate who aligns with your views.

issue—then find the candidate who is most aligned with your views.

Bing, however, has developed a reputation for its Bing Predicts algorithms, which have had varying degrees of success. In the knockout rounds of the last World Cup, Bing correctly predicted the outcomes of each match, including the final; Bing didn't fare nearly as well in last year's NBA playoffs, with just 61.7 percent accuracy, according to its own estimates (bing.com/explore/predicts). Bing has also predicted the winners of reality programs such as Dancing With the Stars (95 percent) and The Voice (85 percent) whose outcomes are at least partially determined by social media.

As for the 2014 midterm elections, Bing claimed to be 97 percent accurate in predicting the outcome of the Senate races, 96 percent accurate for the House, and 89 percent accurate in predicting the various governors.

Not surprisingly, Bing will throw its hat in the 2016 elections, a spokeswoman confirmed. "Microsoft will be coming out with predictions in the coming months," she said in an email.

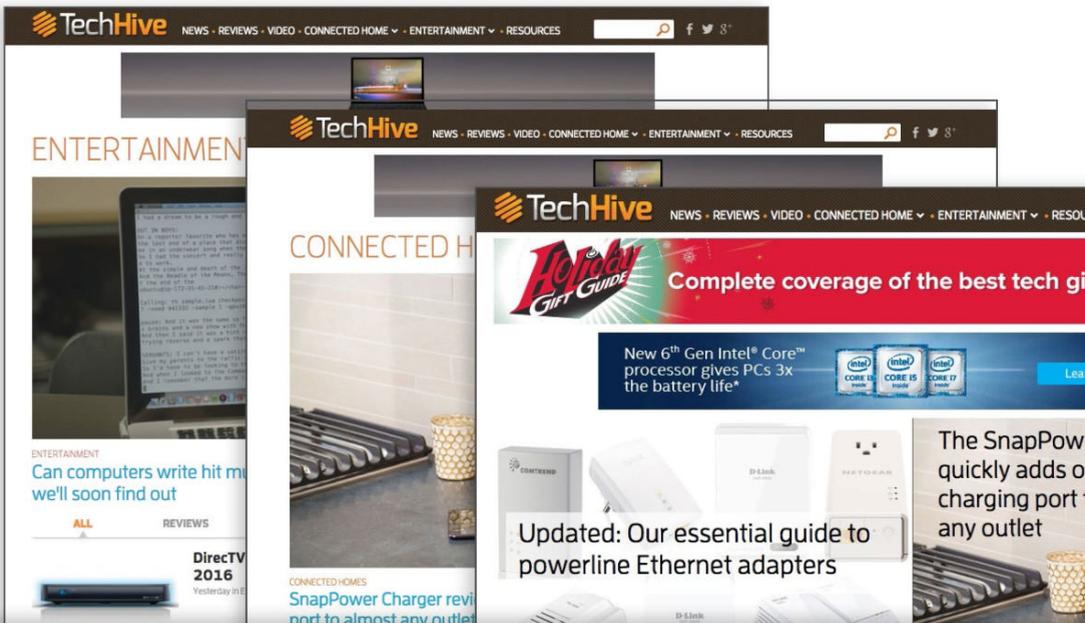
Bing will contend with traditional pollsters and gurus, such as Nate Silver, who correctly predicted the winner of the presidential election in each of the 50 states. Silver now somewhat inexplicably works for ESPN. 

Bing has also predicted the winners of reality programs such as Dancing With the Stars (95 percent) and The Voice (85 percent) whose outcomes are at least partially determined by social media.



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Make smart purchases,
stay safe online.

9 ways to keep your Windows computer safe

Evil people roam the Internet. Here's an overview of what you need to do to protect yourself.

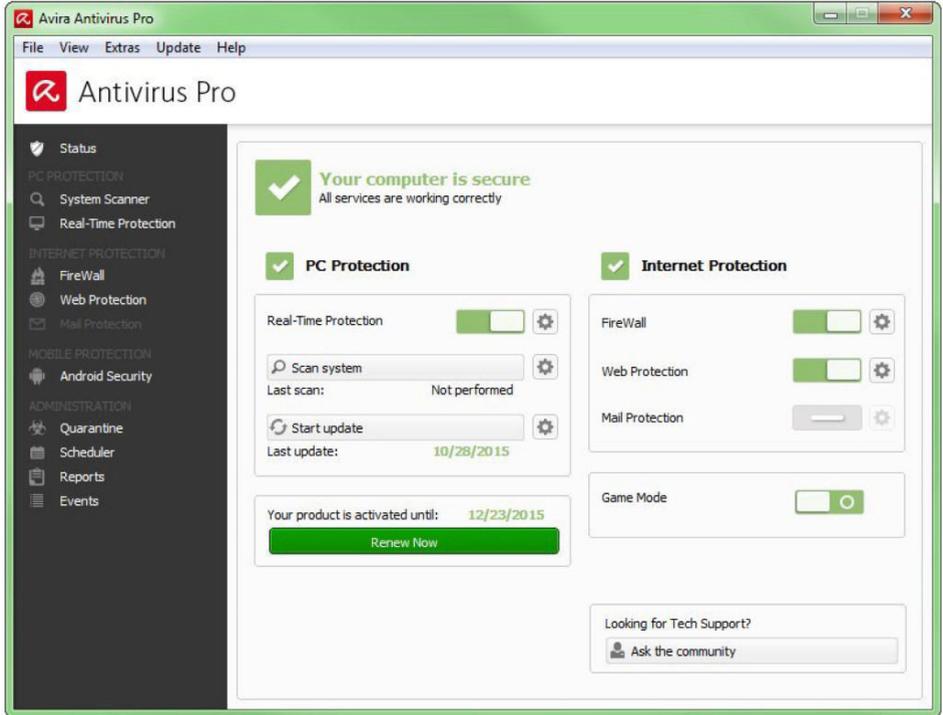
BY LINCOLN SPECTOR



FOR TODAY'S CRIMINALS, the Internet's where the action is. Compared to traditional muggers and burglars, cybercrooks make more money with less risk.

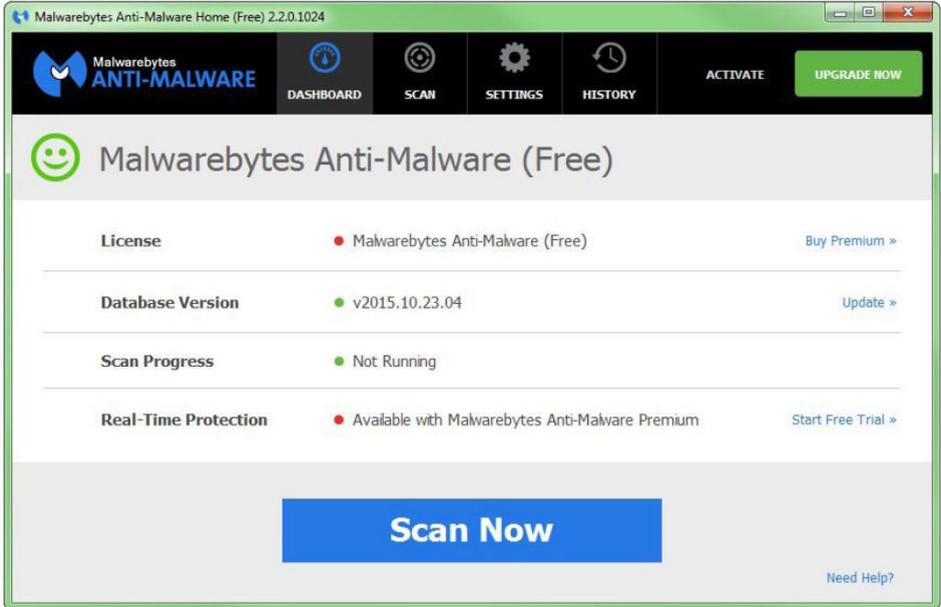
And that means that us honest folk have to be extra cautious. Protecting yourself in cyberspace is more complex than locking your door or keeping a hand on your bag.

I'm concentrating here with protecting your Windows PC.

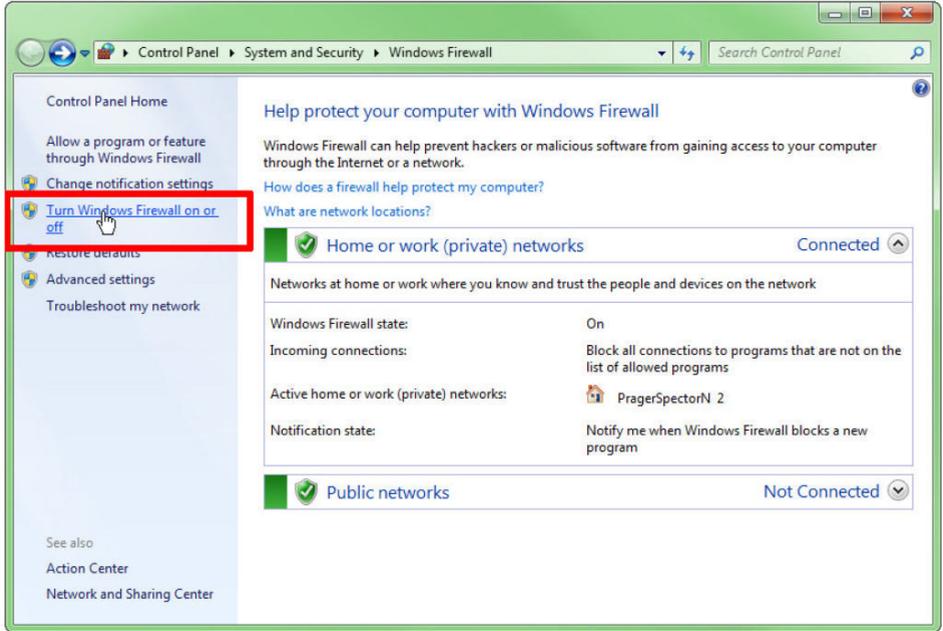


1: Antivirus: Whenever Windows is up, it should be running an up-to-date antivirus program. These work in the background, blocking not only viruses, but all sorts of malware.

Check AVTest (go.pcworld.com/avtestwindows) to pick the best option. Better yet, read Ian Paul's more detailed discussion (go.pcworld.com/bestantivirus).



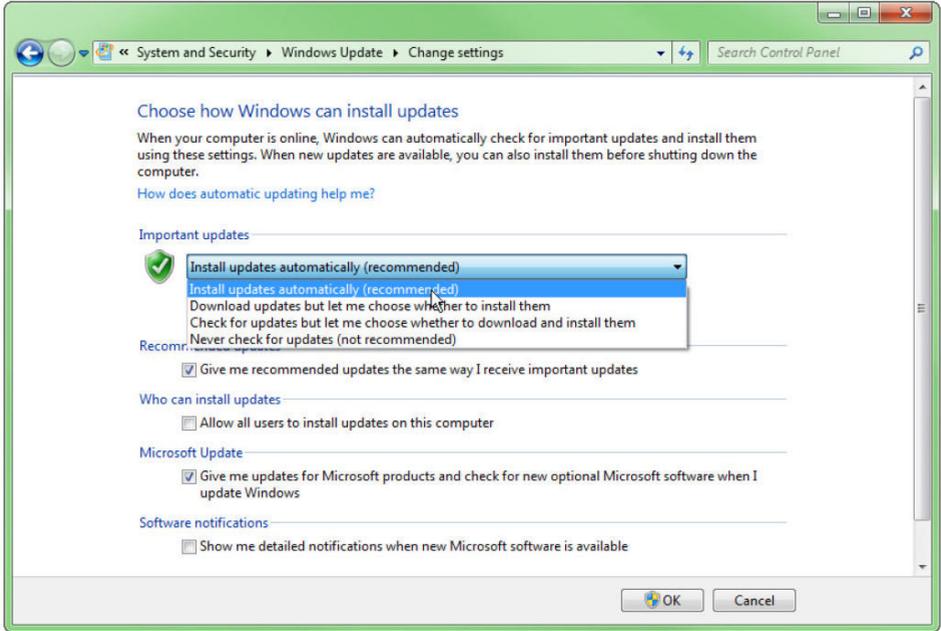
2: Another-opinion malware scanner: Even the best antivirus program can miss an occasional attack. So, once a week, scan your PC with another program that scans only when you tell it to. I recommend the free version of Malwarebytes Anti-malware (malwarebytes.org).



3: Firewall: Like an antivirus, this type of program runs in the background at all times. But this one controls the traffic between your PC and the rest of the network (and Internet).

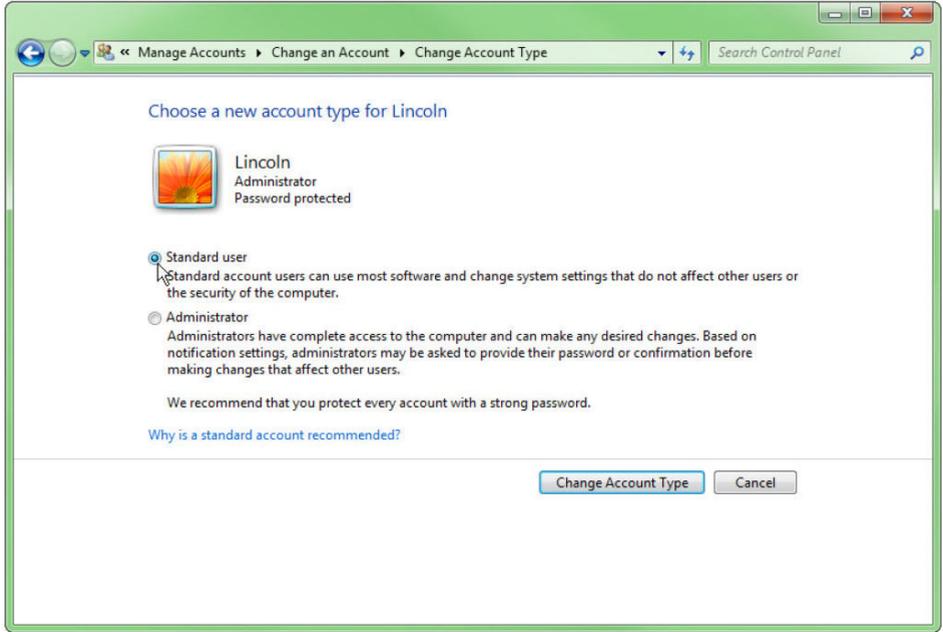
Windows comes with a perfectly good firewall, but you should make sure it's on. Search for **firewall** and select *Windows Firewall* in Control Panel.

In the left pane, click *Turn Windows Firewall on or off*.
Select the obvious option.

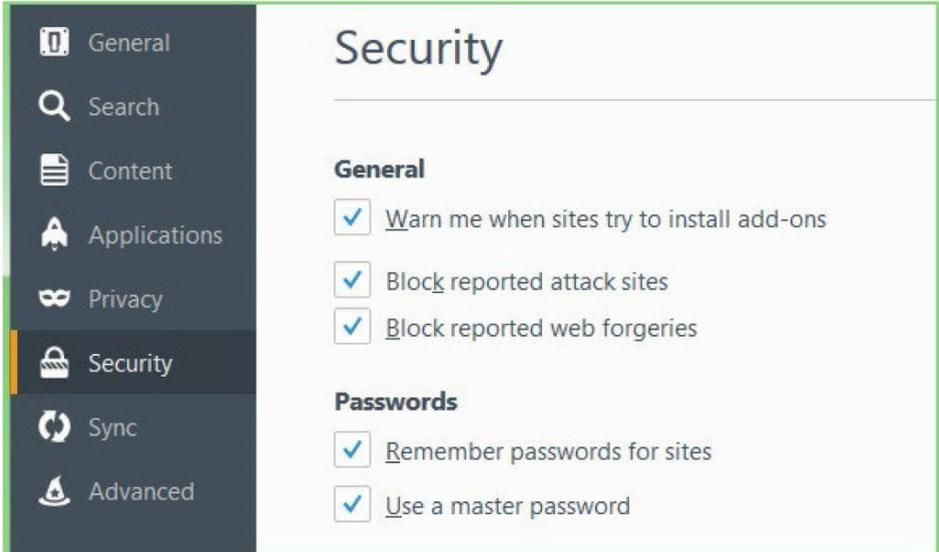


4: Updates: Make sure Windows updates itself automatically. In Windows 7 or 8, search for and launch *Windows Update*. Click *Change settings* in the left pane. If *Install updates automatically (recommended)* isn't selected, select it.

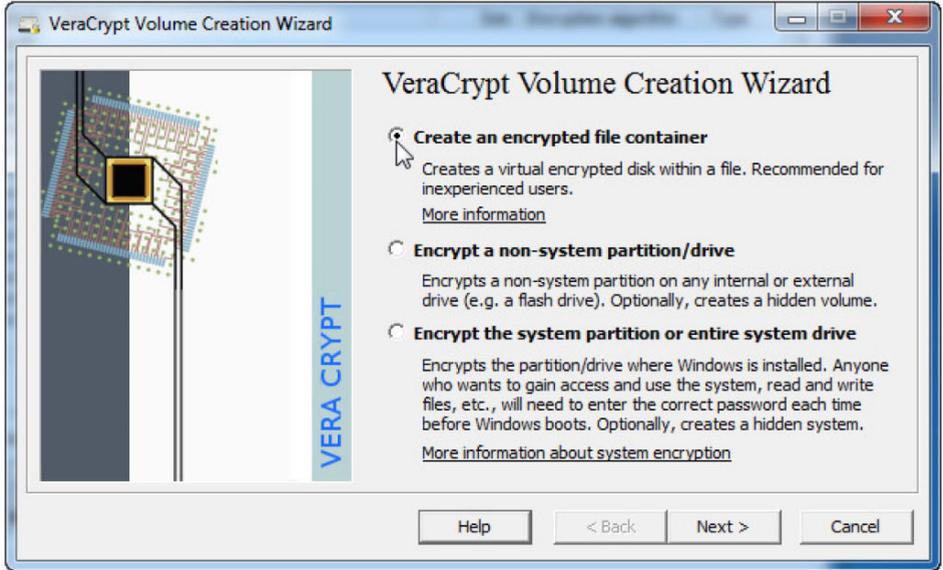
In Windows 10, search for **windows updates** and select *Windows Updates Settings*. Scroll down to the bottom of the window and click *Advanced options*. Make sure *Automatic (recommended)* is selected.



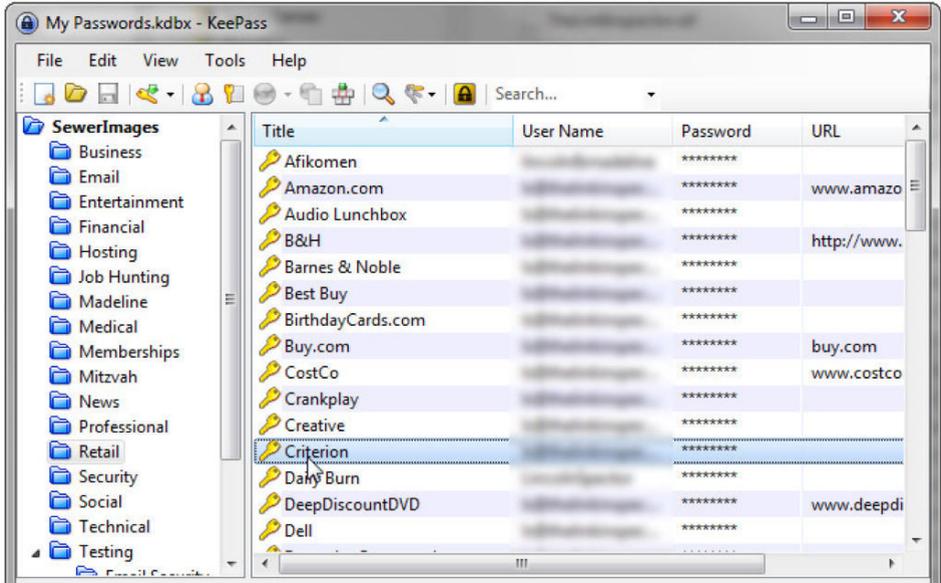
5: Two accounts: You need an administrator-type account for managing Windows, and a separate-type standard for work and play. If you're currently doing everything inside one administrator account, go to Control Panel's *User Accounts* tool. Create a new Administrator account, then change your previous account's type to *Standard*. Continue to do your work in your old, now-standard account.



6: Your browser: Just like Windows, your browser needs to be up-to-date and secure. Go to your browser's settings to make sure it updates regularly and that it's set to block suspicious sites.



7: Encryption: If your PC is stolen, why let the thieves get your secrets, as well. Put your most sensitive files in an encrypted container (go.pcworld.com/encryptcontainer).



8: Passwords: You need a separate password for every website you log into, and each password must be long, strong, and complex (go.pcworld.com/strongpwd). How do you remember them all? With a password manager (go.pcworld.com/keepasspm).

9: Email: Your email client probably has a good spam filter, but it's not perfect. Some bad messages may get through. Learn to identify them (go.pcworld.com/malicious). 🛑

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REVIEWS & RATINGS

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HP Spectre x2: A Surface clone for a lot less cash

BY MARK HACHMAN

THE FORMULA FOR HP'S NEW SPECTRE X2 (go.pcworld.com/hpspectrex2) is pretty simple: Clone the look and feel of Microsoft's popular Surface and sell it at a price that heavily undercuts it. But the result is actually a lot more nuanced.

By clone, I mean most people who see the Surface—err, Spectre x2 will actually think it's a Surface Pro 4 (go.pcworld.com/sp4rev). It has touch. It has pen support. It has the same cover-style keyboard that attaches magnetically and flips around for tablet mode—I'm surprised it isn't cyan-colored.

It's hardly a carbon-copy, though. Our review will show subtle and not-so-subtle differences that could make or break the decision for some, but for many, it'll come down to price. Regardless of the details, compared to the Surface Pro 4, the Spectre x2 offers a lot of value for the money.

Sizing up a Surface clone

The Spectre x2 is a svelte 8mm thin—just over 13mm with the keyboard. That pretty much matches the Surface Pro 4's thickness.

It's definitely larger, though: 11.75 by 8.25 inches tall, compared to the Surface Pro's 11.5 inches wide and a scant 8 inches tall. That makes it the largest of the Surface-style devices other than the Surface Book (go.pcworld.com/surfacebookrev).

The Clone

Wars: The Spectre x2 is 8mm thin and 1.78 pounds. With its keyboard, it'll push 13.2mm and weigh 2.7 lbs.





Here's how thick the Spectre x2 is compared to the Surface Pro 4 and Surface 3.

The Spectre x2's display resolution is 1920x1280 for a 3:2 aspect ratio, compared to the odd-duck Surface Pro 4 res of 2736x1824. Both have 12-inch screens. The Spectre x2 panel in our unit seemed skewed



You can see the size of the HP Spectre x2 peeking out from the bottom with a Surface Pro 4 and the much smaller Surface 3 piled on top.

toward blue and was also limited to 330 nits' brightness compared to the Surface Pro 4's 380 nits. Users may be more bugged by the large bezel—It's almost MacBook Air-like in girth.

Rather than a lid-style kickstand, HP opted for a frame. The company said this allows a larger chassis for more hardware. With the Surface, you pull on the kickstand to release it. With the Spectre x2, a slide switch releases it. On a few occasions the kickstand didn't pop out enough, forcing me to start over. The piece is metal and strong enough that it doesn't feel like it'd break off, even if you used it as an ad-hoc handle.

One more notable difference: Where the Surface Pro 4's kickstand tilts from about 15 to 75 degrees, the Spectre x2's range is a briefer 15 to 60 degrees. On occasion you'll wish you had that extra few degrees.

The keyboard's keys are backlit and well-spaced. The action is good

and every bit as comfortable as on the Surface Pro. An aluminum deck adds a little more rigidity compared to the Surface Pro 4 and helps prevent keyboard bounce when used on your lap. It also makes the keyboard a little heavy.

HP missed an opportunity by only using the magnet on one side. I'd welcome a magnet that holds the keyboard when folded against the back too.

The click-style trackpad is very wide and generally a pleasure to use once you get used to the wider aspect ratio. I did have to turn up palm rejection, and the piano hinge makes it more difficult to "click" at the top than at the bottom. The trackpad is Microsoft-Precision-Touchpad-certified and uses the Microsoft drivers for gesture controls.

The audio's not bad—see Lenovo's LaVie Z (go.pcworld.com/laviez)—but you won't win any beat box contests with the Spectre x2 either. The tiny speakers just past the function keys, and two more in the tablet body, are slightly less impressive and slightly more shrill than the Surface Pro 4's array. You lose some of the output when the keyboard is removed, and audio fires away from you when the keyboard is folded back.



The Spectre x2 uses a frame-style kickstand rather than the solid piece of the Surface it apes. To release, you have to slide that tiny little switch.



The keyboard has good action and no obvious button placement errors.

For ports you get an analog combo audio port, MicroSD and two USB-C ports. The USB-C implementation supports charging through either side, and HP wisely includes a USB-C-to-USB-A dongle. Frankly, I'd rather see a standard USB-A port on PCs until the shiny bright world of USB-C is truly universal. Lose that dongle on the road and you're toast. The USB support is listed as USB 2.0 on HP's website, but it appears to be an Intel USB 3.0 controller. Alternate mode for display out is supported, and I tested HDMI with no issues. But you'll need to buy the dongle for that.

A RealSense camera on back

The Spectre x2 features an integrated webcam in front and interestingly, a RealSense camera on the back. Where the Surface Pro 4's front-mounted, RealSense-like camera is intended for facial recognition with Windows Hello, HP expects its camera to be used for RealSense applications. Right now it's a work in progress: The one app available was a beta for itSeez3D, which allows you to make 3D models of a person. I tried scanning a co-worker in two different lighting situations, and the results weren't pretty.

HP Spectre X2

PROS

- Good bang for the buck
- More stable keyboard

CONS

- CPU performance lags Core i5
- Battery life just average

\$1,150

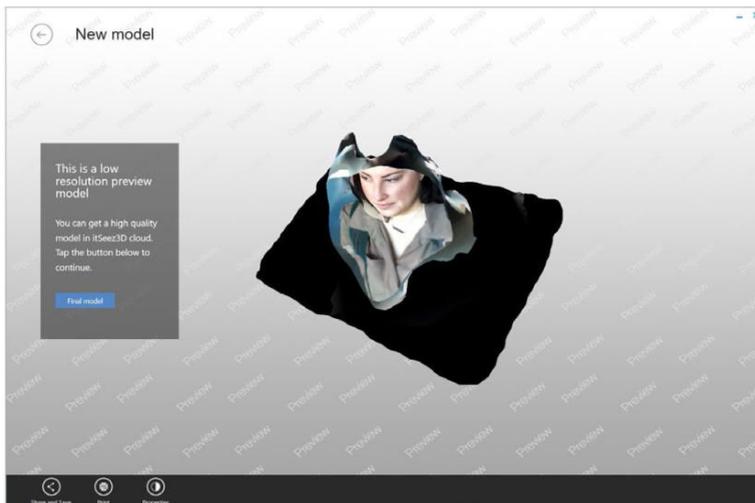


The Spectre x2 includes pen support using a Wacom active stylus rated at 2,048 levels of sensitivity. Yowza! In the pure specsman ship game, that sounds like a lot more than the Surface Pro 3's 256, the Surface Pro 4's 1,024, and the iPad Pro's 1,024. Unfortunately the pen is an extra-cost option (though fairly cheap at \$40), so I didn't have it to compare to the Surface Pro or iPad Pro implementations. Regardless, it's probably fine for signing a PDF or document on occasion or doodling while your boss drones on in a meeting.

What's inside

Inside you get Intel's Skylake-based Core m3 through Core m7, and from 4GB of LPDDR3/1600 to 8GB of LPDDR3/1600. SSD options run from 128GB to 512GB. The model I reviewed is the Core m7 model with 8GB of RAM and a 256GB SSD.

The SSD is an m.2 Lite-On model hooked up to SATA rather than the faster PCIe. Sequential read speeds will saturate the SATA bus at 550MBps, but writes are a mid-pack 284MBps according to Crystal Disk Mark 5. For comparison, the mid-range Surface Pro 4 with its NVMe M.2 drive will hit three times that in sequential reads and



The beta
itSeez3D app for the RealSense camera is clearly still in beta.

Here's a full view of the kickstand design HP uses on its Surface clone.



writes, at about 521Mps. For normal use you won't notice the difference, but under heavier disk chores, like unzipping a large file or copying from a fast USB device, you'll see it.

For wireless you get 2x2 802.11ac and Bluetooth 4.0. LTE. The latter is available only on the mid-range and higher-end models.

If you're turning your nose up at Core m, you shouldn't. When introduced at the end of 2014 with the Broadwell Core M, performance was all over the map depending on how OEMs implemented their fanless designs. The chip eventually earned a poor rep, but it's not deserved. In fact, I'd take a Core M over even Intel's newest Atom x7 any day of the week and twice on Sunday.

In this particular Spectre x2, you're seeing Intel's top part: Core m7-6Y75. Let's take a look at how it performs.

CPU performance

As this is the first Skylake-based Core m chip we're testing, I wanted to dig a little deeper into pure performance—it's worth a few more charts than normal for the purposes of this review.

First up is Cinebench R15. It's a 3D rendering app, perhaps an unlikely use on the Spectre x2 but still a great tool for measuring computing grunt.

I'm testing all the cores here with Cinebench R15, which takes about five minutes to render one frame of a 3D scene. The performance of the Spectre x2 and its Core m7 is a little underwhelming, but not that bad for where it swims. If you look at the chart on the next page, you can see the Core i5 and Core i7 parts with their fans and higher power consumption ratings in front.

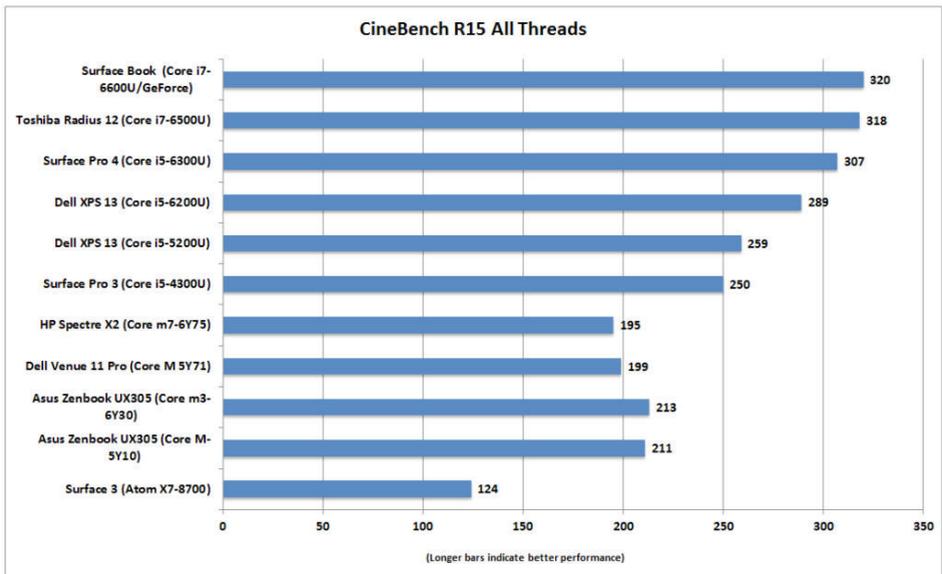
The two Asus laptops, the Dell convertible tablet and HP Spectre x2 are all fanless Core M, and it shows. Of the four Core M and Core m-based devices, the Spectre x2 is the slowest by a small margin. The explanation is likely due to its size and having a hot screen pressed up against it. The Dell Venue 11 Pro is also a tablet convertible, but it's as thick as a phone book so cooling seems to be less of an issue. The two Asus Zenbooks are laptops rather than tablets, so their cooling systems are under less pressure. That Atom-based Surface 3? In racing, it's called dead last.

Office performance

You may see the Cinebench R15 scores and look down on Core m7, but how does that translate to a task closer to what most people do? For that, I turned to PCMark 8's Work test. It's basically a measurement of



HP's Spectre x2 next to a Surface Pro 4 and Surface 3.



performance while browsing, word processing, performing light-duty spreadsheets, and video chatting. It really should be called the Office Drone test. The results confirm what you should already know: For Office Drone work, you don't need much and you probably won't be able to feel the difference between a Core m3 or Core i5 chip. The Spectre x2's Core m7 actually turns in the best performance of the fanless Core m devices, which tells me that under lighter workloads that only stress the CPU in short bursts, it's actually faster.

Graphics performance

Moving on to graphics, I turned to 3DMark's Cloud Gate. Here we can see the nice upgrade the Skylake-based Core m chips get. The Spectre x2 is actually a little faster than the two-generation-old Haswell Core i5 chip in the Surface Pro 3. Graphics also step up over the Core MY71 in the Dell Venue 11 Pro, which was one of the top Core M chips of its time. Even the lowly Core m3 hammers the older lower-end Core M parts.

The Core m and Core M CPUs

lag behind Core i5 and Core i7 chips in pure CPU performance.

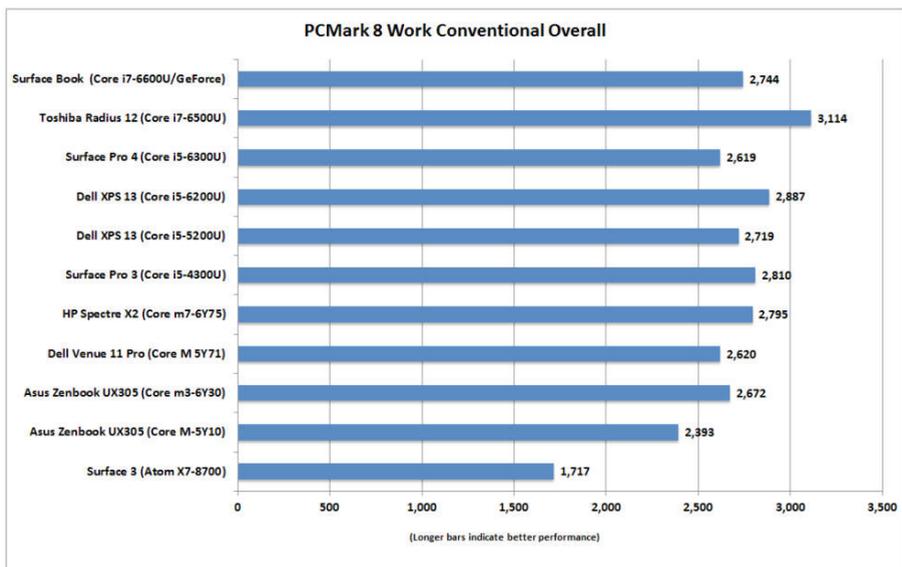
Battery life

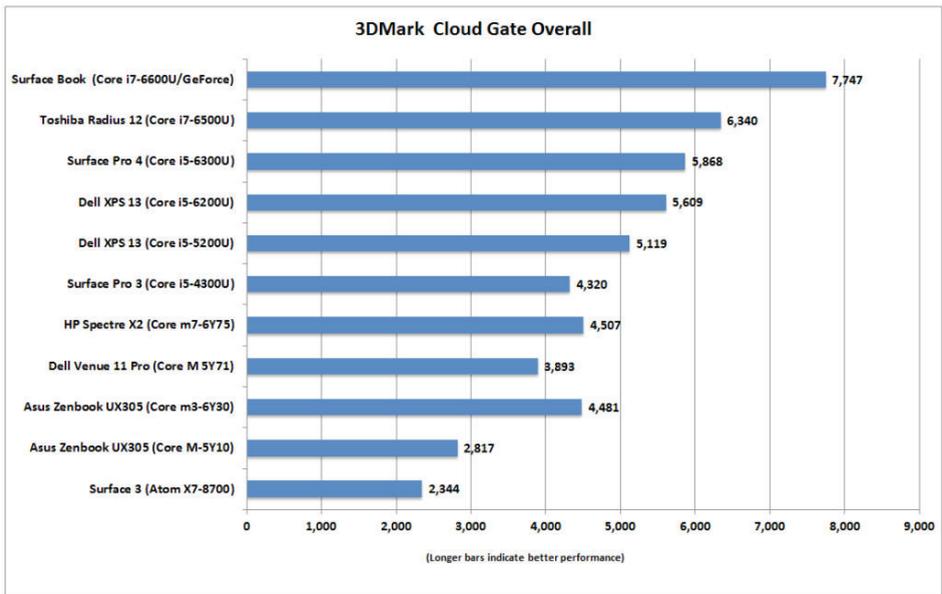
Normally we rely on MobileMark 2014 1.5 for our battery tests. This month, however, the test gave us nothing but heartbreak on three different laptops, so something with the latest Windows 10 update is playing havoc. For plan B I decided to use the same video rundown test I did for my Surface Book vs. Mac Book Pro (go.pcworld.com/sbvsmbpro) story. I basically looped a 4K short independent movie on airplane mode, with audio on and running into a pair of Samsung ear buds. For backlighting I selected a fairly bright 255 to 260 nits. This is a brightness setting you might use in a well-lit office or home.

As the screen uses most of the power in a device, you can expect this high brightness to reflect in shorter run times. If I cut the brightness in half or more, I'd expect it to add 30 to 40 percent or more battery life. Battery life is also impacted by the video player, so I selected Windows 10's Movie and TV player. It's the most efficient player, period (which I'll document in a future story.)

HP claims 10 hours of video playback for the Spectre x2, while

For most Office tasks, you'd be hard-pressed to feel a difference between a Core i7 or Core m chip.





Microsoft claims 9 hours for the Surface Pro 4. Obviously the video file they played, the volume they set, and the screen brightness was different. As the Spectre x2 has a slightly larger battery, technically more efficient CPU, and lower-resolution screen, I expected it to at least beat the Surface Pro 4. However, its results using the beefy 4K content and brighter screen gassed out at about 6.5 hours. The Surface Pro 4 actually pulls in a little later but still well under 7 hours of run time.

The reason why the Surface Pro 4 prevailed (slightly) likely comes down to the awesome display Microsoft uses. It's incredibly efficient and was measured to use just 4.8 watts of power. For comparison, the iPad Air 2's panel uses 8.3 watts. HP doesn't provide specifics for the Spectre x2's panel, unfortunately, so my educated guessing ends there.

Another area where you're not seeing the savings gains of the Core m7 is the light load video playback puts on the chips. With the efficiency of Windows 10 Movies & TV app, both devices are basically using minimal CPU power to play the 4K video file. The Spectre x2

Graphics performance of the newer Skylake Core m-series doesn't disappoint.

loses the efficiency contest with the Surface Pro 4, but the worst of the bunch remains the Toshiba Radius 12. That's likely due to its 4K resolution screen. That's just a lot of pixels to light up.

Bang for the buck

Price is one category where the Spectre x2 really shines. The model with the Core m7 processor, 8GB of RAM, and the 256GB SSD with the keyboard and LTE will set you back about \$1,150. If we bop on over to Surface-land, a grand gets you a Surface Pro 4 with the bare minimum of 4GB of RAM and a 128GB SSD. You get the pen for free, but the must-have \$130 keyboard brings you to \$1,130 total.

To get a comparable amount of storage and RAM on a Surface Pro 4, you're looking at the Core i5 model for \$1,430 with the keyboard. That doesn't even count the LTE modem in the Spectre x2, which Microsoft doesn't offer currently—and if it did, it'd probably cost \$100.

One advantage you get with the Surface Pro is Windows 10 Pro vs. Windows 10 Home on the Spectre x2. To get Pro on the Spectre x2, it's another \$70 and closes the price gap. For most consumers it won't matter but you won't be able to run BitLocker with Win10 Home. At least there's device encryption though. Here's the official OS comparison (go.pcworld.com/win4buscompare).

Business users may also be put off by the apparent lack of Intel's vPro that makes it easier to manage a fleet of machines. I say *apparent* because HP tells me vPro isn't available on the Spectre x2. Instead you need an HP Elite x2 (go.pcworld.com/arkvpro). What's a little unclear to me is why Intel's ARK (go.pcworld.com/arkvpro) shows the Core m7 with vPro support. For vPro support, you also need a chipset that supports it, but the Core m7 is a package deal with the chipset on it so I would imagine that if the CPU supports it, Intel ships a chipset with it. I'm working to clarify this.

The Spectre x2 is such a deal, it really competes with the budget Surface 3 too.

The Spectre x2 is such a deal, it really competes with the budget Surface 3 too. Yes, the Surface 3 is smaller and lighter, and that plays well to its basic computing use. But the base Spectre x2 with a Core m3 chip, 4GB of RAM, a 128GB SSD and keyboard included will set you back \$800. To get to that same RAM and storage with a Surface 3, it will cost you \$729.

I've made my peace with Atom, and Atom X7 is definitely an improvement on the previous iteration, but you're getting a lot more computer for Spectre x2's extra 11 ounces of weight.

Conclusion

So is the Spectre x2 a better Surface than the Surface Pro 4? I had high hopes, but it looks like Microsoft's higher-end components are paying off.

For a first attempt, though, this ain't bad. I really see the Spectre x2 as more of a half-step behind the Surface Pro 4. For people who just want the same form factor for general use, the Spectre x2 is a worthy alternative and certainly gives you more value against the Surface Pro 4, and more performance against the Surface 3. 🔥

Is the Spectre x2 a better Surface Pro?
Not quite, but it's certainly a better deal.





Tested: Why the iPad Pro really isn't as fast as a laptop

BY GORDON MAH UNG

STOP THE PRESSES. The PC is dead, and so is the Mac. Killed by the more powerful iPad Pro. At least that's what some tech writers proclaimed after Apple's latest iPad Pro wonder hit the streets.

But is the iPad Pro really a PC killer? After days of poking and prodding, I can safely say, "Hell no. Far from it."

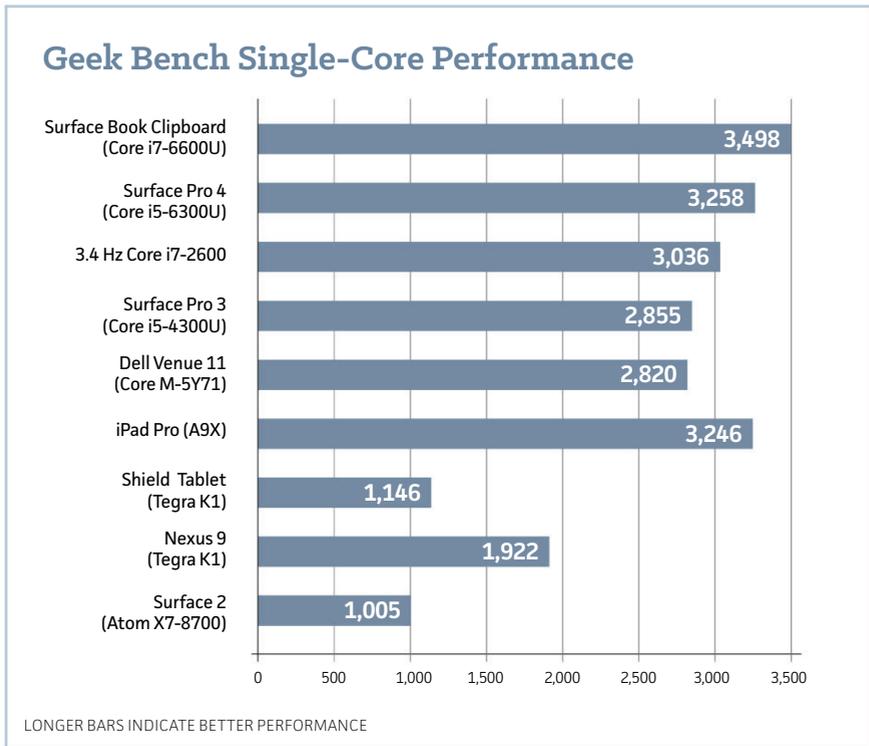
Before this turns into a flame-fest, let me say this: The iPad Pro is shockingly fast, as *Macworld's* review (go.pcworld.com/ipadprorev) drives home, and Apple has again worked its mastery of hardware,

software, and virtually unlimited resources to build an amazingly fast chip for the iPad Pro. But let's not get ahead of ourselves. My battery of tests shows that in some things, it ain't that fast.

How we got here

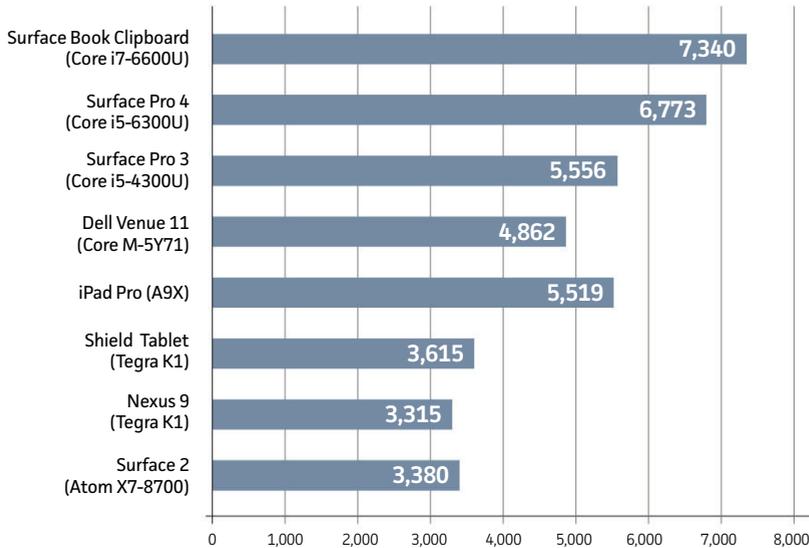
What started the "Intel and its CPUs are doomed" talk were benchmarks showing the A9X SoC in the iPad Pro overpowering Intel's older Haswell chips and even its newest Skylake CPUs.

Many of those conclusions were based on performance results from the popular multi-platform Geek Bench 3 benchmark, as well as browser-



Fan boys have used Geek Bench 3's performance results to write screeds that the x86-based PC (and Mac) are officially goners.

Geek Bench Multi-Core Performance



LONGER BARS INDICATE BETTER PERFORMANCE

The iPad Pro loses a little ground in the multi-core Geek Bench 3 result, but zowie!

based benchmarks such as Mozilla's Kraken and Google's Octane 2.0. This limited data set had the faithful buzzing that the end was nigh for x86.

If you like to test hardware, you know the weakness of the last two tests: A browser test isn't a test of the CPU/SoC, it's a test of the chip plus the browser and OS optimizations underneath it. On the iPad Pro the browsers are pretty much the same, as Apple makes all use its highly optimized rendering engine. On the PC, your browser pick matters. Browser-based benchmarks are hardly the best tools on the PC either.

Geek Bench 3 is different. The creators of Geek Bench 3 have stated their goals are to create a cross-platform test that isolates the CPU as

much as possible, using algorithms that it believes are valid for chip performance. If you peep at the chart, you can see what got people in a tizzy.

Yes: Whoa. That iPad Pro in single-core performance (which is a good metric to use to judge across platforms where some chips have more cores) is every bit as fast as the CPU in the newest mid-range Core i5 Surface Pro 4 in Geek Bench 3. It's uncomfortably close to that Core i7-6600U in the far pricier top-end Surface Book, too.

For the record: Almost all of the tests in this section were run with the latest OSes and updates at the time applied. The only OS that was out of date was my corporate-issue Windows 8.1 box with its 3.4GHz Core i7-2600, which I threw in for kicks.

Although I think it matters less, I'll hit you with the results from Geek Bench 3 for multi-core too. The iPad in multi-core performance is on a par with the older Haswell-based Surface Pro 3, but it loses to the newer Skylake-based Surface Pro 4. Why? I'm not sure, but the Intel chips' Hyper-Threading resource management could be a factor. That's why I think the single-core performance is more meaningful.

The iPad in multi-core performance is on a par with the older Haswell-based Surface Pro 3, but it loses to the newer Skylake-based Surface Pro 4.

Goodbye, Intel

So how do all the devices stack up in other benchmarks? First up is BAPCo's TabletMark V3. While Geek Bench 3 attempts to create what its makers think is an accurate measure of CPU performance using seconds-long "real world" algorithms, BAPCo's approach is actually more "real world." BAPCo's consortium of mostly hardware makers set out to create workloads across all the different platforms that would simulate what a person does, such as actually editing a photo with HDR, browsing the web, or sending email.

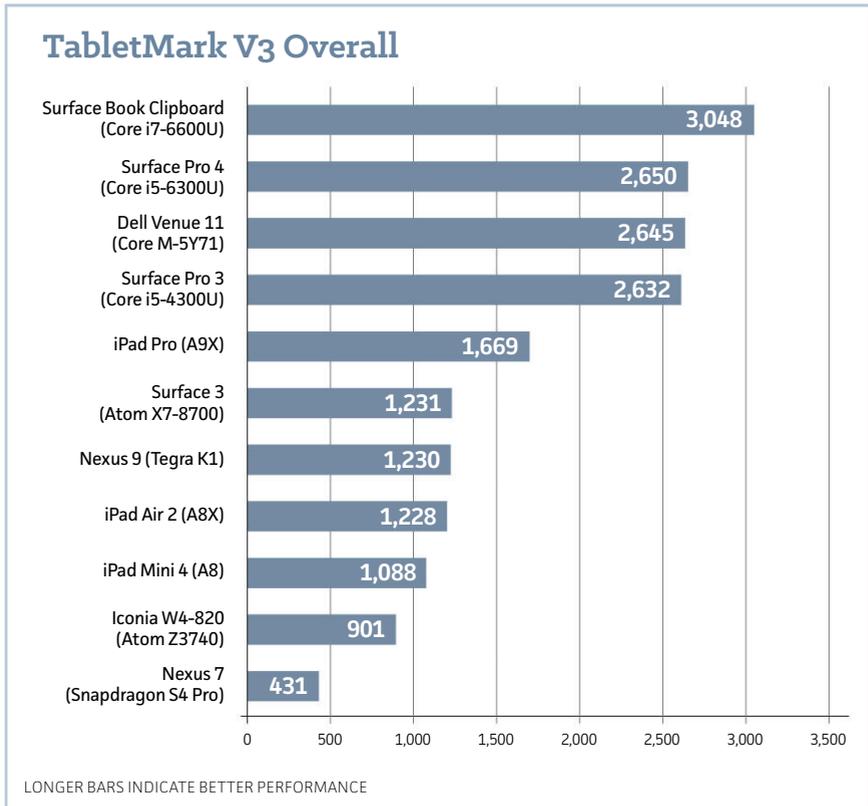
Because there's no universal app that runs in Windows, Windows RT, Android, and iOS, BAPCo custom-created apps that did the same thing

with the same interface across all platforms. Indeed, when you watch it run on the platforms, it looks like someone is using an application on all three doing the same task on all three.

A white paper on the benchmark discloses the approach as well as the libraries, compilers and APIs used in the test. The test runs in real time, which can take a few hours on some devices. Here's how the iPad Pro fares.

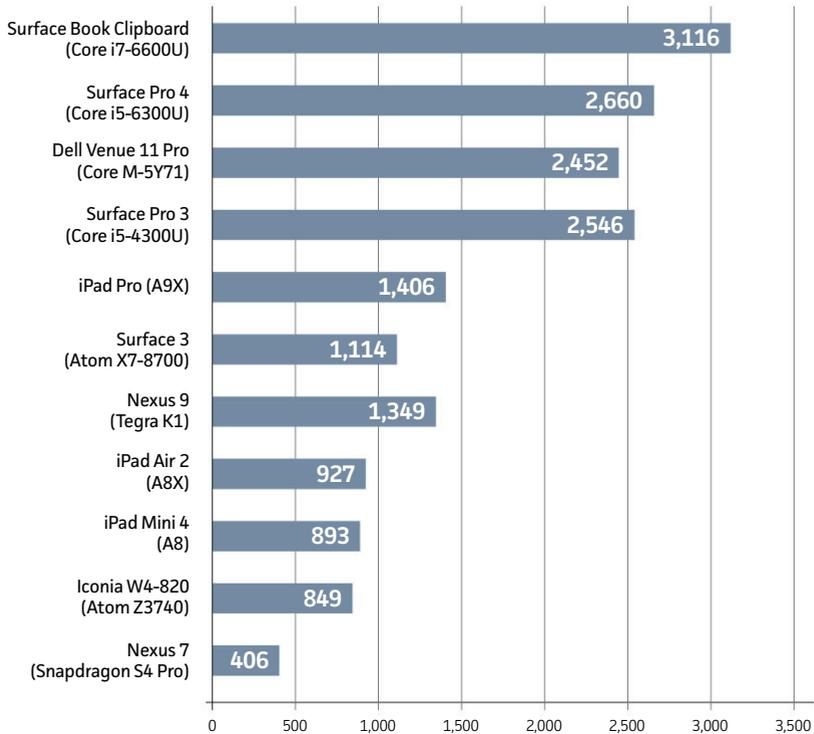
TabletMark disagrees

In TabletMark V3, the iPad Pro doesn't look quite as threatening, does



BAPCO's TabletMarket V3 doesn't look quite as dire as Geek Bench 3.

TabletMark V3 Web/Email



LONGER BARS INDICATE BETTER PERFORMANCE

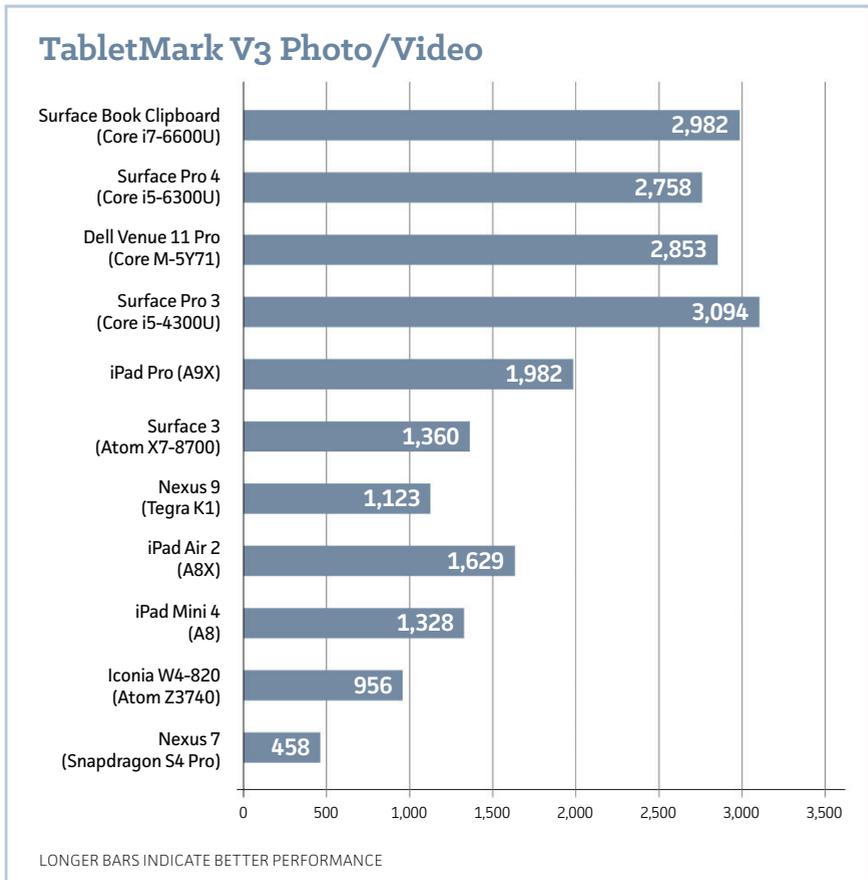
TabletMark's V3 score indicates the iPad Pro doesn't compete with Intel's Broadwell or even older Haswell CPUs.

it? Even the Intel Haswell Core i5-4300u in the two-year old Surface Pro 3 easily outpaces the A9X here. It isn't even far ahead of the tablet pack. The worst performer for x86 is the budget Surface 3 with its Atom X7-z8700. For shame, Atom, for shame.

The benchmark has two performance modules, which give you an idea of how fast the device would be in web browsing and email. The

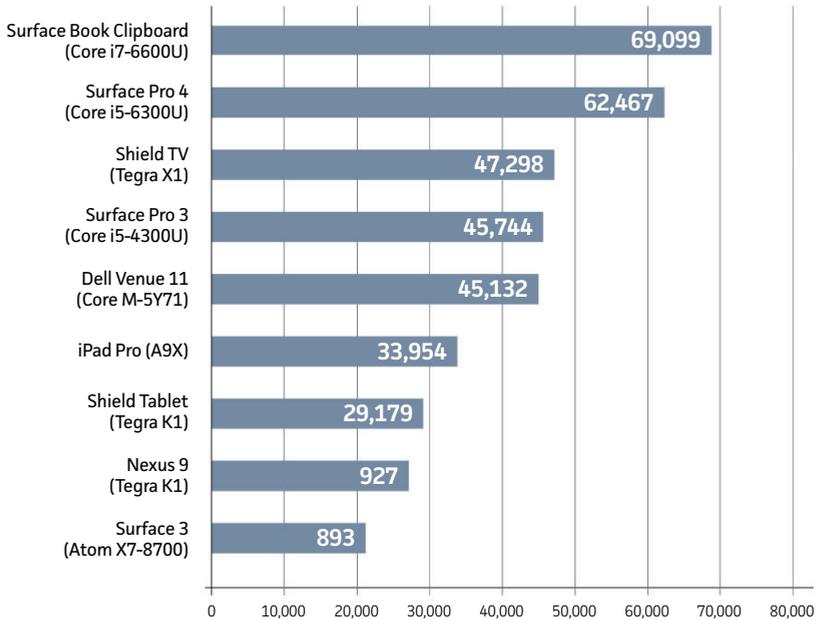
result for the iPad Pro is tepid, with performance just beating the Nexus 9 and its Tegra K1.

TabletMark V3 also measures photo and video performance, which gives the iPad Pro a healthy lead over the ARM competitors and the Atom X7-Z8700. But the A9X doesn't come close to the Core i5 or Core i7 devices above it in the chart, or even the Core M.



You'd think the iPad Pro would ace photo and video tests, but it lags behind the Core i5, Core i7, and even Core M.

3DMark Ice Storm Unlimited Overall



LONGER BARS INDICATE BETTER PERFORMANCE

The iPad Pro's A9X chip can't even make it to the middle of this pack, posting a score behind even the Dell Venue 11 Pro and Surface Pro 3.

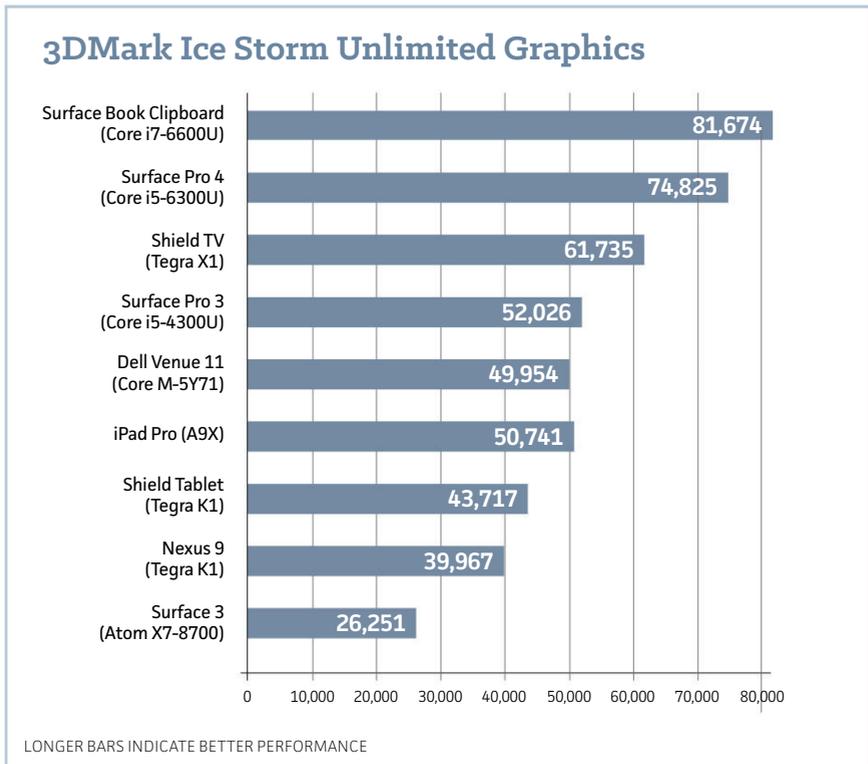
The puzzler is the performance of the Surface Pro 3 and the Dell Venue 11 Pro, which use older chips. I expected this to be in the bag for the Skylake parts, but the Broadwell-based Core M and the even older Haswell Core i5 are hanging right there.

Every other test I've run shows Skylake with a healthy performance bump over Broadwell and Haswell. I attribute that to the chip running at higher clock speeds, and other micro-architecture improvements. For what it's worth, I don't generally bother with TabletMark V3 when I test anything with any actual performance potential. I haven't found it to scale with faster CPUs, and other tests are far more intensive.

3DMark and graphics performance

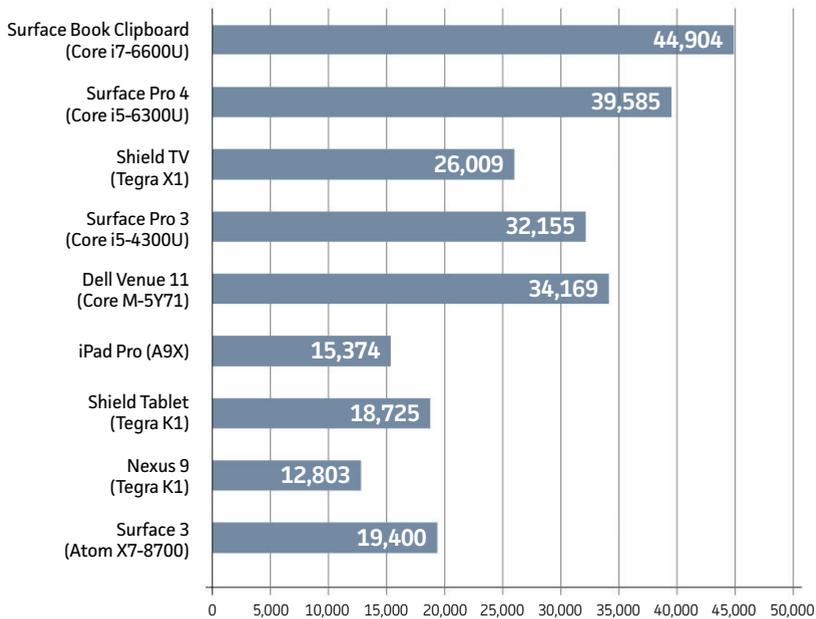
For graphics performance I turned to 3DMark's Ice Storm Unlimited. It's a popular test that happens to run on iOS, Windows, and Android. It renders the test without regard to the screen resolution and is a pretty good measurement of lower-grade graphics performance. By lower grade, I mean this isn't Assassin's Creed Syndicate, which will reduce even a \$650 GeForce 980 Ti to 45fps.

All of the devices here used integrated graphics for this test. The Surface Book was in Clipboard mode, with its GPU disconnected and two feet away. The overall score factors in game physics and the



In 3DMark's Ice Storm, the iPad Pro can't even pass the older Surface Pro 3.

3DMark Ice Storm Unlimited Physics



LONGER BARS INDICATE BETTER PERFORMANCE

3DMark's Physics scores for the iPad Pro are actually slower than the Atom-based Surface 3.

graphics performance.

Apple put a lot of resources into giving the A9X a bunch of graphics performance, and it shows. It slightly outpaces the Nvidia Tegra K1 in the Nexus 9 and the Shield Tablet in 3DMark. But if you keep looking up that chart, you'll see the A9X is still a good clip behind the Dell Venue 11 Pro and the Surface Pro 3. Please note, that Venue 11 Pro's Core M is an older power-sipping chip that uses 4.5 watts, not a 15-watt chip like in Surface Pro 3.

The improved graphics core in the Skyake Core m3 is even more impressive. I'm currently testing the Asus UX305 with the Skylake-

based Core m3, and it's posted an overall 3DMark score of 51,181, which would make it third in the 3DMark Ice Storm Unlimited Overall chart.

I had access to an Nvidia Shield TV, which can run 3DMark in Android TV, so I threw the score from the Tegra X1 into the mix for reference.

The idea is to show where Google's Pixel C (See our review on page 81) could fall, as it should be the first mobile use of a Tegra X1. Before you think the Tegra X1 will whip the A9X, you should remember that the Shield TV is thicker than any tablet and runs on unlimited AC, not DC. There's no need to worry about chewing through the battery in the Shield TV, unlike with the upcoming Pixel C, so the latter's graphics performance could fall shorter. We'll see.

3DMark breaks out performance for two areas: Graphics and physics. The Asus UX305 with its Core m3 isn't on the chart, but it produces a score of 65,904, so third again.

One thing I will say after all of this is my opinion on Atom X7 is changing for the worse (go.pcworld.com/atomx7). It would be nice if Intel's budget chip didn't drag its butt across the finish line dead last in just about every test.

3DMark also runs a physics test, which measures how a platform would run a theoretical game engine. In short, it's supposed to measure how fast a device's CPU would be, not its GPU. The result here actually puts the iPad Pro and the A9X at a pretty big disadvantage against all of the x86 chips—yes, even the lowly Atom. Nvidia's Shield Tablet and the Shield TV also run past Apple's A9X. The rest of the legit x86 chips are sipping lemonade and reading the paper while the iPad Pro crosses the finish line. 🛑

It would be nice if Intel's budget chip didn't drag its butt across the finish line dead last in just about every test.

The search for answers

BY GORDON MAH UNG



THE IPAD PRO'S POOR SHOWING may lie in how the A9X works and the way Futuremark builds its benchmark. Futuremark has been through this before, when the iPhone 5s proved no faster than the iPhone 5 in the physics test despite claims of double the performance from Apple. Futuremark's investigation (go.pcworld.com/3dmarkapple) led to how the A7 chip in the iPhone 5s (and iPad Air) handles non-sequential memory structures. Futuremark said it was a conscious design change Apple made between the A6 and A7 that hurt its performance, and 3DMark was showing the result of that.

But rather than make a change just to help show off Apple's performance, Futuremark chose to stick to its benchmarking method, declaring:

"3DMark is designed to benchmark real world gaming performance. The Physics test uses an open source physics library that is used in Grand Theft Auto V, Trials HD and many other best-selling games for PC, console and mobile. Higher scores in 3DMark Ice Storm Physics test directly translate into improved performance in games that use the Bullet Physics Library and are a good indicator of improved performance in other games."

My own test

I didn't want to rely on just third-party benchmarks for this article. Instead I wanted to keep it real by finding an actual heavy-duty use case suited for a productivity tablet. Such as, say, a test that measures how fast a device handles an Excel spreadsheet used in trading scenarios. For that I turned to a publicly available test (go.pcworld.com/excelbenchmark) put out by Excel Trader.

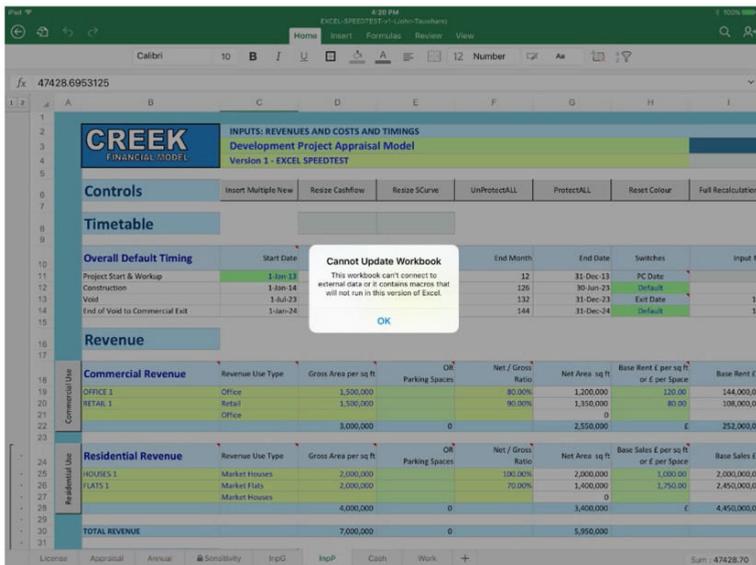
Excel, unlike Word, can use all the CPU power you throw at it. My thought was: Let's put benchmark theories and disclaimers aside. This is a real app. A real task. By someone who can drive an Excel spreadsheet like Richard Petty navigating Riverside.

But...boom. The test doesn't run on the iPad Pro.

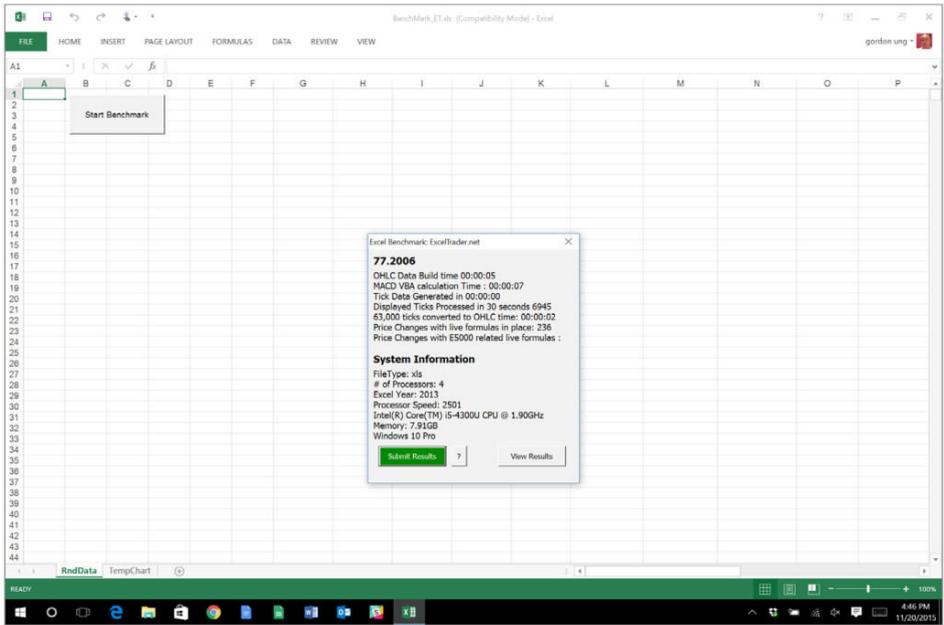
I tried both the Excel 2007 and the Excel 2011 tests available from Excel Trader. No dice. Meanwhile, on the Surface Pro 3 with Excel 2013 I had no issues running either of the site's test files:

It's Microsoft's fault

To be fair, some of this failure goes back to Microsoft's uneven support



Does Excel on the iPad Pro offer 100 percent compatibility? No.



of Excel on the Mac platform. But it also shows that you can't quite do "everything" on an iPad Pro that you can on a PC, even now that Microsoft is actively supporting the iPad. People really do rely on Excel to push some very complicated financial and statistical modelling, or use a lot of Office's Visual Basic scripting. Is it what 75 percent of people do? No, but if you're in that 25 percent that needs it, you'll be pissed it doesn't work. Or you'll just buy a Surface.

Well, hell, I needed to test something. I certainly can't run AutoCAD 2016, Photoshop CC, or Premiere Pro CC on the iPad Pro. Ahem.

So I decided to settle for something a person would do on both platforms—something that makes you drum your fingers on the desk. Like decompressing a 1GB ZIP file that also has 256-bit AES encryption applied to it. I took several thousand tiny 5K .ini files, added low-resolution screen shots and web photos, then ladled on some higher-res JPG files, a 267MB .MTS video file shot on my Sony NEX, maybe a hun-

Full compatibility means everything works. Not just some or lots of it. Here's what Excel Trader's benchmark file looks like when it runs.

dred PDF files and a dozen or so MP3 files. Finally I compressed them all with 256-bit AES using 7-Zip. The file was copied to each device.

On the Windows machines, I used 7-Zip 15.11 beta to decompress the files. The results were timed with a stopwatch, and an average of the last three runs of a four-run series was recorded, with the first test discarded. Disclaimer: This type of testing can be unreliable inasmuch as sometimes results can't be consistently reproduced. Nonetheless, I've run it enough times on all of the platforms to have confidence in it.

With the Windows machines, there were no issues. Not one. The iPad, though, gave me fits depending on the app I used. Winzip, for example, just hung even trying to decompress an encrypted file a quarter the size. I finally found an app that would work in iZipPro. It reliably decompressed the file over and over and over again without issue.

The result in my jury-rigged test? Pretty good, but no cigar.

Keep in mind, this test is more of a system-level test than a pure CPU test. Memory bandwidth, storage performance, file system and CPU are all working for the result you see here. Once the file has decrypted the .MTS file, for example, it's just writing a copy back to the drive as fast as it can.

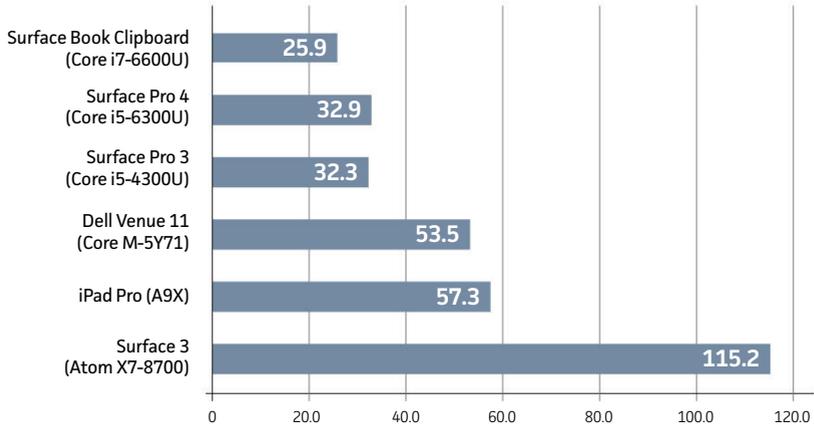
In this one test, the iPad Pro can't touch even the two-year old Surface Pro 3 and its Haswell chip, but the Core M in the Dell Venue Pro 11 is just barely ahead of the iPad Pro. It's a good show for the A9X, but a two-year Haswell chip finishes the job in half the time. Atom X7? Um, yeah, Coach wants to talk to you after practice today.

With the Windows machines, there were no issues. Not one. The iPad, though, gave me fits depending on the app I used.

But what about Geek Bench 3?

The bulk of these tests would indicate the A9X is a really fast ARM chip, at the top of the mountain—for ARM-based tablets. If you still want laptop-like performance with a full-service OS though, you'll need a full Core-class chip.

Unzip 1GB Encrypted Files (sec)



SHORTER BARS INDICATE BETTER PERFORMANCE

I timed how fast each device could decompress a 1GB file.

That's not what you'd think if you peeped at Geek Bench 3. Per core, remember, it's a CPU test that shows the iPad Pro to be every bit as fast as a current Core i5 Skylake CPU.

Some have claimed the problem is how Geek Bench 3 weights its results. SHA2 encryption, for example, is overly represented for CPU performance. Given the hardware acceleration in the A9X, it's showing Apple's chip to be far faster than it actually is.

Geek Bench 3 lets you view sub scores, and here's how SHA2 performance played out across various devices, including a desktop 3.4GHz Core i7-2600 and a water-cooled 4GHz Core i7-4790K chip. Because it's single-core performance, the Hyper-Threading and additional cores don't cloud the issue. The results are rather interesting.

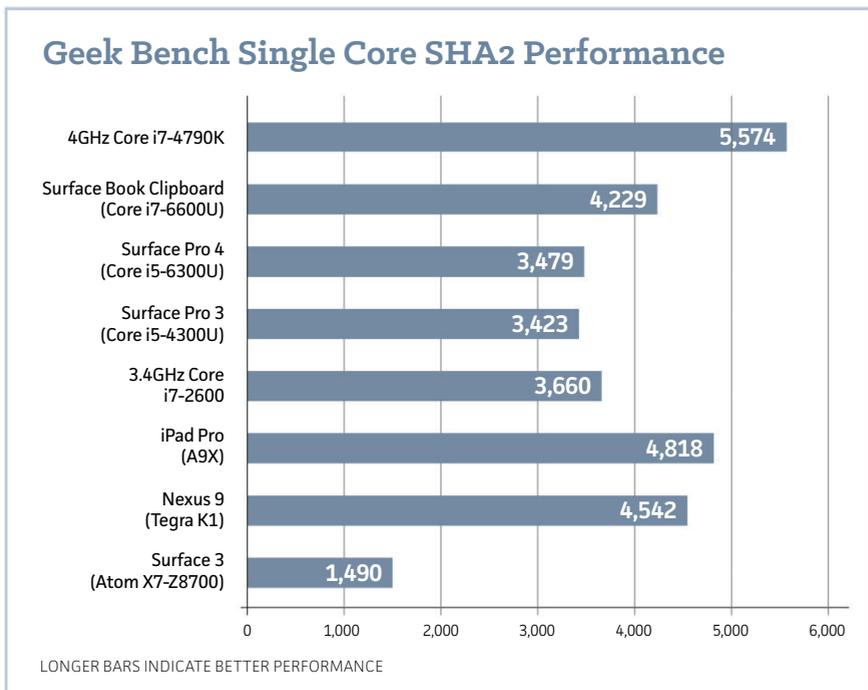
If you believe Geek Bench 3's SHA2 numbers, the A9X in the iPad Pro and Nvidia's Tegra K1 are actually faster than all of Intel's current mobile dual-cores in SHA2 encryption performance.

Both are also faster than a desktop Sandy Bridge chip. To put that in perspective, the SHA2 performance of the Tegra K1 and A9X aren't too far behind that of an 88-watt 4GHz Core i7-4790K chip.

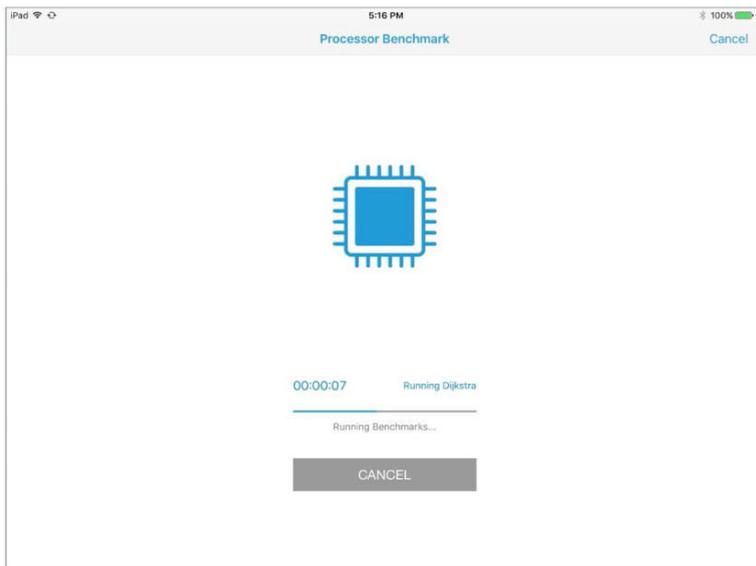
Geek Bench 3 is hardly without controversy either. Often cited by its detractors is a post by calm sage Linus Torvalds from a forum in RealWorldTech.com, where he went Kanye West on Geek Bench 3.

"Wilco, Geek Bench has apparently replaced dhrystone as your favourite useless benchmark," Torvalds wrote. "Geekbench is SH*T."

"It actually seems to have gotten worse with version 3, which you should be aware of," Torvalds wrote. "So basically a quarter to a third of the 'integer' workloads are just utter BS. They are not comparable across architectures due to the crypto units, and even within one architecture the numbers just don't mean much of anything. And



Critics have said Geek Bench's over-reliance on a SHA2 performance skews the test.



Geek Bench 3

has been criticized by Linus Torvalds for being “useless.”

quite frankly, it’s not even just the crypto ones. Looking at the other GB3 ‘benchmarks,’ they are mainly small kernels: not really much different from dhrystone. I suspect most of them have a code footprint that basically fits in a L1 cache.”

Geek Bench’s side of the story

To get Geek Bench’s side of the story, I spoke with John Poole, one of the primary developers behind the test. Poole said he understands the controversy and has taken it to heart, but he also disagrees with Torvalds.

“We have a lot of respect for him,” Poole said. “I think he’s wrong in this case.”

Torvalds argues against the value of small code loops in measuring performance, but Poole said the future is mostly about smaller loops. Poole said moving a window around a screen or opening a window is mostly a solved problem for CPUs.

“What happens when we get to games or applications like Photoshop? Then you see the movement to smaller, hotter loops. Your’e going to see

things where you're running the core loop of a physics engine or the core loop of a rendering engine or a core loop of a Javascript interpreter," Poole said. "You're talking about these much smaller, much hotter loops, and I think Geek Bench measures this quite nicely."

Poole said they've been very transparent with what the test measures and have provided extensive documentation as well. In order to measure the chip performance, Geek Bench tries to execute the same code on every platform, Poole said.

Poole claims the question of whether the A9X is faster than, say, a Core m3 is beside the point. Today, the software that you can run on a laptop just isn't available on the iPad Pro, rendering Apple's productivity tablet mostly a curiosity until software changes that.

Still Poole said he does wonder how the A9X would run OS X. I do too, as it would make comparisons far easier to measure.

To be fair to Geek Bench, benchmark developers are often accused of serving internal political needs. BAPCo, the software and hardware consortium, has its roots in the PC industry and some feel it's too PC-centric. Even among PC vendors, there was strife when AMD quit the group and accused BAPCo of being too closely aligned with Intel.

BAPCo officials always say their intentions are to create benchmarks that offer insight to the public. If the test is cooked to favor Intel or x86, it certainly didn't show when the new version was released earlier this year and Intel's older Atom chips were kicked down the stairs by Apple's and Nvidia's CPUs.

I spoke with BAPCo's John Peterson about the philosophical differences between the two.

"TabletMark utilizes a wide variety of APIs provided by each platform to represent productivity/media app performance and battery life. The workloads are implemented in a way that's meant to reflect the implementation choices app developers would make for each of the platforms," Peterson said. "GeekBench generally utilizes its own libraries to perform tasks, while TabletMark utilizes the available

"We have a lot of respect for him," Poole said. "I think he's wrong in this case."

platform APIs to perform equivalent functionality in a more platform-tailored way.”

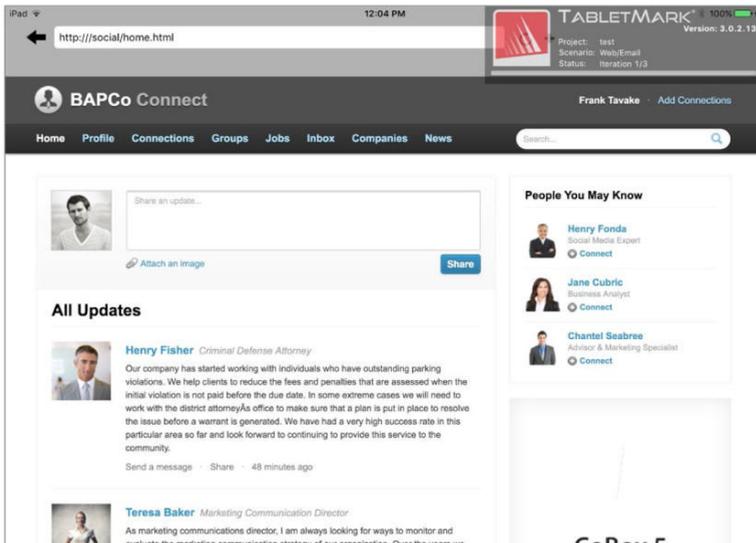
Peterson also said relying on browser-based benchmarks, which many testers have done, is inherently problematic, as you’re limited to what hardware is exposed to the browser.

What about editing three 4K streams?

One of Apple’s most impressive claims is the ability to “edit” three simultaneous 4K movie streams—something that is no fun on a desktop and probably out of reach of most laptops.

To test that, I decided to throw the platform a fastball. I grabbed several 4K RAW video files shot on a Red digital cinema camera.

On the Core i7 Surface Book, I installed Premiere Pro CC, created a project, added several of the R3D files to the timeline, and tried to play it back. Without doing a render, it wasn’t going to happen at full-res without major hitching—and this with the assistance of the GeForce GPU. Once rendered out, editing and scrubbing through the timeline was possible.



TabletMark V3 running on the iPad Pro uses each device’s APIs and takes an hour or more to run.

On the iPad Pro I tried to open up the same R3D file in iMovie with no luck. I'm pretty sure the issue is iMovie's inability to read the raw R3D files. I also copied over a 4K-resolution .MOV file to the device but had no luck opening it in iMovie either. I'm not saying Apple is wrong, but I had no luck trying to do what Apple says the iPad Pro can do.

Benchmarking 101

So what does this all mean?

For one thing, I don't think you can look at just a couple of numbers from one or two benchmarks and make a conclusion. That is, unless you're looking to bend the truth to fit a pre-conceived agenda. That's called benchmarking, not benchmarking, and there's a difference.

The truth is, most of the testing I've run shows the iPad Pro isn't faster than a current or even two-year-old Core-class Intel CPU. (Atom, now that's another story.)

It's just not.

But it's still one hell of a chip.

I tried to heat up the A9X to check for performance throttling by repeatedly running 3DMark and simply gave up. It just does not get hot. I can't say the same for the admittedly smaller (and harder-to-cool) Google Nexus 9, which gets hot just browsing the web. Watching the same 4K movie file (that I couldn't actually edit) on the iPad Pro was buttery-smooth even playing in a background window. It's a very impressive tablet.

It still won't replace my Surface Pro 3 nor my laptop because it's not up to desktop-grade functionality. That's not the A9X's fault. It's because the OS and apps aren't up to the "pro" requirements for multi-tasking, nor the precision control of a mouse and keyboard experience.

If Intel's Atom X7 can run a full-service OS, the superior A9X theoretically could, too. That's a win for Apple in the long run, and it should be a wake-up call for Intel. 🔌

The truth is, most of the testing I've run shows the iPad Pro isn't faster than a current or even two-year-old Core-class Intel CPU.

I was one of the **1** in **5**
Children in America who
STRUGGLE WITH HUNGER
join me and help put an
End to childhood hunger.

Viola Davis



**HUNGER IS
ALL OF US**

HELP UNDO CHILDHOOD HUNGER. GO TO HUNGERIS.ORG

THE
SAFeway
FOUNDATION

The *Hunger Is* campaign is a collaboration between The Safeway Foundation and the Entertainment Industry Foundation to raise awareness and improve the health of hungry children.

EIF
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INDUSTRY FOUNDATION

The Safeway Foundation and the Entertainment Industry Foundation are 501(c)(3) tax-exempt organizations. Photo by: Nigel Parry

Google Pixel C: A killer Android tablet with an unfulfilled productivity mission

BY JON PHILLIPS

THE PIXEL C, (pixel.google.com) Google's new ultra-premium Android tablet, has unfinished business. Yes, it's chiseled from a sumptuous hunk of anodized aluminum and boasts a gorgeous, super-high-res display. And, yes, it's packed with top-shelf silicon that delivers palpable performance dividends.

It also runs a pure, unencumbered build of Android Marshmallow. That makes it bloatware-free, and the recipient of Google's most timely OS and security updates. But Google is positioning the Pixel C as a halo device for Android's productivity features—and in this



Watch the video at
go.pcworld.com/pixelcvid



mission, this productivity mission, the tablet falls short.

The Pixel C's most interesting hardware feature is a \$149 keyboard accessory that magnetically attaches to the bottom of the tablet. Google's unspoken productivity message is loud and clear: *Look at how much you can do in Google Docs now that your tablet has a proper keyboard.* But while it's a really good keyboard, it's married to an overall tablet experience that hasn't been deliberately optimized for work scenarios.

It's a shame, because the Pixel C (\$499 for 32GB and \$599 for 64GB) is nearly state-of-the-art hardware. The only feature it really lacks is the same awesome fingerprint sensor that's found on the Nexus 6P (go.pcworld.com/nexus6prvw) and 5X (go.pcworld.com/nexus5xrev). This is a disappointing omission, but if you're looking for a pure Android tablet, know that the Pixel C is a more generously appointed device than the Nexus 9 (go.pcworld.com/nexus9rev), whose 32GB version costs only \$20 less than an equivalent Pixel in the Google store.

However, if you need a no-compromise productivity tablet, and don't care about the OS you're running, then you'll probably do better with hardware from Microsoft, Apple, and even Samsung (go.pcworld.com/galaxytabs2). Their tablets are all better suited for multitasking and other productivity scenarios.

If you want to know how the Pixel C performs as a workhorse, jump to the section titled "Love the keyboard—but is that it?" For now, let's get into the tablet's industrial design.

Sublime industrial design—with pretty lights

When paired with the keyboard, the Pixel C looks like a miniaturized version of the Chromebook Pixel (go.pcworld.com/cbpixelrev), borrowing the same

Google Pixel C

AT A GLANCE

Killer industrial design, awesome performance, and a great hardware keyboard telegraph the Pixel C's intentions. Now Google just needs to make Android a productivity tablet OS.

PROS

- No-compromise build quality and industrial design.
- Exceedingly competent keyboard accessory.
- No-excuses display and CPU performance.
- Pure Android—just how we like it.

CONS

- No multi-window support.
- Android still doesn't feel like a productivity OS—and that's a missed opportunity.

\$599 (64GB)





Killer industrial design?

Check. Useful keyboard accessory? Check.

winning design cues from that Chrome OS laptop. The tablet's aluminum cladding has a premium, satiny feel, and the body's gentle lines and curved corners feel great in the hands.

And, yes, that's *hands*, plural. At 9.5 inches wide and 1.14 pounds, the Pixel C feels chunky compared to the slightly smaller and lighter Nexus 9, and unless you have really big hands, you won't be able to thumb type on Google's stock soft keyboard. That said, the Pixel C didn't flex when I did my best to torque, twist, and otherwise torture the chassis. I can't say the same for the Nexus 9, which creaks and bends under pressure.

Like Google's Chromebook, the Pixel C has a lightbar at the top of its aluminum backside. Besides serving as a persistent, physical expression of Google's colorful branding scheme, the lightbar signals to other road warriors that you're a very special person with a very special tablet—and that's about it. Double-tap the surrounding aluminum, and the lightbar briefly turns into a battery-level indicator. Beyond that? Nothing.

The Pixel C's 10.2-inch LTPS display is far, far from ornamental, however. With a 2560x1800 resolution and 500 nits of brightness, it looks spectacular. Its pixel density (308 pixels per inch) beats the 8.9-inch, 2048x1536 Nexus 9 (281 ppi); the 9.7-inch, 2048x1536 iPad Air 2 (264 ppi); and the 12.3-inch, 2736x1824 Surface Pro 4 (267 ppi).

And, personally, I like the Pixel C's oddball 1:√2 aspect ratio. It may have forced Google into trimming down some of its hardware keyboard keys (more about that soon), but it provides extra width when viewing websites in portrait mode, and much-appreciated extra depth when working with text documents in landscape mode.

Pixel-for-pixel, the C's display is both brighter and more saturated than the Nexus 9 display. It's also a larger display, making the Pixel C the obvious choice if you want pure Android in the biggest screen size possible.

Screaming Tegra X1 performance

A big screen demands big silicon behind it, and the Pixel C packs enough silicon to take on an army. The headline chip is an Nvidia Tegra X1, which integrates a GPU based on the Maxwell architecture that

The Pixel C's anodized aluminum case is defined by gentle lines and curved corners. This is how it looks when it's magnetically sandwiched with the \$149 keyboard.





The Pixel C's lightbar. Here we see its twinkling interpretation of Google's design motif. Double-tap the case, and the lightbar turns into a battery indicator.

has been so successful in Nvidia's latest PC graphics cards. There's also 3GB of LPDDR4 RAM. Currently, the only other notable device running the Tegra X1 is Nvidia's own Shield Android TV box. We have scant experience with this chip, but can now share it's a total screamer.

During real-world use, the Pixel C never lagged or hiccupped on any screen transitions, browser scrolls, or video playbacks. The user interface is fluid and slippery, and I've never seen a mobile device of any kind download and install apps so quickly. Likewise, benchmarks demonstrate the Pixel C's sheer ownership of other Android devices.

In PCMark's Work Performance test, Samsung's Galaxy Tab S2 9.7, a natural competitor, achieves a spectacular 5840. But the Pixel C trounces that score with a 6711. And in the 3DMark gaming test results chart, the Pixel C obliterates the competition. Test after test after test, the Pixel C made other Android devices look like dated technology.

Google says the Pixel C delivers over 10 hours of real-world battery life, and anecdotal use suggests the tablet's high-performing silicon and demanding display don't suck an inordinate amount of juice. But, unfortunately, we weren't able to verify the lifespan of Google's 34.2 watt-hour battery with PCMark—the benchmark repeatedly failed to complete its

rundown test. We'll update this review once we get a test result.

The Pixel C charges relatively quickly via its USB Type-C port. I don't mind that Google is going with the newfangled charging spec, especially because I have a growing collection of 15W charging adapters, thanks to my Nexus 6P daily-driver smartphone.

Besides that lone USB port, the Pixel C also features four mics for far-field voice input. It's a great idea, but I found the Nexus 6P to be far more responsive to "OK Google" voice commands from more than a few feet away.

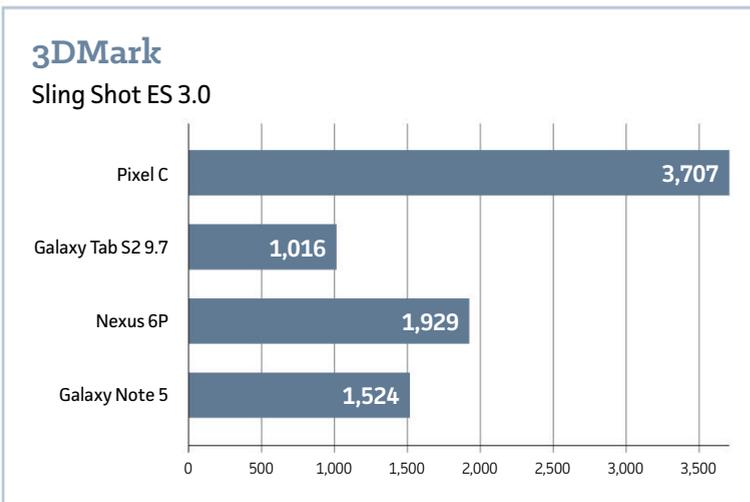
Besides an 8MP rear camera and 2MP front camera—neither of which we care too much about because, er, this is a tablet—the only other outward-facing components worth mentioning are two stereo speakers on either side of the Pixel C's aluminum chassis. Their output is tinny, but notably high volume. The excellent front-facing Boomsound speakers on the Nexus 9 have much warmer sound, but

The Pixel C's display is a bright, vivid, brilliant amalgamation of pixels—4,608,000 to be exact. Super-high-performing components hide inside the machine as well.





If you want a pure Android tablet, know that the Pixel C (left) is larger, comes with a better display and processor, and costs only \$20 more than a Nexus 9 (right) with the same storage capacity.



don't crank nearly as loud.

Love the keyboard. But is that it?

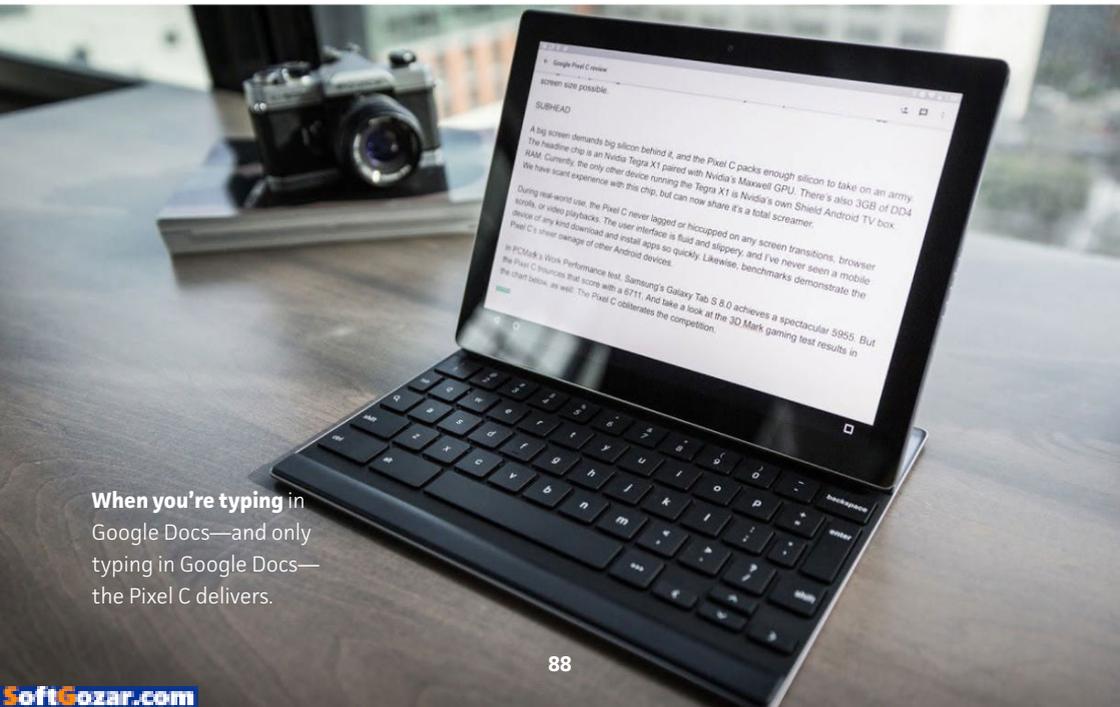
The Pixel C Keyboard might cost \$149, but it's a more substantial piece of kit than the \$130 Type Cover for Microsoft Surface devices. It's also a far better input device than the \$169 Smart Keyboard for iPad Pro. The Pixel C keyboard offers a generous 1.4 mm of key travel,

and just feels exceedingly well-prepared for use and abuse.

Google's keyboard attaches to the Pixel C via a magnetic interface that bonds the two pieces together in a confidence-inspiring grip. Just try shaking the tablet with the keyboard attached: You have to throttle the Pixel C like a paint mixer before the keyboard even threatens to fly off. The two sides communicate with each other over Bluetooth LE, and the keyboard charges inductively whenever it's attached to the tablet during a charging cycle.

When cradled in the keyboard, the Pixel C's screen tilts from 100 degrees (basically fully upright) to 180 degrees (though it stops being useful after about 135 degrees). We love the continuous range of motion, and once you choose a tilt angle, the screen stays put.

If we have any criticisms at all, it's the keyboard's lack of backlighting and truncated key layout. The letter and number keys are perfectly fine, but this isn't a full-size keyboard. Some keys (like the rando bracket and pipe keys) are missing, and some are smaller than



When you're typing in Google Docs—and only typing in Google Docs—the Pixel C delivers.



standard. The right-side backspace, enter, and shift keys—each comically small—caused a few misfires during typing.

Regardless, the keyboard is a great productivity tool. And some day, when Google updates Android with a few key features, the Pixel C will be a kickass productivity tablet as well.

Most glaringly, Android still doesn't include any type of multi-window mode that let's you use two apps side-by-side. This feature is buried deep (go.pcworld.com/andmultiwindow) in Marshmallow's source code, but Google still hasn't activated it for general consumer use. It's a shame that home screen-level multitasking wasn't released alongside the Pixel C, because multi-window is a headline feature in Microsoft, Apple, and even Samsung productivity tablets.

And this ties into my overarching Pixel C complaint: The tablet hardware itself is awesome, but aside from the keyboard, the Pixel C doesn't really feel like a "productivity tablet" as we've come to know them in 2015. There's no multi-window support. There's no pen support. Google Docs remains exactly the same as it did yesterday, even though it's crying out for customized synergy with the Pixel C experience.

Once you choose a tilt angle, the Pixel C doesn't budge from where you set it.

In short: There are no new surprise-and-delight productivity features that say, “We’re Google, and we’ve just made Android even more useful for getting things done.”

Sure, Google Now On Tap is built directly into Marshmallow, and it’s a great tool for running contextual information searches in a wide variety of apps. I love it—but it’s not a game changer. Even worse, throughout testing I was continually annoyed by Chrome constantly defaulting to dumbed-down mobile views of my favorite websites. Even the Nexus 9, with its smaller screen, shows full desktop views of the exact same sites. The Pixel C is supposed to be a productivity tablet, yet it makes surfing the web a more tiresome, unproductive affair.

In sum, the Pixel C cries out for a new Android software experience to complete its productivity story with a dazzling payoff. Indeed, if it launched with multi-window support, it would have earned a 4.5 verdict, or perhaps even a perfect score. This despite the fact that some of us at Greenbot and *PCWorld* feel it’s just a bit too heavy compared to Samsung’s 9.7-inch Galaxy Tab S2 (go.pcworld.com/galaxytabs2)—which does do multi-window.

Am I being too harsh? I don’t think so. This is a Pixel, damn it. Google has complete control over the manufacturing and user experience, and



Mind the wee backspace, shift, and enter keys. They’re smaller than standard-issue keys.



as the company states in its reviewer's guide, "We create Pixel products when we see an opportunity to rethink an experience inhouse and design a new type of technology that will support and inspire the partner ecosystem." It's a lofty goal, but in this case, it seems the Android and Docs teams weren't invited to the rethinking party.

But make no mistake: The hardware itself is superb. If you want a pure Android tablet, this is the one you buy. And because it's pure Android, it will be one of the first tablets to run Google's version of multi-window when that feature finally exits development and is pushed live to the world. 🔌

Lacking any type of multi-window function, the Pixel C leaves you stuck in a single app.



Samsung 950 Pro NVMe SSD: Stacked NAND, stacked performance

BY JON L. JACOBI

BEEN HANKERING AFTER M.2/PCIe NVMe SSD performance, but just not had the cash to scratch the itch? Samsung is here with relief in the form of the 950 Pro (go.pcworld.com/samsung950pro)—easily the most affordable M.2 NVMe drive to hit the market to date. It uses Samsung's 3D V-NAND, that is, 3D in that cells are arranged both horizontally and vertically (the V in V-NAND) in layers.

Samsung's V-NAND is a pretty cool product, as it can be treated as TLC (triple-level cell/3-bit), MLC (multi-level cell/2-bit), or SLC (single-

level cell/1-bit). As TLC it's pretty slow (about 400MBps), but in the case of the 950 Pro, Samsung treats it as MLC and the results are very, very good—around 2GBps sequential reading and 1.5GBps writing.

Out of the box, the 950 Pro was a complete fail writing—the 35MBps it registered in AS SSD is slow for a hard drive. There was no point in finishing the test as it was apparent that the stock Windows 8.1 NVMe driver and the 950 Pro didn't like each other much. Once we received and installed the Samsung driver, as you can see in the chart, all was well.

Of course, as some SSD vendors are playing games with cache these days, we like to back up the synthetic benchmarks with real-world copy tests. Note that the Kingston HyperX Savage is not one of those, it's a very good SATA SSD that's simply shown here to illustrate the difference between 6Gbps SATA and M.2/PCIe/NVMe.

No surprises. Unlike some current SATA SSDs, there is no monkey business going on.

Affordable at last

OK, I told you it was affordable. How about \$199 for 256GB and \$349 for 512GB? Sure, that's not 30-cents-a-gigabyte cheapo SATA SSD territory, and the 950 Pro probably won't see steep discounts any time soon. Considering the performance, 68 cents per gigabyte is pretty darn cheap. Twice the price, four times the performance—I can live with that formula.

You might think that Samsung would skunk you on the warranty to make up for the lower margins. You might be wrong. OK, they do a bit. But while it's not a whopping 10 years as with the 850 Pro, the 950 Pro carries a substantial five-year warranty and an even higher TBW (terabytes written) rating than its older

Samsung 950 Pro NVMe (512GB)

AT A GLANCE

M.2/PCIe NVMe SSDs are now affordable thanks to Samsung's 950 Pro. Why is that important? Because 2GBps sustained sequential reading and 1.5GBps writing makes a SATA SSD seem like it's standing still. If your OS or app can take full advantage of NVMe, you'll also get far faster small file performance.

PROS

- Extremely fast
- By far the most affordable M.2 NVMe drive to date

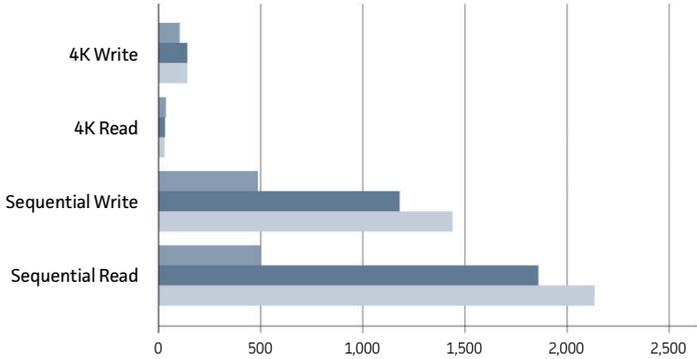
CONS

- Requires Samsung driver for full write performance

\$349 for 512GB; \$199 for 256GB



AS SSD Benchmark (Mbps)



LONGER BARS INDICATE BETTER PERFORMANCE

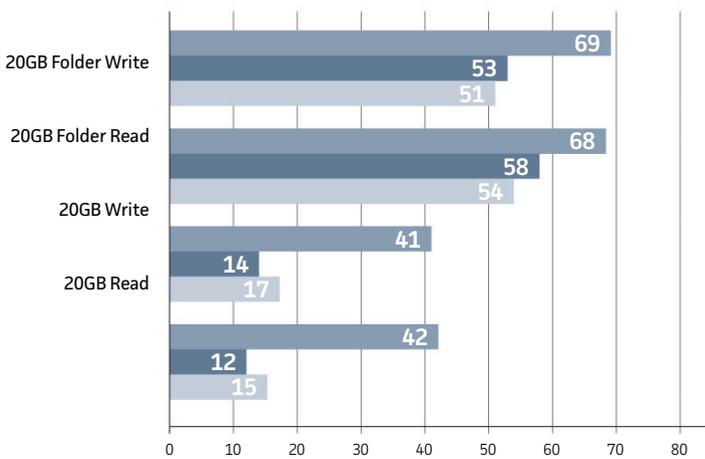
Kingston HyperX
Savage SATA

Samsung
SM951 NVMe

Samsung
950 Pro

As you can see, the Samsung 950 Pro is even faster than the last generation SM951.

20GB Copies (Seconds)



SHORTER BARS INDICATE BETTER PERFORMANCE

Kingston HyperX
Savage SSD

Samsung
950 Pro NVMe

Samsung
SM951 NVMe

You don't see huge gains copying large groups of smaller files and folders, but sequential throughput is light years better with NVMe. Though this test doesn't show it, when threaded, small file write operations are much faster.



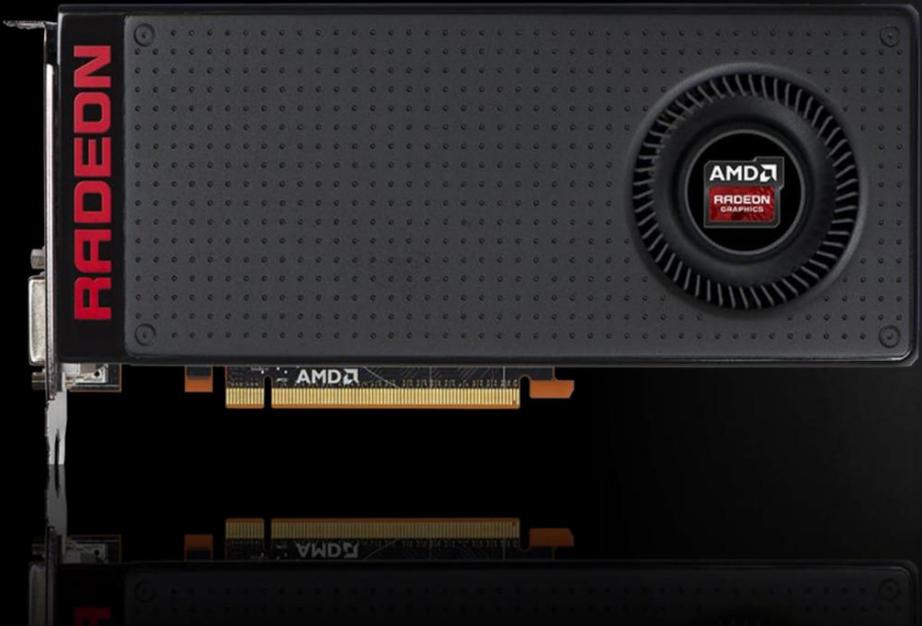
This tiny card is the key to ultra-smooth Windows performance.

sibling: 200TBW for the 256GB model and 400TBW for the 512GB drive. That’s about a terabyte a day for the larger capacity, which is a heck of a lot more data than most users will write. At 20GB a day, that’s over 50 years—long past the useful lifespan of the technology and most likely your data.

Buy it

With the advent of the 950 Pro, the time for upgrading your desktop to M.2/PCIe NVMe performance is truly at hand. Grab a PCIe/M.2 adapter card if your computer doesn’t offer a M.2 slot. I promise that you will not be sorry.

Laptop users will want to exercise more caution. Even if your laptop supports M.2 drives, it may not support PCIe drives nor NVMe so we recommend careful research before you pull the trigger on a mobile 950 Pro upgrade. 



AMD Radeon R9 380X feat. Sapphire: The best graphics card for 1080p gaming, priced to fight

BY BRAD CHACOS

WITH THE LAUNCH of the new Radeon R9 380X, AMD's stepping up to fill a massive hole in the graphics card universe, between the "it's solid for most games at 1080p" Radeon R9 380 (go.pcworld.com/r9380/) GeForce GTX 960 (go.pcworld.com/gtx960rev) tier at roughly \$200, and the "This rocks for 1440/high" R9 390 / GTX 970 at roughly \$300.

Nvidia hasn't bothered releasing a 960 Ti (or what-have-you) for the GeForce 900-series family, and when AMD refreshed its entire Radeon lineup (go.pcworld.com/furygcrefresh) in one fell swoop this past June, there was no R9 300-series equivalent to the older Radeon R9 280X. The crucial \$200 to \$300 price point lay dormant, and gamers looking for modern graphics cards with uncompromising 1080p chops were left wanting unless they wanted to splurge on one of the \$300-plus options. Frankly, \$300 is over the budget of the vast majority of gamers, and the GTX 970 and Radeon R9 390 are overkill if all you want is to hit 60 frames-per-second on your 1080p with all the eye candy cranked to 11.

Enter the \$230 AMD Radeon R9 380X. You read that right: not \$250, but \$230. This is why healthy competition rocks.

Radeon R9 380X tech specs

Rather than being a cut-down R9 390, the Radeon R9 380X is a beefed-up R9 380: more stream processors, more memory, *faster* memory and core clocks, et cetera. Where the R9 380 offers GPU clock speeds up to 970MHz and a pricier 4GB memory option, those are both the starting point for the new card. The Radeon R9 380X is basically the Tonga GPU (which first appeared in the older R9 285) unleashed—which, as one of AMD's newer



Radeon R9 380X's technical details

Process	28nm
Stream Processors	2048
Engine Clock	≥ 970 MHz
Compute Performance	3.97 TFLOPs
Texture Units	128
Texture Fill-Rate	124.26 GT/s
ROPs	32
Pixel Fill-Rate	31.04 GP/s
Z/Stencil	128
Memory Configuration	4GB GDDR5
Memory Interface	256-bit
Memory Speed / Data Rate	Up to 1,425MHz/5.7Gbps
Memory Bandwidth	Up to 182.4 GB/s
Power Connectors	2 x 6-pin
Typical Board Power	190W
CI-E Standard	PCI-E 3.0
API Support	DirectX® 12, Vulkan™, Mantle
FreeSync Support	Yes
Virtual Super Resolution	Yes
Frame Rate Targeting Control	Yes

GPU architectures, means it has full support for all the latest Radeon software features, like FreeSync, Frame Rate Target Control, and Virtual Super Resolution.

The chart above shows nitty-gritty details for the reference R9 380X, but don't expect to see cards packing those specs on store shelves today. AMD says the first wave of R9 380X products will be overclocked, custom-cooled models by a wide range of AMD partners like VisionTek, Asus, XFX, Gigabyte, HIS, PowerColor, and VTX3D, with prices for custom variants starting around \$240.

AMD sent us a Sapphire Nitro R9 380X (go.pcworld.com/nitro380x) for review. When I saw it, I couldn't help but smile: Sapphire recently sent us a Nitro R9 390 (go.pcworld.com/nitro390) for testing, and as you can see

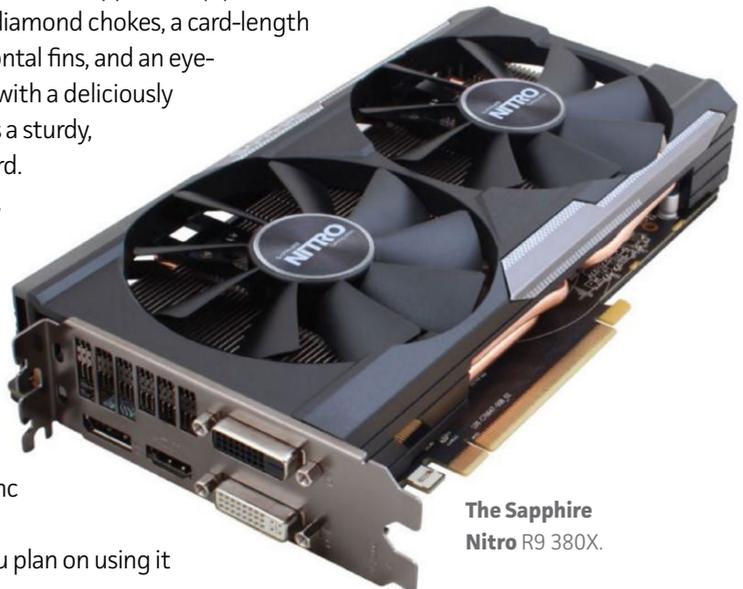
in *PCWorld*'s massive graphics card roundup (go.pcworld.com/gcards), that card's cooling solution is no joke—keeping even the power-hungry 390 cool and ludicrously quiet. The custom Dual-X cooling solution Sapphire slapped on the 380X isn't *quite* the same as the Tri-X cooler on its Nitro 390/390X cards, but it still proved effective (as you'll see later) and almost utterly silent.

There's no doubt about it: Sapphire's cooling solution is rapidly shaping up to be one of the best around, and the thermal control it provides helped Sapphire crank this card's core clock speed to 1040MHz and its memory clocks up to 6GBps. AMD says most of the 380X cards available on day one will feature 50MHz to 60MHz overclocks, much like this one.

Sapphire's Nitro R9 380X features many other niceties as well: thick copper heatpipes, dual ball-bearing fans, black diamond chokes, a card-length heatsink with horizontal fins, and an eye-catching backplate with a deliciously futuristic design. It's a sturdy, premium-feeling card.

Connectivity-wise, there's DVI-D, DVI-I, HDMI, and DisplayPort, the last of which is a must-have if you're considering going with a FreeSync display (which is recommended if you plan on using it

Sapphire's cooling solution is shaping up to be one of the best around, and the thermal control it provides helped Sapphire crank this card's core clock speed to 1040MHz and its memory clocks up to 6GBps.



**The Sapphire
Nitro R9 380X.**

for 1440p gaming, the niche AMD's pushing it for). The R9 380X requires a pair of 6-pin connectors to draw power, with a 190-watt TDP rating.

AMD Radeon R9 380X benchmark tests

We booted up PCWorld's dedicated graphics card benchmark system to test the Sapphire Nitro R9 380X. Here are the relevant tidbits:

- Intel's Core i7-5960X with a Corsair Hydro Series H100i closed-loop water cooler, to eliminate any potential for CPU bottlenecks affecting graphical benchmarks
- An Asus X99 Deluxe motherboard
- Corsair's Vengeance LPX DDR4 memory, Obsidian 750D full tower case, and 1200-watt AX1200i power supply
- A 480GB Intel 730 series SSD
- Windows 8.1 Pro. The testbed hasn't been upgraded to Windows 10 yet, though we plan to do so once DirectX 12 games start rolling out.

If you want to read every nitty-gritty detail about *PCWorld's* testing rig—and see its birth—check out our DIY build guide (go.pcworld.com/diygamingpc) for the machine.

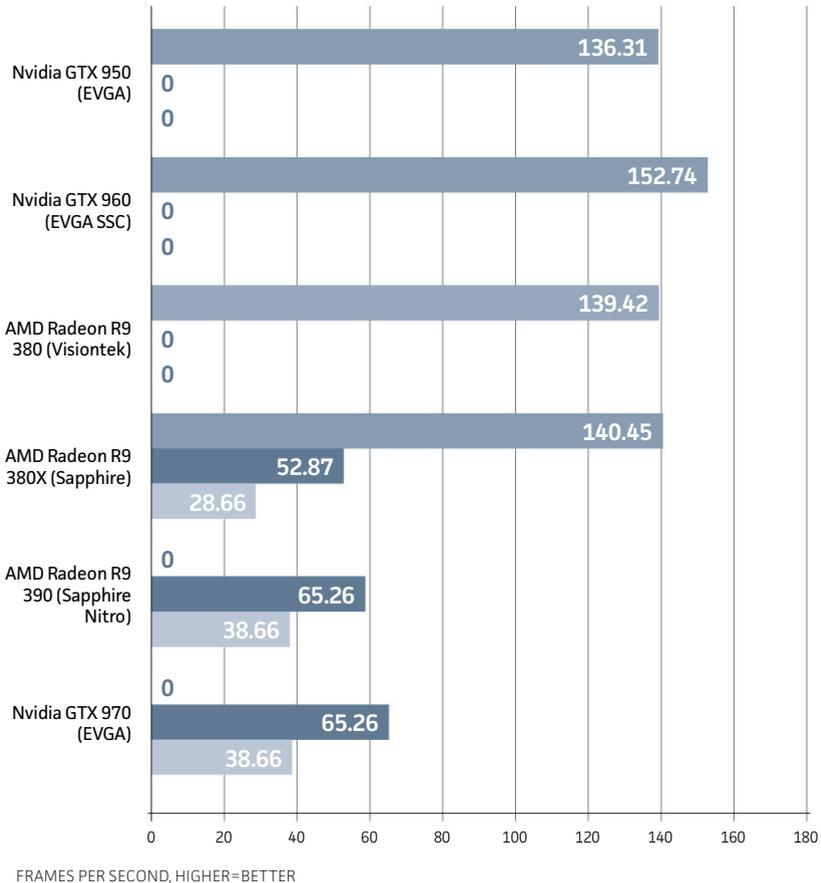
Performance benchmarks

While AMD's positioning the card as an entry-level 2560x1440 gaming option, the text on Sapphire's Nitro R9 380X box says it's aimed at gaming at high levels at 1080p. As such, we're comparing the card against both cheaper 1080p-focused graphics cards—the \$200 VisionTek R9 380, \$200 EVGA GeForce GTX 960 SSC, and \$160 EVGA GeForce GTX 950 SSC—as well as the pricier \$300-and-up Sapphire Nitro R9 390 and EVGA GeForce GTX 970 FTW, which are great 1440p options.

Every game was tested using its in-game benchmark, at the default graphics settings stated unless noted otherwise, with V-Sync, G-Sync, FreeSync, and any vendor-specific features (like Nvidia's Multi-Frame-Sampled Anti-aliasing technology) disabled.

While some high-profile DirectX 12 benchmarks have arisen in recent months, we're not using them yet, as they're based on unfinished titles. No DirectX 12 games are currently available, though they're expected to

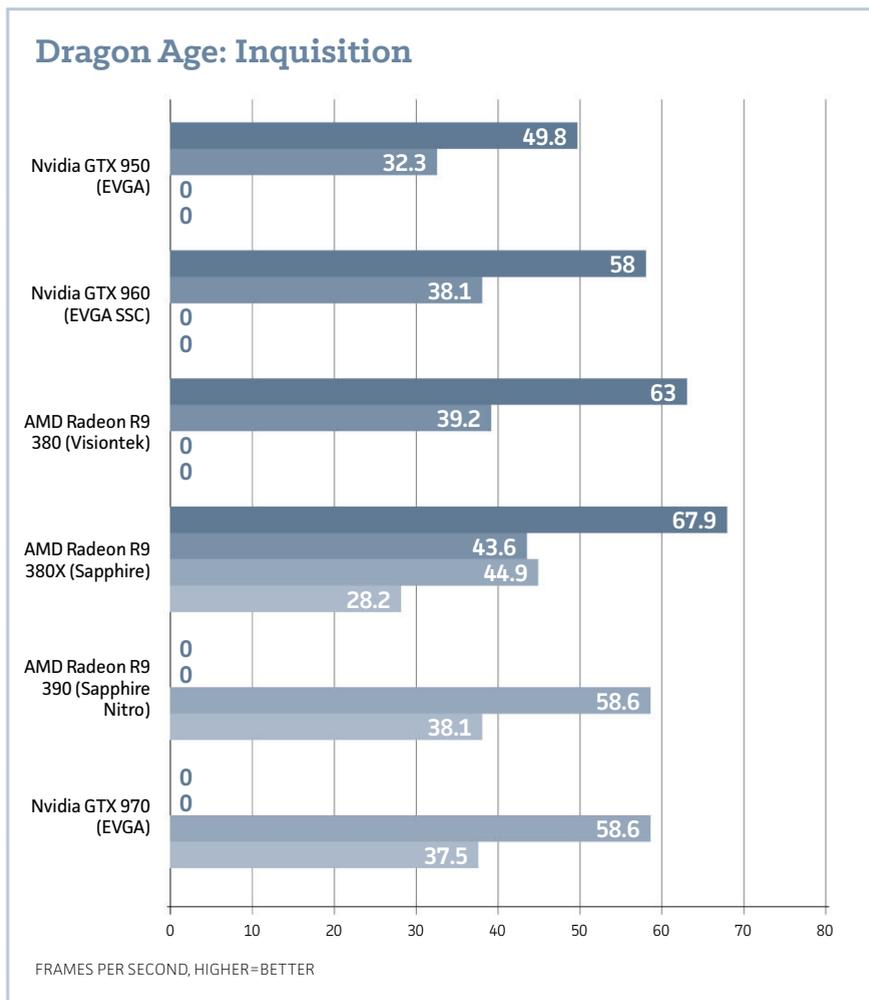
Grand Theft Auto V



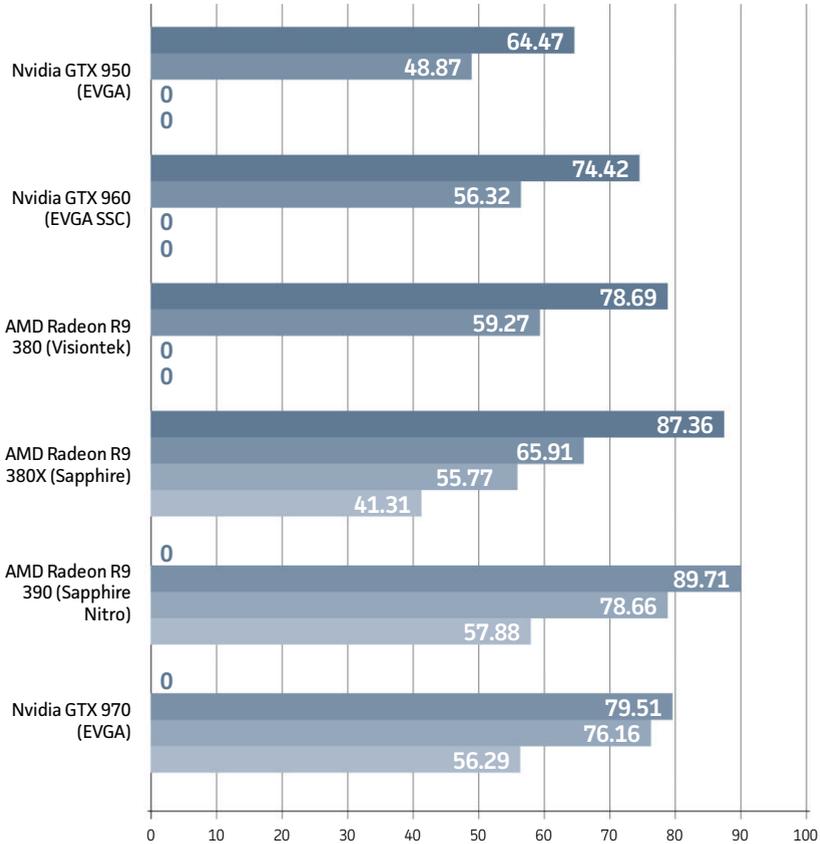
start trickling out before the end of the year. Simply put, while DirectX 12 (go.pcworld.com/directx12faq) is incredibly exciting in theory, in practice it's too early to start testing cards with it yet.

Note that any score of zero (0) on these charts mean we didn't test that particular graphics card using that particular setting, because we're mixing 1080p and 1440p.

Got it? Good. Let's dig in.



Middle-earth: Shadow of Mordor



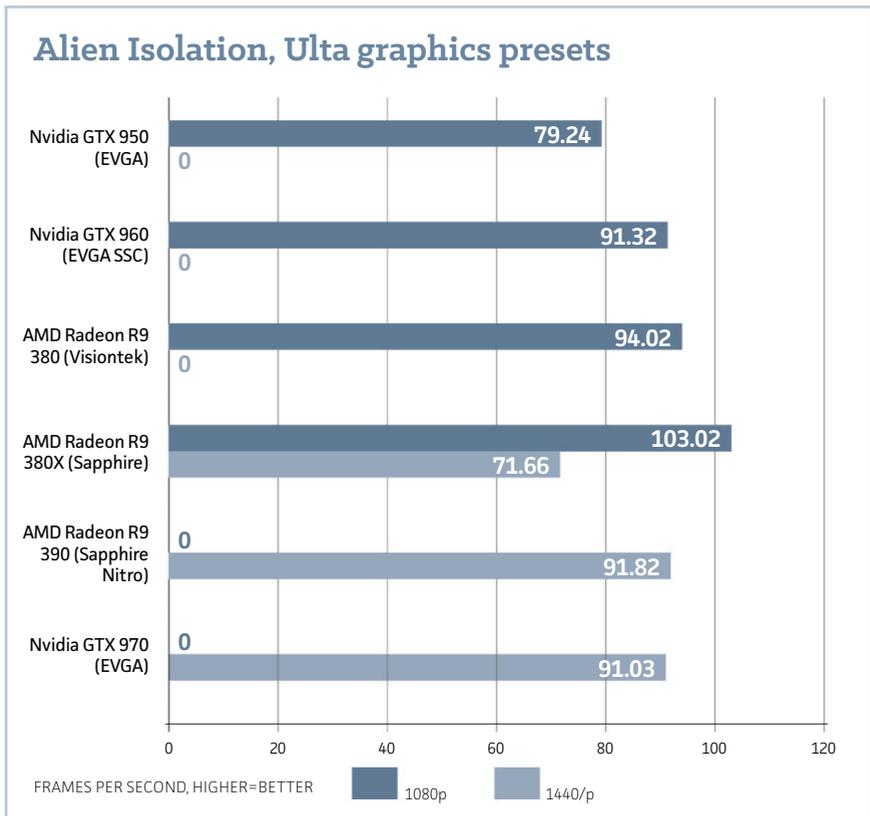
FRAMES PER SECOND, HIGHER=BETTER



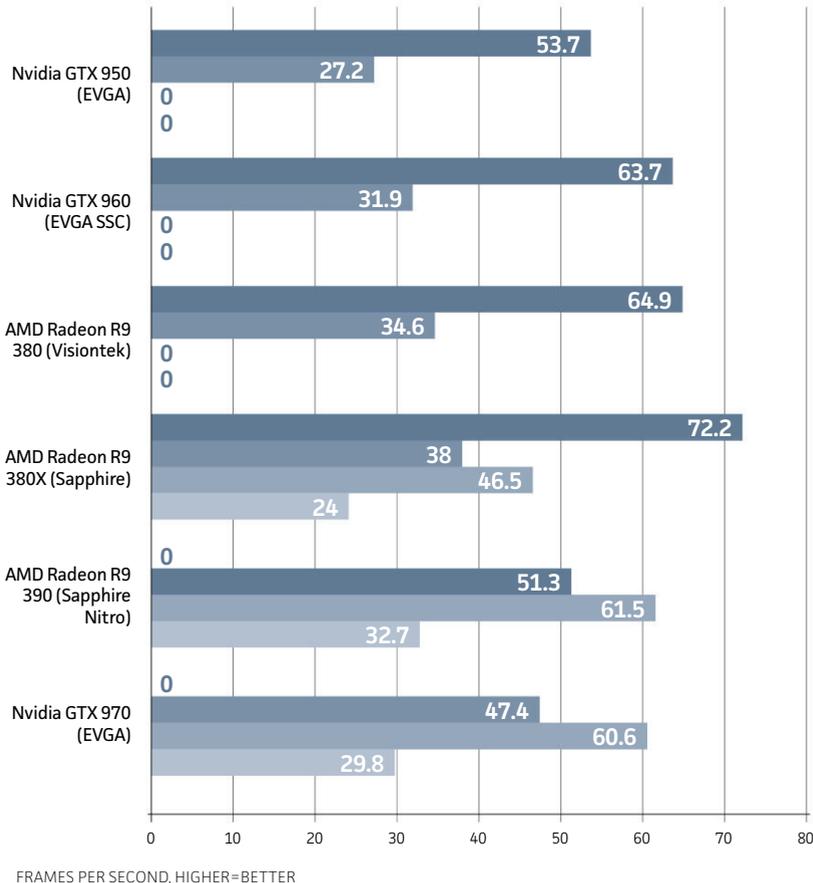
Grand Theft Auto V's memory requirements at higher settings and resolutions can hammer top-end cards, but it scales well and isn't as intensive at 1080p or 1440p. Because the game doesn't have overarching

preset graphics settings like “Medium” or “Ultra,” we tested it a few different ways: with FXAA enabled and every option set to Normal at 1080p, with FXAA enabled and every option set to Very High at 1440p, and using the same 1440p settings but with 4x MSAA and Reflection MSAA enabled.

GTAV's favoritism toward Nvidia cards shines through here. Note that while we test with everything set to Normal at 1080p to level the playing field, the Radeon R9 380X can turn the vast majority of settings up to High or Very High and still hit a constant 60fps. (We'll probably start testing at higher graphics settings in the future.) Without MSAA enabled, the R9 380X averages over 50fps even at 1440p.

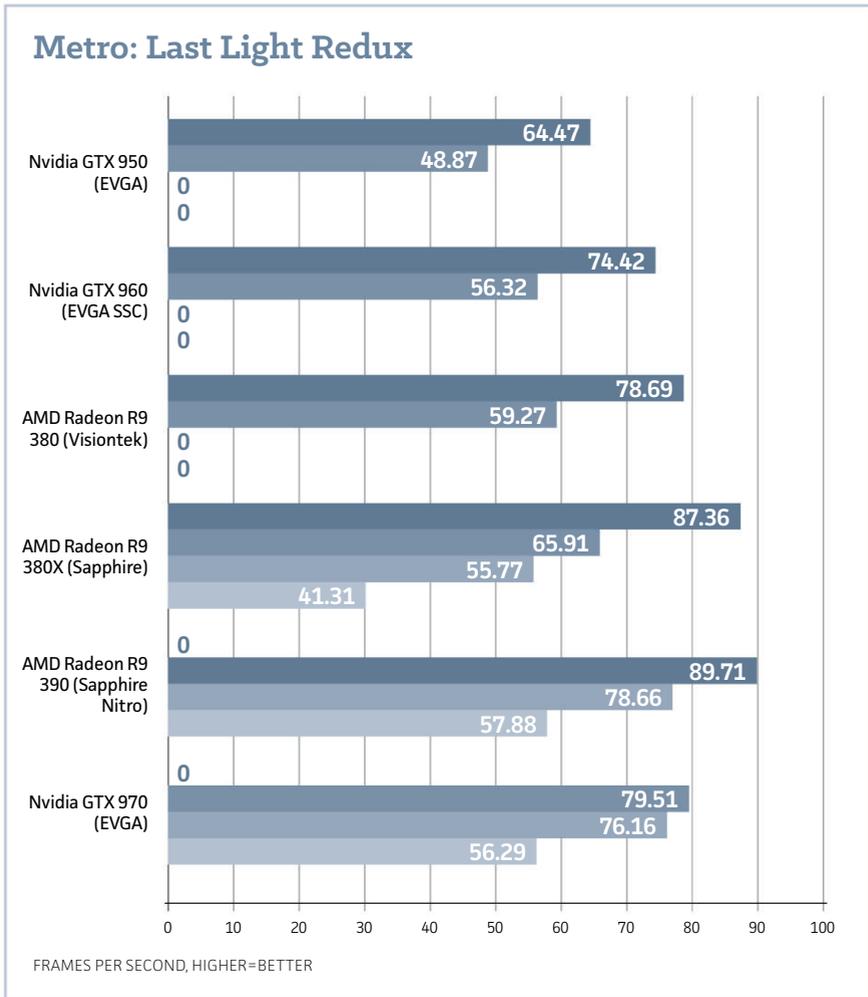


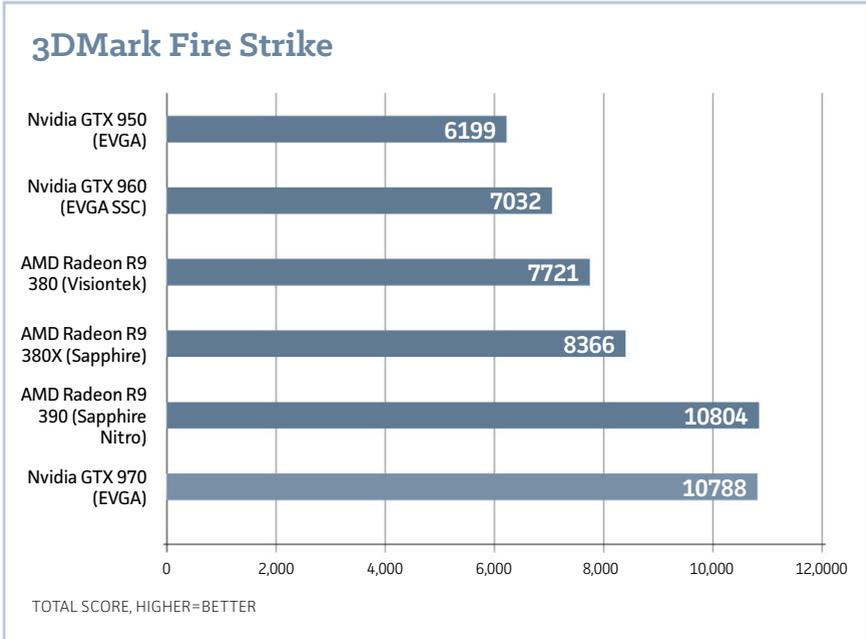
Sleeping Dogs: Definitive Edition



The card cruises past the crucial 60fps barrier at High settings in *Dragon Age Inquisition* too, delivering performance that's a solid 5 to 10 frames per second faster than the \$200 options. DAI's Ultra setting almost goes overboard on the quality and anti-aliasing

options, which nukes frame rates but doesn't offer a comparable increase in eye candy in return. Still, if you want to crank everything to 11, the Sapphire Nitro R9 380X can do so to the respectable tune of 44fps at 1080p. It hits similar frame rates with High settings at





1080p—far below what the R9 390 and GTX 970 offer.

Additional games performance benchmarks

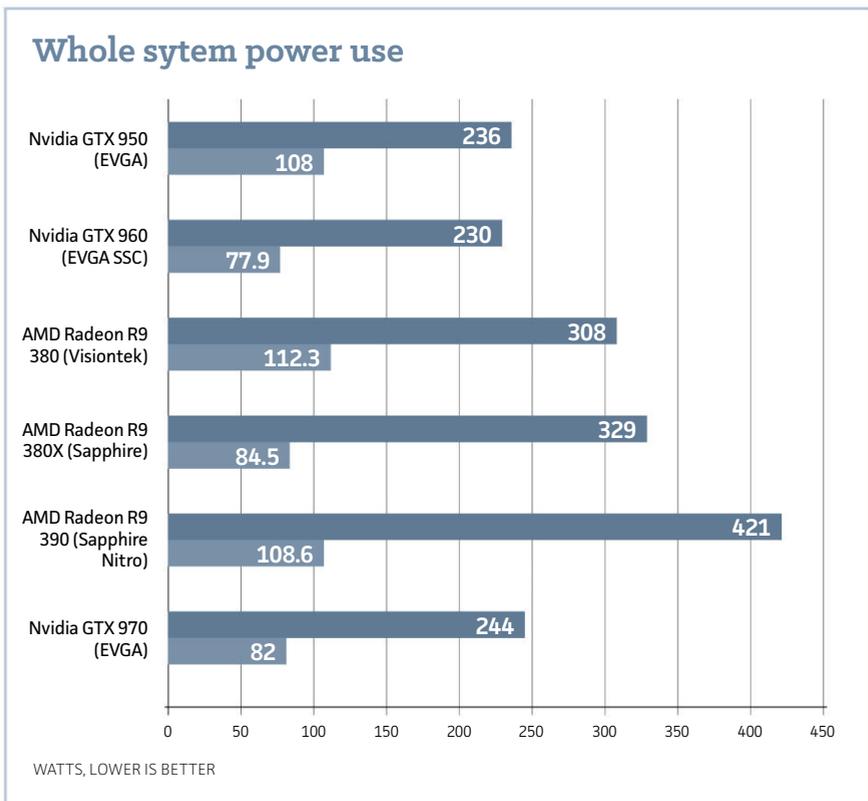
Nvidia’s “The way it’s meant to be played” logo holds a prominent place in *Middle-earth: Shadow of Mordor*’s startup splash screens, but the game actually favors Radeon cards, as our testing has consistently proven over the past year. Because the in-game Ultra preset doesn’t truly boost everything to 11, we test “Ultra” by manually cranking every graphics option to its highest setting, using the optional memory-gobbling HD Ultra Texture Pack on 1440p cards with 4GB of RAM, but not when we’re testing at 1080p resolution.

The Radeon R9 380X hits the crucial 60fps average at both 1080p/ Ultra—again, a 5fps to 10fps lead over the R9 380 and GTX 970, respectively—and 1440p/High. If you’re fine with dialing things down slightly, to 1080p/High, you’ll enjoy blistering 90fps frame rates. *That’s*

responsive gameplay.

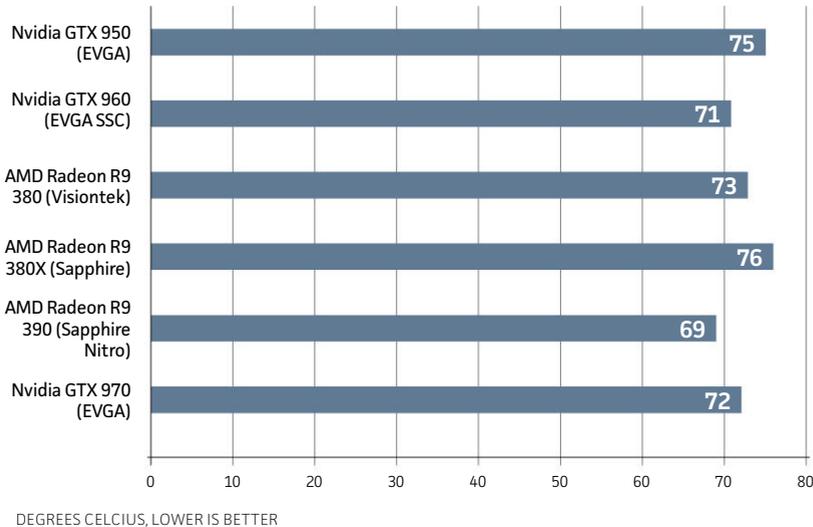
Alien Isolation's gameplay is terrifying, but its performance is anything but. Every card we've tested—even the lowly \$100 GTX 750 Ti—hits 60fps at 1080p/Ultra, while the Sapphire Nitro R9 380X clears 100fps. It hits 71fps at 1440p, but once again, still lags far behind the beefier R9 390 and GTX 970, each of which deliver 20fps more.

Sleeping Dogs: Definitive Edition is an amped-up remake of a sleeper hit game. Its Extreme graphics settings really lean on multiple passes of intensive anti-aliasing options, which drastically reduces frame rate. Pay more attention to the High settings results here. As with every other



■ Load ■ Idle

Maximum GPU temperature under load



game, the R9 380X's results are solidly above the \$200 options at 1080p, but far below the \$300 cards' oomph at 1440p.

Additional performance tests and power draw

Similarly, *Metro: Last Light Redux* is a glitzed-up version of the superb, haunting *Metro: Last Light*. The R9 380X performs well here, though it falls south of 60fps—a critical bar to hit in first-person shooters—at 1440p/High. Not at 1080p/Ultra, however.

We also test all cards using 3DMark Fire Strike, a synthetic benchmark, but one that's well respected and oft-used within the industry.

As usual these days, AMD's cards consume more power than Nvidia's, though the fact that the R9 380X is more potent than the GTX 960 no doubt plays into the 100W difference between the two cards. Power is measured by plugging the entire system into a Watts Up meter, then running a stress test with Furmark—which both AMD and Nvidia dub a

“power virus”—for 15 minutes. It’s basically a worst-case scenario situation. During most actual gameplay, power usage hovered between 270W and 300W for the R9 380X.

GPU temperatures and the bottom line

Considering the higher power draw, it makes sense that the R9 380X runs a wee bit hotter than the R9 380 and GTX 960. It also runs a wee bit hotter than the \$300 graphics cards, but those models tend to have far larger heatsinks and additional fans. Sapphire’s cooling solution holds up superbly in practice and as I mentioned earlier, it runs damned near silent.

Bottom line

When we recently reviewed VisionTek’s \$200 R9 380 (go.pcworld.com/r9380), we summed it up thusly:

“For your money, you’ll get a mostly uncompromising mainstream 1080p gaming experience, hovering around 60fps at Ultra settings in many cases, though you may need to tone down some of the more extreme anti-aliasing options or set the graphics options to High in some of [the] most strenuous titles—but only if the 60fps barrier is sacrosanct to you. If you’re fine with a console-quality 30fps, the VisionTek Radeon R9 380 never faltered below that mark, even with all the bells and whistles enabled in the most strenuous games.”

The extra oomph in AMD’s R9 380X pushes it over the smoothness hump by offering a roughly 8- to 15-percent boost in frame rates compared to its little brother—not a large jump, but a clear one. This card routinely clears 60fps at 1080p at High or Ultra settings, its 4GB of memory seems more future-proof than the 2GB found in base-level R9 380 and GTX 960 models, and Sapphire’s cooling solution is utterly superb. The R9 380X is a clear and worthwhile upgrade to the older Radeon 7850/7870, though existing R9 280X owners will want to sit pat. While you can certainly use the R9 380X as an entry-level 1440p gaming solution, you won’t be able to hit a consistent 60fps with High graphics

settings in most games. In more strenuous newer games—like *Witcher 3*—that’s likely to dip far lower, at which point you might want to invest in a FreeSync monitor as well. Or better yet, if you really want to get into 1440p gaming, save your dollars and spend the extra \$50 on an R9 390 (go.pcworld.com/nitro390) or a GTX 970 (go.pcworld.com/gtx970). The extra money is worth it there (and the Sapphire Nitro R9 390 and EVGA GTX 970 FTW I’ve tested both rock). Those cards simply blow away the R9 380X at 1440p.

Alternatively, you could consider shopping around for one of the precious few R9 290 cards that are lingering at online retailers. We’ve seen them selling for as little as \$200—yes, just \$200—as they’re being flushed from the system, and it delivers superior performance to the R9 380X, though it falls short of the newer R9 390 and GTX 970.

That said, the R9 380X fills a crucial hole in the market, and it’s the best 1080p/60fps card around—for now, at least. I’d be shocked if Nvidia didn’t have a GTX 960 Ti waiting in the wings, but even if it does, the company will be hard-pressed to meet AMD’s fiercely competitive pricing on the \$230 R9 380X. While the R9 380’s street pricing has drifted as low as \$180, the GTX 960 still sells for a solid \$200 and up, and the GTX 950 ain’t far behind at \$160 and up. Nvidia doesn’t have much wiggle room unless it drops prices across the board—or it releases a card with better performance than the R9 380X, and priced higher accordingly.

I’ll say it again: Healthy competition is a wonderful thing. With a newly refocused Radeon Technologies Group, the high-bandwidth memory-powered Fury lineup, completely overhauled software, and now, the best graphics card options for the masses at the crucial \$200 to \$250 price points, AMD seems poised to bring the fight to Nvidia in 2016—though Team Green’s not taking the threat sitting down. 

That said, the R9 380X fills a crucial hole in the market, and it’s the best 1080p/60fps card around—for now, at least.



Windows 10 Mobile: Next-gen Phones focus on unique features to double down on productivity

Continuum, Windows Hello, and Microsoft's own apps are why you should consider this increasingly niche Windows Phone OS.

BY MARK HACHMAN

MICROSOFT'S WINDOWS 10 MOBILE operating system may be a second-tier OS, but it's not second-rate. With its new smartphone OS, Microsoft has doubled down on the productivity message, crafting a utilitarian OS with occasional flashes of magic—most notably its new PC-like Continuum feature.

Microsoft provided us one of its new flagship phones, the Lumia 950 (See our review on page 122), to test out its new Windows 10 for phones. It's running Windows 10 Mobile Build 10586 (go.pcworld.com/build10586), the same version Microsoft shipped to its Insider fast

ring on recently. Microsoft should make that same version available soon, for free, to owners of selected older Windows Phones.

Note, however, that several of the most unique features of Windows 10 depend on the hardware built into the Lumia 950 and Lumia 950XL. Microsoft also assumes that if you're buying a Windows 10 Mobile phone, you already own a Windows 10 PC. It's not essential, but Windows 10 ties together phones, PCs, and tablets far more seamlessly than, say, the Apple MacBook and iOS. Own a PC and a Windows phone, Microsoft seems to say, and you'll be far more productive than if you owned any other platform.

The best feature of Windows 10 Mobile: Continuum

The DVR allowed viewers to watch “live TV” on their own time. Google Maps sounded the death knell of the consumer GPS industry. By far the biggest selling point of Windows 10 Mobile is Continuum, a feature that lets you connect your phone to an external monitor and operate it like a PC. Continuum certainly won't kill PCs or tablets, but it's still a profound shift in computing culture. Just keep in mind that it won't work with all of the apps installed on your phone.



Continuum in action on
Microsoft's
Windows 10
Mobile.



Continuum can connect your phone to an external display with or without wires, but it works best with the \$99 Microsoft Display Dock, which connects to—and powers—either the Lumia 950 or 950XL via its USB-C cable. (The Display Dock does not have a Micro-USB input, such as that used by older Windows Phones.)

Plug a wired keyboard or mouse into the 2.5-inch cube via one of the three USB 2.0 ports, and you're in business. You'll also have the choice of connecting via HDMI (with HDCP 1.3/1.4 copy protection) or DVI. Using DVI, your phone will act as a speaker. You can also connect a Bluetooth mouse and keyboard to the phone itself.

Continuum can also forgo the Display Dock entirely, projecting your phone's screen wirelessly via Miracast to a dongle or directly to displays like the Panasonic CX800 60-inch 4K monitor in our lab. The Continuum app senses nearby wireless displays and helps you set them up. It's amazing to look at, but not really practical yet—I experienced horrible lag and connectivity problems.

With Continuum running, your phone projects a PC-like, slightly low-res desktop view onto your display, roughly similar to the look

The \$99 Microsoft Display Dock lets you enjoy the Continuum feature on a Lumia 950 or 950XL.

and feel of a Surface Pro 4 in tablet mode. Microsoft goes to a great deal of effort to make your Continuum experience feel like you're using a full-fledged computer. You can set a custom, landscape background for your monitor, and apps align themselves in a PC-like taskbar at the bottom of the screen. Tapping the Windows key brings up the Start menu.

In Continuum mode, the 950's display transforms itself into a touchpad. You can slide your fingers around to move the cursor, tap with your finger to open apps, pan and scroll with two fingers, and right-click by tapping those two fingers. You can also access the phone's keyboard to enter text—as well as the mic, which I found to be pretty handy for dictating text. The touchpad is simply an app, however, so you can slide over to another task if needed.

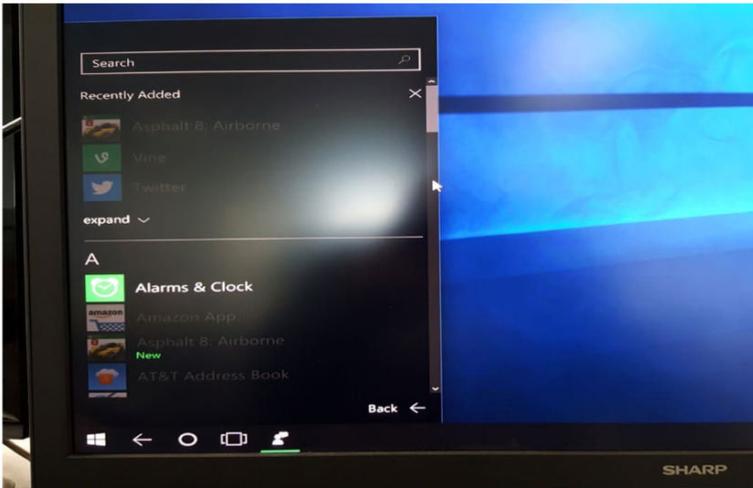
In Continuum, Windows apps scale to fill your entire display. That's a key difference: Android tablets, for instance, can connect to an HDMI monitor via an MHL connector—but you're forced to view the screen

Windows 10 Continuum and the Microsoft Display Dock provide a PC-like experience.





A Windows 10 Mobile phone projected onto a 60-inch screen.



When using Continuum, expect to see some apps grayed out.

inside a narrow rectangle, which mirrors the tablet you have in front of you. The Windows 10 approach is much more useful.

Continuum does have its quirks, however. On my system, I couldn't rename a Word file as I was using it. Word also crashed once, then returned a black screen after I relaunched it. (A subsequent relaunch worked as expected, and the universal apps' practice of constantly saving, er, saved me.) Things looked a bit stretched-out on a

widescreen monitor. And to minimize or close an app, you need to slide your cursor to the top-right corner—there are no visual cues telling you otherwise.

I was very pleased at how I could sit down, open a Word file, begin taking notes on my experience, then return to my desktop PC and pick up where I left off, because everything is saved in the cloud. There's one major limitation: Continuum works only with universal apps for now, such as Outlook/Mail, Messaging, Word, Excel, and Calendar. According to Microsoft, this was for functionality—the company didn't want a lot of oddly formatted apps clogging the Continuum screen—but hopefully the app list will continue to expand.

Windows Hello: a cantankerous convenience

Windows Hello eliminates the need to constantly retype a PIN code by allowing the phone to visually recognize you. It's Microsoft's answer to

Windows Hello looks for your eyes to identify you.





Windows Hello setup requires gazing soulfully into the Windows phone's camera for a few seconds.

the fingerprint readers built into the latest Nexus 6P or Apple iPhone. In general, though, I found performance to be a mixed bag.

Microsoft's recent Surface Pro 4 (go.pcworld.com/sp4rev) and Surface Book (go.pcworld.com/surfacebookrev) use special camera modules that scan your face to create a custom image to compare against the faces the camera subsequently sees. On the desktop, Hello authenticates you almost instantaneously.

The Lumia 950 and 950XL, on the other hand, scan the irises of your eyes to authenticate you. Setup requires allowing the phone's front-facing camera to scan your eyes for several seconds while it creates a reference image. After that, logging into the phone is as easy as looking into the camera's lens.

When Hello works, that's all it takes to unlock the phone. But if you're not holding the phone just so, or the light is a bit off, or you're too close or too far away, then simply tapping your phone's four-digit PIN is sometimes the only thing that works. I gave Hello a second or two to work its magic, and if it didn't take, I just entered my PIN.

Universal apps tie the Windows 10 phone to the PC

Everyone knows about the "app gap"—the sparse supply for Windows Phones compared to the plethora that Android and iOS enjoy. For

better or for worse, Microsoft is making the most of what it has by doubling down on the basic productivity message inside its own universal apps.

It's here that owners of older Windows phones will see the advantages of Windows 10 Mobile, regardless of their hardware. From a UI perspective, Windows 10 uses the same Live Tile interface as Windows Phone 8.1, but with a more muted style that emphasizes wallpapers rather than brightly colored tiles. Menus and options are much more organized, with a nice array of quick-action shortcuts that can be slid down from the top. Dedicated hardware buttons have been replaced with soft icons that slide in from the bottom.

Because they're universal, Windows 10 Mobile apps—Outlook (formerly Mail), Calendar, Maps, Messages, the Store, and more—are designed with the same features as their counterparts on a Windows 10 desktop. Certain apps, however, become more significant on a Windows 10 Mobile phone.

A good example is Maps, an afterthought on the PC but a critical

**My Windows
10 Mobile**
home screen.



part of Windows 10 Mobile. Maps delivers the essentials: a basic map view with traffic options, a lovely satellite view (without the need to launch a separate app), and local search that integrates with Yelp, including reviews, pictures, and hours of operation.

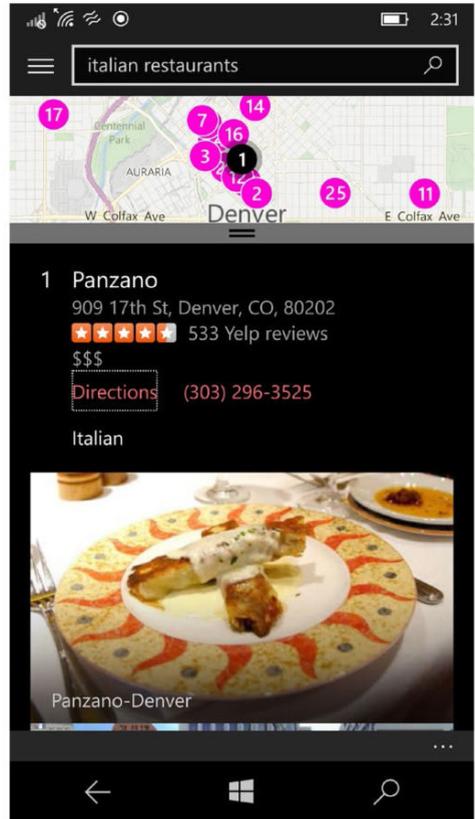
Other key mobile apps include Camera, whose manual controls have now been supplemented with Microsoft's lovely Rich Capture feature, allowing you to dial HDR effects up and down with a slider. Skype messaging has been drawn into the Messaging app, though Skype remains as a standalone app, as does Skype video.

Who could forget about the Office apps—Excel, Word, PowerPoint, and OneNote—which tie into the cloud and into Cortana (“take a note”) as well. Edge is now built in as the default browser, with Reading List entries roaming among platforms. And, of course, there's Cortana, who's grown progressively smarter.

Third-party universal apps include Audible, Box, Candy Crush Saga, CBS, Facebook (forthcoming), FitBit, NASCAR, Shazam, and Twitter, to name just a few. But in general, Microsoft is still shouldering the load.

The bottom line: Microsoft can only do so much

Recent figures put Windows Phone's market share at under 2 percent. It's not clear whether Windows 10 Mobile will do anything to change that. Developers still prioritize Android and iOS first, with Windows as an afterthought.



The Windows 10 Mobile Maps app.

It's important to note, however, that Microsoft's plan to encourage developers to port iOS and Android apps to Windows hasn't yet come to fruition. Microsoft's Android-to-Windows developer effort, Project Astoria, has reportedly failed; however, the program to port iOS apps, Islandwood, is still flourishing. Both roads lead to the same destination. If Microsoft can succeed in convincing app developers to port their apps to Windows, that will add immediate credibility to the mobile platform for both consumer and developer alike. But it all needs to happen soon.

That's the key to Windows 10 Mobile's future viability. We wrote last year that Microsoft needed to unearth what made a Windows Phone unique, and capitalize on it with a flagship phone. It's done so, putting itself out there as the phone for business users everywhere. My verdict for Windows 10 Mobile and the Lumia 950 is a passing grade.

But the fate of Windows phones, I think, is out of Microsoft's control. The company has done so much to entice consumers to Windows phones: previews, incorporating consumer feedback, free upgrades, universal apps, Continuum, you name it—and yet its market share continues to decline. I'd say in a year or two, we'll know: Windows will either continue as its own smartphone platform, or be reduced to a collection of services on Android and iOS phones. 🛑

My verdict for
Windows 10
Mobile and the
Lumia 950 is a
passing grade.

Microsoft Lumia 950: Continuum makes it the first flagship for Windows 10 Mobile

BY MARK HACHMAN

I CAN'T HELP but be hopeful for the future of Microsoft's Lumia smartphones after using the Lumia 950 (go.pcworld.com/lumia950). A few bugs detract from the wow factor of Continuum—a key feature that transforms the phone into a PC-like device—but as a total package the Lumia 950 shows Microsoft is moving in the right direction.

The camera is excellent, as is traditional for the Lumia line. The phone's overall performance is satisfying, and the 950's 5.2-inch,



2560x1440 display is on a par with the screens of many top-end (albeit previous-generation) phones, including the Samsung Galaxy Note 4 and Motorola Nexus 6.

But Microsoft's latest Lumia offers a fantastic feature you won't find anywhere else: Continuum. It transforms your phone into a PC, though it works best with a dedicated \$99 peripheral.

The Lumia 950 includes a new beta version of Windows Hello, which I found to be a mixed bag. I've also spent some frustrating minutes wrestling with the phone's Rich Capture feature to apply HDR filtering post-shot, and suffering repeated crashes. Still, this is the first phone to include Windows 10 natively (see our *Windows Mobile 10* review on page 112) and it's noteworthy because of that alone.

For now, think of the Lumia 950 (\$600 unlocked or \$150 with a two-year contract from AT&T) as a junior varsity player, with the larger, more powerful 5.7-inch 950XL warming up on the sideline. We'll hopefully have the larger phone in for review soon.

Solid construction

We tested the AT&T variant of the Lumia 950 (although the phone didn't come with a working SIM card). At 5.7 inches long, it's about a quarter inch longer than the Lumia Icon, Microsoft's 18-month-old former flagship, though boasts a similar width at 2.87-inches. It weighs 150 grams—about 17 grams lighter than the Icon. The 950 is sturdy, yet comfortable to hold, with rounded corners and a prominent "Microsoft" logo at the top.

The Lumia 950 uses a plastic backing, suggesting another mid-range or low-end effort, which has disappointed Windows Phone fans for the past year.

Microsoft Lumia 950

AT A GLANCE

The Lumia 950 is one of the first phones to combine Windows 10 Mobile, Windows Hello, and support for Continuum, along with the traditionally strong Lumia cameras.

PROS

- Lumia camera hardware continues to excel
- Finally, a Windows flagship phone!
- Continuum technology is really terrific

CONS

- Most will probably buy the larger Lumia 950XL
- Windows Hello is less effective than on Surface tablets
- Some noticeable bugs mar the experience

\$600





But despite its poor exterior messaging, the 950 contains a 6-core, 1.8 GHz Snapdragon 808 chip, 3GB of RAM, and 32GB of internal storage. And that plastic backing is removable, hiding a 3,000 mAh battery inside.

A relative dearth of cross-platform benchmarks (and the thin crowd of Windows Phone benchmarks, period) make for poor comparisons. That said, the Lumia 950 tops the Icon by about 30 percent in the MultiBench CPU benchmark, and blows the mid-range Lumia 830 ([go.pcworld.com /lumia830](http://go.pcworld.com/lumia830)) from November 2014 completely out of the water. We ran games like Asphalt 8: Airborne with no noticeable stutters during gameplay.

That generally puts the Lumia 950 well above its Windows Phone predecessors in terms of compute power. But the phone also tends to get quite warm, especially while charging. We noticed a drop in performance when running benchmarks soon after, evidence of thermal throttling.

With the Lumia 950, Microsoft's Lumia line enters the USB-C generation. No more fumbling around to orient a USB cable the right way.

The Lumia 950 is the first Lumia to use the new USB-C connector, which delivers improved wired connection speed, as well as quick charging. Microsoft says that its charger can charge the phone up to 50 percent in about half an hour, and we'd agree. Don't lose the charger and cable, however, as all of your MicroUSB cords from years past won't fit.

Lumias are known for strong battery life, and I ran the Lumia 950 from 2 pm until 8 pm the next day before it conked out—this with the battery-draining “Hey Cortana” active-listening turned on. According to WPBench’s own battery test, the phone ran for 2 hours 54 minutes with the display constantly on and the CPU pegged at maximum in an endless loop. That’s on a par with other Lumias, such as the older Icon.

Hello, Continuum

As noted above, there are four reasons to buy this phone: Windows 10 Mobile, Continuum, Windows Hello, and the Lumia camera. We've separated the first three into their own separate evaluation of Windows 10, but they're worth briefly reviewing here.

Windows 10 Mobile should be familiar to anyone who's tested the Insider previews. For those who haven't, know that Windows 10 focuses Windows 8 into a more organized arrangement of apps and tiles. The vast majority of Microsoft apps are “universal,” meaning that they'll mimic the look and feel of Windows 10 PC apps, and vice versa. In fact, those apps will scale to fill the available space. This is the entire premise of Continuum, which allows you to connect the 950 or 950XL to an external monitor either wired or wirelessly, and then use universal apps across the display's real estate.

I like Windows 10 Mobile, although I suspect that Microsoft may

Performance benchmarks show that the Lumia 950 is substantially faster than its predecessors.

Phone	Antutu 0.8.0 beta	WPBench 2.6 Free	Multibench 2.4 CPU	Multibench 2.4 GPU	Sunspider 1.0.2
Lumia Icon	24442	511.5	30.658	46.049	538.3
Lumia 929	25834	515.11	31.176	45.408	540.2
Lumia 830	11587	244.01	15.388	47.476	1203
Lumia 950	25204	616.32	39.59	9.791	468.2



In almost full
dark, the Lumia
950 flash
illuminates
objects well,
without
blowing them
out.

have some bug-fixing to do. I noticed some unexpected behavior on occasion: The first time I powered on and set up the 950, for example, the Settings app crashed to a black screen. Other apps occasionally disappeared too—although I suspect part of that had to do with my thumb drifting from the spacebar on the soft keyboard down to the soft Windows key that slides up from the bottom of the screen, replacing the dedicated Windows keys of Lumias past. But the performance, at least on the Lumia 950, is otherwise everything you'd expect of a finished OS.

Microsoft also built in a beta version of Windows Hello that's less effective than what it's built into its Surface line. The Lumia 950 uses the iris of your eyes to identify you, but often requires a few seconds to do so. If you're like me, that's enough time to become impatient and unlock your phone manually instead.

Software muddies the Lumia 950's camera

I confess that I remain an unabashed fan of the Lumia camera hardware, which has slightly improved from, say, the Icon. The Lumia 950 includes a 1/2.4-inch sensor that backs the 20-megapixel, f/1.9 camera. A

“natural flash” helps illuminate more of the scene, while preserving the natural colors of images captured in very low light. And, yes, there’s a physical camera button.

From a software perspective, however, I’m less pleased. One of the key features of the new phones is Rich Capture. Previously, Rich Capture snapped one image of a scene with the flash off, and one with flash on, and after the shot, the camera allowed you to “adjust” the flash exposure by computationally blending the images. With the 950, unfortunately, the hardware now applies HDR instead.

Now, after taking your shot, there are several seconds while the Camera app “applies the finishing touches” before allowing you to do anything with the Rich Capture post-processing—and the app sometimes crashes or simply doesn’t work. Oddly enough, the included Lumia Creative Studio brought out some of those low-lights through its auto-enhance feature.

The Rich Capture

feature allows you to subtly enhance dark areas of a picture using HDR, if you wish.





I also noticed that while you can choose the size of the captured image and the aspect ratio, the Camera app doesn't allow you to select from a list of resolutions—although the video app does. I also saw a bug where the video resolution options wrap into an infinite loop, though I'm sure that will be fixed quickly.

My complaints aside, the Lumia 950 virtually eliminates shutter lag, and the colors it captures are as vivid as ever. Still, many other smartphone platforms now include the “professional” manual options that the Lumia series pioneered, potentially siphoning off the periphery of the Lumia user base.

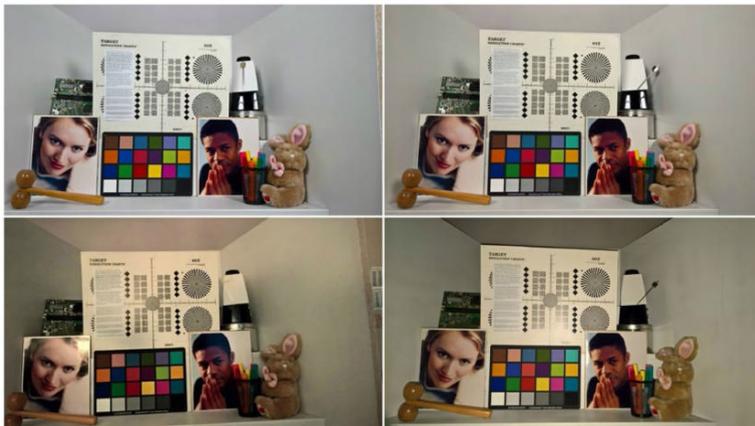
The verdict

Cynics might say that Windows 10 Mobile and the Lumia 950 will continue to be crippled by a lack of popular apps. And they might also point out that Continuum, the “wow!” factor of the Lumia, is really

Colors are captured well on the Lumia, as usual. But it's here where I wanted to use Rich Capture, and I couldn't.

only best enabled via a peripheral, the \$99 Display Dock. As for the camera, well, every phone's got one, right?

If you've owned a Lumia before, you'll probably just shrug at that. Microsoft's phone platform may be shrinking at under 2 percent of all users, but the company's fans are loyal. And, armed with the Lumia 950 and the Display Dock, they'll be able to show off Continuum, a feature that's unique to Windows Phone. 



Sample shots taken with the Lumia 950, clockwise from upper left: full light, minimum light, lamplight with flash on, lamplight with flash off.



*“I want
to be
a bench.
Recycle me.”*



IWantToBeRecycled.org

SoftGozar.com



KEEP AMERICA
BEAUTIFUL

Three big companies.
One big year. See
how these tech
titans fared in the
wisdom of hindsight.

BIGGEST WINS, FAILS, AND WTF MOMENTS OF

2015



Microsoft

Google





Watch the video at go.pcworld.com/ms2015



IDG.tv

MICROSOFT'S BIGGEST HITS, MISSES, AND WTF MOMENTS OF 2015

The tech giant righted itself this year, improving key products—and delivering a few, true surprises.

BY MARK HACHMAN

Windows 10. Surface Book. HoloLens. Office. Microsoft arguably delivered the biggest updates, changes, and surprises of any major tech company this year, most of them positive.

While Microsoft deserves credit for the good, it can't escape the bad—and it ends the year with a few notable disappointments. Look back with us on a very busy year for Microsoft. We've winnowed the list to the biggest hits and misses.



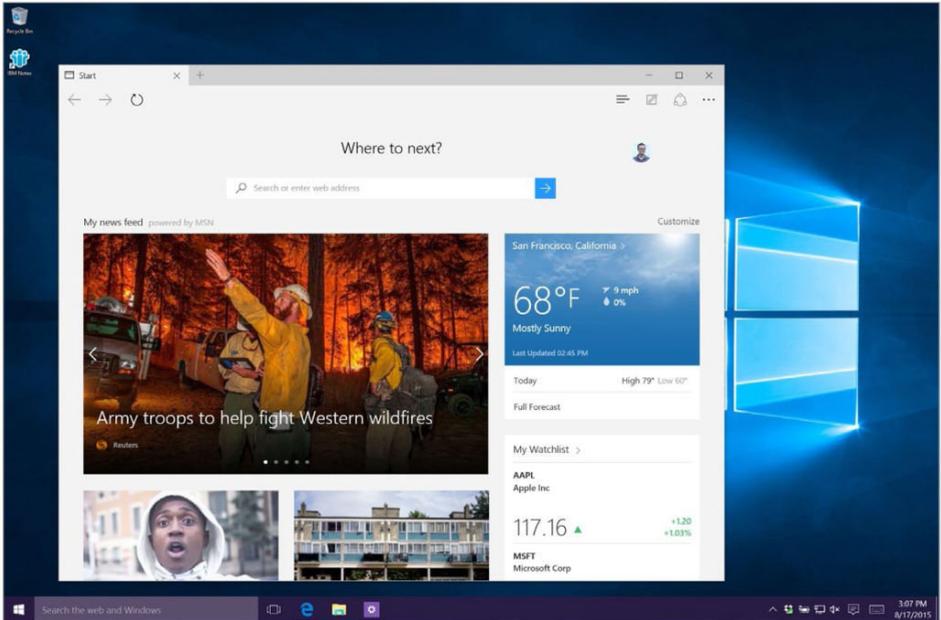
HIT

WINDOWS 10

Windows 10 was the do-or-die makeover for the company's flagship operating system, and in most ways, Microsoft delivered. It removed the worst of Windows 8, brought back the best of Windows 7, and added cool innovations like the Cortana virtual assistant and universal apps that promise to work across all Windows platforms. It isn't even charging for the OS (yet).

Some of Windows 10's big changes are less welcome: its forced updates (go.pcworld.com/w10forcedupgrade), for example, and its eagerness to watch your online activity (go.pcworld.com/w10privacy) so it can help you (or sell you) more. That may help explain why

Windows 10 was still only the third (or fourth, depending on how you look at it) most popular operating system in Microsoft's lineup. But we still call it the [best OS since Windows 7](#).



MISS

MICROSOFT EDGE

So far, it's hard to see what Microsoft accomplished with the release of the new Edge browser. It might be more secure than Internet Explorer, and it's been integrated with Windows 10—but that's about it. At launch, Edge underperformed virtually every other browser. Though it has markedly improved since then, a lack of features—including plug-ins and syncing across platforms—makes Edge just another Microsoft browser we'll use to download competitors like Google Chrome, at least on desktop PCs. On Windows phones, though, it's not too bad.



HIT

SURFACE PRO 4 & SURFACE BOOK

Microsoft has suddenly become a hotshot hardware company. The Surface Pro 4 managed to improve upon the exemplary Surface Pro 3—the combination of Intel’s Skylake processor and an upgraded chassis design eliminated nagging cooling issues. Microsoft’s Surface Book, meanwhile, is a showstopper: a 2-in-1 with a keyboard that houses an extra battery and even an external GPU. Some lingering driver issues have held back both devices—the same sort of bugs that plagued the Surface Pro 3 during its early days—but they’re still outstanding ambassadors for the Windows 10 platform.

MISS

WINDOWS 10 MOBILE OS AND HARDWARE

If only Windows 10 Mobile could borrow some of Windows 10’s mojo. The operating system offers little to convince existing Android and iOS owners to switch: Its user experience is a bit blah, and there’s still the persistent “app gap.” As of early December, Microsoft had yet to roll out Windows 10 to owners of older Windows Phones, meaning that for the bulk of Windows Phone owners, the jury is still out.

Meanwhile, Microsoft's first flagship phone in almost two years barely placates the Windows faithful. Compared against other Windows Phones, the Lumia 950 and larger 950XL represent a true leap ahead—but not when compared to cutting-edge hardware in the Android and iOS camps. They're a solid “me-too” effort rather than a home run—and really, the ecosystem needed the latter. Could a rumored Surface phone save the day?

Of course, there is that one standout feature...

**HIT****CONTINUUM**

Yes, Continuum is something to be genuinely excited about. Yes, it requires a standalone peripheral (either the Display Dock or a Miracast dongle). But what's nifty about Continuum is that Microsoft's universal apps can be projected onto the larger screen—including Microsoft's superior Office Mobile apps, which are supposed to be free only on phones or tablets smaller than 10 inches. Most importantly, Continuum allows Microsoft to claim that a Windows phone can be a PC, too—something that none of its competitors can say yet.



HIT

HOLOLENS

Microsoft's first stab at augmented reality is an undeniable success, even though it has yet to ship. Microsoft's unveiling of the HoloLens in January generated more excitement than possibly any other product announcement in the company's history, and the early hands-on demonstrations (go.pcworld.com/hololens) were jaw-dropping.

There are caveats: It appears HoloLens won't ship until 2016 at the earliest, and even then, only as a developer product. The field of view in which 3D holograms are overlaid on top of real-world objects has seemingly shrunk with each iteration. No one's quite sure exactly what it will be good for, or what it will cost, and so on and so on. But what an absolutely amazing piece of technology.

MISS

MICROSOFT BAND 2

What's black like the HoloLens, curved like the HoloLens, and yet not quite as amazing a piece of technology? Microsoft debuted a second

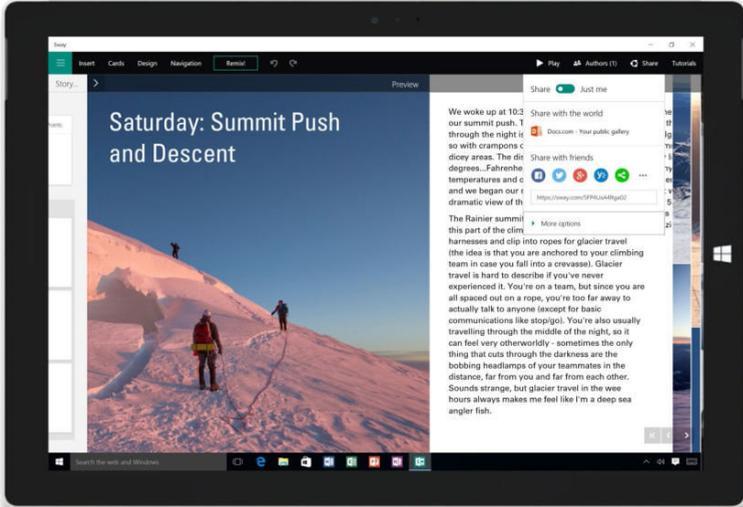


generation of its Band fitness tracker this year, and it still doesn't impress. Sure, it's not really a smartwatch, but we must nevertheless compare its paltry, 20-odd fitness apps to the voluminous collections available for Apple Watch and Android Wear devices.

A recent update seems to signal a greater commitment by Microsoft to developing the Band, but it's going to take more than a few new tiles to make a dent in the wearables market. Perhaps Microsoft is holding out until a proper Windows 10 IoT version launches, such as a third-generation Band. Then can we call it a smartwatch?

HIT**OFFICE 2016**

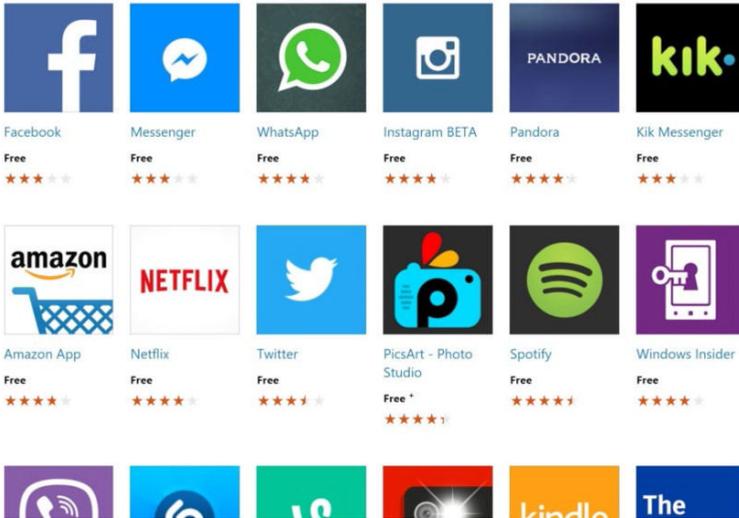
Whether you buy the standalone version or an Office 365 subscription, Office's latest iteration is optimized for team collaboration—one of



the chief demands, we imagine, of Microsoft's enterprise customers. In this, Microsoft delivers. We like the "tell me what to do" feature that cuts through the menu clutter, as well as the new Sway content publishing app. It keeps the business faithful happily productive while also quietly introducing new capabilities that Office will need to stay relevant in a rapidly shifting software landscape.

MISS PROJECT ISLANDWOOD, PROJECT ASTORIA, AND THE WINDOWS APPS MARKET

Microsoft impressed developers and journalists alike by announcing plans to alleviate the Windows 10 "app gap" by providing tools for porting Android and iOS products to Windows 10 and Windows 10 Mobile. The "Project Astoria" bridge to port Android apps to Windows has reportedly stalled, however, leaving its iOS-to-Windows toolset, Project Islandwood, as the last hope. Islandwood, though, is in an "alpha preview" state, and we're not likely to hear anything more about it until March, when Microsoft

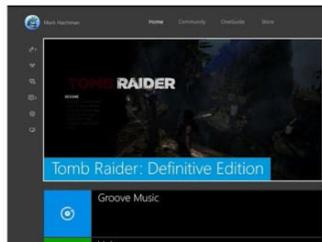


holds its next Build developer conference. Meanwhile, the Windows app market languishes, both on mobile and desktop.

HIT

NEW XBOX ONE EXPERIENCE

Microsoft's revamp of the Xbox One interface reminds me more of a webpage than a game console, but it also provides a backdrop to two other, fantastic features: streaming games from the Xbox One to Windows 10 PCs, and backward compatibility to dozens of games for the Xbox 360. You might think that Microsoft would charge for such features, but no—they're both free. And more features are to arrive in the coming months, including Microsoft's digital assistant, Cortana.



MISS

CUTBACKS IN ONEDRIVE STORAGE

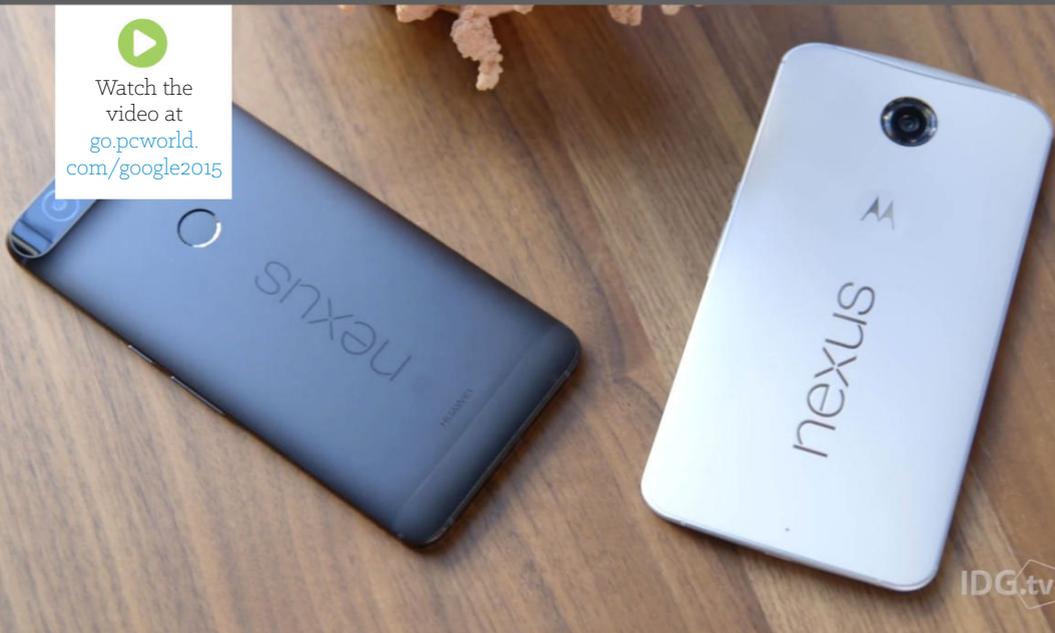


In 2014, Microsoft promised that Office 365 subscribers would eventually receive unlimited OneDrive storage. Microsoft went back on its word. Customers went nuts, but it was too late: Microsoft had taken a moonshot promise and brought it crashing back to earth. Thank goodness for Google and Amazon, right?

Wait: Just a recently, Microsoft quietly launched a preview site for keeping your OneDrive space—but there's a catch. From the rude initial news to this almost reluctant backtracking, this is a miss Microsoft could have avoided by not messing with a good thing. 🛑



Watch the video at go.pcworld.com/google2015



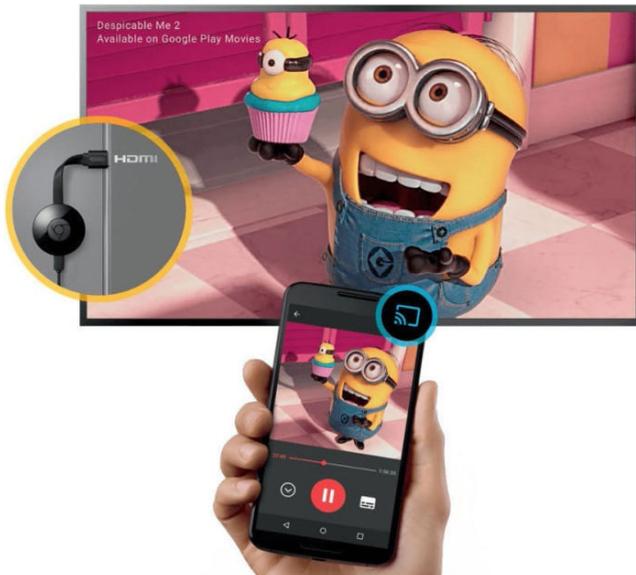
GOOGLE'S BIGGEST HITS, MISSES, AND WTF MOMENTS OF 2015

The mega-company's products and services still managed to shake things up—for better and worse.

BY JARED NEWMAN

For Google, 2015 was a year of transformation, as the company breathed new life into old products, got serious about some previously experimental efforts, and even announced a major restructuring. But it was also a year in which the past caught up to Google, with previously minor nags turning into bigger headaches.

Here are the highlights and lowlights of Google's 2015.



HIT

CHROMECAST CASHES IN

Not everyone was sold on Google's cheap streaming video dongle when it first launched in 2013. But two years later, Chromecast is an unequivocal hit, with 20 million units sold to date. Although the 2015 upgrade isn't a major improvement, it doesn't need to be; new software features and a booming app selection have allowed even the original Chromecast to get better with age.



MISS

ANDROID WEAR DOESN'T GET WORN

Google-powered smartwatches made lots of progress this year, with iOS support, better standalone functionality, and a bunch of better-looking hardware. But so far those efforts haven't translated to significant sales. A November report by Canals claimed that no smartwatch vendor shipped more than 300,000 units in the previous quarter except Apple, which moved nearly 7 million smartwatches by comparison. If there's a key to widespread smartwatch success, Android hasn't cracked it yet.

HIT

GOOGLE PHOTOS SUBTRACTS THE 'PLUS'

Google's photo storage service was always doomed to obscurity as a social networking by-product, and 2015 was the year Google finally acknowledged it. Liberated from



Google+, the new Google Photos is far more compelling, especially with features like automatic (and private) facial recognition. As before, free storage is unlimited if you agree to let Google compress your photos.



MISS

MAP MAKER'S INDECENT EXPOSURE

Google wasn't directly to blame when an image of the Android mascot urinating on an Apple logo appeared in Google Maps last April. Instead, the user-created prank illustrated a serious lack of oversight in Google's Map Maker tools. The embarrassing Easter egg prompted Google to shut down Map Maker for four months while the company worked on better moderation schemes.



HIT

SELF-DRIVING CARS HIT THE ROAD

Although Google has been retrofitting SUVs with self-driving hardware for years, in 2015 a new fleet of prototypes (go.pcworld.com/selfdrivingcars2015) arrived with automation in mind. (Riders can even detach the steering wheel.) They've been cruising the streets of Mountain View and Austin since the summer, capped at 25 mph, with human minders-slash-drivers required to be on board. The path to commercialization is murky, but you can be sure the auto industry is paying very close attention now.

MISS

FEELING THE SQUEEZE FROM APPLE

Google loves to talk about the growth potential for mobile search, but the ugly truth is that three-quarters of the company's current mobile ad revenue comes from iPhones and iPads, the *New York*



Times reported this year. That dependence could become a liability as Apple keeps pushing Google out of the iOS ecosystem. With more powerful search built into iOS 9 Spotlight, and the arrival of Safari ad-blockers, Google's money-making opportunities may shrivel. It's unclear whether app streaming (go.pcworld.com/appstreaming) and deep linking can compensate.



HIT

NEXUS PHONES FOR EVERYONE

Buying an unlocked Nexus phone used to be tough to justify, especially in the United States, where carrier subsidies once reigned. But that's changed with the rise of contract-free service on all the major carriers, who offer cheaper monthly bills when you bring your own phone. The new Nexus 5X (go.pcworld.com/nexus5xrev) and 6P (go.pcworld.com/nexus6prev) are the perfect candidates for this type of service, with bloatware-free versions of Android and some of the best cameras on the market.



MISS

ANDROID CATCHES STAGEFRIGHT

Android's security reputation took another hit this year with Stagefright, a vulnerability that allowed remote device takeover (go.pcworld.com/stagefright) with a simple MMS. Although Google quickly patched the problem (go.pcworld.com/stagefrightfix) on its end, and noted that Stagefright was only proven in a laboratory setting, many users won't ever see a fix, as device makers and wireless carriers fail to keep their software up to date. Meanwhile, researchers keep discovering new vulnerabilities (go.pcworld.com/androidatrisk), further eroding confidence that non-stock versions of Android can remain secure.

HIT

JUST A LETTER OF THE ALPHABET

Arguably the strangest Google news this year was the creation of an entirely new company called Alphabet, in which Google would be just

a subsidiary. Other parts of Alphabet include Verily (formerly Life Sciences), with its glucose-sensing contact lens and longevity efforts, and Access (go.pcworld.com/googleaccess, for Google Fiber and connectivity projects). The jury's still out on whether this restructuring really matters, but it at least shows confidence that Google's weirder experiments can become legitimate businesses.



is for Google



MISS

**OKAY, GO AHEAD
AND BE EVIL**

Google's switch to Alphabet did bring one immediate drawback: Its code of conduct no longer says "don't be evil," and instead tells employees to "do the right thing—follow the law, act honorably, and treat each other with respect." The new code is arguably more realistic, but it also notes that the board can approve "waivers of this Code for directors or executive officers." Finally, the company's top brass have the freedom to be as nefarious as they like. 🚫



Watch the video at go.pcworld.com/apple2015



APPLE'S 10 BIGGEST WINS, FAILS, AND WTF MOMENTS OF 2015

New Apple TV? Yes! Apple Pencil delays?
Boo. Apple car? Hmm...

BY CAITLIN McGARRY

As Apple makes more and more money by selling more and more iPhones, it seems like the company barely has to try to remain at the top of the heap. And yet 2015 was one of Cupertino's biggest years ever in terms of innovation, with product refreshes almost across the board (sorry, Mac Pro), a new device category (hey, Apple Watch), and a streaming service to rival Spotify.

But the shiny patina of new devices didn't distract anyone when Apple missed the mark this year, as it sometimes does. From the weird staggered rollouts of the Apple Watch in spring and Apple Pencil in fall to Apple Music's iCloud disaster, Apple wasn't without its missteps in 2015.

Then there were the head-scratching rumors, the indecipherable product decisions, and more moments that made us go, "Wait—what?" Let's recap Apple's big year.



HIT

RECORD-BREAKING IPHONE SALES

Apple made \$32.2 billion by selling 48 million iPhones in the last quarter of 2015, capping off what CEO Tim Cook called Apple's "most successful year ever."

The company's revenue grew to almost \$234 billion in the fiscal year, which included just two days of iPhone 6s and 6s Plus sales. Apple

sold 13 million iPhones during that launch weekend, and is expecting to make between \$75.5 billion and \$77.5 billion when it reports holiday quarter earnings at the end of January.

The iPhone has been on the market for eight years, so how does Apple continue to sell so many? It's thanks in part to China—the Chinese continue to buy iPhones in droves, and this time around, the country was one of the latest model's launch day markets.

**HIT**

(ALMOST) EVERYTHING IS NEW

Apple didn't just put out new iPhones, as it does every fall. Practically every product in the company's lineup was refreshed in 2015. We got new MacBooks, including a 12-inch gold model, iMacs, the long-awaited 12.9-inch Pro (go.pcworld.com/ipadprorev) and a high-powered iPad mini, a completely overhauled fourth-generation Apple TV, an entirely new product category with the Apple Watch.

These hardware updates weren't minor ones, like the lackluster iPad mini 3 released last fall. The new iPhone's flagship features (go.

pcworld.com/iphone6rev) include 3D Touch and a revamped camera; the iPad mini 4 is now as powerful as an iPad Air 2, the new MacBook is the most portable laptop around; and the Apple TV has a full-fledged App Store and Siri integration.

This year was huge for Apple hardware.



APPLE TV'S LONG-AWAITED REBOOT

The new Apple TV (go.pcworld.com/appletvrev) deserves a separate shout-out for being a really, really good set-top box. Apple waited three years to overhaul the TV, and in that time it was left in the dust by rivals Roku, Amazon Fire TV, and even Google's Chromecast streaming stick.

That ended in November with the new Apple TV, which has its own App Store and a healthy roster of must-have apps, plus a brand-new touchpad remote with Siri integration. It can even support games, with the touchpad remote substituting for a game controller (unless you want to shell out more for an MFi game controller.).

The Apple TV isn't perfect—although it's gotten better after a key software update (go.pcworld.com/tvos91)—and more tvOS apps are desperately needed. Plus, we still have hope that Apple will cut through the red tape and pull off a live TV streaming service that will let us finally cut the cord. But the fourth-gen TV is better than ever, and its \$149 starting price tag isn't too bad, either.

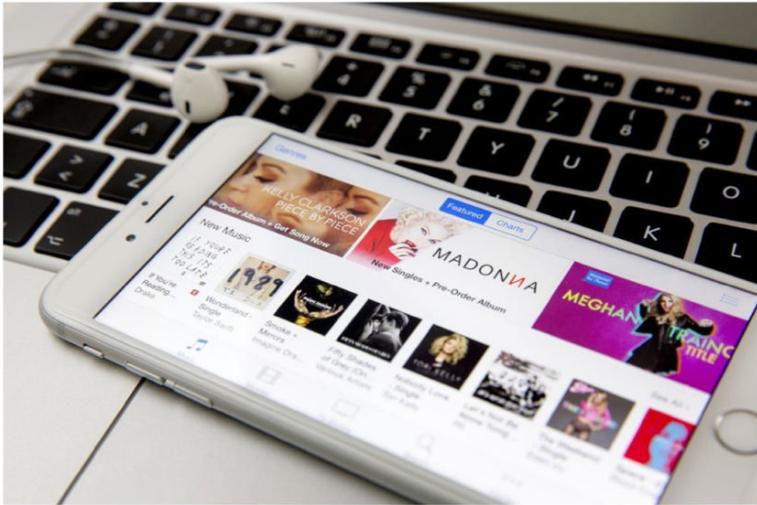


HIT

APPLE WINS OVER TAYLOR SWIFT

Apple Music ran into trouble before it even launched (and then some more trouble afterward, which we'll get into later), but the company managed to get the world's biggest pop star on its side.

ICYMI: Apple was planning to withhold royalties during the free 3-month trials offered to Apple Music subscribers, and when Taylor Swift caught wind of this, she took to Tumblr to post a gently admonishing open letter to the company. They listened, promising to pay royalties during the free trials after all, and Swift endorsed the service by offering up her 1989 album to stream for the first time, then giving Apple the exclusive rights to her 1989 World Tour Live documentary that aired Dec. 20. (Apple paid Swift for that pleasure.) It was a win for all involved.



MISS

APPLE MUSIC AND THE SCRAMBLED LIBRARIES

Apple rolled out Apple Music on desktops with iTunes 12.2, bundling its streaming library with your iTunes purchases with the help of iCloud Music Library. But when iTunes users enabled iCloud Music Library to merge streaming tracks with purchased ones, they watched iTunes mangle their existing libraries.

In some cases, there were minor problems like album artwork gone wrong. In other, more serious circumstances, iTunes wiped or corrupted thousands of tracks from some libraries, resulting in hundreds of angry Apple support forum complaints and one very high-profile rant (go.pcworld.com/applemusicrant).

Apple Music managed to rack up 15 million listeners in spite of the ruckus, though who knows how many more subscribers would've stuck around if their libraries had remained intact?



MISS

WHERE'S THE APPLE PENCIL?

The 12.9-inch iPad Pro launched in November with two complementary accessories, the new Smart Keyboard and Apple Pencil (go.pcworld.com/applepencilrev), the company's first iPad stylus. Without the stylus, the new tablet is just a really, really big iPad. With it, creatives have a tool that makes the most of all that screen real estate. So when the iPad Pro went on sale and its accessories, specifically the long-awaited Pencil, were in short supply, Pro buyers were more than a little unhappy. While the Smart Keyboard was also on back order, Apple was also selling an excellent third-party option, Logitech's Create. Apple Pencil has no equivalent, so its absence was a frustrating one for Pro users who had to wait weeks to use the giant tablet to its full potential.

MISS

THE STRANGE APPLE WATCH LAUNCH

For its most personal device ever, Apple restricted purchases to online only. Buyers couldn't line up at Apple stores to snag an Apple Watch (go.pcworld.com/applewatchrev) at the height of the hype, and some watch models were on back-order for weeks after launch.



Not being able to buy Apple's latest device anywhere but online at Apple.com was a bit of a shock for buyers used to finding the latest gadgets in retail stores, too. In fact, as *Macworld* columnist Jason Snell said, the real Apple Watch party didn't start until six months after its release, when Apple finally was able to fulfill demand in launch countries and widened the watch's availability to include third-party retailers.

MISS

MALWARE HITS iOS APP STORE

2015 will be remembered as the year malware finally penetrated the iOS App Store (go.pcworld.com/iosappstoremalware), proving that Apple's walled garden isn't impervious to infection. Before this year, you mainly had to worry about malware on jailbroken devices, because Apple's App Store approval process is notoriously tough. But this year, the iOS App Store was hit twice with malware scares, both times in China.



Apps infected with malware managed to bypass the company's security safeguards by using a modified, sketchy version of Xcode, the code used to write apps for iOS, OS X, watchOS, and tvOS. Developers in China downloaded XcodeGhost, an infected version of the code, from Chinese servers because the process was faster. Then those apps distributed the malware after gaining entry to the App Store.

YiSpecter, another malware strain, popped up just weeks later, also in China, but was less severe than XcodeGhost.

XcodeGhost (go.pcworld.com/xcodeghost) didn't have a huge impact on apps, but it proved that sometimes developers will take shortcuts that Apple didn't foresee, jeopardizing the safety of your devices in the process. The going rate for hacking iOS is \$1 million, so Apple's software is still incredibly secure, but the scares this year prove it's not perfect.

MISS

THE NEW MACBOOK

Apple's lithe 12-inch MacBook combines technologies that aren't yet standard, but could be one day. The Force Touch trackpad, super thin keyboard with reduced key travel, and lone USB-C port make the new MacBook a truly next-generation laptop, which is awesome in theory. In reality, the keyboard isn't the easiest to type on, and the USB-C connector makes the new MacBook incompatible with basically every other device you own.



It's frustrating for now, because the USB-C ecosystem (go.pcworld.com/usbc) is still so small. That will change in the future, but people who drop \$1300 on the 12-inch MacBook will face struggles that buyers of other MacBook models don't, at least for awhile longer.



MISS

THE APPLE CAR RUMORS

This one is a head-scratcher for sure: Earlier this year, rumors began to swirl that Apple was recruiting a slew of car experts to join the company. At the same time, Apple CEO Tim Cook and design chief Jony Ive began hinting in press interviews that the automobile space was an interesting one. Of course, Apple hasn't come out and said, "Hey, world, we're building an electric car!" But all signs point to a secret auto project (go.pcworld.com/applecar) in the works at 1 Infinite Loop.

Let's review the evidence: Apple has hired not just car experts, but specialists in deep learning and artificial intelligence. It's unclear if Apple is exploring an electric car or a self-driving one, but over the summer, documents revealed that Apple was on the hunt for a private facility to test something—presumably a car, since that facility is a former naval station where other self-driving vehicles have been tested. Then in August, Apple execs met with California Department of Motor Vehicles reps to discuss the state's self-driving vehicle regulations.

Apple has been interested in cars for some time—that's why the company developed CarPlay, which puts the iPhone experience in your car's dashboard. We wouldn't be surprised if Ive designed the coolest car on the block—we're just not expecting it anytime soon. 🚗



**“ SURE,
AT FIRST I WAS A LITTLE TAKEN ABACK
BY THE WHOLE PEEING STANDING UP THING.
BUT I TAUGHT HIM TO THROW A STICK
AND NOW HANGING OUT WITH HIM
IS THE BEST PART OF MY DAY.”**

**– EINSTEIN
adopted 12-09-10**

**A PERSON
IS THE BEST
THING TO HAPPEN
TO A SHELTER PET**

 **adopt**

theshelterpetproject.org



HERE'S HOW

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icons: How to clean
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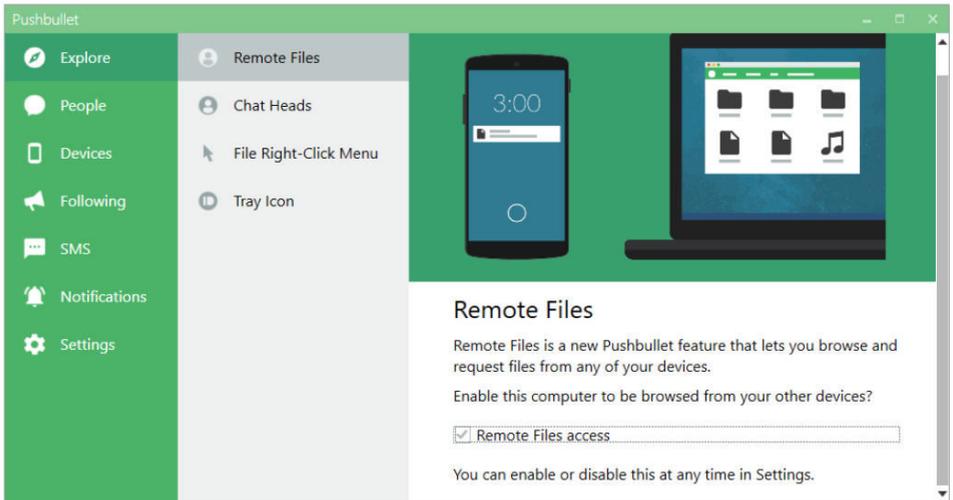
Two easy ways to remotely access files on your PC

WE'VE TALKED BEFORE about how syncing files across all your devices is only as useful as your ability to put the files you need in the right place. When that doesn't happen, it's handy to have a backup plan for accessing critical files remotely.

We took a look at Chrome Remote Desktop (go.pcworld.com/chromeremote) as a potential solution. Here's a look at two other ways you can get remote access using apps and services that might already be part of your everyday routine.

Phone to PC

Popular media sharing app Pushbullet (go.pcworld.com/pushbulletremote) recently added remote access to its long list of features for trading files between devices. The new feature, dubbed



Remote Files, allows you to access your PC's files on your Android device.

To use Remote Files you need the Pushbullet (pushbullet.com/apps) for Android app on your phone, as well as the desktop program from Pushbullet—the browser extensions won't work here.

Once you've got both apps up and running, open the desktop program and go to Settings. Then scroll down and check the box next to Remote Files Access.

After that, allow a few minutes for your phone to realize your desktop machine is ready for access. Then, open Pushbullet on your phone, tap the "hamburger" menu icon in the upper left corner, and select Remote Files from the slide-out navigation panel. You should see the name of your desktop listed. Tap it, and you've got full access to files saved in your User account. (You can't access system files using Pushbullet.)

The only thing to remember with Pushbullet is that—obviously—your PC must be on and connected to the Internet for your phone to access files remotely.

Remote Files is free, but you are limited to transferring files up to 25MB, and the company says you can only use the feature for a limited,

Pushbullet has
a new remote
access feature
called Remote
Files.

yet unspecified, amount of transfers per month. You can remove those limits with a pro account, which costs \$40 a year or \$5 per month.

OneDrive

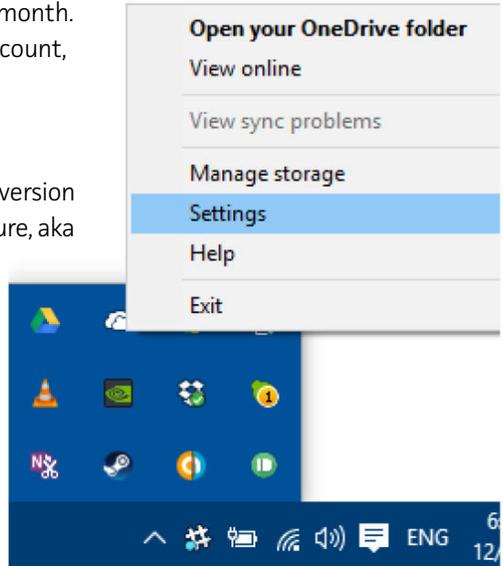
When Microsoft upgraded Windows 8 to version 8.1 it removed OneDrive's fetch files feature, aka remote access. With Windows 10, that feature is back. Windows 7 users can have this feature as well if they download the OneDrive desktop app (go.pcworld.com/onedrivedownloads).

To get fetch files working on Windows 10, all you have to do is click the upward facing arrow in the system tray on the right of your taskbar, then right-click the OneDrive icon and select Settings. A pop-up window will open. Click the Settings tab and check the box next to "Let me use OneDrive to fetch any of my files on this PC."

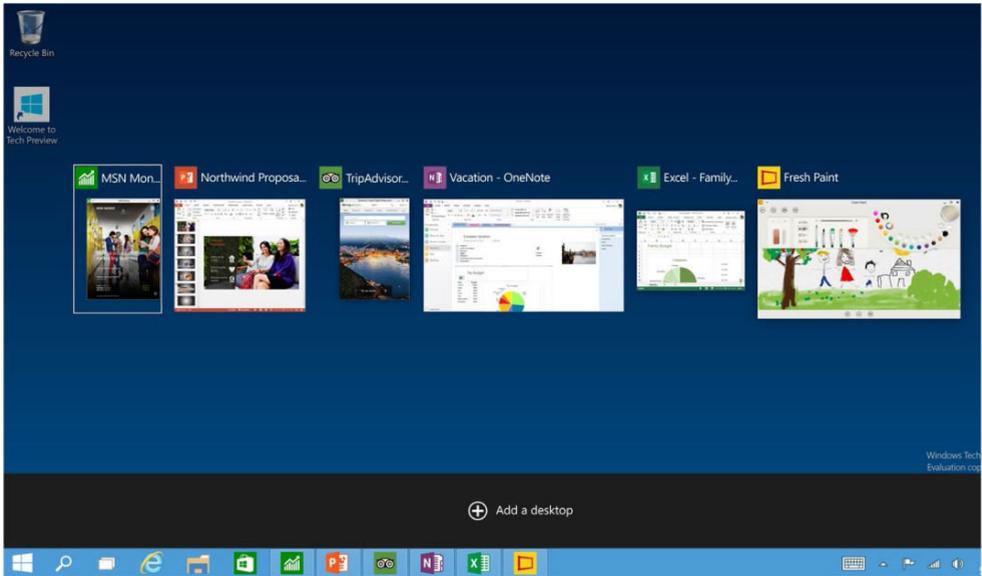
Next, open OneDrive.com, and in the left-hand navigation column, click on PCs, followed by the name of the computer. A new tab will open, giving you access to the files on your PC.

Just like Pushbullet, your PC must be on and connected to the Internet for OneDrive's fetch files feature to work.

Remote access probably isn't something you'll need very often, but it's a great thing to have ready in your back pocket for those times you really need it—because when you need it, you *really* need it. 🛑



Get started with fetch files by enabling it in OneDrive's settings on the desktop.



Windows taskbar icons: How to clean up the clutter

There's only so much space in the Windows taskbar, so here's how to use it wisely.

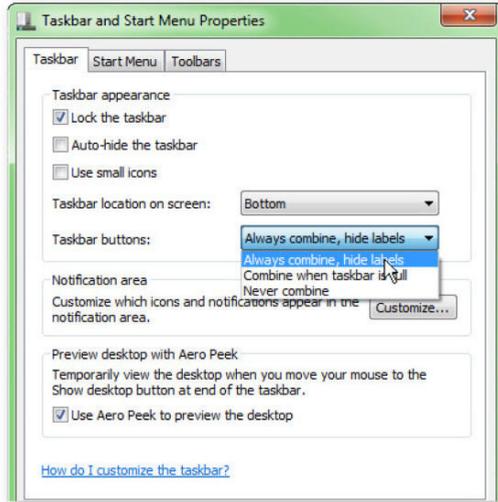
Lis has a taskbar "running over with icons," and needs to clean things up a bit.

IF YOU KEEP a lot of programs running at the same time, or if you have pinned a lot of them to the taskbar, that row of icons at the bottom of the screen will overflow. You won't be able to see all of them.

One obvious solution is to close some of those programs. This will clear the taskbar and improve performance. Shutting down your PC in the evening and booting fresh in the morning will help.

But if you have to keep all those programs running, there are some other solutions.

First, you can change how the running programs are displayed on the taskbar: Right-click the taskbar and select Properties. In the taskbar tab, click the Taskbar Buttons pull-down menu and pick an option.



These are the options:

Always combine, hide labels: This saves the most space, showing one icon per application—without descriptive labels.



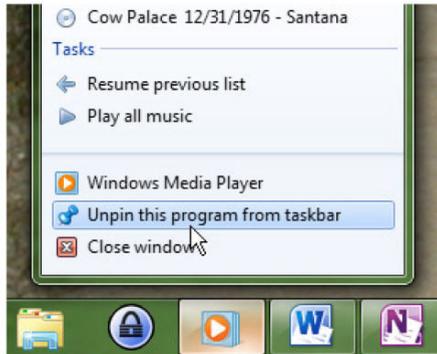
Never combine: This is the real space-waster. If you have four Chrome windows open, the taskbar will display four Chrome icons, each with a space-wasting label.



Combine when taskbar is full: This will display as one or the other of the above options, depending on the circumstances.

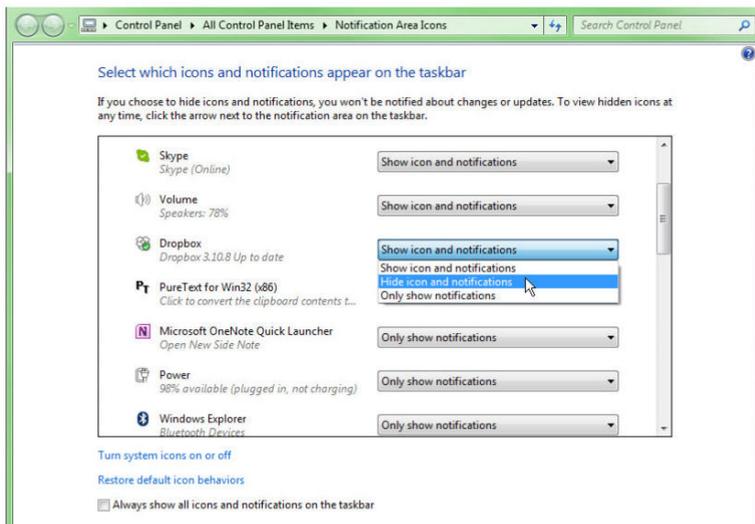
Some other tricks:

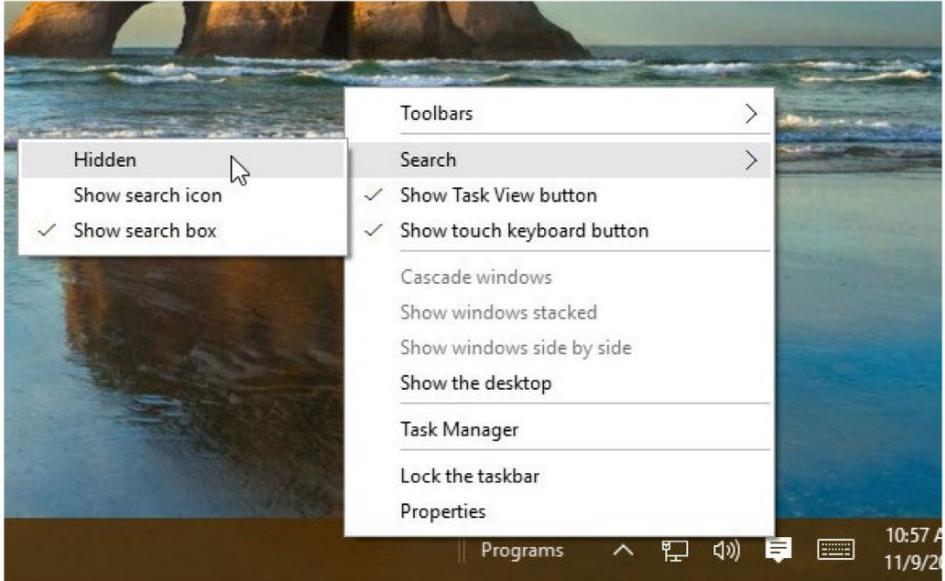
You can unpin some of the programs you've permanently pinned to the taskbar. Right-click the icon on the taskbar and select Unpin This Program From Taskbar. There are other ways to make a program easy to launch—such as pinning it to the Start menu.



You can also shrink the notification area—sometimes called the *systray*. It's that line of tiny icons on the right end of the taskbar. Once again, right-click the taskbar and select Properties. In the taskbar tab's Notification area box, click the Customize button.

In the resulting dialog box, you can select how each of these icons is displayed. Any option other than Show Icon And Notifications will give you a bit more room.





Windows 10's Search field takes up a lot of space on the taskbar...unless you hide it. Right-click the taskbar, select Search, and then select any option other than the default Show Search Box.



If you select Show search icon, you can bring up the search field by clicking on the magnifying glass. If you select Hidden, click Start and just start typing. 

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Tech Spotlight

A video showcase of
the latest trends



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PCWorld's best PC games of 2015: These games rocked our socks in 2015

» 2015's blitz of new top-tier PC games was so outstanding that narrowing down to just 10 favorites was a struggle. These are the ones that gave *PCWorld's* gaming team—reporter Hayden Dingman and editor Brad Chacos—the biggest smiles in 2015.

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