LAPTOP REVOLUTION

Qualcomm puts smartphone brains into Windows PCs

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*Pictured: Stand Up To Cancer Ambassador, **Bradley Cooper** along with American Airlines team members currently fighting, surviving and co-surviving cancer.*

PCWorld JANUARY 2018

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YOUR HOPE

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Jimmy Smits, SU2C Ambassador
Photo By: Timothy White

Qualcomm invades Intel's turf with Snapdragon PCs that push battery life over performance

Qualcomm showed Snapdragon PCs from Asus and HP that promise two-day battery life and always-on connections. **BY MARK HACHMAN**

Qualcomm is invading Intel's turf, announcing Windows PCs that use the same Snapdragon chips as your phone, with battery life that can last well into a second day of use.

At its recent Snapdragon Technology Forum, Qualcomm showed off its Snapdragon 835 Mobile PC Platform on an HP Envy x2 tablet and an Asus NovaGo

ultrabook. (A third PC, from Lenovo, will be announced at CES in Las Vegas.) Both run on the company's Snapdragon 835—yes, the same processor (and cellular modem) inside popular phones like the Samsung Galaxy Note 8. Qualcomm uses its success with smartphones to justify its foray into PCs. You demand all-day performance from your phone, while it's constantly connected to the Internet. Why shouldn't your PC deliver the same?

Let's clear up one concern right away: Qualcomm's Windows PCs are running Windows 10, not the abandoned Windows RT variant that only ran Microsoft's UWP apps. However, these PCs emulate non-UWP apps, slowing performance. Qualcomm hopes you'll be willing to trade some speed for the promise that the Snapdragon Mobile PC platform will deliver 14 to 24 hours of constant use, interspersed with idle periods of "connected standby" time.

What this will mean for you: At some point, the performance of your phone, tablet, or PC exceeds your demands—what we call "good-enough" computing. Qualcomm's betting we're already there, at least for a chunk of potential users, and it's focusing on basic productivity, always-on (cellular) connectivity, and battery life.

Many questions hang in the air: Is "good-enough" computing good enough for you? How well does a Snapdragon PC perform on

everyday apps that are emulated, such as Google Chrome? How close to reality are these battery life claims? Will customers want to pay for an additional cellular plan? If Qualcomm can deliver on its claims and offer (affordable) always-on WWAN connectivity, a little competition for Intel is always good news for consumers.

POWER, NOT PERFORMANCE

Keep in mind that chip makers like Intel—and, to a lesser extent, AMD—are interested in selling you chips that offer the highest performance possible for the lowest price. That's not Qualcomm's priority.

"Most people working in these form factors are interested in the connectivity piece, and things like music, email, some productivity, shopping—it's mostly an extension to a phone," said Miguel Nunes, senior director of product management for Qualcomm. "We don't see people using heavy workloads, like graphic design. If they

Many questions hang in the air: Is "good-enough" computing good enough for you? How well does a Snapdragon PC perform on everyday apps that are emulated, such as Google Chrome?

do, they shy away from these form factors."

"I've been using one of these [Snapdragon-powered] devices for several months," Nunes added. "It's replaced my Surface Pro device, and I go multiple days without charging." Nunes was referring to a Snapdragon-powered version of one of the devices, the HP Envy x2. *PCWorld* reviewed a similar tablet, the HP Elite x2 (go.pcworld.com/hpx2), which includes an Intel Core m chip inside. The Elite x2 delivered over seven hours of battery life under our tests, which included constant video rundown. Qualcomm claims that same tablet will deliver 20 hours of battery life with a Snapdragon inside of it.

Put another way, Qualcomm believes that a device with a 48 watt-hour battery—basically the battery within the latest Microsoft Surface Pro—will last 21.2 hours when looping 1080p video. (For reference, the Surface Pro lasted about 8.5 hours before running out of battery in our tests.)

Qualcomm also released a partial list of the specs of each machine, in part to reassure potential customers that they were getting a "true" PC, with support for the various peripherals and other components that make up a PC.

Put another way, Qualcomm believes that a device with a 48 watt-hour battery—basically the battery within the latest Microsoft Surface Pro—will last 21.2 hours when looping 1080p video.

Asus NovaGo

Display: 13.3-inch, 1920x1080 LED-lit panel
CPU: Qualcomm Snapdragon 835 Mobile PC Platform
Memory: Up to 8GB
Storage: Up to 256GB UFS 2.0
Connectivity: Qualcomm X16 modem (4x4 MIMO); 802.11ac (2x2 MIMO)
Input: Stylus, two USB 3.1 Type-A ports
OS: Windows 10 S

The Asus NovaGo ultr powered by a Qualcomm Snapdr processor.
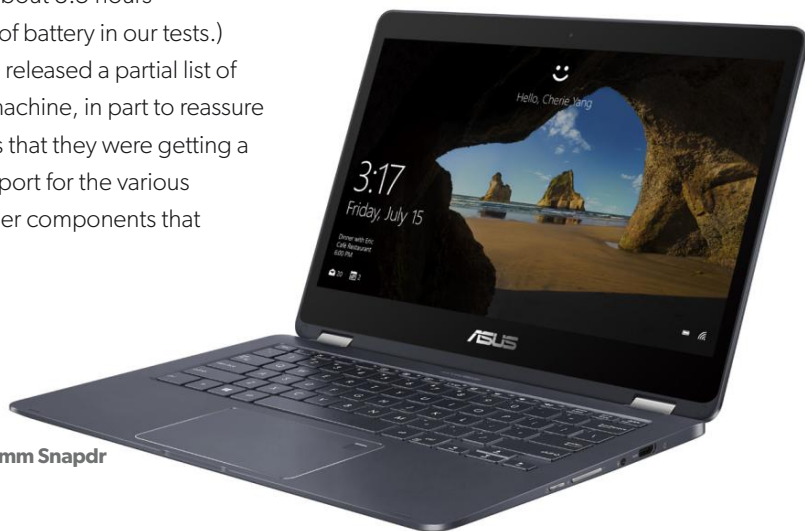
Dimensions: 12.4 x 8.7 x 0.59 inches, 3.06 pounds
Price: $599 for 4GB RAM/64GB storage; $799 for 8GB RAM/256GB of storage
Ship date: Undisclosed

HP Envy x2
Display: 12.3-inch WUXGA+ (1920x1200) panel
CPU: Qualcomm Snapdragon 835 Mobile PC Platform
Memory: 8GB LPDDR4
Storage: Up to 256GB
Connectivity: Snapdragon X16 LTE modem
OS: Windows 10 S
Price: Undisclosed
Ship date: Undisclosed

Qualcomm executives declined to reveal details of the Lenovo Snapdragon device,

which will be announced at CES in Las Vegas.

Interestingly, both the HP Envy x2 and the Asus NovaGo use Windows 10 S. That's important because in our tests, using Windows 10 Pro significantly reduced the battery life. Testing the Microsoft Surface Book running Windows 10 S yielded a whopping 765 minutes of battery life. "Upgrading" to Windows 10 Pro cut the battery life to 654 minutes, a decrease of 14.5 percent. Qualcomm's coming out strong, with a long list of PC partners. Terry Myerson, the corporate vice president in charge of Microsoft's operating systems division, revealed that hundreds of Qualcomm-powered devices had been in use on the Microsoft campus for months, a fact confirmed by other Microsoft attendees.

Myerson also said on stage that he didn't plug in his device in a week of use, although it was unknown how he used it.

SNAPDRAGON PCS WILL BE SLOWER, BUT DOES IT MATTER?

To its credit, Qualcomm admits that the performance of a Snapdragon PC will be slower than what you get from its Intel- or

The HP Envy x2 will be one of the first to include a Qualcomm Snapdragon chip inside.

Snapdragon leads the way in battery life
Days of use power projections show a significant lead

This battery life model is a breakdown of the most common scenarios that a user performs throughout a day, weighted by projected use.

2X longer battery life for continuous use scenarios (screen on)
• > 20 hours of local video playback
• > 14 hours of continuous use

2X longer battery life for typical use scenarios including device going into Connected Standby (screen on and off)
• ~4x longer battery life in Connected Standby
• 24 hours of typical workload use

Source: QTI test results

Scenario	Weight	Snapdragon 835 Pre-commercial device (48Whr battery)		Competitor A: (39Whr)		Competitor B: (39Whr)	
		WiFi	LTE	WiFi	WiFi	WiFi	LTE
Desktop Idle	25%	3.2 hrs	3.2 hrs	1.2 hrs	1.7 hrs	1.5 hrs	
Browsing	38%	5.4 hrs	5.4 hrs	2.0 hrs	2.9 hrs	2.5 hrs	
Productivity	25%	4.0 hrs	4.1 hrs	1.5 hrs	2.2 hrs	1.9 hrs	
YouTube	5%	1.1 hrs	1.1 hrs	0.4 hrs	0.6 hrs	0.5 hrs	
Skype Audio Call	2%	0.3 hrs	0.3 hrs	0.1 hrs	0.1 hrs	0.1 hrs	
Skype Video Call	5%	0.7 hrs	0.7 hrs	0.2 hrs	0.4 hrs	0.3 hrs	
A. Projected hours of use (100% screen on)		14.6 hrs	14.7 hrs	5.3 hrs	7.8 hrs	6.7 hrs	
B. Projected hours of use (60% screen on / 40% screen off)		24 hrs	24.2 hrs	N/A (no connected standby)	12.5 hrs	N/A	
C. Local video playback (1080p)		21.2 hrs	21.2 hrs	5.5 hrs	10.7 hrs	10.7 hrs	

Qualcomm breaks down the estimated battery life of its Qualcomm Snapdragon 835 PCs here…

AMD-based competition. In part, that's because the Snapdragon chips aren't designed to process the code natively. Instead, the Snapdragon 835 passes the code through some intermediary steps, including an abstraction layer and emulator.

Up to 2X longer battery life so your PC can last beyond all-day
Leave your power cord behind
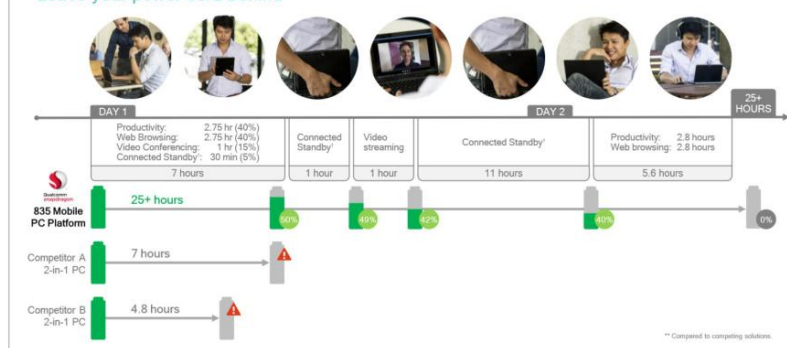
…and here, with a more detailed breakdown of the Qualcomm Snapdragon 835's power consumption.

This was a step that Windows RT devices, and the ARM chips they ran on, left out. Fortunately, that emulated code is then cached, so if it's re-run the performance will be at or near native.

As a result, Windows UWP apps (Mail, Calendar, Edge, plus native Skype apps like Twitter, Spotify, and the like) will always run at the chip's maximum performance. A whole host of traditional .EXE apps, including most games, browsers like Chrome and Firefox, and synthetic benchmarks, simply won't run as fast.

There are also a few additional wrinkles that emerged after the Windows-on-Snapdragon announcement. For one thing, 64-bit apps aren't supported at all, at least not yet.

These are the "performance" metrics Qualcomm wants you to think about when considering Snapdragon 835 Mobile PCs.

"We are working on an ARM64 SDK that will enable developers to author applications for ARM64 and we'll have more news to share in the future," a Microsoft spokeswoman said in an email.

Second, the emulation technology doesn't support applications that require kernel-mode drivers, such as some antivirus applications. That will leave Snapdragon PC users largely dependent on the Windows Defender antivirus software built into Windows 10.

Finally, Microsoft executives at the Snapdragon Summit acknowledged that apps with high CPU usage would suffer a greater performance penalty, so that gaming really won't be a focus of these devices.

Naturally, Qualcomm is downplaying any impact. Any application is dependent upon a combination of CPU, GPU, memory, and storage, Nunes said. "You will see a few differences here and there…but it's nothing that's going to impact the user experience."

"You may see something launch in 1 second, on the other platform it launches on 1.4 seconds," Nunes explained. "That's 40 percent slower, but really, that doesn't matter."

Nunes instead emphasized the power efficiency of the Snapdragon 835 Mobile PC Platform. "It's better to address the battery

life, as that's what most people care about."

When asked to define the performance penalty that emulation would cost, Nunes again demurred. "Really, it depends on the app," he said.

Fortunately, it seems like some of these concerns may be overblown. Pat Moorhead, a former AMD employee and now an independent analyst, told *PCWorld* that he had used a Qualcomm-powered product for several days and that Chrome performed acceptably—"better than I expected," he said.

Qualcomm feels it can make up some of that gap as more powerful CPUs throttle themselves, reducing the clock speed under load to control heat output. But executives admit you'll notice differences between native and emulated apps. In part, that's due to a design quirk in the ARM architecture that underlies the Snapdragon chip: ARM uses a combination of "big," powerful cores together with more power-efficient "little" cores. It's these little cores that help provide the long battery life, but can't quite keep up when under load.

SNAPDRAGON PCS WILL TEST OUR TASTE FOR 'GOOD-ENOUGH'

For the average user, the Snapdragon 835 Mobile PC Platform's strengths and weaknesses play into how the PCs will be marketed. When Asus and HP ship the new

Qualcomm-powered devices, the companies will emphasize "user experience" metrics like how fast apps will open, rather than synthetic benchmarks like Cinebench or PCMark.

Also, the apps you use will matter. "You can run Chrome on it. Edge is significantly more optimized, but Chrome will work," Nunes said.

For the average user, the Snapdragon 835 Mobile PC Platform's strengths and weaknesses play into how the PCs will be marketed.

If Qualcomm's Snapdragon 835 Platform Mobile PCs are to take off, consumers are going to have to accept PCs "good-enough" performance in exchange for two days or so of battery life and pervasive WWAN connectivity. So far, we've had two architectures try that argument on for size: Intel's Core m and Atom chips. Intel's Core m arguably succeeded. The Atom did not, offering a sluggish computing experience often compounded by anemic storage and memory.

For years, however, consumers have pleaded with smartphone makers to increase the battery life. Now Qualcomm has the opportunity to help PC makers do the same. Will they succeed? As soon as we can get devices in our hands, we'll tell you. ⏻
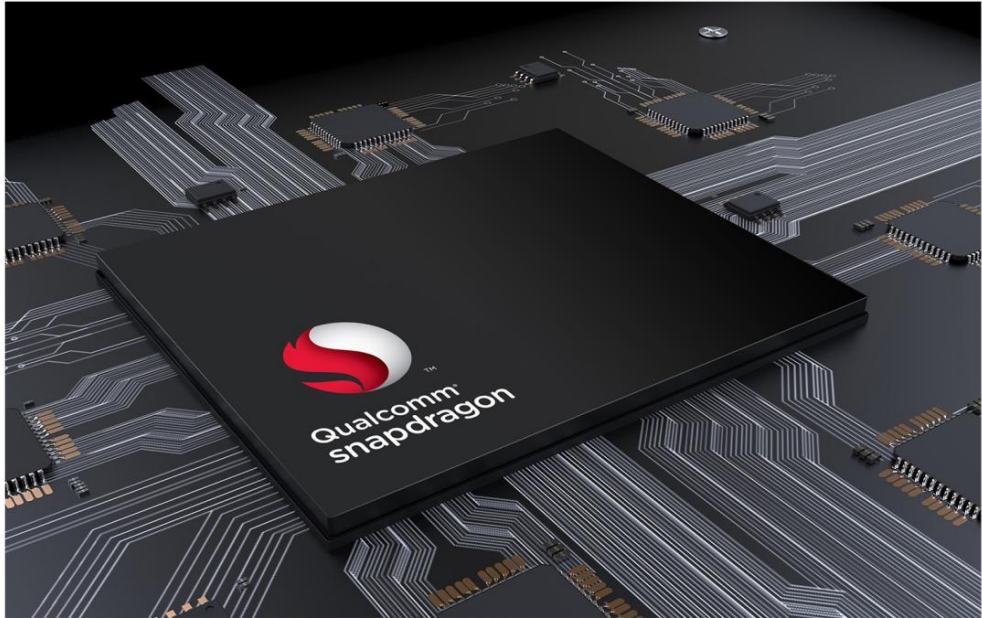
Qualcomm's Snapdragon 845 will bring speed, security and smarts to high-end phones

Android phones using Snapdragon 845 will ship next year, Qualcomm said. **BY MARK HACHMAN**

In early December, Qualcomm revealed its first concrete details of the Snapdragon 845, the next-generation mobile chip that stands a good chance of being in your next smartphone. The 845 will ship in early 2018, and appear in phones sometime after that.

Qualcomm calls the Snapdragon 845 a

chip to improve both artificial intelligence and immersion, blending the future of smart devices with the past. At its heart lies the Kryo 385, the semi-custom, upgraded CPU. It's still an eight-core device, with four performance cores running at 2.8GHz and four energy-efficient cores running at 1.8GHz. That represents a 25- to 30-percent improvement

IMAGE: QUALCOMM

on the existing Snapdragon 835 in the performance cores, and a 15-percent improvement in the smaller, energy-efficient cores.

Phones that use the new Snapdragon 845 will be able to loop more than 20 hours of continuous HD video before expiring, executives said. Those phones will also be able to capture four hours of

continuous video playback, or play VR games for over three hours. Talk time, using what Qualcomm calls Ultra HD Voice, will last over two days, the company said.

Qualcomm believes in "heterogeneous" computing, a fancy name for designing specific parts of the chip for specific tasks. With the Snapdragon 845, Qualcomm has focused on five different areas: "immersion," AI, security, connectivity, and performance.

IMMERSION: CAMERAS WITH BETTER BRAINS

Immersion is seamlessly capturing the world around you, said Tim Leland, vice president of product management for Qualcomm. The 845 improves in two different areas: capturing the world around you, and improving on those experiences.

The key to Qualcomm-powered cameras is the Spectre 280, the image signal processor that's designed to deliver best-in class image quality even when there's a lot of movement or not a lot of light. Previous Snapdragons—the Snapdragon 820, for example—focused on 4K playback at 60 frames per second. The key feature for the Snapdragon 845 is to capture Ultra HD Premium content at 60 fps—that's the 4K standard that includes 10-bit color depths as well as Rec. 2020 color space representation. According to Leland, your smartphone videos will look more lifelike than ever before.
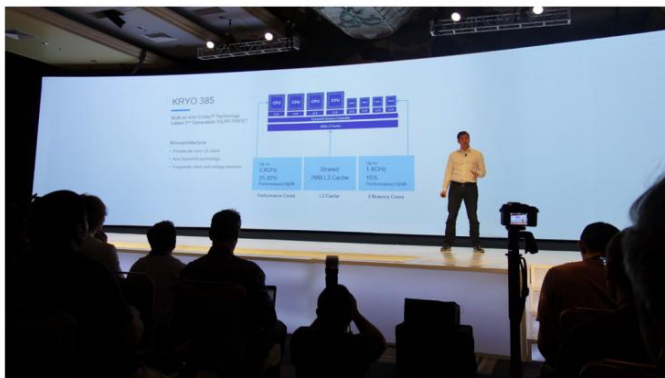
Qualcomm also believes that 845-powered smartphones can break the 100 mark in DXomark, generally considered the standard for image quality in smartphones.

Camera phone resolutions have settled into the 12- to 16-megapixel range, so chip makers like Qualcomm are moving to other aspects, such as color quality. (The Shapdragon 845 supports up to 32MP

Cameras powered by the Qualcomm Snapdragon chips have steadily improved. With the Snapdragon 845, Qualcomm is supporting higher-quality images.

cameras with no shutter lag, at 30 fps, executives said.)

Color volume will increase, including color depths, which will help reduce banding in skies and other backgrounds. The Spectre 280 will improve the color gamut—the range of colors that the image signal processor can support. The Snapdragon 845 will be able to encode to the Rec. 2020 color gamut, offering significantly higher color quality than the existing Rec. 720 color gamut. The Spectre 280 will also support the Rec. 2020 range in luminance, improving the quality of HDR shots.

"We think consumers will be amazed at just how high the quality of video is with the Snapdragon 845," Leland said.

One of its coolest features is a twist on computational photography—what Qualcomm calls a "real-time cinemagraph." With this feature, you'll be able to record a scene as video, then composite it over the same scene, recorded as a photo. The end result will be that part of a scene will be recorded as a video, such as a fish swimming in a fishtank. The remainder of the scene will appear as a photo. It's an effect you'll need to see to believe.

Other features that the Spectre 280 core will support include image compositing and slo-mo video at 720p HDR10, and at 480 fps. Motion-compensation temporal filtering

The Qualcomm Snapdragon 845 also includes mixed-reality or XR capabilities.

and accelerated image stabilization will use video from adjacent video frames to improve the quality.

The Spectre 280 will also include features designed for machine vision, such as depth sensing. Computer vision will be used to apply bokeh filters, as well as to analyze faces.

XR is Qualcomm's umbrella term for the combination of augmented and virtual reality. XR has been improving every generation, Leland said. For example, the Snapdragon 835 introduced six degrees of freedom, as well as 1.5K x 1.5K at 60-fps resolution. With the 845, Qualcomm is adding room-scale, six-degrees-of-freedom SLAM (simultaneous localization and mapping). Snapdragon 845-powered devices will track your hands, too, working with accessory makers to make sure their products are tuned for the Snapdragon 845 chip.

Another key part of the Snapdragon 845 is the Adreno 630 graphics core, used for gaming and applications like XR. The Adreno 630 will boast 30 percent faster graphics, and 30 percent better battery efficiency, Leland said. The Adreno 630 will also be smarter, using features like foveated rendering to detect what you're looking at, applying the highest-resolution details to where your attention is focused. Otherwise, it dials down the detail. Multiview rendering, another new feature, plays into this: A scene is rendered once for one eye, then automatically offset for the other eye.

ARTIFICIAL INTELLIGENCE: SNAPDRAGON 845 POWERS NEW DIGITAL ASSISTANTS

The Snapdragon 845 was designed to address a shift in AI, according to Gary Brodman, director of product management at Qualcomm. Consumers aren't willing to wait for data to be transferred to the cloud, acted upon, then sent back down to the device. Instead, they want the smarts right within the

device itself.

Qualcomm calls the 845 its third-generation mobile AI platform. Additions such as core optimizations make on-device machine learning more efficient and powerful, Brodman explained, such as working with other cores on the device to help them recognize objects. In general, the 845 is 10 percent more energy-efficient and offers 10 percent more performance, Broadman said. Neural-network performance has improved by a factor of three times over the Snapdragon 835.

Broadman outlined a few ways AI will benefit consumers: applying visual themes (think Van Gogh's Starry Night) to video as it's being shot, for instance, or using a "deep portrait" feature to apply bokeh with just a single camera lens. And, of course, there's Face ID, a way to unlock your phone when it recognizes you.

SECURITY: ADDING A DIGITAL VAULT TO SNAPDRAGON 845

With the Snapdragon 845, Qualcomm built what it calls a "secure vault" right in the heart of the platform, according to Sy Choudhury, the senior director of product management for Qualcomm. Trusted computing environments are being hacked, and state-sponsored agencies are in play. "Even though we felt we had a high level of security, we felt we needed to raise the bar," Choudhury said.

The Secure Processing Unit is its own separate, isolated core, with its own CPU, crypto engine, and memory, as well as its own random number generator and even a power supply. Within the Snapdragon 845, all of the authentication takes place within the Secure Processing Unit, and all of the biometric information is stored there.

Some of the detail Qualcomm offered on its new security vault. Naturally, it wasn't willing to reveal too many details to educate the bad guys.

"The reality is that when you're saving your files, those files are encrypted with a digital key—within Android Oreo and Windows 10, each file is encrypted with a unique key. That's really good security," Choudhury said.

With this new security model, what were previously discrete components on a board can now be integrated within the processor, Choudhury said.

CONNECTIVITY: FASTER DATA MAKES THE SNAPDRAGON 845 A BETTER CHIP

Qualcomm's wireless business is eager to push the world toward 5G connectivity, and the new Snapdragon X20 modem is the company's second gigabit modem. It's 20 percent faster on average than the previous X16 modem, with 1.2Gbps sustained speeds. It's aided by 5X carrier aggregation, receiving up to 5 separate radio channels on your device with four separate antennas (4x4 MIMO).

Anecdotally, Qualcomm calls this "wireless fiber," according to Peter Carson, senior director of product marketing. The x20 also supports dual-SIM and dual voice-over-LTE technologies on both SIMs, giving more robust voice quality on either SIM. (Dual-SIM devices are normally sold in regions where users travel frequently from country to country, like Europe.)
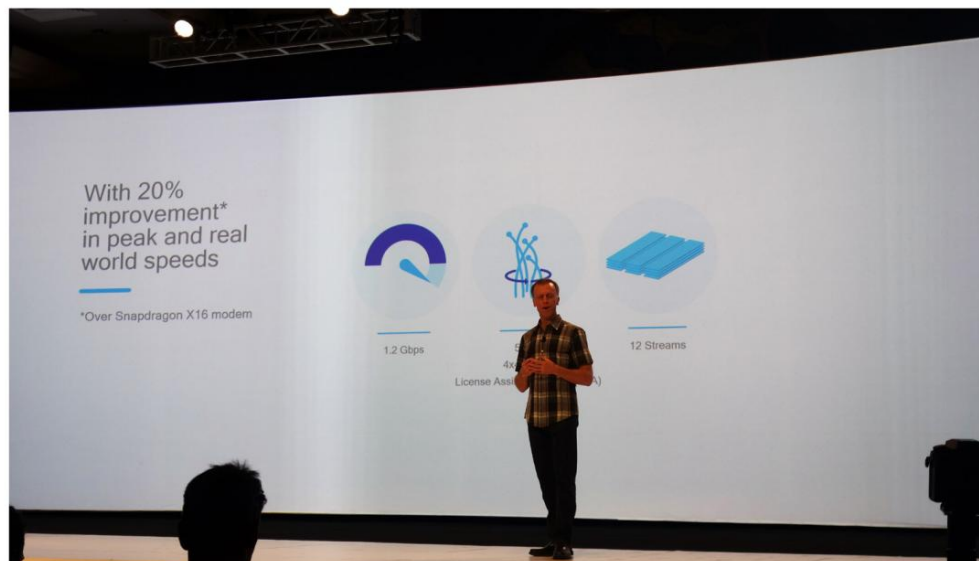
Increased connectivity is a key part of the Snapdragon 845 and the new X20 modem.

The 845 includes multi-gigabit Wi-Fi, with 802.11ad baseband that can switch among separate modules within a phone to give you better reception. The 845 also boasts a set of Wi-Fi protocol enhancements—fast initial setup—that will improve the Wi-Fi setup time by 16 times, adding 30 percent more effective capacity. All that means, Carson said, is that you'll be able to go to a conference or an airport and have a better chance of connecting to congested Wi-Fi networks than before.

Advanced Bluetooth TrueWireless is Qualcomm's name for broadcasting HD-quality music to several headsets—allowing you to share music from a single phone to several nearby friends. Bluetooth TrueWireless uses Bluetooth headsets as a mesh network of sorts, routing audio from headset to headset. The upshot? Up to 50 percent battery savings compared to the Snapdragon 835, Carson said.

"It's a big step toward the 5G experience," Carson said.

BATTERY LIFE: CUTTING POWER IN SNAPDRAGON 845

Qualcomm's research shows that battery life is the number-one smartphone purchase criteria, said Travis Lanier, senior director of product management for Qualcomm. "At the end, battery life is one of the determinants for the satisfaction of a smartphone," Lanier said.

"We're listening."

With the Snapdragon 845, Qualcomm is offering more than 20 hours of continuous video playback, or capture of over four hours of continuous HD video. VR gameplay will be possible for over three hours of continuous gameplay. With Ultra HD Voice, you'll be able to talk for more than two days continuously, Carson said.

The 845 also supports QuickCharge 4, which will charge your devices from 0 to 50 percent in 15 minutes. It's already supported by 160 devices, Carson said, and is a superset of the related USB-PD charging standard.

According to Lanier, battery life improvements are made possible by heterogeneous computing—a fancy name for parts of the chip that are optimized for specific tasks. One challenge is artificial intelligence, where the whole chip is involved. Fetching data can cost power, so Qualcomm added a 3MB cache to improve performance.

SNAPDRAGON 845 IS COMING IN 2018

Qualcomm believes the Snapdragon 845 is ready for a multitude of different applications, keeping you connected while your phone helps you take sophisticated video and plan your next lunch meeting. Qualcomm's Snapdragon 845 chip is scheduled to appear in high-end phones beginning in 2018. ⏻

Titan V revealed: Nvidia's monstrous Volta GPU finally comes to PCs

But the wait continues for PC gamers. **BY BRAD CHACOS**

Nvidia's cutting-edge Volta GPU architecture has finally come to desktops. Recently, Nvidia launched the monstrous, golden Titan V, a $3,000 graphics card (go.pcworld. com/gold) with 12GB of HBM2 memory and over a thousand more CUDA cores than the game-slaying Titan Xp (go.pcworld.com/ttxp). But this beast isn't made for gaming—though it'd no doubt be very good at it.

Instead, Nvidia says this card "transforms the PC into an AI supercomputer." While the still-available Titan Xp (go.pcworld.com/titn) was theoretically a compute card, but better suited as a best-in-class gaming card, the Titan V doubles down on data crunching. Nvidia is giving Titan V owners free access to AI, deep-learning, and high-performance computing software via the Nvidia GPU cloud (go.pcworld.com/gpuc). To boost the hardware's machine learning capabilities, the card is equipped with the same "tensor cores" found in the Volta-packing Tesla V100 (go.pcworld.com/v100) that launched in May.

In fact, the Titan V's core specs are very similar to the Tesla V100's configuration, but the desktop card's HBM2 runs slightly slower—and there's 4GB less of it. Nvidia says the Titan V delivers up to 110 teraflops of power in AI calculations, "9X that of its predecessor," thanks to the introduction of the tensor cores.

NVIDIA TITAN V SPECS, FEATURES, AND PRICE

Transistors: 21.1 billion
CUDA cores: 5,120
Tensor cores: 640
GPU clock speed: 1200MHz base, 1455MHz boost
Memory capacity: 12GB HBM2
Memory clock: 850MHz
Memory interface: 3,072-bit
Total memory bandwidth: 652.8GBps

Texture units: 320
Power: 250W TDP via 1x 6-pin and 1x 8-pin power connectors
Ports: 3x DisplayPort, 1x HDMI
Price: $3,000 on Nvidia.com (go.pcworld.com/gold)

Considering how massive (go.pcworld.com/ma55) the Tesla V100's GPU/HBM combo wound up being, it's very impressive indeed that Nvidia managed to cram this much power into a dual-slot desktop graphics card. To see how the new Volta GPU architecture compares to the Pascal architecture used by current Nvidia consumer cards like the GeForce GTX 1080 Ti, head over to our explainer on what PC gamers need to know about Volta (go.pcworld.com/v0lt).

But the most important thing gamers need to know about Volta is that we're still waiting for it in consumer graphics cards, seven long months after the architecture's original reveal. While the Titan V would likely crush modern games, this monster is squarely focused on machine learning. Don't spend $3,000 on a highly specialized compute GPU just to play Witcher 3. Read *PCWorld*'s best graphics card guide (go.pcworld.com/bgcg) to find the perfect fit for your budget instead, or sit tight and wait for Volta to come to the GeForce lineup. Who knows, maybe it'll appear at CES in January. Volta has to come to consumer graphics cards sometime, right?

Right? ⏻
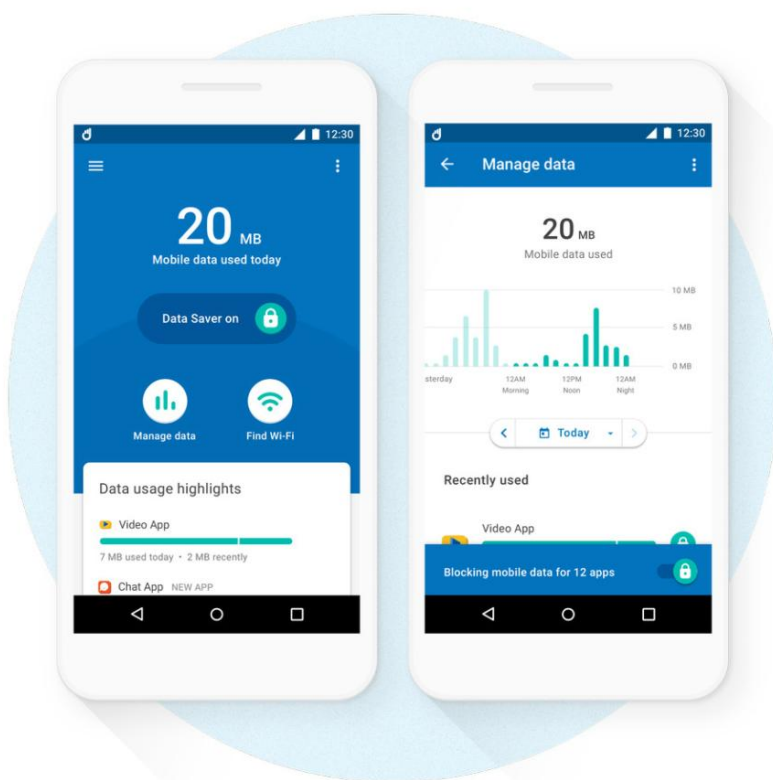
Google's new data-tracking app could save money on your mobile bill

Shut down apps that are gobbling up your data. **BY MICHAEL SIMON**

Google's newest Android app might be its most useful of all. It's called Datally (go.pcworld.com/dty), and it has one function: to stop apps from gobbling up your precious gigabytes of data.

The simple, intuitive app is designed to help you get a handle on your mobile data usage and stop rogue apps from surreptitiously using it up. So, if you get a message from your carrier about using an abnormal amount of data, you can use
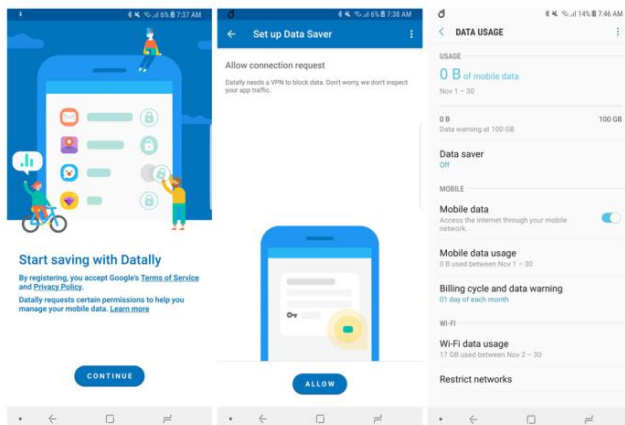
Data trackers have been built into Android for a while, but Datally makes it drop-dead easy to use them.

Datally to pinpoint the app that's doing the most damage and shut it down.

There's nothing necessarily new in Datally—data trackers have been built into Android for a while—but never has it been presented in such a user-friendly way. Many Android users don't know to venture deep into the Settings app to see their mobile usage, so Datally pulls those features out of Settings > Network & Internet > Mobile Network, and presents it in an easy-to-understand way.

After a brief setup, where you'll need to allow Datally access to a VPN in order for it to work, you'll be taken to a screen that clearly shows how much data you've used today. From there, you can dial into your weekly or monthly usage (via the Manage Data button), set up threshold alerts, and control which apps have access to your mobile data. There's

also a Data Saver kill switch that will shut down all mobile data at a tap.

But the coolest feature might be its Wi-Fi tracker. Tap the Find Wi-Fi button and Datally will retrieve a list of nearby places that offer public Wi-Fi networks. You can even get directions via Maps and rate the quality to help other users in the area.

Google says it has been testing Datally in the Philippines over the past few months and it has saved people up to 30 percent in their data. The app is available in the Play Store (go.pcworld. com/pstr) for phones running Android 5.0 and above.

Why this matters: Whether you're bumping up against monthly caps or trying to stop your carrier from throttling your speeds, we all need to be mindful of how much data we're using. A rogue app or two could make a big difference. And it's not just data—Datally could save your phone's battery life, too, by identifying apps that are doing too much when you're not using them. Datally is such a simple, useful tool that I wouldn't be surprised to see Google bundle it into Android P, whether as a stand-alone app or a settings menu. As a part-time iPhone user, I'd love to see it show up in the App Store one day too (but I'm not holding my breath). ⏻
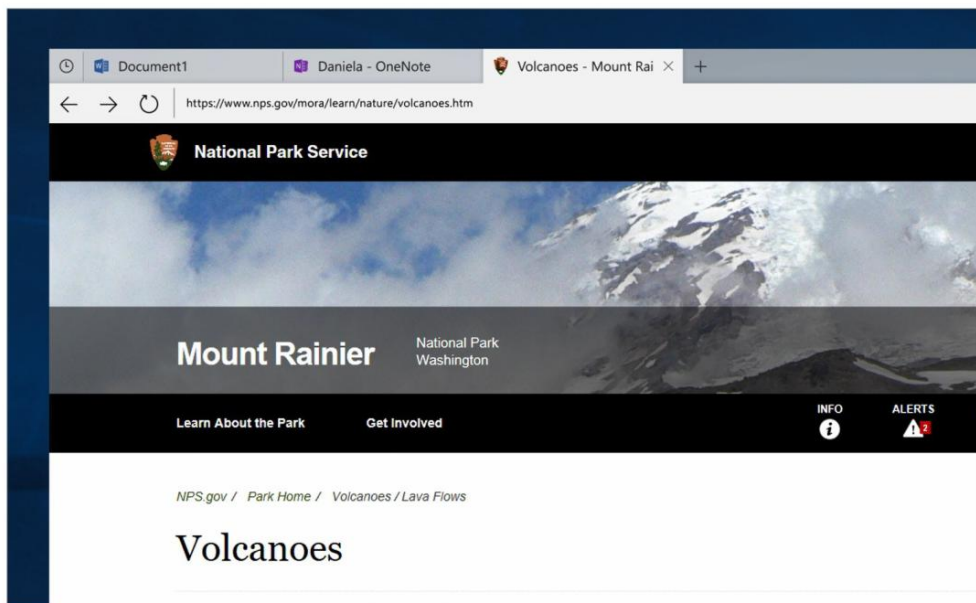
Windows 10's future look could be Sets, a tabbed app interface Microsoft will start testing

Sets combines the apps and files you need to complete a task in a tabbed window—even ones you worked on weeks ago. **BY MARK HACHMAN**

Microsoft said recently that it plans to overhaul Windows 10 with a browser-like, tabbed application view dubbed "Sets" that groups apps and files by project. The changes will roll out over a period of months, if not years—but an upstart competitor already has a similar idea.

Think of Sets as a mashup of existing and emerging Windows 10 technologies. Take Windows Explorer and the little-used Task View within Windows 10, mix in the newer "Pick up where you left off" and Timeline features, and wrap it all into a single-window experience. The idea is that every task requires a set of apps—Mail, a browser,

PowerPoint, even Win32 apps like Photoshop—and those apps will be optionally organized as tabs along a single window.

But that's not all. Microsoft knows that one of the most difficult things to remember isn't what you were working on a week or so ago—browser histories help with that. It's remembering all of the associated apps and documents that went with it: a particular PowerPoint document, that budget spreadsheet, the context an Edge tab provided. The idea is that the delayed Timeline feature (go.pcworld.com/time) will eventually group and associate all of these into a Set, so that when you open one, Windows will suggest the others, too.

It's a complex concept, with a complex tag line: Sets is a way to "organize and resume multi-faceted tasks," according to Microsoft.

Sets will first make its way to Windows Insiders for feedback on the new UI. Microsoft will also seek out support for the Sets concept from developers across the board, from Adobe to Salesforce.

Meanwhile, Stardock, which has provided its own UI tweaks to Windows for years, has struck first, releasing a product, Groupy (go.pcworld.com/grup), that reproduces some of the basic changes Sets provides.

What the future holds: This new look and feel for Windows is being rolled out for Insider beta testers first, and then later to standard Windows users. The question is when: Microsoft releases major updates to Windows in the spring and fall, but with the timeline Microsoft is talking, it could be literally years before Sets reaches your desktop. (Microsoft might not keep the "Sets" name, either.)

Microsoft is making clear that this is an *optional* feature, so if you prefer to work within a traditional Windows environment,
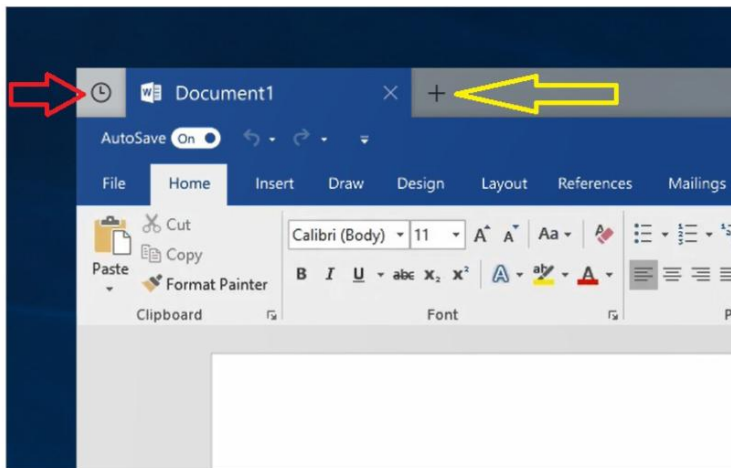
Though Timeline will also be enabled via Task View, you should also be able to access it via the icon in the upper left. This is not a web browser or a web version of Word; it uses the new Sets model. Note the new tab icon to the right.

rearranging windows and using features like Snap, you'll still be able to.

SETS: WHEN WINDOWS 10 APPS BECOME TABS

The concept includes two major components: the organization of the different app windows into Sets; and the longer-term evolution of how Windows intelligently recognizes how Sets should be formed, which is part of the rollout and evolution of Timeline. Timeline will be rolled out almost immediately to Insiders, followed shortly by Sets.

You'll see changes to the Windows interface with both aspects. With Sets, users will have the option to add apps to tabs, in much the same way Edge or Chrome works.

Don't be fooled—these aren't web apps you're looking at! Essentially, Microsoft is reworking the Desktop Windows Manager within Windows 10 to enable app switching via tabs, versus more traditional windows.

The Timeline changes will also eventually roll out as part of another, neglected portion of the Windows UI: Task View (go.pcworld.com/task), the icon that's right next to the Cortana search bar on the Windows 10 taskbar.

Normally, a student writing a term paper would launch several apps at once: a OneNote class notebook to pull from, additional research tabs within Edge, as well as the actual paper within Word. All of these apps rarely interact. There's also the problem
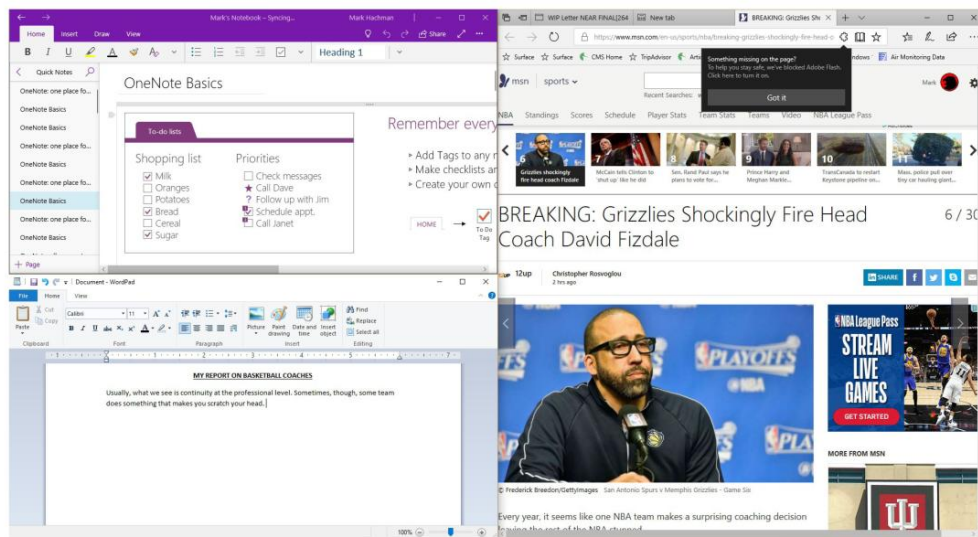
This is the traditional (and effective) way of working with multiple documents within Windows 10: Snap View. Sets would slim this down to just one window.

of what might be called "browser tab bloat:" Within a browser, users keep adding tabs, only some of which may be relevant to the task at hand. Sets, and later Timeline, will associate only the relevant apps and browser tabs with one another.

Microsoft thinks that it has built mechanisms in place that either automatically, or with a slight change to user behavior, get the right things grouped together, within a Sets window. So while you have 32 tabs open in your browser, the two tabs you were using together with your homework are now with your homework.

The early vision of Sets looked a lot like a browser: links in the Mail app opened in Calendar, right next to each other, and each tab could be dragged and rearranged.
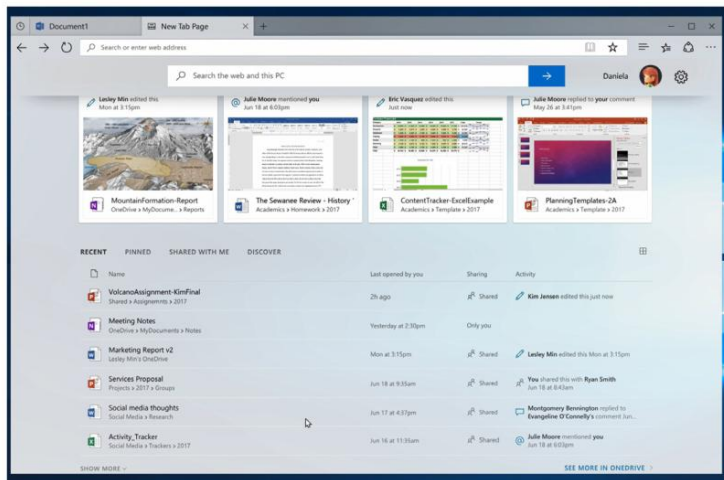
Opening a new tab will bring up this new tab page, which looks a lot like a web browser—except that Office documents are highlighted.

Searches for documents in a shared OneDrive were downloaded and opened as new tabs. UWP apps and traditional Win32 apps mixed
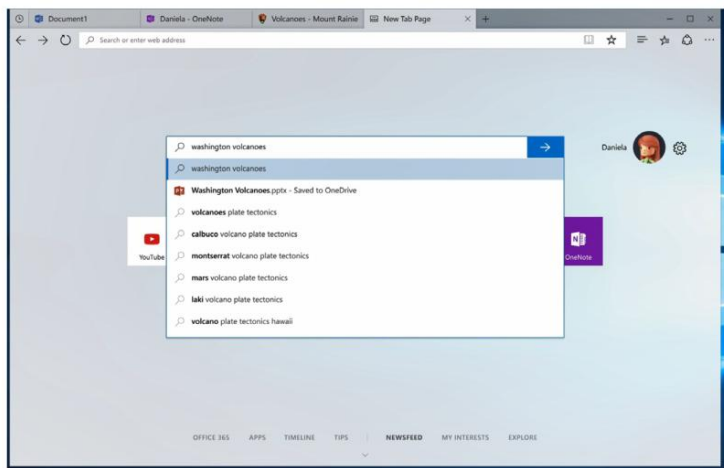
Interestingly, the new tab page within Sets also includes a search bar, which searches the web as well as your PC, just like Cortana.
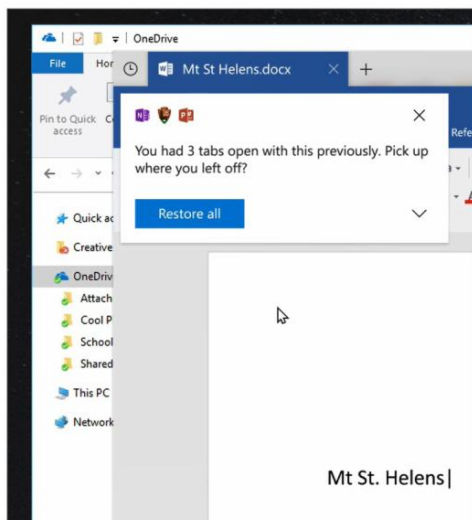
Sets meets the "Pick up where you left off" feature, offering to open up all of the prior app tabs at once.

together, each with their own tab.

Naturally, it's all keyed to your Windows account. In another scenario, a student saved her work on one machine and resumed on another. Once she signed in, Sets either suggested the group of app tabs she was working on previously, or just opened them automatically, picking up where she left off.

The Settings menu attached to Sets is designed so that the new interface is entirely optional, and can be toggled on and off. Microsoft also plans to make apps Sets-compatible on a per-app basis, so while Word and Mail could be tabbed, you could ensure Photoshop never is.

WINDOWS 10 SETS WILL ROLL OUT SLOWLY

Sets may have started rolling out by the time you read this, but it won't roll out quickly. You might not get it, even if you're a member of the Windows 10 Insider program. Part of the testing process involves rolling out Sets to a limited group—including a "control group" of users who won't get it, and can provide contrasting feedback.

Sets will also be restricted initially to UWP apps, such as Mail and Calendar. In the version of Sets rolling out to Insiders, you'll be able to create simple Sets, such as receiving an email about an event, opening the Calendar app in a tab to reserve the date, then finding the location on the Windows 10 Maps app. Over time, simple, traditional Win32 (.EXE) files will be supported, too, but only those that don't modify the title bar. Those apps may be added to Sets by the end of 2017, but most likely will appear early next year.

From there, the plan is to add the more complex Win32 apps that modify the title bar. The most important of these? Office 365 apps. Traditional Office 365 apps like Word, with support for Sets, will be added sometime in 2018.

From there, Microsoft has a choice: Either work with developers like Adobe to code Sets support into apps, or do it independently. It appears Microsoft will try the former path.

At some point, everybody will get Sets, Microsoft says. But it will take months.

WANT SETS RIGHT NOW? TRY STARDOCK'S GROUPY.

But what if you could get something like Sets right now? There's an alternative: Stardock's Groupy app (go.pcworld.com/grup), which recently debuted as a beta for Windows 10.

Groupy (currently part of the $30 Object Desktop Suite [go.pcworld.com/30ob]) does quite a bit of what Sets promises: It groups apps together as a series of tabs, allowing you to hide applications underneath one another without losing them. New apps can be collected and added to the Groupy window (which, at this point, isn't really resizable like a true window) or pulled out from a Groupy group and left as separate windows. What can't be done, right now, is for those Groupy groups to be "archived," as Windows Timeline will do. You can also end up with two rows of tabs, when a row of browser tabs appears underneath the Groupy group's app tabs.

Naturally, Groupy is more of a custom interface than a built-in part of Windows. But it's still a good start. You can pay $30 now

for the suite, or $10 for the stand-alone version of the app Stardock is set to release in December.

TIMELINE: PICK UP WHERE YOU LEFT OFF, EVEN WEEKS AGO

In some ways, Sets follows the same "from many, one" maxim that some of its more recent products embody: Delve's ability to find relevant documents, Outlook Groups, the shared workflow in Teams, collaboration within Office documents. Sets applies that to your own workflow, with the idea that Windows will know all of the various documents you used to create a presentation, for example.

We can already see the first glimpses of Sets with Edge's ability to "share" documents from Android or iOS to Windows 10 PCs, and with Cortana's ability to suggest the apps you
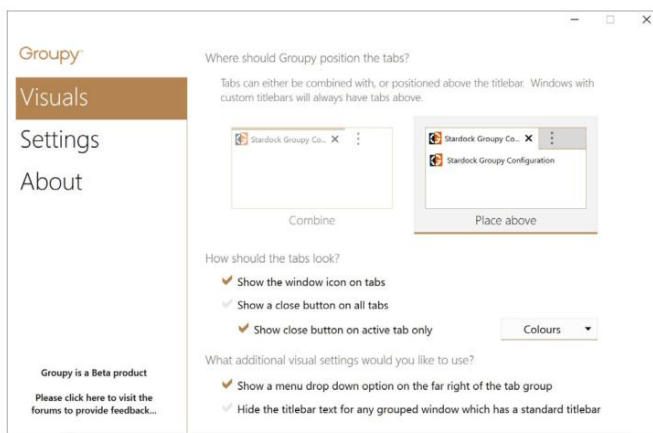
The Groupy settings menu offers a variety of options for configuring the tabbed groups of apps.
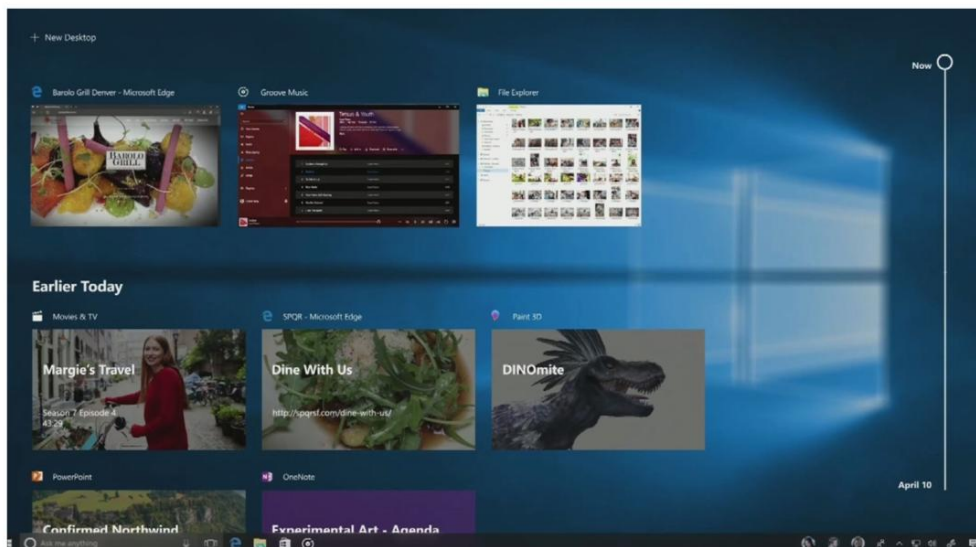
An old version of Timeline that Microsoft showed off at its Build conference.

were using on another PC. Timeline sort of fell into place as a related technology, while the little-used Task View fell out of favor.

Timeline will log your activities to the cloud, allowing those users signed in with a Microsoft account to roam from PC to PC. According to the early build PCWorld.com saw, Timeline dominated the space normally dedicated to the virtual desktops within Task View. Because of the relatively low amount of data needed to record Timeline, there was really no practical limit to how far Timeline's history could go.

One thing Timeline won't be used for—at least not now—is versioning. If you have a budget spreadsheet you altered a month ago, you won't be able to call that version up, at least not within Timeline.

Naturally, Microsoft is also working through how it implements Sets and Timeline within mobile apps—especially as, for all intents and purposes, Microsoft has decided not to develop new mobile operating systems. While Sets might be impractical within the constraints of the mobile phone, Timeline might be feasible, or at least a version of Timeline that's aware of what your phone was doing before you sat down at your PC.

All that, though, remains part of the very murky future for Sets and Timeline. It could be the end of 2018 or even early 2019 before general Windows 10 users have access to both, and much could change in the interim. ⏻

HDMI 2.1 released: 10K resolution, dynamic HDR, and FreeSync-like game smoothing

Goodies for gamers and media enthusiasts. **BY BRAD CHACOS**

The next generation of HDMI is here, and it holds some major benefits for PC gamers and media buffs alike. The HDMI 2.1 standard, released recently by the HDMI Forum after being announced at CES 2017 (go.pcworld.com/cs17), supports higher resolutions, new HDR features, and game-smoothing variable refresh rates, among other features.

HDMI 2.1 delivers massively more bandwidth than HDMI 2.0—a whopping 48Gb/s compared to the 18Gb/s achieved by today's technology. That allows HDMI 2.1 to hit much higher resolutions and refresh rates.

IMAGE: MELISSA RIOFRIO

HDMI 1.4
10.2 Gbps

HDMI 2.0
18 Gbps

HDMI 2.1
48 Gbps
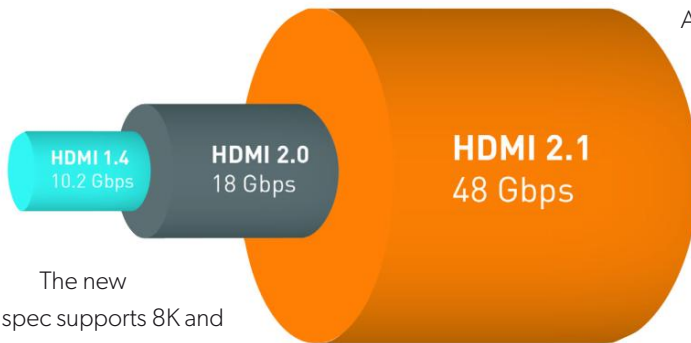
The new spec supports 8K and even 10K resolutions, but those are better thought of as future-proofing or targeted toward commercial applications. Modern gamers will appreciate the introduction of 4K/120Hz display support, though. Today's 4K monitors are limited to 60Hz and the GeForce GTX 1080 Ti (go.pcworld.com/Ti80) and Titan XP (go.pcworld.com/ttxp) graphics cards can already max those out in modern games. But 120Hz-plus displays are already coming in the first quarter of 2018 in the form of glorious G-Sync HDR monitors (go.pcworld.com/gsnc) by Asus and Acer, and Nvidia's next generation of graphics cards (go.pcworld.com/v0lt)—hopefully due sooner than later—will presumably have the power to drive such demanding displays.

HDMI also formalizes support for variable refresh rates. Variable refresh rates are the secret sauce behind Nvidia's G-Sync and AMD's FreeSync displays (go.pcworld.com/dspl), synchronizing the refresh rate of your monitor to your graphics card for buttery-smooth tearing- and stutter-free gameplay.

AMD already has its FreeSync technology working over HDMI (go.pcworld.com/fr33) in some monitors but HDMI 2.1 bakes VRR into the standard—a welcome change as VRR has largely been limited to DisplayPort connections, and those aren't often found in budget displays. HDMI is practically universal.

HDMI 2.1 also introduces Quick Frame Transport, which "reduces latency for smoother no-lag gaming, and real-time interactive virtual reality." Smoother gaming seems to be a big push for the new standard.

> HDMI 2.1 also introduces Quick Frame Transport, which "reduces latency for smoother no-lag gaming, and real-time interactive virtual reality."

Videos also get a boost, mostly due to dynamic HDR, which allows a video to send high-dynamic range metadata to your HDR television on a scene-by-scene or even frame-by-frame basis, rather than simply at the start of a video. That creates a better-tuned, more vibrant image throughout. Dolby HDR currently supports dynamic metadata, and it's being (slowly) added to

	HDMI version						
	1	1.1	1.2–1.2a	1.3–1.3a	1.4–1.4b	2.0–2.0b	2.1
Full HD Blu-ray Disc and HD DVD video	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Consumer Electronic Control (CEC)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DVD-Audio	No	Yes	Yes	Yes	Yes	Yes	Yes
Super Audio CD (DSD)	No	No	Yes	Yes	Yes	Yes	Yes
Auto lip-sync	No	No	No	Yes	Yes	Yes	Yes
Dolby TrueHD / DTS-HD Master Audio bitstream capable	No	No	No	Yes	Yes	Yes	Yes
Updated list of CEC commands	No	No	No	Yes	Yes	Yes	Yes
3D video	No	No	No	No	Yes	Yes	Yes
Ethernet channel (100 Mbit/s)	No	No	No	No	Yes	Yes	Yes
Audio return channel (ARC)	No	No	No	No	Yes	Yes	Yes
4 audio streams	No	No	No	No	No	Yes	Yes
2 video streams (Dual View)	No	No	No	No	No	Yes	Yes
Hybrid Log-Gamma (HLG) HDR OETF	No	No	No	No	No	Yes	Yes
Static HDR (HDR static metadata)	No	No	No	No	No	Yes	Yes
Dynamic HDR (HDR dynamic metadata)	No	No	No	No	No	No	Yes
Enhanced audio return channel (eARC)	No	No	No	No	No	No	Yes
Variable Refresh Rate (VRR)	No	No	No	No	No	No	Yes
Quick Media Switching (QMS)	No	No	No	No	No	No	Yes
Quick Frame Transport (QFT)	No	No	No	No	No	No	Yes
Auto Low Latency Mode (ALLM)	No	No	No	No	No	No	Yes
Display Stream Compression (DSC)	No	No	No	No	No	No	Yes
	1	1.1	1.2–1.2a	1.3–1.3a	1.4–1.4b	2.0–2.0b	2.1
	HDMI version						

the rival HDR10 format.

Quick Media Switching aims to end jarring black screens when videos switch, and eARC lets HDMI's audio return channel handle lossless audio. Our sister site TechHive has a deeper look at the home theater-boosting features in HDMI 2.1 (go.pcworld.com/thtr).

You'll need a new high-bandwidth HDMI 2.1 cable to support the fresh features, but fear not: Such a cable is also backward-compatible with existing HDMI implementations. Don't expect to see these on the streets in the near future, though, as the HDMI Forum says the HDMI 2.1 Compliance Test Specification will be published in stages between the first and third quarters of 2018. ⏻

SDR   Static HDR   Dynamic HDR

HP patches hundreds of laptops to remove hidden keylogger

Your touchpad can listen to your keyboard. **BY BRAD CHACOS**

If you bought an HP laptop anytime in the last five years, it could be tracking your every keystroke. Over the weekend HP revealed that nearly 500 of its notebooks dating as far back as 2012 shipped with a secret keylogger installed. Alongside the announcement, HP released driver updates to eradicate the software on affected laptops.

Security researcher Michael Myng (go. pcworld.com/hpky) discovered the keylogger when probing the Synaptics touchpad software on an HP laptop. HP's security bulletin says the "potential security vulnerability" affects all laptops with "certain versions of Synaptics touchpad drivers"—not necessarily just HP models.

The keylogger is disabled by default, however. "A party would need administrative privileges in order to take advantage of the vulnerability," the bulletin states. "Neither Synaptics nor HP has access to customer data as a result of this issue." HP told Myng that the keylogger was a debugging tool.

HOW TO REMOVE THE KEYLOGGER IN HP LAPTOPS

The same security bulletin (go.pcworld.com/scty) includes separate software update links for every HP laptop loaded with the keylogger. HP says you should install those updates "as soon as possible." CSO (go.pcworld.com/keyl) counted them all up and found a total of 475 affected laptops, with 303 being consumer laptops. Spectre, Envy, Pavilion, Omen, Compaq—they all contain the keylogger.

You'll need to know your laptop's model number to download the correct software package. You can find HP laptop model numbers by looking for the information on a sticker on the bottom of the machine. If you don't see the sticker, you can press Fn + Esc simultaneously to summon HP's System Information window. You're looking for the "product name" entry. Once you know it, head to HP's security bulletin, press Ctrl + F, and type in your laptop's details to quickly find the correct update for your system. You don't want to sift through all 475 listings individually to find the right one!

This isn't the first time HP has run into keylogging trouble in 2017. In May (go.pcworld.com/ptch), HP patched 30 laptops after a diagnostic update to the audio drivers accidentally resulted in capturing every keystroke and saving it to a local file. We're leaving superb systems like the HP Spectre x360 (go.pcworld.com/x360) on *PCWorld*'s list of the best laptops (go.pcworld.com/best) because the actions weren't nefarious, but here's hoping the company steps up its software quality assurance going forward. ⏻
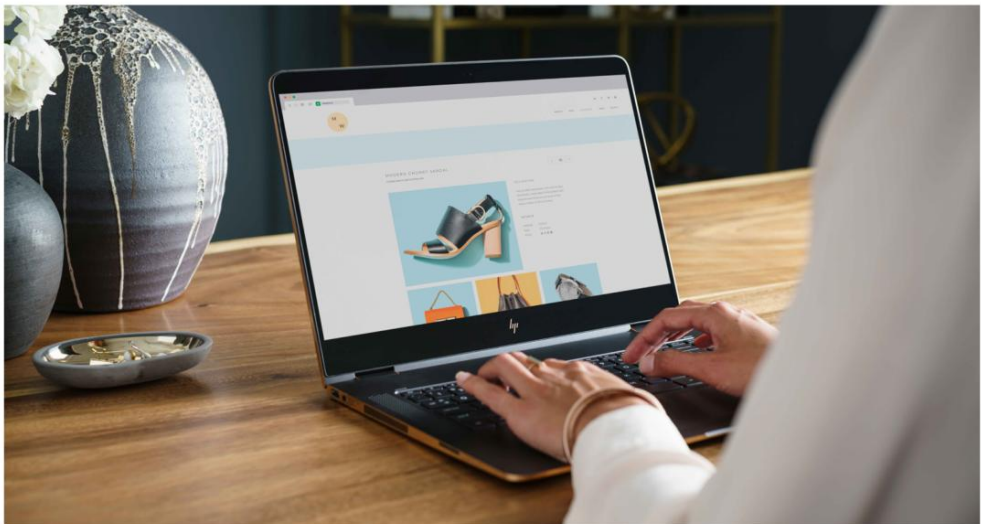
SAVE A LIFE. DON'T DRIVE HOME BUZZED.
BUZZED DRIVING IS DRUNK DRIVING.

Ad Council

U.S. Department of
Transportation

**AMERICA,
LET'S DO LUNCH.**

Julius Gaines, SINCE 1933. He's got a curious intellect that can't be satiated.
Now, he and 1 in 6 seniors face the threat of hunger and millions more
live in isolation. So pop by, drop off a hot meal and say a warm hello.
Volunteer for Meals on Wheels at **AmericaLetsDoLunch.org**

Microsoft Surface Book 2: The ultimate laptop improves in every way but one

An under-the-hood power issue with the Surface Dock, a USB-C port, and the charger is the only flaw in Microsoft's new convertible tablet laptop. **BY MARK HACHMAN**

Microsoft's Surface Book 2 solves a big problem for Microsoft: How do you market the Surface Book as a performance notebook when it's two years out of date? As our review shows, by making it bigger and faster, with longer battery life. Only a power problem slows it down.

With the Surface Book 2, Microsoft brings 8th-generation Intel Core processors and

powerful, discrete Nvidia GPUs with enough horsepower to start thinking of the Surface Book 2 as a graphics workstation. But Microsoft's big October surprise (go. pcworld.com/surp) was the debut of not one, but two Surface Book 2 devices: a 13.5-inch and a new 15-inch model (we

The 15-inch Surface Book 2 (left) sits next to the original 13.5-inch Surface Book, which otherwise looks nearly identical.

reviewed the latter). Neither is a simple clamshell notebook, though calling them convertible 2-in-1s instead seems like we're selling them short.

As our review of the 15-inch Surface Book 2 shows, however, the new generation isn't perfect. An ambitious decision to use a USB-C port has ripple effects for expansion capabilities. There's a power issue. And then there's the price: up to almost $3,300! Should you buy it? Yes, there's reason to look elsewhere. But none of its flaws are deal-breakers.

BASIC SPECS

You'd think that Microsoft's Surface Laptop (go.pcworld.com/5urf), given its name, would be the company's flagship notebook. But it's not. The Book is. I very rarely ever undocked either the first- or second-

generation Surface Book, and the combination of a sturdy construction, full-sized ports, terrific battery life, and excellent performance makes the Surface Book 2 the undisputed star of Microsoft's mobile lineup. Compare it to Apple's MacBook Pro (go. pcworld.com/mcbp), if you'd like: On paper, the Surface Book 2 tops it.

If you already own a Surface Book, you know what the Surface Book 2 looks like: It's virtually identical. But now it has a bigger sibling, as the Surface Book 2 ships in either a 13.5-inch or a 15-inch form factor. The cheapest Surface Book 2 is priced at $1,499 (with a 10 percent discount for military, students, faculty and even parents of K-12 or higher-ed students). Though it uses a 7th-gen Intel Core i5-7300U with an integrated GPU, the other models will ship with the 8th-gen Core i7-8650U.

We tested the priciest Surface Book 2 available: the $3,299 15-inch model.

Here are the basic specifications of the Surface Book 2:

CPU: Core i5-7300U (dual-core, 2.6GHz-3.5GHz); Core i7-8650U (quad-core, 1.9GHz-4.2GHz)

RAM: 8GB or 16GB 1,866MHz DDR3

GPU: Intel HD Graphics 620; Nvidia GeForce GTX 1050/2GB GDDR5 (13.5-inch); Nvidia GeForce GTX 1060/6GB GDDR5

Display: 13.5-inch PixelSense (3,000 x 2,000, 267 PPI); 15-inch PixelSense (3,240 x 2,160 (260 PPI)

Storage: 256GB/512GB/1TB NVMe SSD

Ports: Two USB 3.0 (Type A), one USB-C, two Surface Connect (one user-accessible)

Weight: 4.18 pounds (5 pounds with power brick)

Dimensions: 12.3 x 9.14 x 0.51-0.90 inches (13.5-inch); 13.5 x 9.87 x 0.59-0.90 in. (15-inch)

Chassis material: Magnesium

Microsoft has a new digital stylus—what it calls a Next Generation Surface Pen (go. pcworld.com/spen)—as well as the Surface Precision Mouse (go.pcworld.com/mose).

Microsoft has a new digital stylus—what it calls a Next Generation Surface Pen—as well as the Surface Precision Mouse.

Microsoft Surface Book 2

★★★★☆

PROS
- Top-notch, all-day battery life
- Excellent performance, particularly in graphics
- Stellar display, complete with extra visual modes

CONS
- Premium notebook, premium price
- Underpowered Dock makes multi-monitor support problematic

BOTTOM LINE
Microsoft adds to its "ultimate laptop," the Surface Book 2, by increasing the performance, battery life, and display size.

$3,299

Neither ships with the Surface Book 2, and neither is required. Our Book 2 shipped with the Windows 10 Creators Update, and not the Fall Creators Update—possibly due to a bug in the FCU that essentially turns off the Pen (go.pcworld.com/pbug).

DISPLAY AND CHASSIS

Microsoft's Surface Book has always reminded me somewhat of an answer to Lenovo's classic ThinkPad, replacing the classic black bento box with a nearly uniform silver slab. Unlike the Surface Pro and the Surface Laptop, there are no color options, and the only adornment is the Windows logo on the outer casing. Raise the display into a laptop configuration, and the keyboard's backlighting is the only visual cue that the Surface Book 2 is awake and active.

Your eyes, therefore, are sucked toward the big, bright, vibrant screen. Our Surface Book 2's display pumped out 412 nits, more than enough. And while a 3.2K IPS display might not quite reach that magic 4K milestone, the superb visual quality lives up to the Surface brand. More pixels would have negatively affected performance and battery life. It's a good trade-off.

Though Microsoft doesn't tout the Surface Book 2 as a content-creation machine as it does the Surface Studio, the Book 2 does include both of its color profiles: standard RGB, and its "enhanced" profile, which makes colors a bit more vivid. If you'd like, you can also use the Surface Dial peripheral on the ten-point touchscreen. While docked, the Surface Book 2 reclines to about the same 50-degree angle as the original Book, not nearly flat enough to let the Dial rest without sliding to the ground.

While undocked in tablet mode, though, the Surface Dial works fine.

Though the Surface Book's weight climbs toward four pounds, the incredibly long battery life means you can leave your charger at home. (If you're an acolyte of the Microsoft ecosystem, you probably already own a Surface Dock [go.pcworld.com/dock] for expansion and charging, anyway.) Still, it's no wonder why Microsoft's device chief Panos Panay refers to the Surface Book 2 as essentially a desktop, as the device is big and bulky, though not especially heavy.

The Surface Book 2 is a 2-in-1 convertible. Though it lacks the 360-degree hinge of most such models, the display can be flipped over and reattached into a tent mode for viewing videos, or detached to function as a conventional tablet. Press a button on the keyboard, and after a second or two the "muscle wire" retracts, and the tablet

The Surface Book 2, reclined, together with the USB 3.0 ports and the card reader on the left side. The accordion hinge looks very similar to the original Surface Book's.

Detached, the Surface Book 2 tablet is large and bulky, though not especially heavy.

connector provides the data interface between the base and tablet. Though you can connect a charger or Surface Dock to this port, there's very little point in doing so.)

The silvery metallic exterior of the Surface Book and Surface Book 2 both exude an almost military-like solidity. In a year or so of using the original Surface Book as a daily driver, it became slightly dented in places from normal wear and tear within a sometimes crowded backpack, and suffered a larger divot from a Kinect that plunged from the top of my rolltop desk as it lay, closed, on my desk. Neither affected its performance. That's a good indicator that the Surface Book 2 will be equally durable.

Piling an additional notebook or two on top of the Book never damaged its iconic, accordion "dynamic fulcrum" hinge, which remains within the Surface Book 2. When the Book 2 is closed—now with a more authoritative click—a small gap remains near the hinge. While that space may still be oddly frustrating to some, it doesn't affect performance and seems as structurally rigid as before. The tablet does wobble when you jiggle the base, though not as much as with the original Surface

disconnects from the base.

Microsoft claims the tablet disconnects more quickly than in the previous Surface Book, though in testing both, I couldn't see much difference. After a second or two, the Surface Book 2 releases the tablet, and you can lift it free. This is no Amazon Kindle, though: Undocked, the 15-inch tablet is almost ludicrously huge, and unless you're in the NBA, I doubt one hand will have enough breadth to hold it comfortably. By itself, the tablet weighs 1.8 pounds, surprisingly light for something so big, but it's still awkward. Once detached, it feels like it needs a Surface Pro-like kickstand. The tablet is multi-touch, with the standard ten points of contact.

(Undocked, you'll discover that a Surface

The "hinge gap" remains on the Surface Book 2.

Book. It's a reminder, though, that this isn't a true notebook.

Perhaps the most surprising thing about the Surface Book 2, though, is simply how quiet it is. Microsoft uses a passive cooling system to cool the clipboard or tablet portion of the Surface Book 2, forgoing the fan entirely. Yes, it's a fanless Core i7!

THE KEYBOARD, AND THE PORT/POWER DEBACLE

The Surface Book 2 didn't mess too much with one good thing: Its keyboard feels essentially unchanged from the first iteration. Note, however, that it follows the Surface Laptop's layout, rather than the original Book's: Microsoft eliminated the "Insert" key, and added a separate key for toggling through various backlight controls. Otherwise, a wider bezel surrounds the keyboard on the 15-inch model, really emphasizing how vast the available space is.

I've always found the Surface Book's

keyboard quite comfortable to type upon, with a firm response and good key travel. The Surface Book 2 keyboard felt ever so slightly stiffer, with response that felt a tad shallower. The trackpad feels identical: slick, smooth, and responsive.

The Surface Book 2 also includes 802.11ac for wireless connectivity, which connected satisfactorily as I roamed around my home and office. Bluetooth 4.1 Low Energy is also built in, which avoids collisions with the Wi-Fi signal. Finally, there's a bonus for gamers: Xbox Wireless is built into the 15-inch version, meaning you can connect your wireless Xbox One controller for gaming on the go.

Microsoft did mess with the port allotment, however, and it's one area where I feel the Surface Book 2 takes a step back.

The left side of the Surface Book 2 base should look familiar to Surface Book owners: with two USB 3.0 Type A connectors, plus a UHS-II SDXC card reader. Microsoft even preserved the

3.5mm headphone jack.

Along the right side, though, things change: Alongside the expected Surface connector, there's a USB-C connector—and that's it.

Previously, Surface Books included a Mini DisplayPort connector, a simple way to connect to a single monitor by way of a Mini DP–to–HDMI cable. To connect to multiple monitors, you used the Surface Dock (go. pcworld.com/sfdo), a $200 hub with two additional Mini DP connections.

With the Surface Book 2, the Mini DP connector is gone. Instead, you'll need to invest in new infrastructure, beginning with a new adapter—a USB-C–to–HDMI cable (go. pcworld.com/u2hd), perhaps—that will cost you about $20. Theoretically, the USB-C connector also anticipates a future where you'll be able to connect the Surface Book 2 to an ecosystem of external hard drives and

other devices. But Microsoft's implementation also lacks the Thunderbolt I/O implementation, part and parcel of Apple's MacBook Pro and an easy way to connect multiple displays to a device that supports it.

That means connections to external monitors are somewhat limited. Officially, the Surface Book 2 can drive two 4K monitors at 30Hz either via the USB-C port or the Surface Dock. Alternatively, either the Dock or the USB-C port can power a single 4K monitor at 60Hz. (If you try simultaneously to connect a monitor via USB-C and a second monitor over the Dock, only the Dock-connected monitor will light up, Microsoft says.) We successfully connected the Book 2 to a conventional 1080p monitor at full frame rate, but managed only 30 frames per second on a 120Hz 4K HDTV.

Microsoft's traditional solution for multi-monitor setup has been the Surface Dock, which allows you to connect up to two external displays via a pair of Mini DisplayPort connectors. But that has a problem, too: The 144-watt Dock doesn't supply as much power as the Surface Book 2's 180-watt native charger. Microsoft says that, under load, a Surface Book 2 powered by the

The Surface Book 2's USB-C port breaks with tradition.

Dock may use up so much power that it will drain the battery and enter sleep mode.

During testing, I played a few 3D-intensive games for nearly an hour, while using the Dock, as well as an additional 15 minutes or so while completely undocked. During that time, the battery decreased to about 65 percent overall. During ordinary use—web browsing, office work, et cetera—the Dock supplied sufficient power without issue. And if the Surface Book 2 is connected to its charger, as well as to a single monitor via a USB-C–to–HDMI cable, the Book 2 should operate normally.

Though we tested the Surface Book 2 by itself, with no external monitor attached, additional testing revealed an unexpected issue: undocked, while playing a 3D game, the Windows 10 power slider remains at its most conservative setting, clocking the GPU down somewhat beneath its full potential. If you dial it up to Best Performance mode, the battery begins to discharge, as our separate testing shows (go.pcworld.com/gmng).

Interestingly, the Surface Book 2 battery won't discharge completely. In fact, over time, the GPU seems to throttle itself to bring the power consumption down—but this lowers the performance, too. Microsoft's explanation is that the Surface Book 2 is a content-creation machine for STEM users in the sciences and education, not a gaming platform. This smells like a bit of PR spin to us.

Meanwhile, Microsoft claims that the

Book 2 will charge from any USB-C PD3.0-compliant charger from 7.5W to 95W, with a 60W to 95W USB-C charger powering the Surface Book 2 to 80 percent charged in 1.5 hours time. I didn't have enough time to confirm the latter claim, but as for the former, our Surface Book 2's USB-C port didn't accept power from a few random external chargers or battery packs. (And no, you can't charge the Surface Book 2 from the USB-C and Surface ports, simultaneously—we asked.)

We don't consider the additional power issues a reason not to buy the Surface Book 2, especially if you do plan to use it as a content-creation machine, not as a gaming platform.

All of this talk of ports and power sparked a somewhat lively internal debate. How many people actually connect more than one monitor to a laptop? How many buy a Surface Book 2 for gaming, and how many of those will be unhappy with a GPU that throttles itself over time to prevent the battery from discharging—and isn't fully throttled up in the first place? Our initial review factored in the Dock issues. We don't consider the additional power issues a reason not to buy the Surface Book 2, especially if you do plan to use it as a content-creation machine, not as a gaming

platform. But if gaming is your thing, consider one of these, the best gaming laptops, instead (go. pcworld.com/sept).

SPEAKERS, CAMERAS, THE PEN AND THE PRECISION MOUSE

Like the original Surface Book, the Book 2 sports both front (5MP, 1080-capable) and rear (8MP autofocus, 1080p-capable) cameras that take serviceable pictures and enable Windows Hello's biometric logins. Normally, few people would care about a tablet camera. But the Windows 10 Fall Creators Update that's rolling out now includes such fun utilities as the Mixed Reality Viewer (go. pcworld.com/mirv), where you can snap a photo with the rear camera and drop in a computer-generated dinosaur, giant taco, or bug right into the scene. Our review unit shipped with the older Creators Update, however.

The Surface Book 2 continues the Surface Book tradition of decent audio, accompanied by Dolby Audio processing. Though it supplies an adequate range of sound, you'd still be better off routing Spotify through headphones or an accompanying Invoke speaker for better bass response. The speakers are mounted inside the tablet, unlike the Surface Laptop's base-mounted speakers.

Microsoft's new Surface Pen ships in a variety of colors.

Microsoft also provided what it calls a "next-generation" Surface Pen for review. To be honest, the increasing levels of sensitivity—4,096 in this version—have moved beyond our ability to test. Microsoft's new Pen looks nice, writes smoothly, and is powered by a replaceable AAAA battery. That's enough.

We didn't receive Microsoft's new Precision Mouse in time for review, but we were quite impressed in the short hands-on time we had earlier (go.pcworld.com/hnds).

PERFORMANCE

We expect an Nvidia GTX 1060-powered system (go.pcworld.com/1o6o) such as the Surface Book 2 to perform well. Microsoft created extra pressure, however, by claiming the Surface Book 2 would perform three to four times better than the original Surface Books. In our performance charts, you'll see us compare the Surface Book 2 to its predecessor, as well as some recent laptops

we've reviewed that have discrete graphics: Dell's XPS 15 (go.pcworld.com/dx15), Lenovo's Yoga 720 (go.pcworld.com/y0ga), and Samsung's Notebook 9 Pro (go.pcworld.com/9pro).

We threw both mainstream and gaming benchmarks at the Surface Book 2. Somewhat surprisingly, the Surface Book 2 doesn't necessarily top the heap in general productivity performance, but as a graphics workstation it's among the very best.

Our first test is PCMark Work 8 Conventional, which simulates everyday activities like web browsing, video chat, and document editing. It's a good test for isolating the CPU's role in everyday use. Any machine scoring 2,000 or above will sail along smoothly during these low-intensity tasks. The Surface Book 2 lands square in the middle: a little

PCMark 8 Work 2.0
Conventional Native Resolution

Dell XPS 15 (Core i7-7700HQ)	3,486
Samsung Notebook 9 Pro (Core i7-7500U)	3,362
Lenovo Yoga 720 15in (Core i7-7700HQ)	3,163
Microsoft Surface Book 2 (Core i7-8650U)	3,117
Microsoft Surface Laptop (Core i5-7200U)	2,901
Microsoft Surface Book (Core i5-6300U)	2,826
Microsoft Surface Book (Core i7-6600U)	2,744
HP Spectre x360 (Core i7-7500U)	2,706
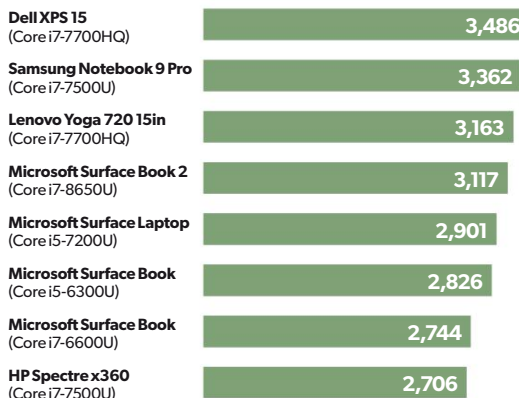
LONGER BARS INDICATE BETTER PERFORMANCE

PCMark 8 Home 2.0
Conventional Native Resolution

Dell XPS 15 (Core i7-7700HQ)	3,489
Samsung Notebook 9 Pro (Core i7-7500U)	3,362
Lenovo Yoga 720 15in (Core i7-7700HQ)	3,360
Microsoft Surface Book 2 (Core i7-8650U)	2,974
Microsoft Surface Book (Core i5-6300U)	2,826
Microsoft Surface Book (Core i7-6600U)	2,744
Microsoft Surface Laptop (Core i5-7200U)	2,714
HP Spectre x360 (Core i7-7500U)	2,429
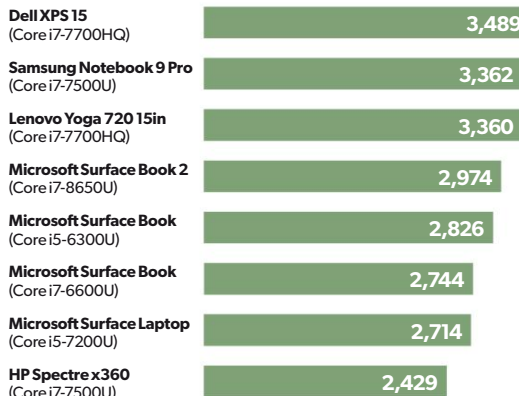
LONGER BARS INDICATE BETTER PERFORMANCE

Remember, the eighth-generation Core chips use four cores and eight processing threads.

faster than its predecessors, but a little slower than the trio of recent competitors.

The Home and Creative broaden the scope somewhat, adding light gaming, photo editing, and finally some image and video processing. In general, how the Surface Book 2 compares against the Surface Book most likely ties into the base processor clocks of both chips: 2.6GHz for the original Book, 1.9GHz for the Surface Book 2. When needed, the Book 2 can boost up to 4.2GHz—but in these tests, it

doesn't need to. As with the Work Conventional test, it scores below similar laptops with discrete GPU.

Remember, the eighth-generation Core chips use four cores and eight processing threads. Applications that take advantage of all of them perform better than the earlier dual-core Core chips. Maxon's Cinebench benchmark takes advantage of this, with benchmarks that exercise all available cores. Here, the Surface Book 2 is in the middle of the quad-core leading edge, while all the dual-core systems fall into place behind them.

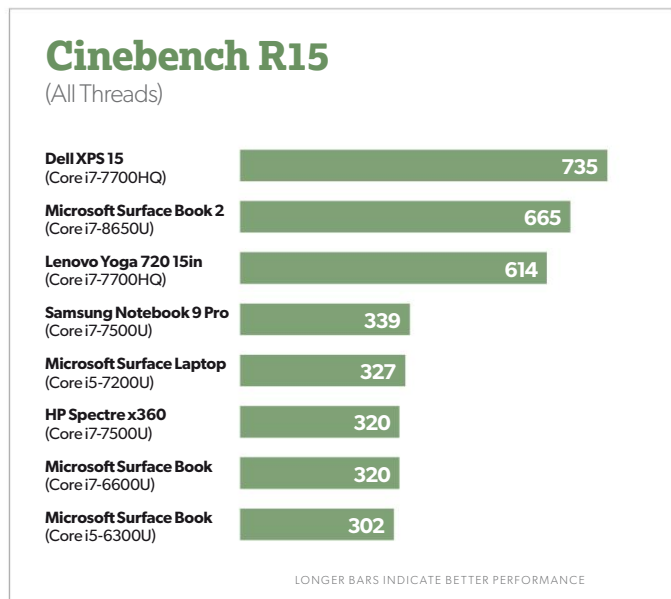We ran HandBrake, a prolonged test that converts a Hollywood movie into a format suitable for an Android tablet. One of the advantages of Windows 10 and the new Core chips is that they're optimized for video playback. Still, the test is both a good workout as well as a real-world application, especially if you're preparing some in-flight entertainment for your kids. Here, Microsoft's Surface Book 2 is the slowest of the quad-cores, possibly because it throttles its fanless Core i7 chip under prolonged load.

The Surface Book 2 differs slightly from gaming machines in that it's more

Cinebench R15
(All Threads)

Device	Score
Dell XPS 15 (Core i7-7700HQ)	735
Microsoft Surface Book 2 (Core i7-8650U)	665
Lenovo Yoga 720 15in (Core i7-7700HQ)	614
Samsung Notebook 9 Pro (Core i7-7500U)	339
Microsoft Surface Laptop (Core i5-7200U)	327
HP Spectre x360 (Core i7-7500U)	320
Microsoft Surface Book (Core i7-6600U)	320
Microsoft Surface Book (Core i5-6300U)	302

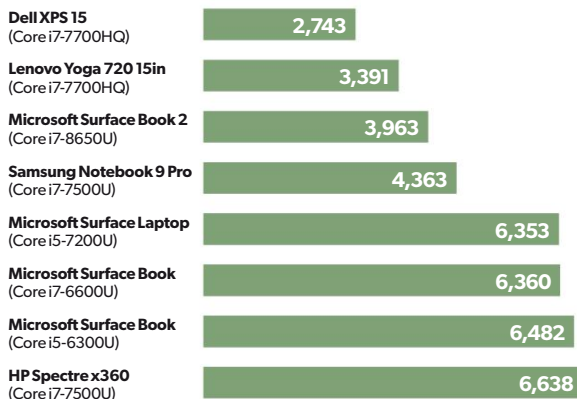LONGER BARS INDICATE BETTER PERFORMANCE

of a general-purpose performance notebook. If you'd like, you can download a Play Anywhere title for the Xbox, like *Gears of War 4,* and fire it up on the Surface Book 2. Conversely, Microsoft also offers a complimentary three months of Adobe Creative Cloud—check the installed Surface app for the offer—as encouragement to use it for more traditional creative pursuits. Either way, it's hard to go wrong.

Here, we tested using the 3DMark Sky Diver benchmark, where the Surface Book 2 really begins to strut its stuff, outpacing all comers. Compared to the prior-generation Surface Book with discrete GPU, Microsoft's claim of a 3X to 4X performance difference is proven out.

I also played around with performance-hungry games from yesteryear, like *Crysis 2,* and maxed it out on my 1080p monitor at

HandBrake Encode 0.99
(seconds)

Dell XPS 15 (Core i7-7700HQ)	2,743
Lenovo Yoga 720 15in (Core i7-7700HQ)	3,391
Microsoft Surface Book 2 (Core i7-8650U)	3,963
Samsung Notebook 9 Pro (Core i7-7500U)	4,363
Microsoft Surface Laptop (Core i5-7200U)	6,353
Microsoft Surface Book (Core i7-6600U)	6,360
Microsoft Surface Book (Core i5-6300U)	6,482
HP Spectre x360 (Core i7-7500U)	6,638

SHORTER BARS INDICATE BETTER PERFORMANCE

3DMark Sky Driver 1.0
Overall

Microsoft Surface Book 2 (Core i7-8650U)	19,190
Dell XPS 15 (Core i7-7700HQ)	17,174
Lenovo Yoga 720 15in (Core i7-7700HQ)	15,325
Samsung Notebook 9 Pro (Core i7-7500U)	8,863
Microsoft Surface Book (Core i7-6600U)	6,220
Microsoft Surface Laptop (Core i5-7200U)	3,841
HP Spectre x360 (Core i7-7500U)	3,704
Microsoft Surface Book (Core i5-6300U)	3,658
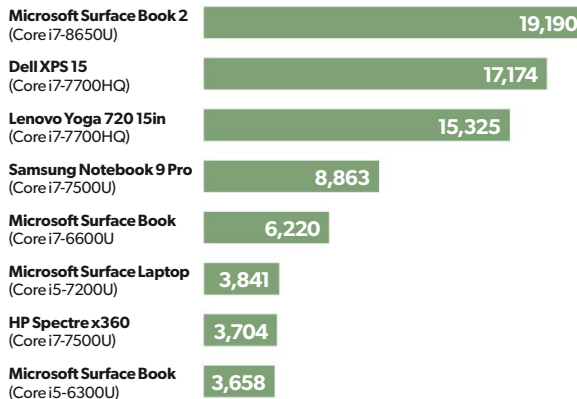
LONGER BARS INDICATE BETTER PERFORMANCE

Battery life
(minutes)

Microsoft Surface Book 2 (Core i7-8650U)	819
Microsoft Surface Laptop (Core i5-7200U)	765
Microsoft Surface Book (Core i5-6300U)	637
Microsoft Surface Book (Core i7-6600U)	605
Samsung Notebook 9 Pro (Core i7-7500U)	590
HP Spectre x360 (Core i7-7500U)	429
Lenovo Yoga 720 15in (Core i7-7700HQ)	426
Dell XPS 15 (Core i7-7700HQ)	331
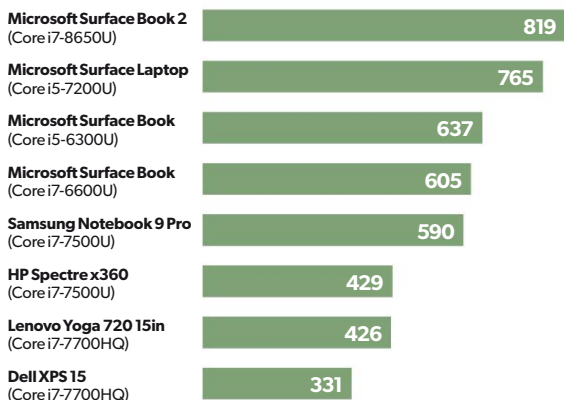
LONGER BARS INDICATE BETTER PERFORMANCE

Over time, we've expanded the notion of "all-day battery life" from a generous six hours to more than eight hours and above.

Ultimate performance levels. Modern games, such as *Watch_Dogs 2*, also rendered smoothly at High and Very High settings. Just for fun, I tried *Far Cry 3* on the Surface Book 2's native tablet settings. It didn't quite deliver playable frame rates, though the detail was amazing.

Finally, there's battery life—a traditional strength of the Surface Book, and one that carries over here. We gauge a laptop's stamina with our video rundown test. We first charge the laptop to 100 percent, then set its screen between 250 and 260 nits to simulate the brightness level you'd use in an office. With a pair of earbuds plugged in and the volume set to 50 percent, we run a 4K video file (the open-source *Tears of Steel*) on continuous loop in Windows 10's Movies & TV app until the laptop shuts itself off.

Over time, we've expanded the notion of "all-day battery life" from a generous six hours to more than eight hours and above. The Surface Book 2 carves out new territory at the high end, pushing past a whopping 13 hours with ease. Microsoft's Surface Book 2 includes two different batteries: a 23.2 Watt-hour battery in the tablet, and a separate 62.2 Wh battery in the base. (Interestingly, those are the design capacities, as measured by Windows; the batteries actually charged to 23.6Wh and 65.6Wh, respectively.)

Sure, 13 hours is far less than the 17 hours at which Microsoft rates the Surface Book 2. But Microsoft typically dials down the brightness to below the levels at

which we test. On the other hand, our tests didn't take advantage of the Windows 10 Fall Creators Update's ability to prolong battery life (go.pcworld.com/btry) by playing back video at a lower resolution, or running entirely in battery-saver mode. As our previous tests showed, aggressively managing battery life can tack on as much as 30 percent more runtime—enough to match up with Microsoft's own numbers.

VERDICT

Reports of the PC's death have ushered in a renaissance of sorts, producing marvelous designs from Microsoft, HP, Lenovo, and others. I used the original Surface Book as a daily driver for months, if not years, and I'm an unabashed fan of that original—and now, the Surface Book 2.

The trap that Microsoft sets, though, is not unlike Apple's: The company tacitly encourages you to think within its ecosystem and only its ecosystem, rather than its competition. Once you begin looking elsewhere, options like the Lenovo Yoga 720 (go.pcworld.com/y0ga) begin to look more attractive, and at possibly cheaper prices, too. Other alternatives include the Dell XPS 15, which tops the performance charts, above—save for battery life, where it finishes at the bottom. Otherwise, what's a few thousand dollars between friends?

> **The trap that Microsoft sets, though, is not unlike Apple's: The company tacitly encourages you to think within its ecosystem and only its ecosystem, rather than its competition.**

There's one question we can't answer: stability. One of the unfortunate legacies of the Surface products is a shakedown period of a few months where some early models suffered anything from "hot bag" refusals to enter a sleep state (go.pcworld.com/slep), to screen flickering. Our Surface Book 2 exhibited a strange buzzing noise (a short? a speaker flaw?) almost immediately, which persisted for about an hour or so, then vanished completely. We experienced no other glitches.

The bottom line? If you can afford a Surface Book 2, we'd recommend it. So many of its attributes are simply fantastic, including its graphics performance and stellar battery life. If Microsoft had avoided all of the complications associated with its decision to incorporate USB-C (omitting Thunderbolt, upgrading the Dock), as well as the power issues, we'd be hard-pressed to find anything wrong with the Surface Book 2 at all. Microsoft has made its "ultimate laptop" even better, in many ways. Just not all of them. ⏻

Dell XPS 13 (2017): Intel's 8th-gen CPU makes a great laptop even greater

Quad-core performance in a tiny laptop is a big deal. **BY GORDON MAH UNG**

Forgive us if you've heard this one before (go.pcworld.com/befr) but Dell's latest XPS 13 is truly the best one yet. Seriously.

Newly upgraded with Intel's 8th-generation CPUs, the XPS 13 offers unheard-of performance in an ultra-portable laptop. By "unheard-of," we mean the XPS 13 offers performance approaching and occasionally surpassing that of much larger and much heavier powerhouse laptops.

Granted, it hasn't changed much on the outside. As we go through the features and specs, though, you'll see the significant changes happening on the inside.

PRICES, SPECS AND FEATURES

Prices: Our review unit currently sells for $1,300 from Dell's website (go.pcworld.

com/dlwb). Other SKUs from Dell's site range from the lowest-end $800 version, with a 7th-generation Core i3-7100UCPU, 4GB of RAM, and a 128GB SSD; and the top-of-the-line $1,750 model with the same 8th-generation Core i7-8550U and 256GB SSD.as our unite, but its memory is boosted to 16GB.

CPU: The star of the show is Intel's new 8th-generation Core i7-8550U. Based on the same basic microarchitecture as CPUs used in older versions of the XPS 13, the 8th-gen chip's secret sauce is

The XPS 13 hasn't changed much on the outside, but this 8th generation upgrade is worth it for performance fiends.

doubling the CPU cores (read our in-depth review (go.pcworld.com/coi7) of the 8th-gen CPU for all the details). Up to now, most mainstream laptops have stuck to dual-core CPUs because quad-core CPUs would have required more cooling and bigger, heavier shells to handle the heat. Not anymore. It's truly exciting to see quad-core power fitting into thin and light laptops

RAM: 8GB of LPDDR3/1866. The low-power version of DDR3 doesn't allow for the use of expansion slots, so the RAM is soldered to the motherboard. The good news is Dell used a pair of modules to enjoy the greater bandwidth of dual-channel mode, rather than use a single module that would give you only half the bandwidth.

GPU: There's room for a quad-core chip but not for discrete graphics, so what you get is Intel UHD 620. You might think the "U" means something special, but from a performance point there really ain't none.

Display: You pretty much get the same 1920x1080 matte screen with "Infinity" bezel on the XPS 13 that we've seen since the first model was introduced in 2015. The one in our unit puts out very decent 400 nits (much like the prior version). While it doesn't have the pizzazz of a "glossy" screen (which Dell

You pretty much get the same 1920x1080 matte screen with "Infinity" bezel on the XPS 13 that we've seen since the first model was introduced in 2015.

offers in the touch-screen version) it does a great job of reducing glare.

Storage: A 256GB Toshiba M.2 NVMe SSD handles the storage, and if you're willing to risk opening up the XPS 13, you should be able to swap in a larger drive.

Ports: For connectivity, you get two USB 3.0 (5Gbps) Type A ports, an SD card reader, combo audio and a single Thunderbolt 3 port. That Thunderbolt 3 port is a two-lane implementation rather than four-lane, so maximum throughput is less than what you'd get with some competing laptops. There's also a square lock port supporting Noble locking cables.

The XPS 13 supports (and ships with) a standard barrel charger, but you could also charge via the Thunderbolt 3 / USB-C port. While having a dedicated charging port means the Thunderbolt 3 / USB-C is available for other uses, we hope the next version will offer two Thunderbolt 3 ports and a USB-C charger in the box.

Weight: The non-touch version we tested weighs in at a barely-there 2 pounds, 12 ounces.

Dimensions: The size of the XPS 13 remains the same at 11.98 x 7.88 x 0.33 inches. It has a much smaller footprint than a MacBook Air 13, but it's thicker than HP's

Dell XPS 13 (2017)

★★★★⯪

PROS
- Quad-core CPU delivers impressive performance in most tasks
- More than 12 hours of battery life
- Nearly flawless thin-and-light design

CONS
- Integrated graphics restricts it to mainstream apps
- Webcam is awkwardly placed at the bottom of the screen

$1,199

Spectre X360 13T. Think of it as "stout."

In practical terms, this XPS 13 hasn't changed much from the prior (2016) version using 6th-gen CPUs. That's actually been one of the complaints about the XPS 13: It hasn't had a major redesign since this generation made its debut in 2015.

You know what? We're OK with it. Why should Dell mess with success? Apple, for example, hasn't really made major exterior changes to its popular MacBook Air 13 since, 2011 or maybe 2010. We, frankly, can't tell.

The XPS 13 still wins on size and portability. We still love the trackpad. We think the keyboard is a little small (but still good), and we still think the webcam is really awkwardly placed along the bottom of the display bezel.

The right side of the XPS 13 has the SD card reader, one of its two USB-A ports, and the Noble lock port.

The real change here is inside, and it's all about performance.
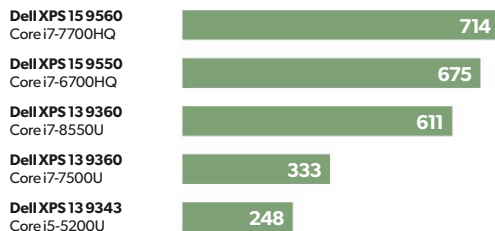
PERFORMANCE: WHAT A DIFFERENCE 8TH-GEN MAKES

When Intel announcedd he 8th-gen Core CPU, it it had successfully squeezed quad-core performance into places it couldn't before, we were highly skeptical of how much actual practical performance you could wring out of a tiny laptop, when all quad-core laptops before it weighed usually twice as much.

We tested the 8th-gen XPS 13 against two predecessors: a 7th-gen Core i7 XPS 13 and a 5th-gen Core i7 XPS 13. We also roped in two much larger XPS 15 laptops with quad-core chips—6th-gen Skylake and 7th-gen Kaby Lake chips, specifically.

The results thoroughly surprised us. For example, using Maxon's Cinebench R15, we can gauge the relative performance of the 8th-gen Core i7 XPS 13 vs. a 7th-gen Core i7 XPS 13. As you can see, the XPS 13 destroys its dual-core 7th-gen predecessor and runs up very close to the XPS 15s on multi-threaded workloads. Impressive.

Cinebench R15.038
Multi-core performance

Dell XPS 15 9560 Core i7-7700HQ	714
Dell XPS 15 9550 Core i7-6700HQ	675
Dell XPS 13 9360 Core i7-8550U	611
Dell XPS 13 9360 Core i7-7500U	333
Dell XPS 13 9343 Core i5-5200U	248

LONGER BARS INDICATE BETTER PERFORMANCE

Cinebench R15.038
Single-core performance

Dell XPS 13 9360 Core i7-8550U	157
Dell XPS 15 9560 Core i7-7700HQ	147
Dell XPS 15 9550 Core i7-6700HQ	139
Dell XPS 13 9360 Core i7-7500U	136
Dell XPS 13 9343 Core i5-5200U	108

LONGER BARS INDICATE BETTER PERFORMANCE

Handbrake 0.9.9
Encode (sec)

Dell XPS 15 9560 Core i7-7700HQ	2,743
Dell XPS 15 9550 Core i7-6700HQ	3,033
Dell XPS 13 9360 Core i7-8550U	3,567
Dell XPS 13 9360 Core i7-7500U	5,876
Dell XPS 13 9343 Core i5-5200U	7,934
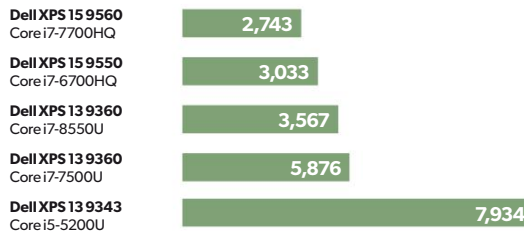
SHORTER BARS INDICATE BETTER PERFORMANCE

Cinebench also allows you to run a single-thread test, which means the laptop's running on a single core. Running the five laptops through the same test, the 8th-gen XPS 13 actually outperforms the 7th-gen XPS 15. No, that's not a typo: The tiny XPS 13 can outshine the beefier XPS 15 in some single-threaded tasks.

Mind you, the performance is all relatively close. Because the vast majority of programs people run typically use only a single CPU core, however, this speaks well of the new XPS 13's capabilities.

One question we wanted to know was how well the XPS 13 and its 15-watt quad-core CPU would hold up on longer, harsher loads when compared to a larger XPS 15 and its 45-watt quad-core CPU. We suspected performance would drop off a cliff once you subjected the CPU to a really heavy load.

The intensive HandBrake test can take 90 minutes or more on many dual-core laptops. The XPS 15 with its 7th-gen Kaby Lake quad-cores comes out in front by a very healthy margin, as does the XPS 15 with its 6th-gen Skylake quad-core. But that tiny XPS 13 turns in a very respectable score. Again, we're talking about a laptop that's almost half the weight of its bigger cousins.

GRAPHICS PERFORMANCE

Moving on to graphics, we compared the three generations of XPS 13 we had on hand (using the latest drivers) on 3DMark's Skydiver graphics test. We didn't include the XPS 15, in this comparison, because clearly the larger laptop's discrete graphics chip would destroy the XPS 13.

Looking at the results of the 7th-gen and the 8th-gen XPS 13 laptops, the 8th-gen is in front by a tiny margin—after all, they both have the same Intel UHD 620 integrated graphics. Both are basically fine for low-ambition or entry-level gaming tasks, but

3DMark Skydiver 1.0
Graphics

Dell XPS 13 9360 Core i7-8550U	4,297
Dell XPS 13 9360 Core i7-7500U	4,019
Dell XPS 13 9343 Core i5-5200U	3,321

LONGER BARS INDICATE BETTER PERFORMANCE

PCMark 8 Work 2.0
Conventional

Dell XPS 13 9343 Core i5-5200U	2,835
Dell XPS 13 9360 Core i7-7500U	3,329
Dell XPS 15 9550 Core i7-6700HQ	3,350
Dell XPS 15 9560 Core i7-7700HQ	3,594
Dell XPS 13 9360 Core i7-8550U	3,608

LONGER BARS INDICATE BETTER PERFORMANCE

nothing to text home about. If you want more of a gaming experience, look for a laptop with discrete graphics.

To gauge performance in everyday tasks, we use PCMark 8 Work Conventional. The 8th-gen XPS 13 ties with the 7th-Gen XPS 15, but all contenders—even the dual-core, 5th-gen XPS 13—stick pretty close. The lesson here: If all you do is browse the Internet and run Microsoft Office you don't need a quad-core CPU, so don't put out money for a feature you won't use.
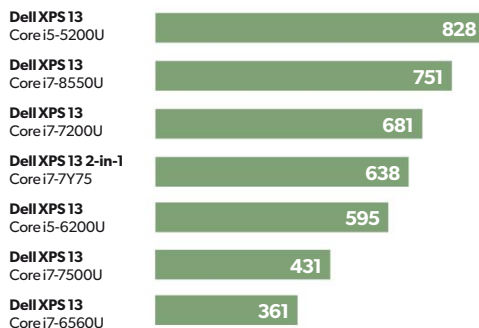
BATTERY LIFE

Our last test is probably the most critical for a portable laptop: battery life. For that we loop a 4K video using Windows' built-in Movies & TV player, with the laptop in Airplane mode and with earbuds in place (and audio cranked to about 50 percent). We set the screen to a relatively bright 250 to 260 nits and let the laptop run from a full charge until it dies.

We compared the 8th-gen, quad-core XPS 13 to an even broader swath of its forbears. We were very curious to see whether the quad-core CPU would take down the battery.

The answer is no. First, video playback today, using a modern, efficient media player, resides almost entirely in the domain of the graphics chip.

4K Video Run Down
(minutes)

Dell XPS 13 Core i5-5200U	828
Dell XPS 13 Core i7-8550U	751
Dell XPS 13 Core i7-7200U	681
Dell XPS 13 2-in-1 Core i7-7Y75	638
Dell XPS 13 Core i5-6200U	595
Dell XPS 13 Core i7-7500U	431
Dell XPS 13 Core i7-6560U	361

LONGER BARS INDICATE BETTER PERFORMANCE

But the winner is…the original XPS 13 with a 5th-gen Core i5-5200U, which pounds out almost 14 hours of playback—and this despite having a smaller battery. We think it helps that it has a low-power SATA SSD and also its 4GB of RAM vs the 8GB of RAM (more RAM uses more power).

Coming in second with a very decent 12-plus hours of battery run time is the the 8th-Gen XPS 13. That's good performance.

The worst performance comes from Dell's high-resolution XPS 13 models with touchscreens. Feeding all of those pixels takes power, so be ready to pay for it in battery life.

Basically, expect very good battery life on the XPS 13 for video playback, though it will certainly drop on more intensive tasks. Read our deep dive on another

The worst performance comes from Dell's high-resolution XPS 13 models with touchscreens. Feeding all of those pixels takes power, so be ready to pay for it in battery life.

laptop's battery performance to get more information on how battery life can vary (go.pcworld.com/batt).

Price: Of course, the most important "spec" is probably the price. As reviewed, the XPS 13 with the 8th gen CPU, 8GB of RAM, 256GB SSD and touch screen came in at $1,299 (although we swore it was originally $1,199 when we looked initially.) With the Black Friday season upon us though, Dell had cut the price of it to $999. That's a hell of a deal, frankly for the performance you're getting.

Dell offers one step up in the form of the XPS 13 with a quad HD or 3200x1800 resolution touch screen. Internally, it's the same CPU but Dell ups the RAM to 16GB of LPDDR3/1866 and larger SSD options up to 1TB. The base touch screen QHD version with a 256GB SSD pushes the price up to $1,749, with recent Black Friday prices lowering it to $1,549. That isn't quite the steal the FHD version is and you'll likely take a battery life hit.

VERDICT

In the end, color us impressed. We fully expected the XPS 13 with its quad-core CPU to offer only marginal improvements at best, but the performance results were amazing.

For those who do CPU-intensive tasks, the XPS 13 can truly hang with laptops that weigh almost twice as much. It's close enough that some might even consider skipping big laptops for the XPS 13. Not all, of course. Those who need more RAM or far more graphics grunt still have nowhere else to turn—though recent innovations like Nvidia's Max-Q (go.pcworld.com/maxq) and the upcoming Intel/AMD Radeon partnership (go.pcworld.com/amrd) could change that.

But let's not diminish the fact that you can now get quad-core performance in a 2.5-pound laptop. As we said, this Dell XPS 13 is truly the best one yet. ⏻
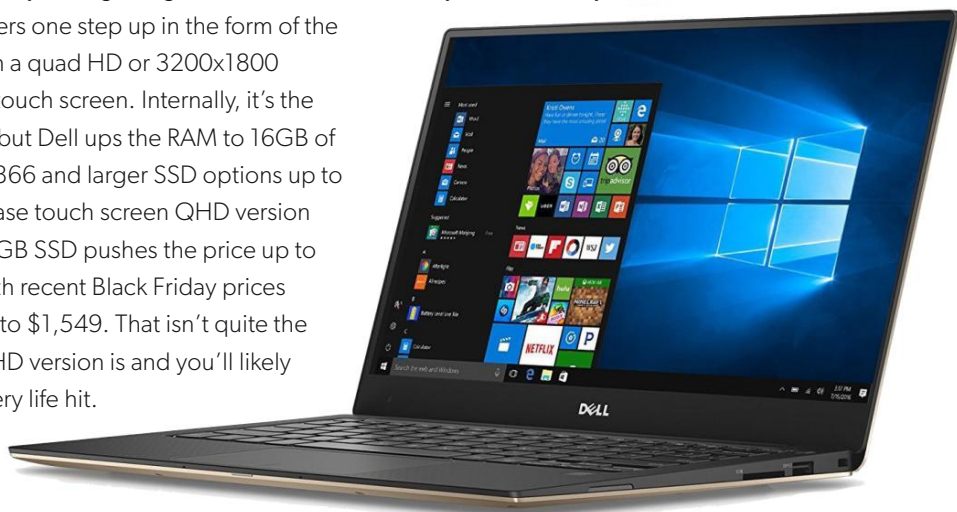
Alienware 15: It's built like a tank you can actually carry

Some gaming laptops aren't truly portable, but the Alienware 15 won't break your back. **BY HAYDEN DINGMAN**

How much does two inches matter? You wouldn't think it wouldd be a huge factor, but when I reviewed the Alienware 17 (go.pcworld.com/al17) I called it "staggeringly huge" and said it was "time to hit the gym" if you wanted to carry one around. Since then, I've spent a few weeks using the Alienware 15—a laptop with the potential to be just as powerful, but in a slightly lighter package.

And it turns out that's good enough.

THIS ONE IS JUST RIGHT

Don't get me wrong: The Alienware 15 is still a massive laptop, especially if you put it up against competing 15-inchers. This isn't a Razer Blade-style device, and portability suffers. Alienware could really use a lightweight line as an alternative—and maybe we'll start seeing those soon, as the line between Alienware and Dell begins to blur.

But I felt like the Alienware 17 was completely unmanageable. It was a set-it-and-forget-it laptop, one you plop on the desk and then never move. With the Alienware 15 you might want to bulk up your back muscles, but carrying it is definitely doable.

How do I know? I gave the Alienware 15 the full backpacker treatment, using it as my main machine for three weeks or so while I was on vacation and hauling it between hotel rooms, packing and unpacking it from my bag, putting it in the bin for airport security screening, and even reviewing games on it in the late-night hours.

So yeah, I wouldn't call it easy per se, but it was certainly doable. When I brought the Alienware 17 on the road (for a much shorter trip, I might add) I struggled daily. The Alienware 15 was a welcome companion, powerful enough to game on by night without throwing out my back by day.

Would I accept slightly worse performance for a thinner laptop? Absolutely. For those who need true desktop power on the road, two inches can make one hell of a difference, though.

And that's really the only difference. The Alienware 15 measures 15.3 x 12 inches, is an inch thick when closed, and weighs in at 7.6 pounds (compared to 9.6 for the Alienware 17). The power adapter is also smaller, measuring probably half the thickness and weighing 1.8 pounds instead of 2.5 for the Alienware 17's brick.

Other than that, the Alienware 15 and 17 are twins. Both sport the same 1080p display running at 120Hz. The speed is a welcome feature, though colors wash out at full

The Alienware 15 measures 15.3 x 12 inches, is an inch thick when closed, and weighs in at 7.6 pounds (compared to 9.6 for the Alienware 17).

brightness and viewing angles are a bit narrow—same as the 17, though it's mercifully less noticeable on the 15's smaller screen.

The whole thing is encased in a chrome and black chassis, emblazoned with the Alienware logo on the outside and the sleek typelogo under the display. Alienware's lighting is just as impressive and over-the-top on the 15, with RGB light channels running down each side of the display, on the lid, and even underneath the trackpad. That last has grown on me during my time with first the 17 and now the 15, and I've come to find it almost as useful as keyboard backlighting at night.

My biggest complaint with the 15 is the same as with the 17: The hinge. Rather than joining at the rear, the monitor is instead set forward about an inch. That leaves a hunk of plastic sticking out behind the monitor, which is where most of the fans vent.

The Alienware 15's hinge is proportionately smaller than the 17's, but it's still an eyesore. It's also just annoying, especially on a plane or in similarly tight quarters where the hinge takes up much-needed desk space.

The hinge hassle is compounded by the fact that the laptop's ports are almost all located in the rear: Power, HDMI out, ethernet, USB-C, and Alienware's proprietary Graphics Amplifier port. Not only is it hard to plug in the laptop in when you can't see the port, its rear location also further limits how close you can set the Alienware 15 to a wall, because the cable sticks out at least another two inches.

Putting ports on the rear of a laptop isn't unique to Alienware. It's not a very

The Alienware 15's hinge is proportionately smaller than the 17's, but it's still an eyesore.

user-friendly design, though, and it doesn't take portability into account at all—underscoring the reality that these are more "Desktop Replacements" than laptops.

The benefits: It's sturdy, for one. Also, you can lay the display completely 180-degrees flat, though I can't imagine a situation when you'd want or need to do so.

Unfortunately, having the fans vent behind the screen doesn't cut down on noise as much as I expected. I thought that might be one reason for the design, but like its larger sibling, the Alienware 15's fans are distractingly loud at full load, whether hidden behind the display or not.

SMALL PACKAGES

Those looking for portable desktop power are well served by the Alienware 15. Not only is it a more portable device than its 17-inch peer, it can pack just as much power inside. The Alienware 17 we looked at was outfitted with an Intel Core i7-7820HK and an Nvidia GeForce GTX 1080. With deep pockets you can put the same configuration into the

Alienware 15.

Our Alienware 15 was one step down, both in price and power, with an Intel Core i7-7700HQ, a GTX 1070, and 16 GB of DDR4 RAM. Storage took the form of a 512GB SSD and a 1TB hard drive.

Not too shabby. As I said, I did multiple game reviews on the Alienware 15 and it ran without a hitch, usually on a mix of High and Very High settings. Digging into our tried-and-true benchmarks, you can see that the Alienware 15 managed 93.9 frames per second in *Rise of the Tomb Raider* at 1920x1080 on Very High, and 130.9 frames per second in *Middle Earth: Shadow of Mordor* at 1920x1080 on Ultra with the 4K texture pack installed.

That compares favorably with other

1070-equipped laptops as well as slower 1060 units. The HP Omen 17, for instance, scored 95.5 and 118.9 respectively on the same benchmarks with an i7-6700HQ and a GTX 1070.

As for how it stacks up against the likes of a 1080-equipped Alienware 17, you're looking at 102.2 and 154.9 frames per second in *Tomb Raider* and *Shadow of Mordor*— definitely a gap, though not a huge one.

The Alienware 15 even stacks up favorably against 1080 Max-Q laptops, which is to be expected— our testing has generally shown a Max-Q 1080 puts out performance comparable to that of a well-vented 1070. This pattern doesn't really show up in gaming benchmarks, mostly because gaming benchmarks tend to be only a few minutes long. Thus, the Asus ROG Zephyrus GX501 scored 104.8 in *Rise of the Tomb Raider* and 136.8 in *Shadow of Mordor*, comparable to the Alienware 17.

If we jump over to 3DMark, though, where the tests tend to be longer, we see that the Alienware 15 scored a 4,097 in FireStrike Ultra. Compare that to 4,091 for the GX501 and you can see that as heat builds up, the Max-Q 1080

throttles at right around the same performance level as the Alienware 15's better-vented GTX 1070—and the Alienware 15 is less expensive. Impressive. The HP Omen 17 scored a 3,837 and the Alienware 17 posted 4,960, for the curious.

As for the CPU, the Core i7-7700HQ performance is pretty standard. That's a very

Rise of the Tomb Raider
Very High Quality 1920x1080 (fps)

Alienware 15 R4 Core i7/GTX 1070	93.9
Gigabyte Aero 15X Core i7/GTX 1070 Max-Q	90
Gigabyte Aero 15 Core i7/GTX 1060	65.3
Dell Inspiron 15 7000 Core i5/GTX 1060 Max-Q	61
Dell Inspiron 15 7000 Core i5/GTX 1050 Ti	44.6
Dell XPS 15 Core i7/GTX 1050	32.6
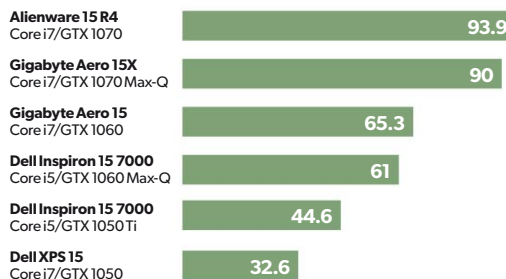
LONGER BARS INDICATE BETTER PERFORMANCE

Shadow of Mordor
Ultra Quality 4K Textures (fps)

Alienware 15 R4 Core i7/GTX 1070	130.9
Gigabyte Aero 15X Core i7/GTX 1070 Max-Q	117
Gigabyte Aero 15 Core i7/GTX 1060	86.7
Dell Inspiron 15 7000 Core i5/GTX 1060 Max-Q	83.8
Dell Inspiron 15 7000 Core i5/GTX 1050 Ti	56.8
Dell XPS 15 Core i7/GTX 1050	42
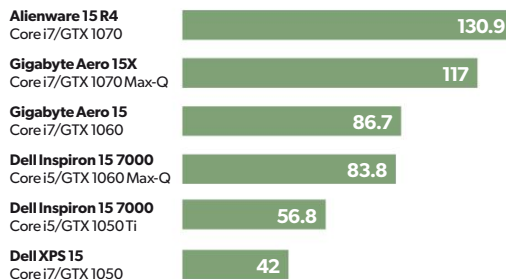
LONGER BARS INDICATE BETTER PERFORMANCE

popular laptop part, and indeed in our Handbrake test (where we convert a 30GB MKV file to the Android Tablet preset) the Alienware 15's 45 minutes and 43 seconds comes in right in line with the GX501's 46 minutes and 23 seconds, the Gigabyte Aero 15's 46 minutes and 15 seconds, and so on. (By comparison, the Alienware 17's i7-7820HK did the job in a little over 38 minutes.)

It's a very solid laptop. The one weak point is the battery, coming in at an ever-so-average 3 hours and 45 minutes in our standard rundown test, where we set the laptop's display to 250-260 nits in brightness and loop a 4K video until the battery goes dead. Lifespan is even worse while gaming: Expect 1.5 to 2 hours in that scenario, or even less.

Hey, as I said earlier: At least the power adapter's smaller for the 1070 model.

VERDICT

Two inches makes a world of difference, though. I couldn't see using the Alienware 17 as my day-to-day laptop. All 17-inch machines are huge, but a 17-inch machine that's still over an inch thick and weighs 9.5 pounds? No way.

The Alienware 15 probably wouldn't be my first choice, but it puts out incredible, desktop-level performance. Even with a GTX 1070 the Alienware 15 handled everything I threw at it with aplomb, and did it while still fitting inside a normal-size backpack. Barely fitting, but come on—I'm trying to be charitable here. ⏻

Handbrake
Encode (sec)

Model	
Alienware 15 R4 Core i7/GTX 1070	2,743
Gigabyte Aero 15 Core i7/GTX 1060	2,775
Gigabyte Aero 15X Core i7/GTX 1070 Max-Q	2,800
Dell XPS 15 Core i7/GTX 1050	3,033
Dell Inspiron 15 7000 Core i5/GTX 1060 Max-Q	3,921
Dell Inspiron 15 7000 Core i5/GTX 1050 Ti	3,960

SHORTER BARS INDICATE BETTER PERFORMANCE

Battery life
Playing 4K video (minutes)

Model	
Gigabyte Aero 15X Core i7/GTX 1070 Max-Q	477
Dell Inspiron 15 7000 Core i5/GTX 1050 Ti	472
Gigabyte Aero 15 Core i7/GTX 1060	410
Alienware 15 R4 Core i7/GTX 1070	340
Dell XPS 15 Core i7/GTX 1050	331
Dell Inspiron 15 7000 Core i5/GTX 1060 Max-Q	326
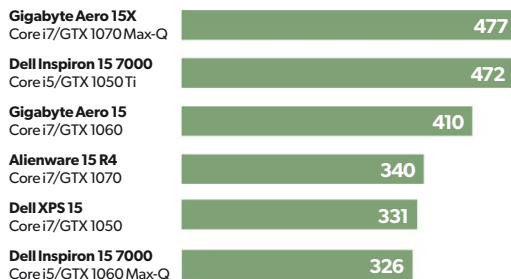
LONGER BARS INDICATE BETTER PERFORMANCE

MSI Trident 3 Arctic: Looks like a console, runs like a high-end desktop

If only this had been around for all our '90s LAN parties. **BY HAYDEN DINGMAN**

A maller form-factor PCs typically go one of two ways: First, you can prioritize the small part of the equation. This leaves you with something beautifully tiny, but at the cost of future upgrades—space-saving comes with the caveat of proprietary and non-replaceable parts. (See: Alienware Alpha (go.pcworld. com/alfa).) Or you can prioritize future upgrades, which typically means a larger and less aesthetically pleasing machine.

The MSI Trident 3 is the rare machine that can do both—at least to some extent.

MSI TRIDENT 3 VS. CONSOLES

It really is tiny. Scale can be tough to judge in photographs, but at 13.6 by 9.2 by 2.8 inches, the Trident is so small it's hard to believe there's a full-size PC inside. It's smaller than my launch-version Xbox One for instance, and quite nearly smaller than the

MSI Trident 3 Arctic

★★★★⯨

PROS
- Approximately the size of the Xbox One X/ PlayStation 4 Pro
- Easy access to internal components, and relatively upgradeable

CONS
- Swapping out the hard drive is arduous
- Accessing the internals voids your warranty

BOTTOM LINE
The MSI Trident V3 is quiet, easily upgraded, and packs a GTX 1070 inside a chassis the size of the Xbox One X. Pretty incredible.

$1,499

new Xbox One X (go.pcworld.com/xb0x). (It's smaller depth, but the Trident is about an inch longer and maybe half an inch taller.) The Trident sits comfortably in "console-sized" territory, in any case.

And it *seems* even smaller than it is. The Xbox One's blunt VCR-like chassis looks every inch its size. The Trident's canted angles are needlessly flashy perhaps, but also slimming.

Speaking of flashy: I could do without the RGB lighting. That's the one aspect I think detracts from the design, if only because it's distracting. Given the small size of the Trident I assume most people will place it on something, be it a media center shelf, a desk, whatever. Having an RGB-lit "Y" shape on the front panel ensures the Trident won't simply blend into the background, instead blink-blink-blinking away at you all night long.

It won't bother everyone, and it's also customizable—you can hop into MSI's settings panel and turn the lighting off, "solving" the problem. There's just not much point to it being there at all on a machine seemingly so suited for living room use, though.

I love the choice of white for the chassis, though. Most of MSI's Trident models come in the company's standard black-and-red color scheme—as "generic gaming machine" as you can get. The model we looked at comes in "Arctic White" though, with a red MSI badge and red labels on the front ports. It's slick. I tend to prefer black boxes—I feel they hold up better over time—but there's no denying that fresh out of the box the white Trident is an eye-catcher. Bonus: Less noticeable dust.

The front panel is laden with ports, which also behooves living room use. Most noteworthy is a front-facing HDMI port, which MSI intends for easy VR usage. I haven't had much reason to use my HTC Vive (go. pcworld.com/htcv) with the Trident, but I appreciate the gesture. At the moment, plugging in a VR headset means crawling behind my tower PC. Front-facing I/O is

Speaking of flashy: I could do without the RGB lighting. That's the one aspect I think detracts from the design, if only because it's distracting.

certainly more convenient.

You'll also find 3.5mm headphone and microphone ports on the front, plus one USB-C and two USB 3.1 jacks. And despite the machine's small size, the rear also features a surprising number of ports—two more HDMI ports on the motherboard itself, five USB ports, gigabit Ethernet, power, Line-In, Line-Out/headphones, and microphone. Then there's the graphics card, which features an additional two HDMI ports (for a total of five on the machine), two DisplayPorts, and one DVI.

Wrapping up the design, I'll note that the Trident also comes with a stand, allowing you to run the machine vertically. This is the weakest part of the package though, with the stand apparently more concerned with aesthetics than keeping your PC intact. The

stand neither snaps onto the machine nor screws into it, relying instead on the Trident's weight and four tiny rubber pads to keep it upright. If you plan to toss the Trident onto a shelf? It might be enough. But if you have an unstable desk, pets, children, or are maybe just clumsy? I wouldn't recommend running it vertical. Even a moderate nudge could send it teetering and (if you're unlucky) toppling over.

SPECS, PRICE, AND PERFORMANCE

Okay, so it's console-*sized*. Now how does it stack up? And the answer: Pretty damn good. Actually, the Trident we looked at was loaded, for a machine this small.

Most Trident setups run with an Nvidia GeForce GTX 1060, which is a perfectly serviceable card. (Actually, that puts it about on par with the Xbox One X.) The $1,450 model we looked at though takes the next step, somehow packing an 8GB GTX 1070, plus an Intel Core i7-7700 clocked at 3.6 GHz, 16GB of DDR4 RAM, and both a 256GB SSD and a 1TB hard drive. Again, that's into a machine *smaller than the original Xbox One*.

It's incredible. Sure, you're not going to get the same performance as a full

The Xbox One X (left) and Trident (right), as seen from above.

It's not illuminated here, but that odd "Y" shape on the corner is the RGB LED zone.

tower with a GTX 1080 Ti (go.pcworld.com/nvti) inside, but in a machine this size? Wow. As I said, even the Xbox One X tops out at GTX 1060 levels of power, which makes the Trident V3 more powerful than even the most powerful console on the market today. We ran the Trident through our usual battery of benchmarks, with impressive results—impressive if only because something this small put up scores similar to full-sized towers.

For instance, in *Rise of the Tomb Raider* at 1080p with settings on Very High, the Trident 3 averaged 107.9 frames per second. That's right in line with other 1070-equipped machines like a 1070-equipped Gigabyte PC that we've looked at, which averaged 107.8 frames per second. The same goes for *Shadow of Mordor* with the 4K texture pack installed—130.2 frames per second for the Trident V3, 129.2 for the Gigabyte machine.

The Trident 3 even holds its own in lengthier benchmarks. That's impressive. In-game benchmarks are usually only a few minutes long at best, so you don't really see thermal throttling because the hardware doesn't heat up enough for it to matter. But in one of 3DMark's lengthier tests or our CPU-centric Handbrake encode you sometimes see heat dispersion problems you might've otherwise overlooked.

Not here. In 3DMark's FireStrike Extreme test the Trident put up a score of 7828, which compares favorably to the Gigabyte machine's 8313. And in our Handbrake test, where we transcode a 30GB MKV file down to the Android Tablet preset, the Trident 3 did it in about 38 minutes and 46 seconds—only 16 seconds longer than the Gigabyte. All evidence points to there being no significant thermal issues. The machine gets hot for sure, but as far as I can tell it's not significantly affecting performance.

"Okay, so then noise is an issue right? If it's moving that much heat, obviously the fans must be distracting." Nope! Surprisingly it's both relatively cool and quiet. Not whisper-silent, to be sure, but at even moderate volumes my sound system drowned out the

Trident's fans—and that was with it on my desk. If you placed it across the room, you'd probably never hear it. It's certainly quieter than 2013's Xbox One model, and about on par with the new Xbox One X.

UPGRADEABILITY

But the most important aspect of the Trident 3: It's not only small, but upgradeable. *Properly* upgradeable, mostly thanks to the aforementioned GTX 1070. See, most Trident models ship with a GTX 1060—a low-power card. As such, they get away with running on a 230 watt power brick.

That's fine, as long as you only ever plan to replace the 1060 with an equivalent card, but even upgrading to a 1070 would likely cause problems under load with that diminutive a

power supply.

Since our model ships with a 1070 though, it also packs a 330 watt supply. That's not *much* more than the baseline Trident, and it still comes in ugly power brick form so you'll have to find some extra room to stash it, but you might have a bit of headroom for overclocking if you're careful. The GPU is also easily accessed, and can be swapped out for any other small form-factor card as long as you keep the power restrictions in mind. Three or four years down the line you should be able to plop in a GTX 1470 or whatever and be good to go.

The GPU isn't the only part that's upgradeable though. Two screws gets you into the case, which is enough to replace the RAM immediately. The CPU would take more doing, but you can dismantle the cooling system and swap it out if desired. That would only be in the event of complete failure though—the motherboard is proprietary, and given Intel's fondness for switching CPU sockets lately you're probably not going to be able to drop in a new-generation processor later.

RAM and CPU on the left, GPU on the right.

I only have a couple complaints. Accessing the hard drives is a royal pain, requiring you to flip the machine over and remove the entire bottom panel. It'd be easier to just use an external drive (go.pcworld. com/exdr) I guess, but it's annoying given the Trident's 1TB drive. First thing I'd want to do is upgrade that, and it's harder than it needs to be. More annoyingly, you void your warranty by tinkering. That's not too uncommon with prebuilts, but there is indeed a sticker over one of the screws as you head inside.

If you want to really tinker? Sure, get a full tower or build your own. Still, if you want a small machine that remains a decent investment three or four years down the line? The Trident 3 gives you enough runway to upgrade the most important components a few times, and replace the most likely points of failure too. That's better than a lot of machines its size (not to mention gaming consoles).

VERDICT

The MSI Trident 3 Arctic offers the power of an upper-mid tier PC in a chassis the size of the new Xbox One X—and with the ability to upgrade it even further in a few years with a hypothetical GTX 1470 or whatever. It's attractive, it's small, it's (mostly) discreet, and it's also surprisingly inexpensive. The 1070-equipped model we looked at retails for a mere $1,450 on Amazon. Doing some rough back-of-napkin math, I estimate you'd only save maybe $200 or $300 on a bare bones Mini-ITX build of your own, and while you'd gain some additional room for upgrades later it definitely wouldn't turn out this sleek, nor manage heat this efficiently.

Whether you're looking for a living room machine, a dorm-room PC, or something convenient to take to those LAN parties you and your friends are still (in 2017!) having, the Trident 3 is definitely worth a look—specifically this GTX 1070 model. The 1060 units? Eh, I'd probably give those a pass. But this is one hell of a deal. ⏻

WD Blue 3D NAND SATA SSD: One of the fastest TLC drives you can buy

TLC NAND has been a performance drag, until now. **BY JON L. JACOBI**

Amaller form-factor means a larger and less aesthetically pleasing machine. The WD Blue 3D SSD is a SATA SSD with a not-so-secret twin: Sandisk's Ultra 3D SSD. They are in fact the same drive with different labels, WD owning Sandisk and all that. The '3D' term means the drives use stacked (layered, vertical, etc.) NAND. Practically speaking, that means more storage in less horizontal space.

The only real differences between the drives are the outward appearance, the marketing, and the fact that the WD Blue 3D ships in the M.2 form factor, while the Ultra 3D does not. Beyond that, they're peas in a pod. Given their superior performance compared to other TLC NAND drives—that's a really good thing.

DESIGN AND CAPACITY

Though available in the 2.5-inch form factor, WD sent us the M.2 2280 (22mm wide/80mm long) Blue 3D, which is handy for upgrading laptops or desktops that feature an M.2 slot. It's SATA, not NVMe—just to be clear. Be sure to check which flavor your M.2 slot is before you buy. Just FYI, NVMe (go.pcworld.com/n4me) is a lot faster.

The Blue 3D is available in 250GB, 500GB, 1TB (the size we tested), and 2TB capacities, which sell for $95, $165, $310,

IMAGES: WD

and $620 respectively. Those are the prices from WD's site—you may find them cheaper at Amazon, Newegg, or the like.

The Blue 3D is warrantied for three years and rated for 100TBW for every 250GB. That means WD expects you can write 100 terabytes to the drive before experiencing any loss of capacity due to wear and tear on the cells. If you do the math, that's actually a heck of a lot of writes. Probably more than 10 years' worth for most users. And TBW estimates are generally very conservative.

Note that the 250GB version is rated slightly slower than the other capacities. That's common with most drives of 250GB or less, which most often have fewer chips to spread data across.

SURPRISINGLY GOOD PERFORMANCE

We test SSDs using both artificial benchmarks, primarily AS SSD and CrystalDiskMark, and real-world copy tests.

We're happy to report that somehow, to the benefit of users everywhere, WD/Sandisk has managed to create a TLC drive that can

Blue 3D NAND SATA SSD

★★★★☆

PROS
• No loss of sustained write speed as with other TLC SSDs
• Excellent price per gigabyte

CONS
• Boring label design could turn off PC enthusiasts who like to show off their hardware

BOTTOM LINE
The Blue 3D SSD is the first TLC NAND drive whose sustained write performance nearly matches that of MLC NAND drives. Along with its Sandisk 3D Extreme sibling, by far the best bang for your buck in a SATA SSD.

$304

sustain 450MBps performance during long writes. Up until now, about the fastest sustained write speed we've seen out of a TLC drive after it oversteps it's cache is 300MBps. Indeed, after testing with our usual 20GB data set, we threw 320GB at the Blue 3D, and it just soldiered on at a steady 450MBps. There may be a point at which the drive will slow down, but we didn't see it.

By way of comparison, the Samsung 750 EVO (go.pcworld.com/s750) drops to 300MBps when it runs out of cache, was

considered good. Some drives, such as OCZ's Trion 100 (go.pcworld.com/t100) and even Toshiba's latest TR200 (go.pcworld.com/t200), drop to around 100MBps—slower than hard drive speeds. Yowser.

CrystalDiskMark tests the SSD with all caching engaged and is generally a good indicator of real life performance. We run the test with 1GB, 5GB, and 32GB data sets.

Note that the Crucial BX300 (go.pcworld.com/cbx3) is an MLC NAND-based drive, from which we nearly always see 450MBps to 500MBps writing simply because writing MLC's two bits takes less time than TLC's three bits. At least until now. The WD Blue 3D and Sandisk Ultra 3D keep up with it nicely.

The AS SSD benchmark issues the FUA (Force Unit Access—disabling caching in units that acknowledge the command) and is especially useful in determining the bare-knuckle performance of the controller and NAND. We run both AS SSD's 1GB and 10GB tests, quoting the 10GB test results. As you can see in the chart shown above, the WD Blue 3D and its Sandisk Ultra 3D twin mirror each other closely, and keep up with the Crucial BX300. They all make the well-regarded (but pricey) Samsung EVO 750 SSD look slow.

Our real-world tests consist of reading and writing both a 20GB single compressed

CrystalDiskMark 5
Sequential performance (MBps)

Write
CRUCIAL BX300: 485
WD BLUE 3D: 494
SANDISK ULTRA 3D: 491

Read
CRUCIAL BX300: 524
WD BLUE 3D: 525
SANDISK ULTRA 3D: 515

CRUCIAL BX300   WD BLUE 3D   SANDISK ULTRA 3D

AS SSD Sequential througput
10GB (MBps)

Write
SANDISK ULTRA 3D: 489
WD BLUE 3D: 485
SAMSUNG EVO 750: 407
CRUCIAL BX300: 481

Read
SANDISK ULTRA 3D: 516
WD BLUE 3D: 502
SAMSUNG EVO 750: 505
CRUCIAL BX300: 516

SANDISK ULTRA 3D   WD BLUE 3D   SAMSUNG EVO 750   CRUCIAL BX300

archive and a 20GB set of small- to mid-sized files and folders, with the majority of the files being compressed types such as WMV, MP3, and JPG. The real-world copies can, and have, revealed issues like the slow sustained write speed of TLC that synthetic benchmarks can sometimes miss.

AS SSD Sequential throughput
10GB (MBps)

20GB folder write
- CRUCIAL BX300: 68
- SAMSUNG EVO 750: 88
- SANDISK ULTRA 3D: 74
- WD BLUE 3D: 71

20GB folder read
- CRUCIAL BX300: 89
- SAMSUNG EVO 750: 92
- SANDISK ULTRA 3D: 100
- WD BLUE 3D: 96

20GB write
- CRUCIAL BX300: 44
- SAMSUNG EVO 750: 61
- SANDISK ULTRA 3D: 45
- WD BLUE 3D: 44

20GB read
- CRUCIAL BX300: 44
- SAMSUNG EVO 750: 44
- SANDISK ULTRA 3D: 45

SANDISK ULTRA 3D   WD BLUE 3D
SAMSUNG EVO 750   CRUCIAL BX300

For us, the great thing about the evolution of TLC performance is that once again, we can recommend on price without constant disclaimers concerning poor sustained write performance. For the consumer, it means large-capacity 2TB SSDs with great all-around performance.

VERDICT

We have nothing negative to say about the WD Blue 3D. Okay, the label is boring, which isn't trivial if you're building your own PC and want to show off all your hardware finery through the tempered-glass, LED-lit side of your case. But it's fast, affordable, and available in up to 2TB capacities, and we're impressed with whatever trick Sandisk/WD used to eliminate the MLC/TLC performance gap.
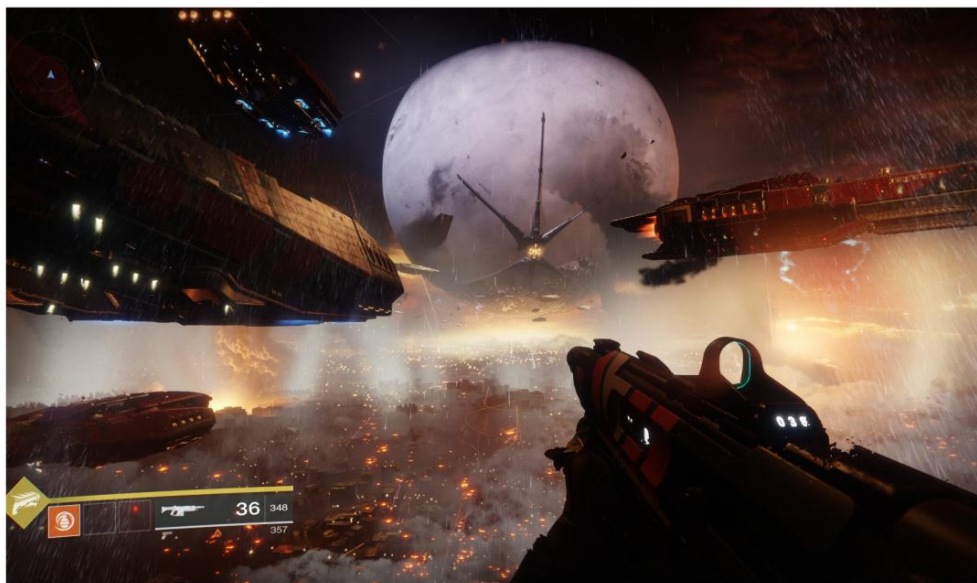
Destiny 2: Gaming junk food that we can't put down

Delicious, mindless fun filled with some empty calories. **BY HAYDEN DINGMAN**

This weekend I finished *Destiny 2*'s campaign for the third time. I've hit the (soft) level cap with all three classes, collected around a dozen exotic weapons, completed most of the Strikes, played some player-versus-player Crucible matches, shot thousands of enemies, killed off Emperor Calus to complete the raid (twice), and even spent two hours running up and down a hallway to exploit some bad code on Bungie's part.

I'm still not sure why *Destiny 2* keeps me coming back for more, the digital equivalent of an irresistible bag of chips. But I've officially run out of reasons to procrastinate writing this review—just in time for the first expansion to drop next week.

STARTING OVER FROM ZERO

Yes, next week. Despite *Destiny 2* only releasing a month ago on PC, the Curse of

Destiny 2

★★★☆☆

PROS
• Shooting. Every. Gun. Is. Excellent.
• The loot grind up to 265 can be addictive

CONS
• Some side activities rendered completely useless early on in the level grind
• Campaign starts strong but doesn't go anywhere

BOTTOM LINE
Destiny 2 is mechanically a fantastic shooter, but a threadbare plot and some odd choices after the campaign wraps up make it more of a foundation to build on. Expect it to take a year for Bungie to polish this one up again.

$59

Osiris DLC will soon be upon us as part of a simultaneous release with the longer-lived console versions of the game. It's timed alongside an update for the base game in which Bungie's basically promised the world (go.pcworld.com/wrld).

It's tricky sometimes to review video games nowadays. No sooner have you pinned down their structure than everything changes. But even in that environment, reviewing *Destiny 2* is a bit like trying to hit a moving target while riding a train in the opposite direction. Making

the whole endeavor doubly intimidating is *Destiny*'s reliance on jargon—if you understood even half the opening paragraph, chances are you already played *Destiny 2*. It's that type of game.

But I'll do my best regardless.

Starting with the basics: *Destiny* is a shooter. There are MMO elements running parallel, and we'll get to those, but at the end of the day it's a shooter. And it's very good at it.

Plenty of video games have guns. Few have guns that roar like *Destiny 2*'s revolvers, or *fliiit* like *Destiny 2* 's assault rifles, or tch-tch-tch like *Destiny 2*'s semi-autos. Doom is probably the only other game in recent memory to imbue firearms with such terrifying power. Maybe *Battlefield*. Maybe.

Add in a variety of mobility options (pseudo-jetpacks, triple jump) and you've got an excellent core. Seriously, I've spent hours compulsively playing *Destiny 2* even with

nothing much to do, just tooling around the open-world areas shooting random enemies. The moment-to-moment action feels that damned good.

Which I guess brings me to the next point: *Destiny 2* is sort of a singleplayer shooter, but not really. There's a campaign, and from what I've heard the story this time around is more coherent than the previous game. But...well, let's just say the original *Destiny* must have been terrible.

The opening is solid. We've covered it a few times now, both in our E3 preview (go. pcworld.com/e3pr) and our initial review impressions (go.pcworld.com/1mpr). Basically, Earth is invaded by an alien race known as the Cabal—specifically a military subset known as the Red Legion. They steal

your powers away and drive humanity into exile. It's evocative.

And then it goes *nowhere*.

What's frustrating about *Destiny 2*'s campaign is that it should be great. It's space opera on a grand scale, with half a dozen alien races, one of which ("The Traveler") is literally the size of a small moon. There's a mysterious magical energy called "Light" that imbues you with incredible powers, and a spaceship that literally uses Mercury for fuel. Not the metal mercury, lower-case, but the *planet* Mercury, capitalized. It grinds Mercury to dust in order to—get this—*blow up the sun*.

I. Should. Be. Jumping. Out. Of. My. Seat. Come on—a planet-eating ship that's preparing to blow up the sun! That's amazing!

And it is, sort of. *Destiny 2* is great at

dumping you into memorable set piece moments. Somehow none of it feels as impactful as it should though. Maybe I just lack knowledge of the *Destiny* universe, but enemies are mostly faceless and inter-changeable, even when they're different alien civilizations entirely. And what little plot is spoon fed to you often comes across as sterile and lifeless, with plot twists materializing out of thin air by characters you've barely met and will soon abandon. There's never any real tension, no stakes to it. You and your little band of heroes make a plan, you execute on the plan, the plan works. Rinse and repeat for seven or eight hours.

To add insult to injury, you have to endure the campaign for each character you make to unlock all the locations and activities. *Destiny* has three main classes: Warlock, Titan, and Hunter. A fair number of people will undoubtedly pick one and stick to it, but this being a pseudo-MMO, those who want to be more versatile in group events will end up running two or even all three classes, and doing so involves grinding through the same dozen or so bland missions again.

So let's talk about the pseudo-MMO aspects of *Destiny 2* because the campaign's really not worth any more words. It exists, it's a bit bloated even the first time through, and any further runs involve mashing the Escape key at every cutscene.

This is a cliché but I'm saying it anyway because it's true: Once the campaign ends, that's when Destiny 2 properly begins. At that point you'll be the maximum level (20) with access to a whole host of character abilities and a "Power Level" around 200. This number is a summary of your character's gear—for instance, you might have an assault rifle rated 205, a helmet rated 195, and so on. As of writing, the "soft cap" is commonly considered 265, meaning it's pretty easy to get to that point. The "hard cap" is 305, meaning all your gear needs to be the maximum power rating of 305 at the same time. (The upcoming expansion will raise both these numbers, presumably.)

The end game

revolves around driving this number up. I'll skimp on the details here, but basically: Any activity you partake in has a chance to drive your Power Level up to 265 by rewarding you with higher-power gear. You can join with other players in one of the open-world areas to take down a powerful enemy or hold off waves of invaders—these "Public Events" reward loot up to a certain level. You can play multiplayer matches, with each match granting loot too. Or complete weekly challenges.

The choice is yours, and it's this grind from 200 to 265 that feels most satisfying—there's a lot for you to tackle, and it isn't tied to the lackluster campaign.

Past level 265 you enter the real end-game and it becomes much, much harder to get loot. At this point you'll find yourself doing only select activities, mostly ones that are refreshed on a weekly basis as those are the only ones that consistently dole out decent gear. The Leviathan raid, a six-person co-op event that takes an hour or two even when you know what you're doing, is one such event. Ditto Nightfall Strikes, which are smaller co-op instances where you have to blitz through rooms of enemies and take
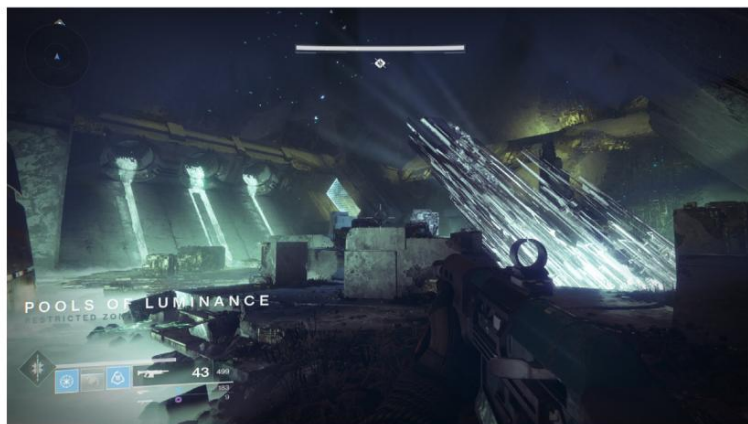
down a powerful boss at the end.

Apologies—if this section seems dry and mechanics-heavy, it's because mechanics are all there is to talk about. I mean, there are bits of story tied to all this, but it's mostly inane radio chatter that's easily ignored the first time you hear it and becomes more and more banal the longer you play. Stuff like "The Cabal are setting up a mining drill, Guardian. Hold them off for [BLANK] minutes until they go away and a treasure chest pops out!"

Think of it like going to a diner and there's parsley on your plate—you're not supposed to eat it. It's just there so someone can pretend you've consumed something high-class instead of Grade B hamburger with some frozen fries. That's the "story" in the late-game.

Destiny 2 is junk food. It really is. If I've procrastinated writing this review, it's because I've never felt more conflicted about a game. It's oftentimes *not very good*.

Player-versus-player modes are complete trash, for instance—horribly balanced, with what feels like pretty middling netcode and a whole host of baffling decisions (like defaulting team chat to "Off"). Actually, chat is a mode-spanning issue, with players unable to even talk to each other in group hubs.

And yet I've put a ton of hours into *Destiny 2* PvP this past week thanks to a limited-time "Iron Banner" event. My reward? A helmet with horns coming out of the side, and also some armor with wolves on the shoulders. I was excited.

This duality, this push-pull, has me completely torn. The Leviathan raid is another instance—the raid is made up of four (or five, if we count the hub) distinct segments, with at least two of them being absolutely dreadful to play. And yet both times I've killed Emperor

Callus and finished the raid for the week I've signed off with "Cool, see you all back here next week then?"

End game content is lacking in general, actually. The game does open up substantially after you finish the campaign, but as I said it then ratchets back down a few hours later once most activities stop being rewarding. The Leviathan raid is the closest you'll get to a proper "storyline" post-campaign, and there are some jaw-dropping moments your first time through, but if you run it weekly you'll soon tire of the same four rooms on rotation.

I expect that like the original *Destiny*, it'll take *Destiny 2* probably a year to hit its stride—though next week's expansion and December's quality of life updates might help.

Or maybe it won't. It doesn't matter. I'll probably be there regardless, because that core,
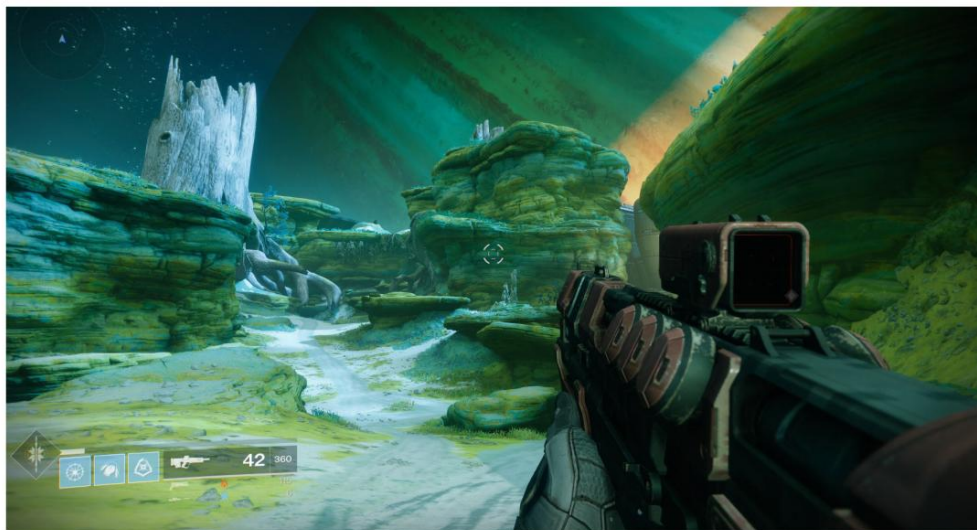
the part where you click and your gun fires and then the numbers go up—that part of *Destiny 2* is so damn satisfying. Mindless, for sure, but I keep coming back to it. Night after night I wrap up playing "Serious Video Games" or whatever and then I end up staring at Battle.net, thinking about popping open *Destiny 2* for a bit.

I've sunk a stupid number of hours into *Destiny 2*. A lot of it was done while listening to podcasts or even watching TV on my second monitor—it's that type of game, and demands precisely that much attention (which is to say: often less than half). I know that, and yet I keep coming back.

Why? I don't know.

VERDICT

And maybe *that's* really why I've put off writing this review so long. Normally I'd like you to come away from a review with some

insight, some inkling of why I'd recommend a game or (probably more often) not recommend it. *Destiny 2* has me baffled though. I'm spinning my wheels in it, grinding my way to 305 before next week's expansion, and I don't really know why.

Except that the shooting part is great. And the wolf armor is cool. That's kept me entertained for upwards of 60 hours now, mindless though it might be. *Destiny 2* has mastered the "Filling Up Bars" psychology of game design, even if those bars aren't very interesting once filled. It's gaming junk food.

Not exactly a glimpse into some shrouded corner of the human condition, but it'll have to do. Bungie now offers an expansive free trial with the first two planets and access to the Quickplay playlist in Crucible multiplayer so you can see if *Destiny 2* meets your tastes, too. ⏻
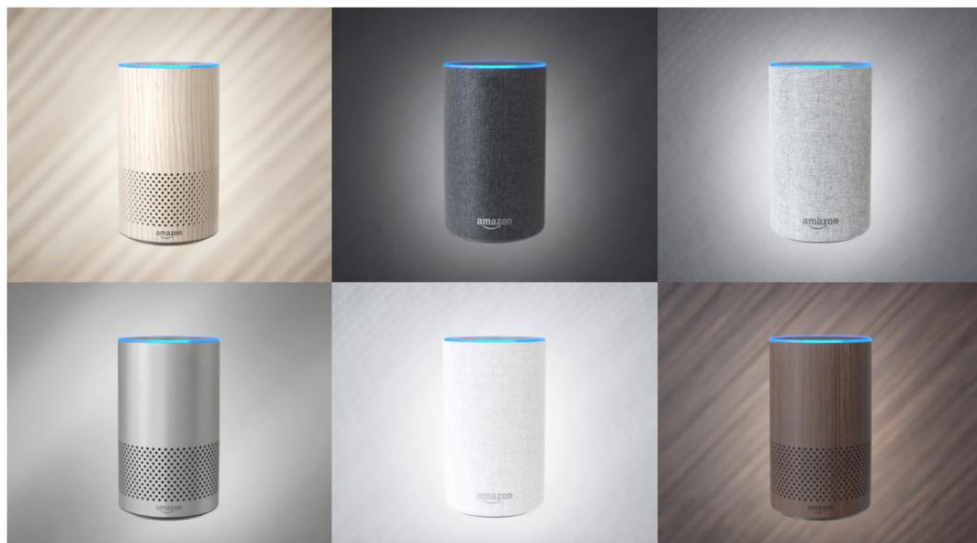
Amazon Echo Plus:
Not plus enough

Amazon's mid-range smart speaker comes up just a little short. **BY MICHAEL BROWN**

The "plus" in the Amazon Echo Plus is an integrated ZigBee smart-home hub. It's a feature that boosts this smart speaker's price tag by a third compared to the $100 second-generation Echo (go.pcworld. com/2nde), and by a factor of three compared to the $50 second-generation Echo Dot. Having one smart appliance do the job of two sounds like a good idea, but most people will be happier with a more powerful smart-home hub that works in

conjunction with Alexa, even if the combination costs more.

Don't get me wrong. Amazon is way out in front when it comes to enabling voice control of the smart home, thanks to partnerships with all the major players—DIY platforms like Samsung SmartThings (go. pcworld.com/smth) and the Wink Hub 2 (go. pcworld.com/hub2) as well as big installers such as Vivint Smart Home (go.pcworld.com/ vivi) and ADT Pulse (go.pcworld.com/ adtp)—and a deep commitment to helping

any and every interested third-party manufacturer tap into its Amazon Voice Service (i.e., its Alexa digital assistant). I can recommend any Echo model—except this one. That's because Amazon built only half of a smart home hub into the Echo Plus—it didn't include support for the other very popular smart home protocol: Z-Wave.

IS THE ECHO PLUS A GOOD SMART HOME HUB?

ZigBee is strong, and you'll find it in lots of products, including the ever-popular Philips Hue smart bulbs (go.pcworld.com/phil). (And as I was writing this story, Amazon was tossing Echo Plus buyers a free Hue white LED bulb). But most stand-alone smart-home hubs—including the two DIY platforms I just mentioned—support both protocols to not limit their customers' choices.

Amazon's effort to build its own smart-home hub seems half-hearted in other ways, too. Take that Philips bulb it comes with: You can ask Alexa to turn it on and off or dim it to a percentage, but you can't tie it to a motion

or door/window sensor that will turn it on when a person walks into a room or when a door opens. And while you can establish rules that will turn the bulb on according to a rigid schedule—on every day at 4:00 p.m., for example—you'll need to create an entirely separate rule to turn it off again. That's just tedious. There are also no provisions for staggering the on/off times slightly to make the behavior look more human to a burglar who might be casing your house. And since you can't create schedules based on sunset and sunrise, you'll need to adjust schedules for daylight savings time twice a year.

Getting started with the Echo Plus and a Philips Hue bulb is as easy as can be, although I had a strange experience when I first set up the Echo Plus itself. Every other

The Echo Plus restores the elegant volume control ring from the original Echo.

Amazon Echo Plus

★★⯪☆☆

PROS
• Built-in ZigBee radio
• Restores volume-control ring from the original Echo

CONS
• Doesn't allow sensors to trigger lights
• No support for Z-Wave smart home devices
• Not a great loudspeaker

BOTTOM LINE
The presence of a ZigBee radio isn't enough for us to recommend the Echo Plus over any of Amazon's other Echo smart speakers, regardless of price.

$119
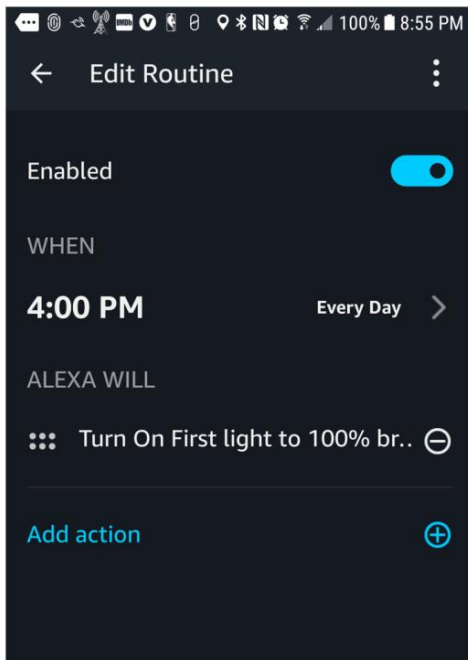
The Echo Plus is the only one of Amazon's smart speakers that can directly control ZigBee devices, but it's very limited as to what it can do with them.

Echo I've configured lit up as soon as I plugged in its power supply. When I plugged in this Echo Plus, I got nothing—no lights, no sounds, nothing. I unplugged it and moved it to another outlet, just in case there was something wrong with the first one, and I got the same result.

I assumed the hardware was DOA and sent my PR contact a note to that effect, but I left the speaker plugged in. About an hour later, I heard the characteristic Echo chord and Alexa's voice greeted me with her cheerful "Hello!" After another 20 minutes or so, Alexa automatically installed a firmware update and restarted the Echo—and it's been working ever since. I'm still waiting to hear from my contact if this is the expected behavior, but I'd be surprised if it was. People are conditioned to hardware doing something—anything—when they plug it into the wall.

Anyway, back to the Philips Hue installation. All you need to do is screw the bulb into a socket and supply power to the socket. Ask Alexa to discover devices, and she'll find the bulb and assign it a name—"first light" in my case—but you can change that name to anything you want as long as each smart device has a unique name. As a practical matter, once you've named something, stick with it. You don't want to go back through and edit all the scenes and routines you'll set up later.

Now if you want to take advantage of *other* features that Philips offers with its Hue

line—more sophisticated schedules, synching your lights to music, or changing the color of color Hue bulbs—you'll need to buy a Philips Hue hub anyway.

On the bright side, provided all your ZigBee smart-home devices are within range of the Echo Plus, you'll need only one Echo Plus to control all of them. Utter a relevant voice command to any Echo (or Echo clone, such as the Fabriq Chorus (go. pcworld.com/chrs)), and that command will be relayed to the ZigBee radio in the Echo Plus over Wi-Fi. Scatter inexpensive Echo Dots all around the house, and you'll never need to yell to control your smart home.

IS THE ECHO PLUS A GOOD SPEAKER?

If you want an Alexa-powered smart speaker that sounds great, buy the Alexa-powered Sonos One (go.pcworld.com/sone) or pair the far-less-expensive Echo Dot with hardwired or Bluetooth speakers. The Echo Plus has somewhat beefier speakers, it delivers a better sonic performance than the second-generation Echo, and it retains the elegant volume-control ring from the original Echo. But the Echo Plus is not as pleasing to my ears as the pricier Echo Show. That said, my strong recommendation of the more-expensive Echo Show is based on its 7-inch

The Echo Plus sounds slightly better than the second-generation Echo, but it doesn't hold a candle to the Alexa-powered Sonos One smart speaker.

display, not its musicality. Sonically speaking, in fact, none of Amazon's Echos are superior loudspeakers to the Sonos One.

The Echo Plus sounds slightly better than the second-generation Echo, but it doesn't hold a candle to the Alexa-powered Sonos One smart speaker.

The bottom line—at least for today—is that the Echo Plus is better as a voice-recognition adjunct to a smart home system than it is as a smart home system that has voice recognition built in. Amazon might add more native smart-home features to the Echo Plus down the road, but it will always be limited to supporting only ZigBee devices. And in the case of the ZigBee-based Philips Hue bulbs, that support is relatively weak. There's just not a lot here to recommend the Echo Plus over either its cheaper or more expensive stablemates. ⏻

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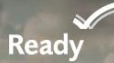
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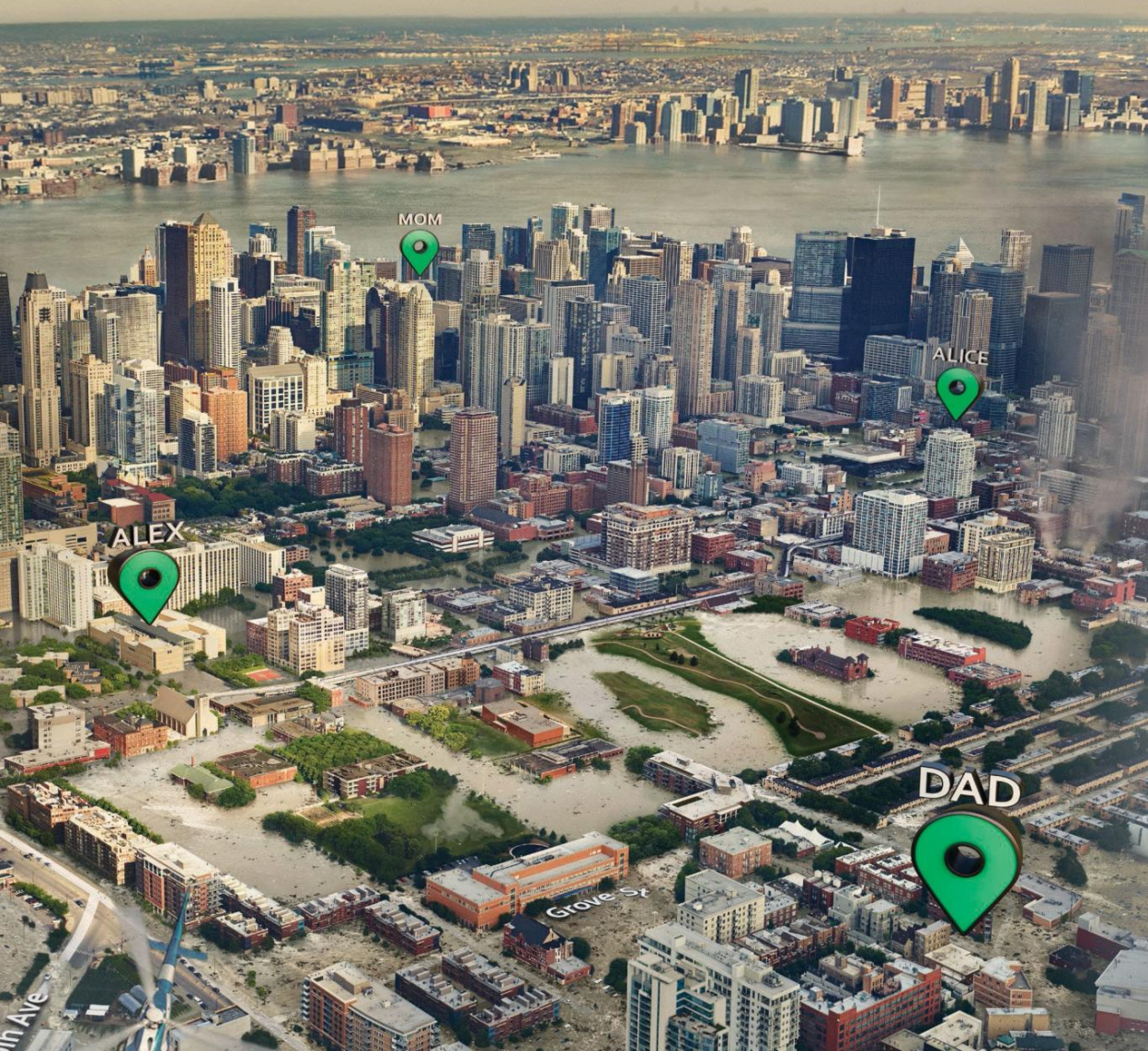
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MEET: AMD Radeon Software Adrenaline Edition

AMD's Radeon Software Adrenalin Edition update puts more power at your fingertips. **BY BRAD CHACOS**

I t hasn't been true for years now, but people still say AMD's drivers suck. Radeon Software Adrenalin Edition (go.pcworld.com/rsae) definitively proves them wrong.

The latest in a series of massive annual Radeon Software feature updates, Adrenalin builds on the success of Catalyst Omega (go.pcworld.com/cato), Crimson (go.pcworld.com/crim), ReLive (go.pcworld.com/relv), and ReLive 17.7.2 (go.pcworld.com/r172) before it, polishing up existing tools like WattMan and Radeon Chill while adding in the most-requested features of Radeon users. But more notably, Adrenalin adds a new on-screen overlay and AMD Link mobile app to make it easier than ever to fine-tune your game settings or keep an eye on your PC's performance.

What you *won't* find are gargantuan performance updates. Some reports written when AMD teased the Adrenalin name suggested this new Radeon Software could supercharge your frame rate. Nope. This doesn't unlock any new Vega features. AMD constantly releases new drivers throughout the year as games are released, and those are where you'll find performance bumps. Sure, you might see some nice cumulative gains if you

haven't updated your drivers since last year's milestone ReLive launch, but these annual releases focus on adding in new features. Adrenalin sure delivers on that part.

RADEON OVERLAY

Let's start with the flashiest features before diving deep into the bountiful quality-of-life updates. Before Adrenalin, adjusting the software options for your Radeon graphics card (go.pcworld.com/rgrc) required exiting your games and diving into the Radeon Settings app. The new Radeon Overlay lets you tune some of your Radeon Settings in-game and constantly monitor your PC's performance.

Pressing Alt + R with Radeon Software Adrenalin Edition installed summons the Radeon Overlay, a slick interface that pops in from the right side of your screen. You'll see several different settings available: ReLive, Performance, Chill, FRTC, FreeSync, and
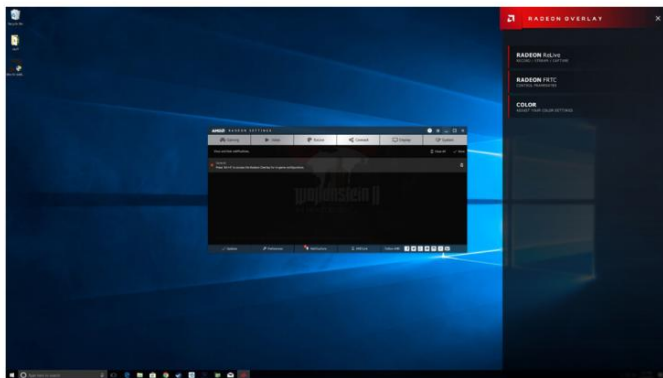
Meet the Radeon Overlay.

Color options. Some of these may be missing if you open the Radeon Overlay outside of a game—I didn't see the Performance or FreeSync options when I opened the Overlay on the Windows desktop, as you can see in the Radeon Overlay image.

Let's go through them one-by-one.

The Radeon Overlay's Select Metrics options.

The ReLive tab includes all the options previously found in the ReLive pop-up toolbar. If you want to record, stream, or screenshot your gameplay, this is the place to be. You can also adjust your microphone volume if you're doing voice-overs. Helpfully, keyboard shortcuts for the tools in the ReLive tab are listed underneath each option, so you can avoid having to navigate through the Radeon Overlay to quickly activate or deactivate ReLive features.

The Performance tab lets you enable a separate performance monitor overlay that shows your system performance, similar to the on-screen displays found in overclocking software like EVGA's Precision XOC and MSI's Afterburner. AMD's version gives you abundant control over how the performance monitor behaves, though. It doesn't appear in these screenshots for some reason, but it's a tiny black box with a column of data in a white font.

The Select Metrics section of Radeon Overlay's Performance tab lets you pick and choose which data you're interested in. FPS (frames per second) is a no-brainer, but you can also track GPU utilization, GPU engine clock, GPU memory clock, GPU temperature, GPU power, GPU fan speed, CPU utilization, and system RAM utilization. Snazzy! You can decide which corner of the screen houses the performance monitor, and the Metrics Options section lets you dictate how often Radeon Software checks for performance information (the default is every two seconds) or even select a file location to log your performance data.

That's all incredibly useful for PC enthusiasts. While GeForce Experience pumps up the fun with Ansel and ShadowPlay Highlights (go.pcworld.com/hili), Nvidia's software contains nothing that rivals AMD's
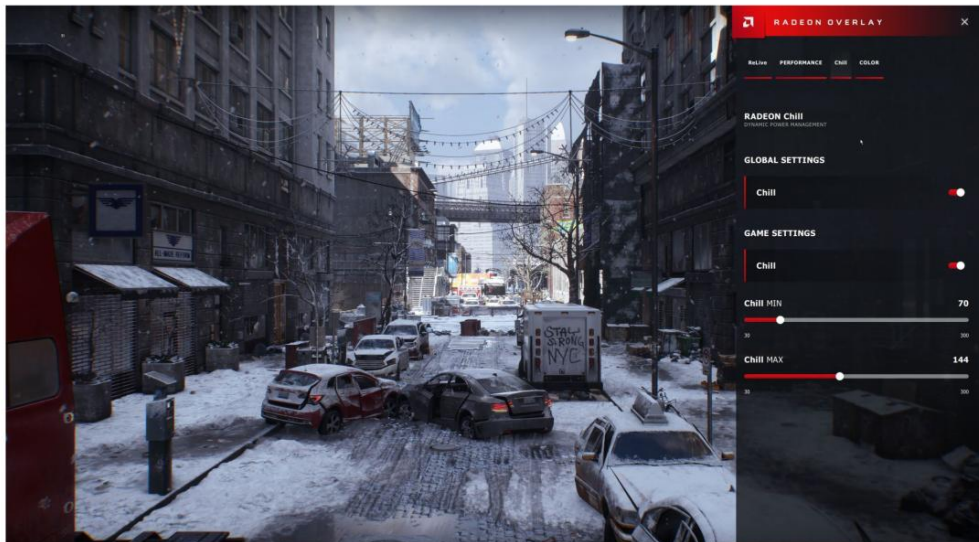
The Radeon Overlay's Chill tab.

performance monitor. One bummer: The performance monitor disappears every time you exit a game, so you need to reactivate manually every time you load into a game. I'd love to see a future update add an option to keep it persistent.

Next up is the Chill tab, which lets you enable or disable AMD's power-saving, temperature-lowering Radeon Chill feature (go.pcworld.com/rach). The tab lets you enable Chill globally or just for the game you're currently playing, as well as set the minimum and

maximum frame rates you want Chill to work inside. Try it out, especially if you've got a power-hungry Vega 64 graphics card (go.pcworld.com/ve64). AMD made some big changes to Chill in Radeon Software
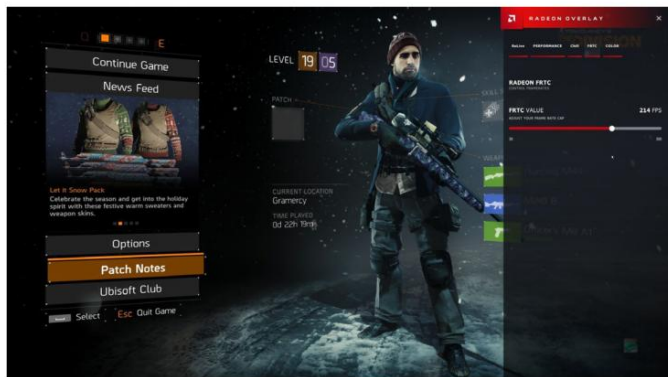
FRTC in Adrenalin's Radeon Overlay.

Adrenalin Edition, which we'll address more directly later.

Frame Rate Target Control (FRTC; go.pcworld.com/frme) puts a cap on your maximum frame rate to keep your GPU from working harder than it needs to, and thus keep power draw and temperatures lower. Why let your Radeon RX 580 scream at 200 fps when you're using a 60Hz monitor? The Radeon Overlay lets you activate the feature and specify your FPS cap, though you'll need to restart your game for it to kick in.

Likewise, the very simple FreeSync tab lets you manually enable or disable AMD's screen- and tearing-killing FreeSync feature (go.pcworld.com/frsy) if you have a compatible monitor, like the stellar Nixeus EDG 27 ($410 on Amazon; go.pcworld. com/nixe).

Finally, the Color section adjusts your display's color temperature, brightness, hue, contrast, and saturation on the fly. If you're running multiple displays, you can fine-tune each one.

All in all, the Radeon Overlay puts a lot of information and performance at your fingertips that used to require leaving your game or downloading a third-party monitoring tool. It's fast and responsive, too.

Color me a fan—but that isn't the only way Radeon Software Adrenalin Edition gives you more control over the way you play.

AMD LINK MOBILE APP

The new AMD Link mobile app is launching as a complement to Adrenalin, with both iOS and Android apps available. AMD Link intertwines with your Radeon-powered gaming PC, giving you access to performance monitoring, ReLive functionality, and AMD news from your phone or tablet.

Connecting AMD Link to your gaming PC couldn't be easier, though both devices need to be on the same network. Clicking Add A PC will walk you through the straightforward process, which involves enabling the AMD Link server in the Radeon Settings on your PC and connecting it to your phone using a QR code or on-screen code. You'll be up and running in no time.

Signing *back* into the app is a little trickier.
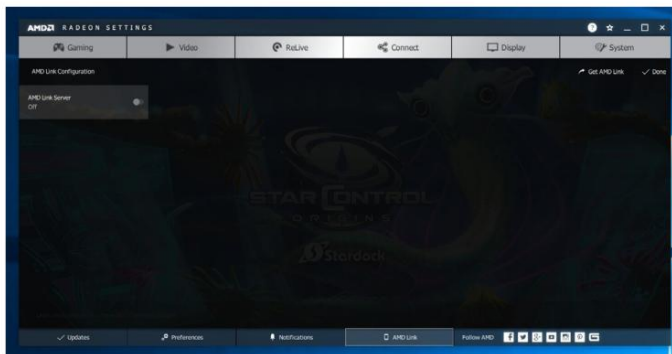
You'll need to activate the AMD Link Server in the new AMD Link portion of Radeon Settings on your desktop.

The connection between your devices gets severed when you turn off your PC. Launching AMD Link again returns you to the Add A PC interface on the home screen. Repeating the process reconnects everything but seems like unnecessary busywork. I asked AMD about it, and a representative informed me that you can reconnect AMD Link to your PC by heading into the Link app's Settings tab, finding the name of your previously connected PC, and checking the box next to it. Indeed, doing so worked—but it's clunky and unintuitive. AMD software head Terry Makedon told me they'll improve discoverability in future versions of the app.

The core AMD Link experience is superb, though. For me, the star of the show is performance monitoring. That tab shows you exactly how your PC is performing in real time, sliced three different ways depending on how you want your data. A current performance sub-tab gives you a snapshot of, well, your PC's
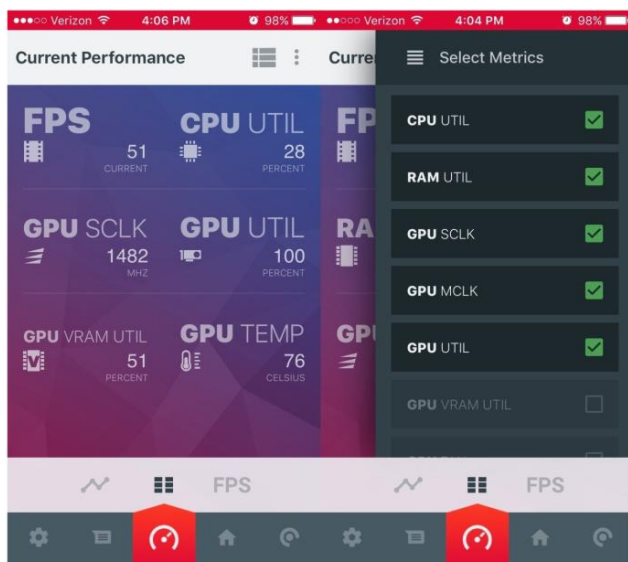
The Current Performance section of AMD Link, and some of the metrics you can select.
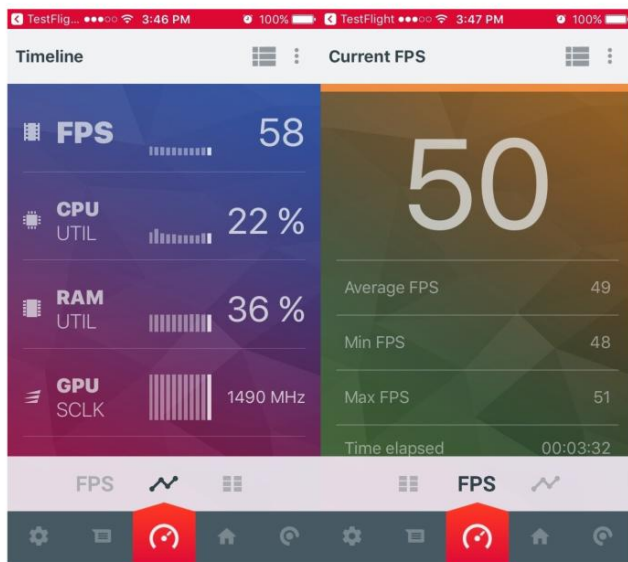
The FPS and Timeline views in AMD Link's performance monitoring.

current performance. You can use the settings gear at the top of the screen to fine-tune what's being monitored—I disabled memory clock and system RAM usage to watch GPU temperatures and graphics card VRAM usage instead, for instance.

The performance monitoring section also offers a Timeline tab that shows performance over time, and yes, you can customize those metrics, too. Finally, a dedicated FPS tab goes deep on frame rate information, showing your current, average, minimum, and maximum frames per second, along with the total time elapsed during your monitoring session.

AMD Link keeps the screen active while it's open. As a person who dislikes cluttering up my gaming experiences with overlays, I've found it useful to plug my phone into a USB port and just lean it against my monitor while I play, using AMD Link to keep an eye on PC metrics.

AMD Link's ReLive functionality is just as useful—perhaps even more so if you routinely stream or record your gameplay. AMD Link is basically a ReLive remote control; you can use it to activate all of the feature's streaming, video recording, and screenshot capabilities
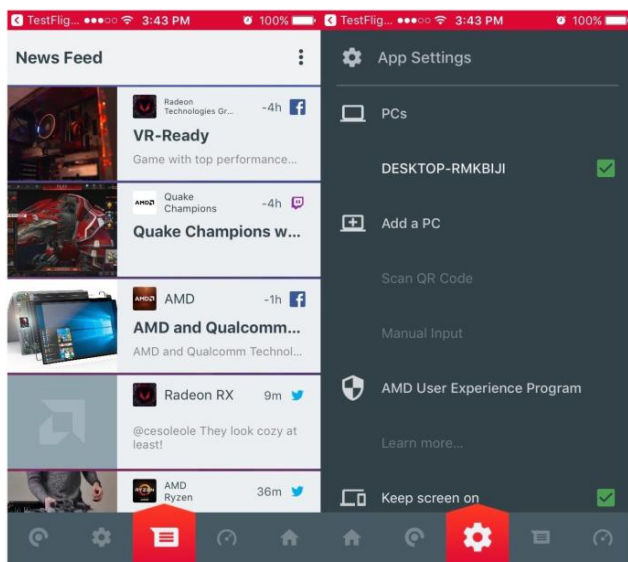
AMD Link's news feed and app settings screens.

right from your phone. You can also browse through a gallery of any media you've captured using ReLive.

Finally, there's also a news feed that shows content from AMD's various social accounts. I don't expect it to get much action.

RADEON SOFTWARE ADRENALIN UPGRADES: WATTMAN, RELIVE, RADEON CHILL, ENHANCED SYNC, AND MORE

After all these words we're only just now getting to the improvements inside the core Radeon Settings app itself. Radeon Software Adrenalin addition has something for everybody, with across the board upgrades for

WattMan, Enhanced Sync, Radeon Chill, ReLive, FreeSync, and more.

Most notably, Adrenalin adds a new central Connect tab to Radeon Settings. The biggest draw here is a Gallery section that serves as a hub for all the screenshots and videos you capture with ReLive. You're able to sort through media types to quickly find the file you're looking for, and upload your eye candy to various social services. Like YouTube, Twitch, Facebook, Twitter, et cetera.

To facilitate that sharing, the Connect tab's Accounts section ties Radeon Software to your social networks.

Resource Center, the final section in the Connect tab, serves as a fountain of knowledge for Radeon products, brimming
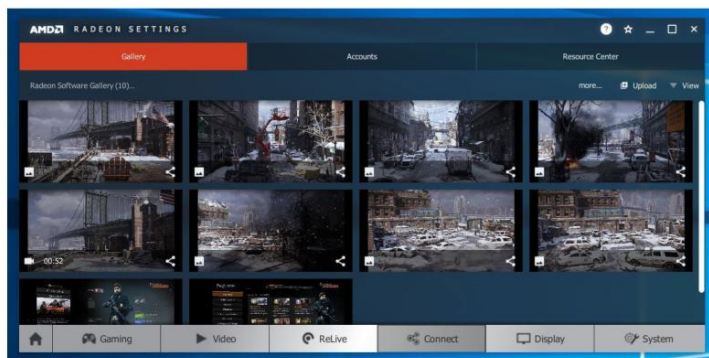
The Connect gallery in Radeon Software Adrenalin.
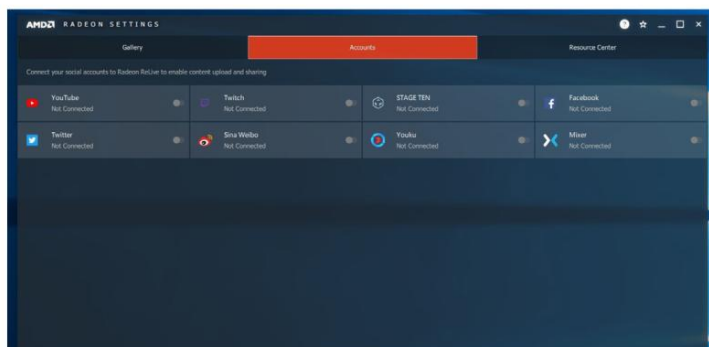
The Connect accounts in Radeon Software Adrenalin.

The Connect tab's Resource Center in Radeon Software Adrenalin.
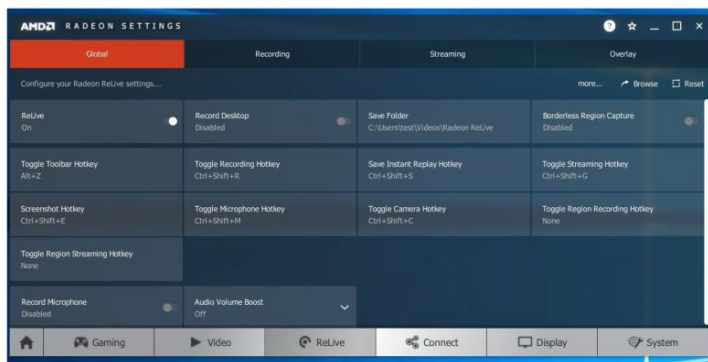
The ReLive global settings now includes borderless region capture and the ability to toggle region hotkeys for streaming and recording.

with how-to guides and links to news on the Radeon website. AMD software head Terry Makedon says there are no plans to include ads or promotions in the Resource Center. (You can already find those on the Radeon Settings home screen.)

You may have noticed the Connect tab intertwines heavily with AMD's ReLive tools, and ReLive itself sees some substantial quality-of-life improvements in Adrenalin—especially if you're a streamer or video producer.

ReLive now supports Chroma keys for webcams, so you can make the room behind you disappear if you have a green screen. A new chat integration overlay lets you show viewer discussions directly in your video feed. Display compatibility gets an upgrade too, with borderless region capture and support for games stretched across multi-monitor Eyefinity setups. Separate audio tracks for your mic and your game can help you step up your audio game.

On the performance side, ReLive now supports Vulkan-based games, and AMD has optimized ReLive's already-sterling performance to reduce its minimal effect on in-game frame rates even further.

AMD's Radeon Chill (go.pcworld.com/rach), the nifty technology that reduces your PC's heat output and power draw by intelligently scaling down GPU usage when it isn't needed, gets a *massive* shot in the arm with Radeon Software Adrenalin Edition. Previously, game support for Chill worked on a whitelist-style system: Only games that AMD tested and confirmed to work with the technology could use it. In Adrenalin, that shifts to a blacklist instead. Radeon Chill can be used with any Vulkan, DirectX 9, DX11, or DX12 game now, and AMD will ban a game only if it proves incompatible with the technology.

Huzzah! Chill works well, with little to no visual or responsiveness degradation in the games I've tried. Expanding its support from a few dozen popular games to the vast expanse of the PC gaming universe is welcome indeed, especially if you're running a power-hungry card like Vega 64 (go.pcworld.com/ve64) or a wildly overclocked Radeon RX 580
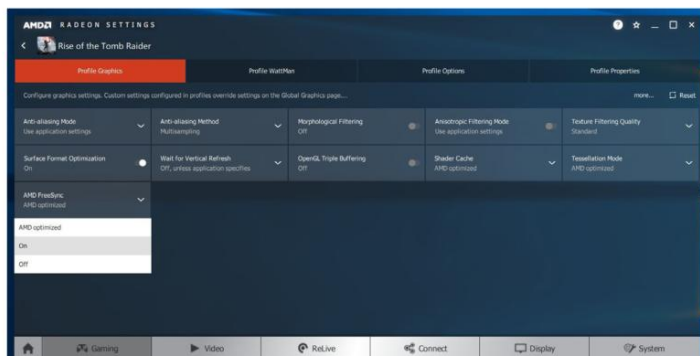
Radeon Software Adrenalin lets you enable FreeSync on a per-game basis.

(go.pcworld.com/r580).

You still need to manually enable Chill in the global settings portion of Radeon Settings' Gaming tab to use it. Afterward, you can head into individual game profiles in Radeon Settings—or use the Radeon Overlay—to enable or disable it for specific games, as well as set the minimum and maximum FPS boundaries for Chill in each game.

You can also enable or disable AMD's FreeSync technology (go.pcworld.com/frsy) in specific games now, if you have a FreeSync-compatible monitor. I have no idea why you'd ever want to turn off FreeSync—the technology synchronizes the refresh rate of your graphics card and display to erase stuttering and tearing for buttery-smooth gameplay—but hey, you can now if you're battling bizarre performance problems.

Enhanced Sync (go.pcworld.com/r172) was introduced in Radeon Crimson ReLive 17.7.2 over the summer. It minimizes screen tearing and increases responsiveness when you're playing games—probably e-sports games like *CounterStrike: Global Offensive*—at ultra-fast refresh rates, similar to Nvidia's rival Fast Sync. At launch, Enhanced Sync only worked with Radeon RX 400- and 500-series graphics cards. Adrenalin expands that to all GCN-based Radeon graphics cards (read: most Radeon cards going back to the HD 7000 series era in 2012). But that's not all: Enhanced Sync now plays nice with Vulkan games, mobile Radeon GPUs, multi-GPU configurations (go.pcworld.com/mgpu), and multi-monitor Eyefinity setups.

Adrenalin also adds the much-needed ability to save and load custom Radeon WattMan (go.pcworld.com/wtmn) overclocking profiles, including profiles created by the community. Be careful with shared profiles, though: If you accidentally

Adrenalin also adds the much-needed ability to save and load custom Radeon WattMan overclocking profiles, including profiles created by the community.
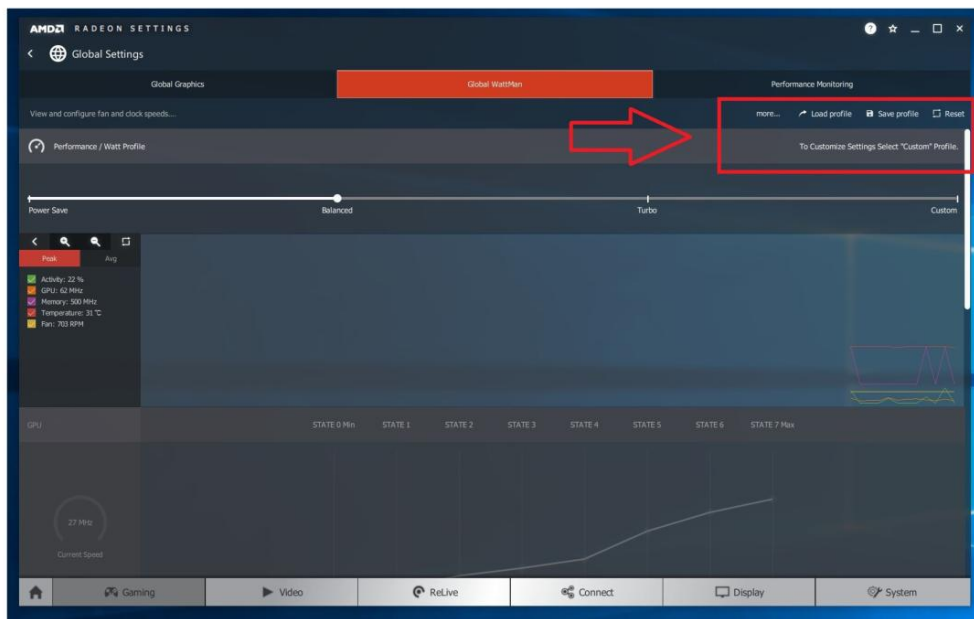
Saving and loading WattMan overclocking profiles comes in Radeon Software Adrenalin.

crank up your entry-level Radeon RX 550 with an overclocked Radeon Vega 64 profile, bad things could happen.

Other little niceties round out the package. They include:

• Borderless windowed mode support in multi-GPU configurations

• Vulkan support for FRTC; optimized compute profiles if you're into data-crunching or GPU cryptocurrency mining

• Radeon Software for Linux improvements

• A star icon in the title bar that brings you to a Radeon Settings feedback page where you can voice your opinions or vote on new features

• Three new interface themes if the stock Radeon Settings colors fail to tickle your fancy.

BOTTOM LINE

Add it all up and there's a lot for Radeon graphics card owners to like. This update polishes the already-gleaming core of Radeon Settings and puts more control and information into the hands of gamers, without even the need to exit your game. Between Radeon Software Adrenalin Edition (go.pcworld.com/rsae) and the Red Team's rapid-fire driver releases in recent years, AMD's software missteps of the past are firmly in the grave. This is good stuff.

HOW TO BUILD A RASPBERRY PI RETROGAMING EMULATION CONSOLE

ASSEMBLE A SIMPLE, INEXPENSIVE CONSOLE TO PLAY ALL YOUR FAVORITE CLASSIC GAMES.
BY BENJ EDWARDS

IMAGE: iSTOCK
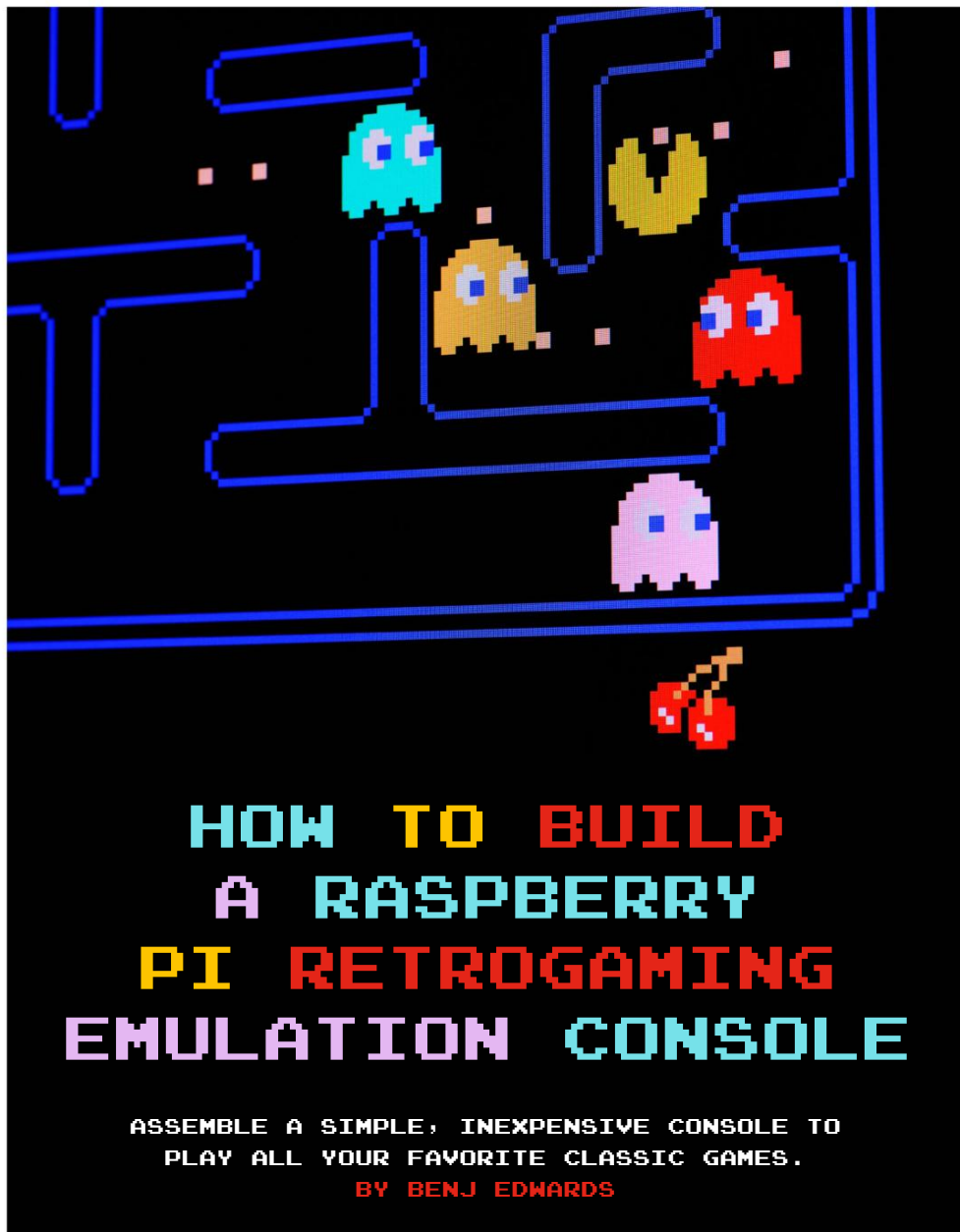
For the past 20 years, retrogaming enthusiasts have dreamed of building a "universal game console" capable of playing games from dozens of different systems. Their ideal was inexpensive, easy to control with a gamepad, and capable of hooking into a TV set.

Thanks to the Raspberry Pi 3 hobbyist platform and the RetroPie software distribution (go.pcworld.com/rtpi), that dream is finally possible. For under $110, you can build a very nice emulation system that can play tens of thousands of retro games for systems such as the NES, Atari 2600, Sega Genesis, Super NES, Game Boy, and even the PlayStation.

All you need to do is buy a handful of components, put them together, and configure some software. You'll also have to provide the games, but we'll talk about that later.

THE PLAN

To make our "ultimate console," we're going to run software emulators and video game ROM files on a single-board computer: the Raspberry Pi 3—an inexpensive computer designed for hobbyist and educational use.

To make this process easy, retrogaming enthusiasts have combined all the software programs we need into a free software package called RetroPie. RetroPie includes (among other programs) a Linux operating system, a large suite of game system emulators, and an interface that makes it easy to use.

For people who aren't familiar with emulation, here's a brief rundown: An emulator, for our purposes, is software that's been programmed to behave in almost the exact same manner as the hardware of an older video game system. It simulates the original console circuitry in software.

Since most computers lack a slot to read data from old video game cartridges, hobbyists have copied video game data into software files called ROM images. (In the case of home PC emulators, such as the Apple II, you may also encounter disk images, which are copies of an entire floppy disk's contents combined into a single computer file.)

You don't need one of these classic consoles to enjoy their games.

A front-end interface is a program that displays a graphical menu that lists available games on the system, lets the user select the game of their choosing with a game controller, and then run the game on the appropriate emulator automatically. In this case, the front-end program included in RetroPie is called EmulationStation.

WHAT CONSOLES ARE SUPPORTED?

Here's a noncomprehensive list of some of the most popular classic game consoles that RetroPie can emulate very well:

• Atari 2600
• Atari 7800
• Atari Lynx
• GCE Vectrex
• NEC TurboGrafx-16
• Nintendo 64
• Nintendo Entertainment System
• Nintendo Super NES
• Nintendo Game Boy
• Nintendo Game Boy Color
• Nintendo Game Boy Advance
• Nintendo Virtual Boy
• Sega 32X
• Sega CD
• Sega Master System
• Sega Genesis
• Sega Game Gear
• Sega Saturn
• SNK Neo Geo
• SNK Neo Geo Pocket Color

• Sony PlayStation
• Sony PSP

RetroPie supports many more platforms with varying levels of compatibility and user experience. You can find a full list of supported systems on the official RetroPie Wiki (go.pcworld.com/rpwk).

The easiest-to-use emulators are part of an emulation system called RetroArch, which combines many emulation engines (called "cores") into one program with a unified interface.

The other, stand-alone emulators included with the RetroPie package produce mixed results that can be frustrating to configure. If you stick to the platforms we listed, you're sure to have a good time.

STEP 1: BUY THE HARDWARE

Now that you know what we're going to do, it's time to buy the necessary hardware. Below is a rough breakdown of the cost of a RetroPie system as of April 2017. These prices come from Amazon.com, so they can vary considerably over time. The actual cost of this system depends on how much gear you bring with you.

BASIC REQUIRED COMPONENTS

You need the computer itself, a case so it doesn't get damaged, and a power supply. The basic "official" Raspberry Pi case does the job very nicely for a low cost.

These are the hardware ingredients for a RetroPi computer.

Regarding power, even though the Raspberry Pi 3 is powered through a micro USB port, it requires a 2.5 amp power supply. That much current is not supplied by most computer USB ports or adapters, so I consider it necessary to buy a special adapter for this purpose, and Amazon sells a good one from CanaKit.

• Raspberry Pi 3 Model B (go.pcworld.com/pi3b): $38
• Official Raspberry Pi 3 Case (black/gray) (go.pcworld.com/pi3c): $10.98
• CanaKit 5V 2.5A Raspberry Pi 3 Power Supply (go.pcworld.com/pi3p): $9.99

Obviously, you also need a TV to display the games and an HDMI cable to hook the Pi 3 to the TV set. If you don't have a spare HDMI cable, buy one (such as this 6-foot AmazonBasics High-Speed HDMI Cable for $7.09, go.pcworld.com/cabl).

To set up RetroPie, you'll also need another computer system (Windows or Mac) that can write to SD cards.

Pick up a storage option
This SD card will hold the operating system, emulators, and game files. A bigger card means more room for games. If you already have a spare 8GB or larger microSD card, you'll save yourself some money. If not, here

are some good candidates:

- SanDisk Ultra 32GB microSDHC UHS-I Card (go.pcworld.com/ul32): $13.27
- Samsung SDXC 64GB Class 10 UHS-1 Card (go.pcworld.com/ul64): $25

Pick a keyboard option

You're going to need a basic USB keyboard during the initial setup. After that, if you stick to console games, you won't need it anymore—unless you want to change some advanced options in the future.

If you want to go wireless, the Rii Mini is a very nice pocket-sized keyboard that can make changing system settings easy from a living room couch if you need to do so in the future.

If you want to go wireless, the Rii Mini is a very nice pocket-sized keyboard that can make changing system settings easy from a living room couch if you need to do so in the future.

- HP K1500 Wired USB Keyboard (go.pcworld.com/k150): $8.13
- Rii Mini Wireless 2.4GHz Keyboard with Touchpad (go.pcworld.com/rimi): $17.99

Pick a controller option

You're going to need a multipurpose controller to play games from many different classic systems. The Pi 3 has Bluetooth built in, so wireless controllers are a good option, although they are tougher to set up.

A versatile option is the 8Bitdo NES30, a wireless Bluetooth controller with NES-stylings, dual analog sticks, and four shoulder buttons.

Alternately, the DualShock 4 works wonderfully for retro games because it has a very good D-pad, is wireless, and is comfortable to hold. With its analog sticks, it also can do double duty for more modern consoles such as the Nintendo 64 and the PlayStation.

- Buffalo Classic USB Gamepad for PC (go.pcworld.com/gapd): $19
- 8bitdo NES30 Controller (go.pcworld.com/ns30): $34.99
- 8bitdo NES30 Pro Controller (go.pcworld.com/30pr): $42.99
- Sony DualShock 4 Wireless Controller (go.pcworld.com/ds4c): $47.79

SAMPLE RETROPIE BUILDS

With those options in mind, let's build out two sample systems.

Bare-minimum build

This is the least expensive complete option, with just 16GB of SD card storage, a cheap USB keyboard (which you will technically only need during setup), and a lower-cost, but still good, wired USB game controller. Again, prices are based on Amazon listings as of

April 2017. Prices may change.

• Raspberry Pi 3 Model B (go.pcworld.com/pi3b): $38

• Official Raspberry Pi 3 Case (black/gray) (go.pcworld.com/pi3c): $10.98

• CanaKit 5V 2.5A Raspberry Pi 3 Power Supply (go.pcworld.com/pi3p): $9.99

• SanDisk Ultra 16GB Ultra Micro SDHC Card (go.pcworld.com/ul16): $8.99

• Buffalo Classic USB Gamepad for PC (go.pcworld.com/gapd): $19

• HP K1500 Wired USB Keyboard (go.pcworld.com/k150): $8.13

• AmazonBasics High-Speed HDMI Cable (go.pcworld.com/cabl): $7.09

Total: $102.18

If you have a little more money to spend, try this build that I use for a more comfortable setup:

Benj's recommended build:
With a 64GB SD card (32GB is fine as well), you have room for many more game ROMs (especially newer games that take up much more space), and with a wireless DualShock 4 and a miniature wireless keyboard, you have a complete wireless living room experience.

My recommended build (see parts list below).

• Raspberry Pi 3 Model B (go.pcworld.com/pi3b): $38

• Official Raspberry Pi 3 Case (black/gray) (go.pcworld.com/pi3c): $10.98

• CanaKit 5V 2.5A Raspberry Pi 3 Power Supply (go.pcworld.com/pi3p): $9.99

• Samsung SDXC 64GB Class 10 UHS-1 Card (go.pcworld.com/ul64): $25

• Sony DualShock 4 Wireless Controller (go.pcworld.com/ds4c): $47.79

• AmazonBasics High-Speed HDMI Cable (go.pcworld.com/cabl): $7.09

• Rii Mini Wireless 2.4GHz Keyboard with Touchpad (go.pcworld.com/rimi): $17.99

Total: $153.31

Not too shabby. If you had told me a decade ago that I'd be able to build something like this for under $200, I would have been flabbergasted.

STEP 2: DOWNLOAD THE SOFTWARE

Of course, the fact that all of the software we'll be using is available to download for free, also helps keep this build so affordable.

Software you will need:
- The RetroPie distribution disk image
- An SD card image writing tool for Windows or Mac

Download RetroPie

To get RetroPie, visit the official RetroPie download page (go.pcworld.com/pdow).

Click the giant red download button for "Raspberry Pi 2/3," and you'll save a file named something like "retropie-*x.x*-rpi2_ rpi3.img.gz," where *x.x* is the current version number of RetroPie. Put this file somewhere you can easily find it, such as on your desktop.

This file is a disk image that contains all the software (including OS, emulators, etc.) you need to run our RetroPie setup on a Raspberry Pi 3. In a moment, we will be writing it to a microSD card using a special tool.

Download an SD card image writing tool

Next we need to download a software tool that will write the RetroPie software disk image to an SD card. We need this tool because the file system used by RetroPie is not the same as the ones used by Windows machines or Macs, so it's not as easy as copying the files directly to the SD card. What

we're doing is writing an already configured Linux OS installation directly to the SD card.

If you have Windows, download Win32 Disk Imager (go.pcworld.com/dski).

If you have a Mac, download ApplePi Baker (go.pcworld.com/appi).

If you have Linux, I seriously doubt you need this tutorial!

STEP 3: WRITE THE SOFTWARE TO THE SD CARD

The RetroPie disk image we just downloaded is compressed. If you're on a Mac, chances are that OS X already uncompressed the image into a .img file automatically after it downloaded.

If you're on Windows and you can't extract a .gz file, download 7-Zip (go. pcworld.com/7z1p), a versatile and free compression tool that will let you extract it.

Next, you need to run the installation program for the SD card image writer tool you downloaded. Install it. Run the tool—either Win3 2Disk Imager or AplePi Baker.

For Win32 Disk Imager: Under the Device section of the program, select the
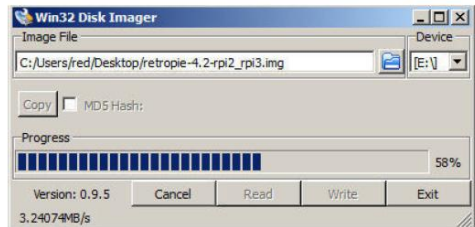
Win32 Disk Imager.

drive letter for your SD card. Make absolutely sure it's the right one, because if you pick the wrong drive, this program could erase all of its data.

Click on the folder icon next to the Image File box in the program. Select the "retropie-*x.x*-rpi2_rpi3.img" file we downloaded and decompressed earlier.

ApplePi Baker.

Assuming you're absolutely sure you have the correct drive selected, click the Write button and wait. It will be done in a few minutes.

For ApplePi Baker: First, under the Pi-Crust section of the program, select the SD card drive you want to write to. It will say something like "/dev/sda3".

Then under the Pi-Ingredients section of the program, click on the [...] button next to the white box and select the "retropie-*x.x*-rpi2_rpi3.img" file we downloaded earlier.

If you happen to have aluminum heat sinks (optional) as part of a kit you purchased, now is the time to affix those to the tops of the two main black chips on the Pi board.
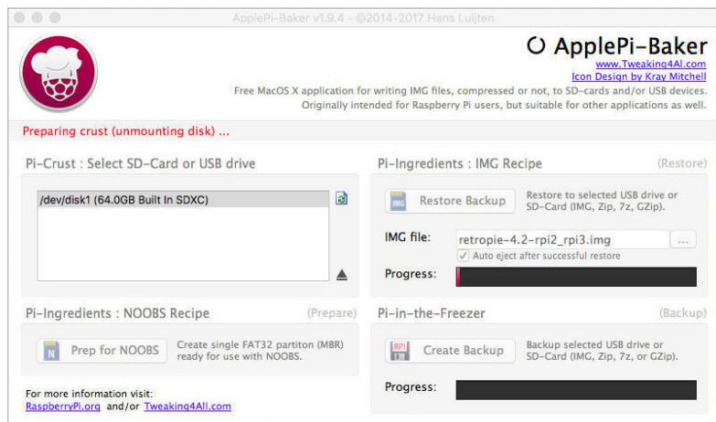
Finally, click the Restore Backup button, and the image will write to the SD card.

Now you have the software on the card and you're ready for the next step.

STEP 4: ASSEMBLE THE HARDWARE

Assemble the case with the Raspberry Pi in it

If you happen to have aluminum heat sinks (optional) as part of a kit you purchased, now is the time to affix those to the tops of the two main black chips on the Pi board.

Then open up the Raspberry Pi Official Case bag and lay its plastic pieces on a table. Carefully insert the Pi into the case and close it. Then attach the self-adhesive rubber feet to the bottom of the case.

Remove the microSD card from the computer you used to write the images.

Insert the microSD card carefully into the

SD card slot on the bottom of the
Pi. The Pi 3 has a friction-fit SD card
slot (previous models had a
click-in-place slot), so push it in
slowly. The SD card label should
be facing outward, away from
Raspberry Pi board.
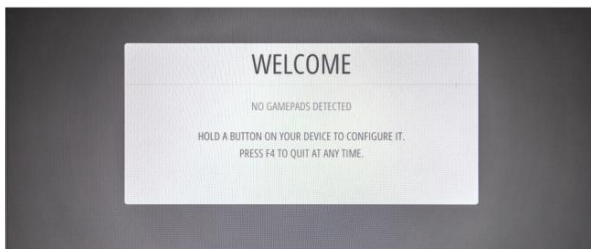
You're in. Just follow the prompts.

Plug everything in

Before starting up the system by plugging it in
(the Pi has no on/off switch, so it will be on as
long as it is plugged in), hook the HDMI cable
to the Pi and to a TV set or monitor.

Also, plug in your USB keyboard or USB
keyboard wireless dongle. Then plug in a USB
gamepad, if you have one. If you're using a
wireless pad, you don't have to do anything
with it yet.

If you're using a wired Internet connection
instead of Wi-Fi, plug a properly wired
ethernet cable into the side of the Pi.

Now's the time to unwrap your handy 2.5
amp power adapter and plug it into an AC
outlet. Carefully plug the micro USB
connector into the side of the Raspberry Pi.
The unit will power up.

STEP 5: CONFIGURE THE SOFTWARE

If everything went as planned when writing
the RetroPie software to the SD card, upon
first plugging in your Raspberry Pi, you will
see a colorful RetroPie splash screen and a
long crawl of text messages whizzing by.

These are Linux boot messages useful for
troubleshooting if something goes wrong. In
general, you can ignore them.

After a few moments, the Emulation-
Station front end will start up. You will see
a white/gray screen that says: "WELCOME.
No gamepads detected. Hold a button on
your device to configure it. Press F4 to quit at
any time."

What you do next depends on whether
you have a wired or wireless game controller.

If you're using a wired USB gamepad:
Hold down a button on the controller until
EmulationStation detects it. Then it will ask
you a long list of questions that let you assign
buttons to controls (i.e. Up, Down, A, B, X
buttons, etc.). Don't mess this up, or you'll
have to unplug the Pi and start over.

Once that's working, you will see a menu
called RetroPie. It contains a list of shortcuts to
set various settings. It's a convenient way to
configure the system without having to drop
to a Linux command prompt.

Using your controller, select RASPI-CONFIG

from the list and hit the primary selection button on the controller. Then skip to the "Configure system-wide settings" section in this tutorial below.

If you're using a wireless gamepad:
If you would like to use a Bluetooth gamepad like the DualShock 4 or the NES30 Pro, you have a lot more work ahead of you.

First, hit F4 on the USB keyboard, and EmulationStation will quit. You will see a black screen with text in the upper left corner. You are now at a Linux command prompt.

Don't panic. Type this exactly, case sensitive: **sudo ~/RetroPie-S etup/ retropie-setup.sh**

Then hit enter. This is the RetroPie setup program, a blue menu with lots of text options. Using the keyboard, find the
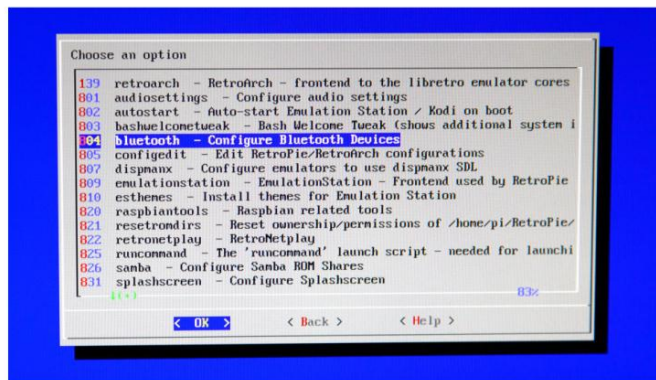
Select Bluetooth.

Bluetooth option and select it.

You'll have to switch the controller into discovery mode—for the DualShock 4, hold down the Share and the PlayStation button at the same time until its light blinks. For the NES30, hold down the power button on the front left of the controller until it turns on. Then you can search for it using the Bluetooth utility and sync with it (hit the second option for the DualShock 4 after it syncs).
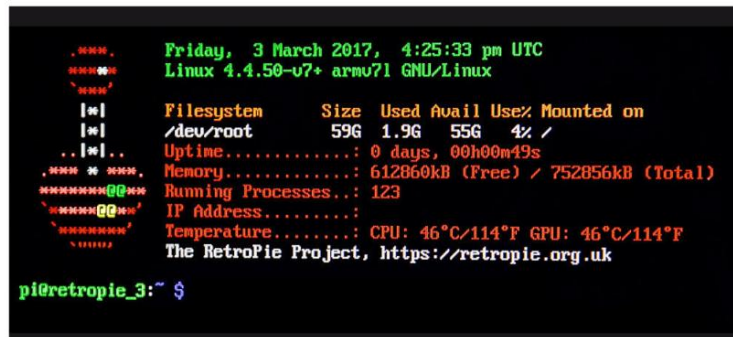
It's not as scary as it looks.

After that, restart your Raspberry Pi. To do this, exit the config program and type this into the command prompt: **sudo shutdown -r now**

The system will reboot. After a few moments,

EmulationStation will start up again. You will see the screen that says: "WELCOME. No gamepads detected …."

This time, instead of hitting F4, tap a button on your Bluetooth gamepad until it syncs up with the Pi.

Then hold down a button on the gamepad until EmulationStation detects it. It will ask you a long list of questions that let you assign which button goes to which control (i.e. Up, Down, A, B, X buttons, etc.). Don't mess this up, or you may have to unplug the Pi and start the button assignments over again.

Once that's working, you will see a menu called RetroPie. It contains a list of shortcuts to set various settings. It's a convenient way to configure the system without having to drop to a Linux command prompt.

Using your controller, select RASPI-CONFIG and hit the primary selection button on the controller.

Configure system-wide settings

If you did what I wrote above, either wired or wireless, you should now be in the Raspberry Pi system settings program. It's a blue screen with text-based menus.

You'll probably want to change a few settings here. The first is Localisation Options (note UK spelling)—which you'll want to configure if you don't live in the UK. The Pi and RetroPie were developed in the UK, and they use a different keyboard layout there than we do in the U.S. It is worth setting up an American keyboard layout and setting your time zone, because those will help if you need to make advanced configuration changes in the future.

The second thing to change is under Advanced Options and then Overscan. When it asks you if you would like to enable compensation for displays with overscan, select No if you're hooked up to an HDMI TV or monitor. Overscan compensation makes the image smaller so
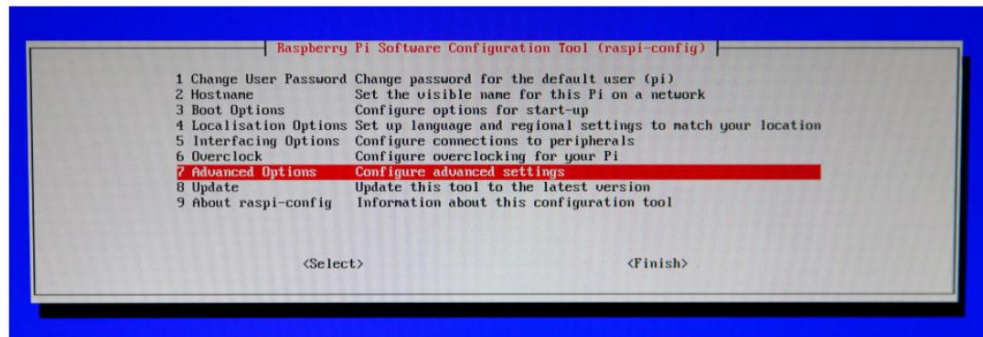
System settings.

you don't lose information off the sides of the screen if you're using an old-style TV set. The only time you'd want to hit Yes here is if you are using a composite TV set with a special cable.

After you're done setting that up, back out of those menus and select Finish. Then restart your Raspberry Pi. If you have a USB controller, hit the start button and choose Restart. If you're at a text prompt, type: `sudo shutdown -r now` and the system will reboot.

Configure Wi-Fi

If you've got a wired ethernet connection, you can skip this step. If not, it's time to use your gamepad to navigate to the RetroPie menu in EmulationStation, then select the Wi-Fi option at the bottom.

This will bring up a text-based Wi-Fi configuration program. Do what it says—search for your access point, and enter your password. Then you should be up and running with an Internet connection.

STEP 6: COPY GAME FILES TO THE RASPBERRY PI

So you've set up the hardware and the software, but you still need game files to have fun with this tiny beast. So let's copy some over. First, I'd like to share a few thoughts on the ethical nature of what we're doing.

Currently, it is not legal in the United

Digital works are fragile things, and the emulation community has done an incalculable public good by encouraging people to play and preserve classic video games.

States to possess and play copies of games you have not bought or have not licensed for play, but I personally believe (speaking on behalf of myself and not this publication) that playing older game ROMS with emulators is ethical when done in moderation. (It is also possible to run legally licensed or purchased ROM files, but that is beyond the scope of this article.)

Digital works are fragile things, and the emulation community has done an incalculable public good by encouraging people to play and preserve classic video games. Nothing less than our cultural legacy is at stake. So partake, my friends, in your shared cultural heritage. And don't feel bad about it. We all have the right to enjoy the fundamental cultural ingredients that came together to make us who we are today. Don't let anyone try to keep that from you.

Hopefully, this reality will some day become reflected properly in law, but until then, we're left building awesome, tiny emulation boxes and rationalizing it however we can.

Copy ROM files via Samba network file sharing

With that disclaimer out of the way, here's how you copy game files easily over to the Raspberry Pi. There are several ways to do it, but I think the easiest method is to use Windows file sharing—called "Samba" in the Linux world. You can do this whether you have a Mac or a Windows Machine.

On Windows: Open up a new Explorer window and type **\\retropie** into the location bar at the top.

On a Mac: Open Finder, select Go from the menu at the top of the window, then select Connect To Server. In that box, type **smb://retropie** and click on Connect.

If for some reason you changed the system's hostname in the settings, you'll need to type that above in place of *retropie*.

Now that you've connected to the Pi via file sharing, you can click on the roms shared folder. You will see a big list of folders named after various game platforms like "atari2600" and "genesis."

Drag-and-drop whatever ROM files or disk images you have into the proper platform-named directories on the Pi. For example, .NES ROM files should go in the nes directory on the Pi, and .SMC Super NES ROM files should go in the snes directory.

After you've copied everything, restart your Raspberry Pi through the EmulationStation Start button menu, and all the games will be recognized automatically. Then you can select whichever one you want and have a blast!

STEP 7: PLAY AND ENJOY

Wow, you've done quite a lot. Now is the time to sit back, relax, and enjoy the fruits of your labor. Play whatever you want, whenever you want, with ease. If you're a 30-something, or older like me, you'll be amazed at how little time you have to play these games compared to when you were a kid. Just remember to take breaks every once and a while to sleep, eat, and feed your kids. ⏻

The payoff.

I DARE YOU TO BE THE teacher I NEVER FORGET

Dare to find a career where you can truly make a difference. Your skills and talents could be exactly what we need to build the next generation of great teachers. Get resources to explore whether teaching is right for you at **teach.org**.

TEACH SM

Ad Council
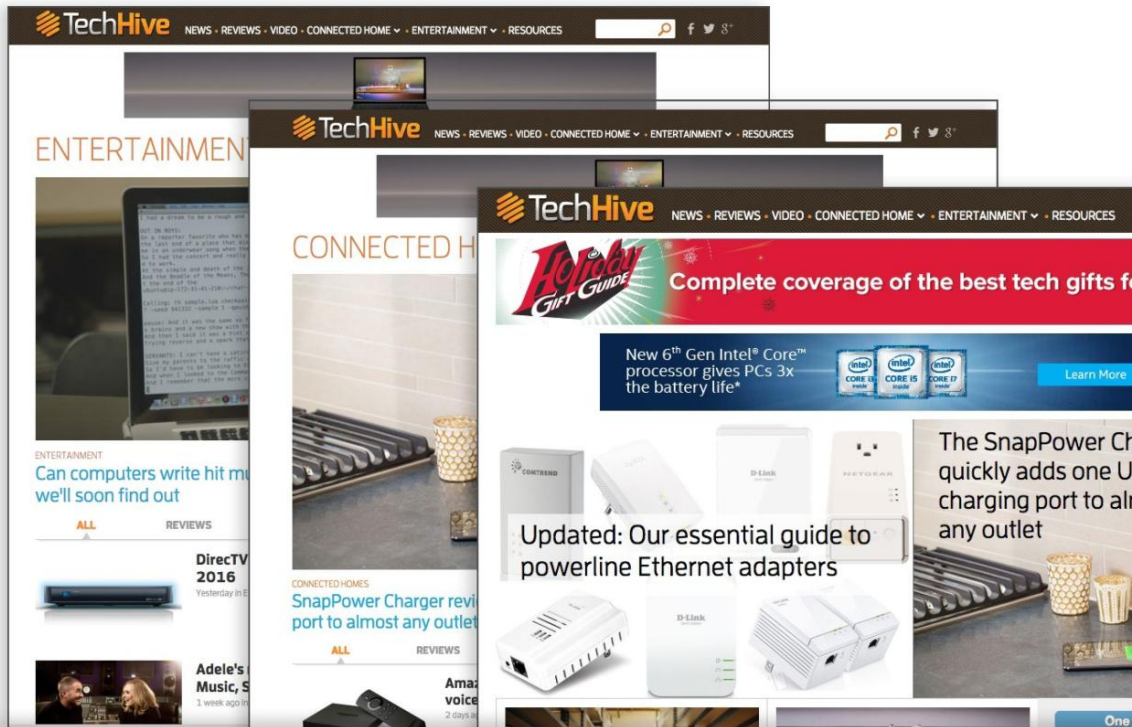
Five hidden features of Android 8.0 Oreo you should be using

Not all the cool features get top billing. **BY RYAN WHITWAM**

Google is pushing Android 8.0 Oreo to Nexus and Pixel devices as device makers scramble to get their phones updated. Google's devices will be the only ones running the new software, at least for a while. What's this Oreo update all about, anyway? Everyone knows about the big stuff, like picture-in-picture and autofill apps, but a lot more is going on if you dig deeper. Here are six awesome hidden Oreo features to get you started.

IMAGE: RYAN WHITWAM
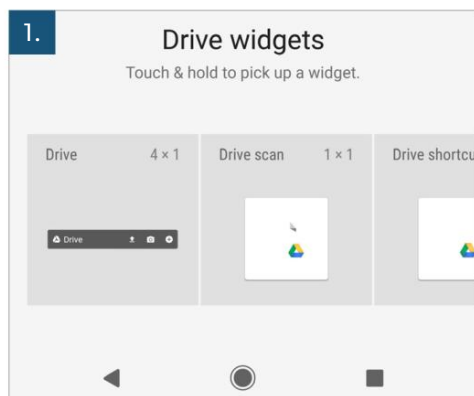
1. WIDGETS VIA APP SHORTCUTS

Google has changed the location and appearance of the home screen widget picker several times, and Oreo brings yet another alteration. This one might make using widgets much easier, though. All of an app's widgets are accessible with a long-press on the app icon. This works in the app drawer as well as on the home screen.

The long-press menu is the same one that shows pending notifications via notification dots, one of the high-profile changes to Android 8.0. Less well-known is the icon that looks like four small squares. That's the widget shortcut. It's at the top of the pop-up for apps that have launcher shortcuts, but it has a full line with a label on those that do not. Tap the icon (wherever it may be), and a panel appears at the bottom of the screen

with just the widget or widgets for that app. You can long-press and drag any of them onto your home screen.

2. ENFORCE BACKGROUND LIMITS ON APPS

Android 8.0 comes with a new raft of tweaks to background processes that prevents apps from bleeding your battery dry. There's a big catch, though: These background limits are enforced only on apps that target the new API level in Oreo. You can force an older app to abide by the new background limits, however.

To make this change, open your system settings and go to Apps & Notifications > App Info. Find the app you want to modify. On the Info screen is a link to battery usage. Tap that, and you can turn off the toggle for Background Activity. Keep in mind, apps that aren't set up to use the job scheduler correctly will have delayed notifications and other bugs when not allowed to run continuously in the background.

hitting the drop-down next to the hour snooze indicator.

4. GRANULAR CONTROL OVER SIDELOADING APPS

In past versions of Android, the "unknown sources" permission was all or nothing. Either every app on your phone could install apps as sideloaded APKs, or none of them could. Android 8.0 changes that to make sideloading a per-app setting. It's safer, sure, but it's also a bit of a pain to manage.

3. SNOOZE NOTIFICATIONS

Android is great at delivering a ton of information in notifications, but you don't always want to pay attention to a notification immediately. In Android 8.0 Oreo, you can snooze notifications until later. You don't have to dig into any menus to set this up, but it's still somewhat hidden.

When you get a notification you want to snooze, slide it left or right, but *don't* swipe it away. Tap the clock icon next to the notification, and it will be snoozed for one hour. At that time, the notification pops up again. You can also change the hour timer to 15 minutes, 30 minutes, or two hours by

If you download or access an APK with the intention of installing it in Oreo, the phone will give you an error and send you off to a menu to change your settings. You can find this menu in Apps & Notifications > Special Access Apps > Install unknown Apps. Apps that have tried to open APKs will appear here. Each one has a settings screen where you can toggle unknown sources on and off. If you aren't going to install APKs from an app, make sure it stays off. This prevents rogue apps from trying to sneakily install APKs by hijacking your taps.
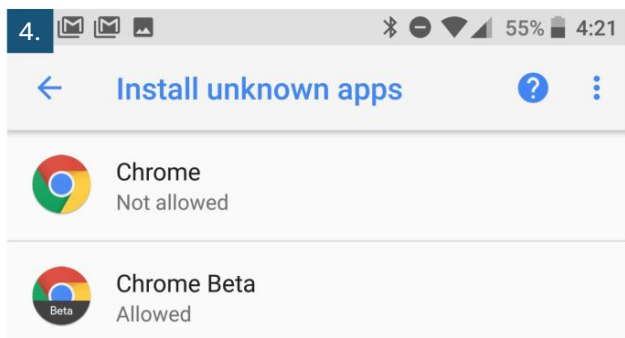
5. CUSTOMIZE NOTIFICATIONS

Oreo includes several changes
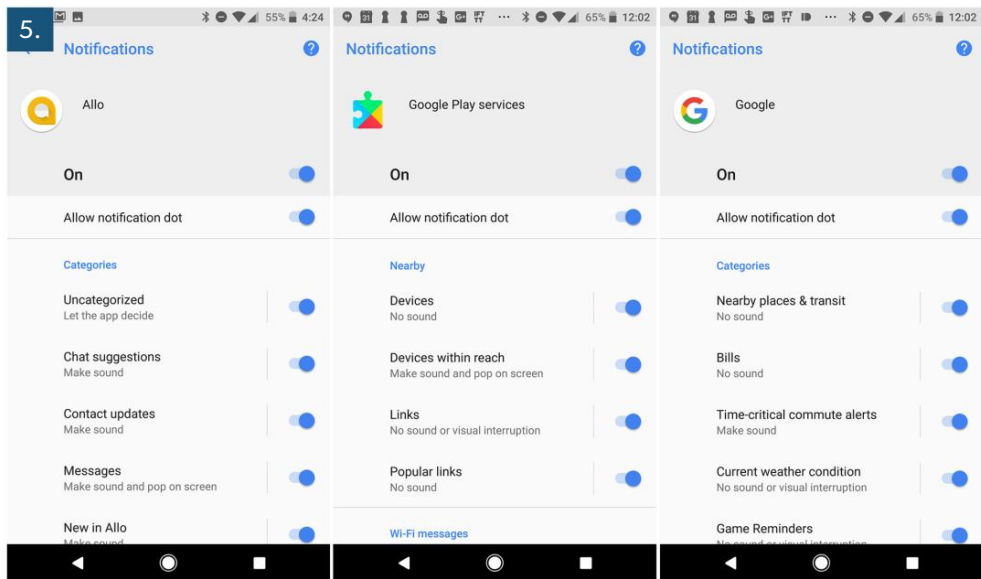
to notifications, including notification dots and notification channels. If you want to filter out some of the noise, both these features include some handy customization options.

Notification dots are straightforward. When an app has a pending notification, its icon gets a colored dot. Long-press and the notification appears in a pop-up in addition to the notification shade. Not everyone wants the extra clutter, though. Dots can be disabled by opening the settings to Apps & Notifications > App Info > [App Name] > App Notifications. Turn off the toggle for notification dots, and they'll never trouble you again.

The above notification menu is also where you'll find channel controls. It can be accessed via the menu, or you can wait for a notification to pop up and move it aside (just like accessing the snooze option above) and tap the settings icon. You can turn off the channel that notification belongs to right from there, or tap All Categories to open the App Notifications menu. All the channels have on/off toggles and separate settings for notification importance and sound. You have a lot of control over what apps can bug you about, but these settings are available only for apps that target Android 8.0.

Oreo has plenty to keep you busy when you factor in all the hidden features. Keep all these tips in mind when you pick up your Oreo device, and you'll master it in no time. ⏻

How to fix your Wi-Fi network

Wi-Fi trouble? The tips and tricks in our troubleshooting guide will help solve your problems. **BY GLENN FLEISHMAN**

Wi-Fi is everywhere and built into everything. It's like oxygen for Internet access, media streaming, gaming, and all types of networking. And it should just work all the time—right? If you've had an average experience with Wi-Fi on mobile devices, laptops, game systems, and more, you know that while a solid Wi-Fi connection might be the norm, those times when it's not can leave you tearing your hair out.

Here, I look at a number of common scenarios that cause Wi-Fi problems and how to solve them, whether you're running your own network or trying to connect to someone else's using any platform.

WI-FI BASICS

Before we get started, a very quick primer on a few Wi-Fi terms I'll bring up repeatedly.

802.11: the name of the IEEE engineering trade group's working group for wireless local area networks (WLANs). WLANs began in earnest with 802.11b in 1999 (802.11a came out at the same time, but had less traction), and the group is all the way up to 802.11ac and 802.11ad today. We expect to see 802.11ax gear announced at CES. These specs define how data is encoded into radio transmissions and exchanged among devices.

Wi-Fi: a trademarked name used to cover network adapters that have passed a certification test to work with each other using various 802.11 specifications.

Frequency bands: Wi-Fi networks use two unlicensed frequency bands: 2.4 gigahertz (GHz) and 5GHz. Many Wi-Fi routers and most modern mobile and desktop devices can create networks or connect over either band—these are "dual-band" base stations or adapters. 802.11b and g exclusively use the 2.4GHz band. 802.11a and ac exclusively use 5GHz. 802.11n works over either band.

Channels: Frequency bands are divided into numbered channels. In the U.S., 2.4GHz has 11 available overlapping channels numbered 1 to 11, while 5GHz has about two dozen scattered across a broader range from 36 to 165. They run in groups for historic reasons in how the bandwidth was granted for unlicensed use to everyone. (5GHz channels are numbered at least four apart, as in 149, 153, and 157, for reasons too involved to explain.)

CAN'T SEE A NETWORK YOU KNOW IS AVAILABLE

You know a network should be reachable from where you're at, but it doesn't show up in your list of available networks to which you can connect. Try these possibilities:

Check whether you disabled Wi-Fi without realizing it. Some Windows laptops and other devices have hardware Wi-Fi switches or buttons that you can press by accident. In Windows 10, the network icon will show a red X through the Wi-Fi in the taskbar. In macOS, the Wi-Fi "fan" in the system menu bar will be an empty outline.

The Wi-Fi Alliance awards this logo to products that meet its interoperability standards, but its absence on a product's packaging could just mean the manufacturer didn't want to pay for the testing and certification.

Some computers have buttons that can turn the onboard Wi-Fi adapter on and off.

Cycle your Wi-Fi adapter. On many devices, you can choose a software setting to disable the Wi-Fi radio temporarily. Airplane Mode is the simplest way in operating systems that offer it, though using it disrupts cellular and Bluetooth connections on your device as well.

Out of range. Wi-Fi doesn't have a hard cutoff as to when it will work and when it won't. Sometimes you can get perfect reception in one place and then later not. That's because the radio signals bounce off surfaces, pass through walls, and can be absorbed by people and materials. Move around and see if the network shows up.

Check your band. While many user devices can connect using either frequency band, you can still find modern hardware that can only connect via 2.4GHz. If you happen to be in a place where the only available signal that reaches is a 5GHz network, all your dual-band hardware will connect just fine, but single-band 2.4GHz gear won't. Because of the different characteristics of the band, it's possible to be in a room in a house, office, or public space where a 2.4GHz signal doesn't reach, but the same base station's 5GHz signal is crisp and clear. The Apple Watch in all its versions supports only 2.4GHz Wi-Fi. Older and inexpensive smartphones and tables may lack 5GHz radios, too, and many smart home products have only 2.4GHz support.

It's a closed network. While it's never been a truly valid way of improving security, some networks are set up so that they don't broadcast their name. In that case, if you don't have a connection profile stored, you must use the method in the operating system to join a network manually, often listed as "Other" in a menu. You'll need to enter the name precisely and, if it's using encryption, choose its security method and enter the password.

The network is down. Check from multiple devices or ask other people using the network. A router may need to be rebooted—or replaced.

CONNECTED, BUT NO INTERNET ACCESS
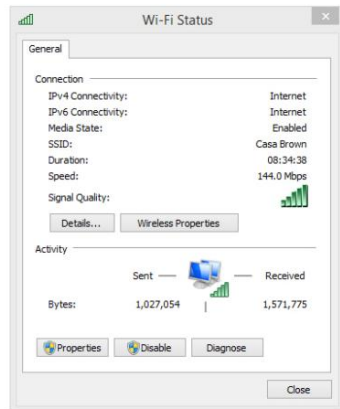
Wi-Fi is just a radio technology, which means you can have a perfectly strong signal and a valid connection, but still lack network access.

Start by checking your network address and see if it's in the "self-assigned" range. If there's something wrong with the way the local network assigns out addresses to devices as they attach, your computer or mobile device will create a self-assigned address, which can't route data elsewhere. In some cases, small networks can run out of addresses to assign! Some operating systems

> Wi-Fi is just a radio technology, which means you can have a perfectly strong signal and a valid connection, but still lack network access.

provide a clue that there's a problem, like the Wi-Fi signal adapter showing an exclamation point in it. In others, you'll need to drill into network status or settings.

In Android: Settings > About Phone > Status.

In iOS: Settings > Wi-Fi, then tap the "i" info button.

In Windows: Settings > Network & Internet, and then choose the Wi-Fi adapter.

In macOS: Open the Network system preference pane, select the Wi-Fi adapter, click Advanced, and click the TCP/IP tab.

If the IP address on your device for IPv4 networking (a set of four numbers separated by periods) starts with 169.254, then it's a self-assigned address,
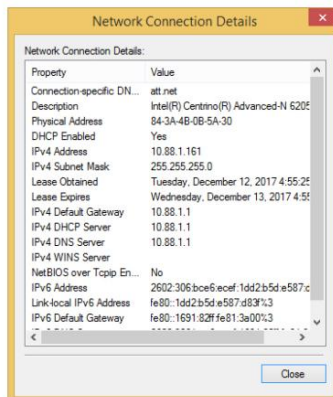
Check the IP address assigned to your device to ensure that it has an address assigned by your router.

which indicates your OS couldn't receive an assignment from the local network's DHCP (Dynamic Host Configuration Protocol) server. (Some work and academic networks might require entering a static set of values, but you should know if you're on one of those.)

Before assuming the network is at fault, however, check your firewall settings, if you have one installed or are using tools built into the OS. Some firewalls prevent connecting to new networks and routing traffic over them without an explicit entry. In most cases, you should receive a prompt that warns you about a new network and asks you to approve it. But depending on your configuration, it's possible the network routing has been blocked silently.

Once you eliminate the firewall or other filters, you can be sure it's the network that's the trouble. If you're not the person who kicks routers when they misbehave, you'll need to find someone who is.

THE IP ADDRESS IS VALID, BUT NOTHING LOADS

If you're using a public hotspot at a café, airport, conference center, or elsewhere, you might have run afoul of a portal or login page without realizing it. Most operating

Speed-test tools like Ookla's Speedtest.net can measure the speed your broadband ISP is providing, but you should test with a hardwired connection whenever possible.

systems' last several versions understand that you might encounter a portal and act accordingly. Until you answer the right questions or click the right buttons, Internet access is locked away.

With a portal page, the hotspot effectively hijacks domain name service (DNS) lookups, so that everywhere you're trying to go redirects to the portal. Apple's macOS and iOS recognize this behavior, and pop up a modal dialog that displays the portal webpage. Once access successfully starts, the OS can tell that DNS is working properly and dismisses itself or shows a Done button that can be tapped or clicked.

Sometimes portals are wonky or, due to firewall or other filtering software, your system doesn't trust these redirections. This would prevent the portal page from appearing.

Open a browser and try to load any page, like cnn.com, and see what happens. If you see loading and redirection start—look at the Location field in your browser and see if the domain or IP addresses change—it's likely something on your system that's blocking completion.

If nothing ever loads in the browser, consult with the venue. You may need to obtain a password, pay, or use a special configuration.

YOUR NETWORK CONNECTIONS ARE INCONSISTENT

There are four main culprits in inconsistent Wi-Fi performance and network access: an erratic broadband connection, distance from a base station, the wrong base station in a set selected, and a congested local networking environment.

Broadband. The first is hard to test unless you can plug an ethernet cable into the router and use a bandwidth tester, like one from Ookla, or a network monitor that shows you performance over time. If you can, however, eliminate that as a possibility before you move forward.

Distance. This seems like an easy one, too: move closer! But if you don't know where the Wi-Fi base stations are located or you're in rooms away from those in which they're

placed, "closer" may be hard to figure out. Because of signal reflection and absorption, it's not always obvious where to move your own base stations for better coverage. NetSpot ($49 from go.pcworld.com/ntsp, for the Pro version for Windows and macOS; there's also a feature-limited free version) can help you visualize your coverage area by building a heat map as you walk around. There's also a free version of Ekehau's Heatmapper that provides similar features.

Wrong base station. A network of identically named Wi-Fi routers with the same security settings lets you roam, whether in a million-square-foot office tower or across rooms in your house. The device you're carrying, however, doesn't always make the right

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Because of signal reflection and absorption, it's not always obvious where to move your own base stations for better coverage.

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choice about the strongest signal. In my small house, we have three base stations due to thick walls. Laptops and mobiles routinely stay connected to a router in the basement when they're within feet of one upstairs. You can pick which base station to join when they're all named the same, but cycling your
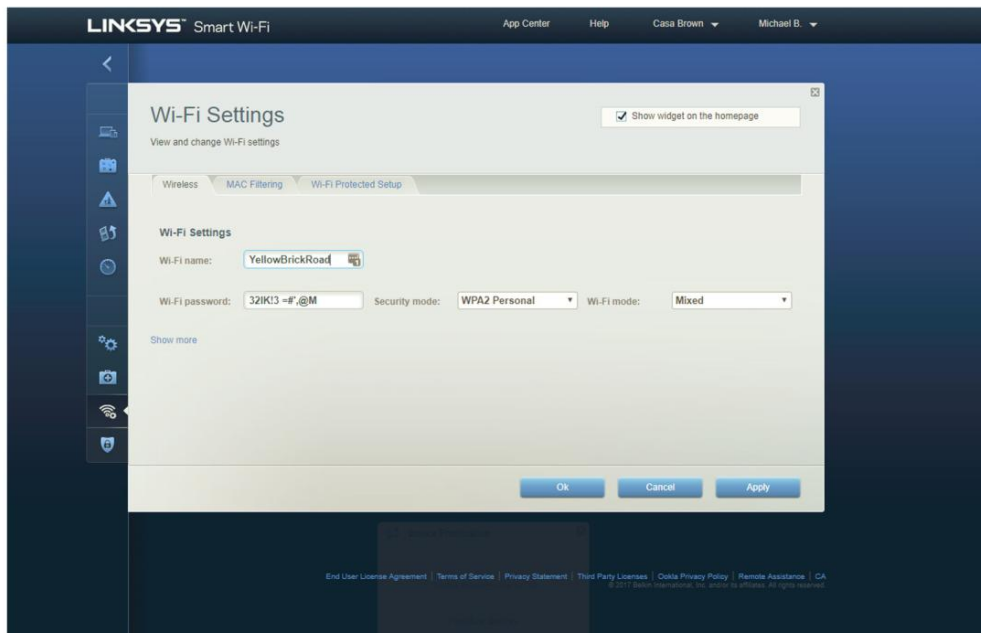
It's a good idea to use a complex password, but they can be difficult to communicate to others. Many modern routers, including the Linksys Velop router shown here, let you share them via text message.

Wi-Fi adapter from on to off to on typically causes it to make a better choice.

Congested local network. If you're at home or in an office where you run the gear, you may be able to improve the Wi-Fi situation around you. Outside of mesh networking ecosystems, you can typically connect to a Wi-Fi router and switch from the default automatic channel assignment in each band to choosing a channel. A little secret about Wi-Fi is that while the signal levels have a single maximum for all channels in 2.4GHz, the 5GHz band is divided into three major pieces, and until 2014, each of them had a different maximum signal limit. The lowest channel range (36, 40, 44, and 48) could only operate at no more than five percent of the maximum of the highest channel range (149, 153, 157, and 161, typically). Setting your 5GHz band to channel 149 solves that if you have equipment that wasn't revised to reflect the new rules, which is the vast majority of base stations that are at least two years old. (You can use a tool like WiFi Explorer [$20 from go.pcworld.com/wfex] to examine what's in use around you.)

One extra tip: Force 5GHz. Many base stations default to naming the separate 2.4GHz and 5GHz networks the same to ease roaming. Most of them, however, also let you choose a separate name for each. If you want to ensure the fastest connection with the highest signal strength, having separate 2.4GHz and 5GHz network names helps alleviate the inconsistency you might experience as a result of connecting to the crowded 2.4GHz band.

CORRECT PASSWORD, NO CONNECTION

A network that requires either a password or a username and password will reject your device if you enter it improperly. But what if you're positive you're entering the password or username and password correctly?

• Check whether you were given the password with correct capitalization, which counts in Wi-Fi passwords as in others. Spaces can be part of WPA2 passphrases, but spaces are hard to indicate when written down. Confirm you're not missing a space.

• Make sure you've selected the correct network. In some places, you'll be contending with dozens or more separately named networks, and you may have selected one named similarly to the one you want. Some businesses and hotspots run

If you want to ensure the fastest connection with the highest signal strength, having separate 2.4GHz and 5GHz network names helps alleviate the inconsistency you might experience as a result of connecting to the crowded 2.4GHz band.

guest networks named only slightly differently than their internal, private networks.

• Overloaded networks and routers with firmware that's malfunctioning might reject a connection, even when you've entered the password properly. Consult with the network's operator—if that's you, reboot the router!

YOUR DEVICE REPEATEDLY REJOINS THE WRONG NETWORK

Most modern operating systems retain a list of every network to which you've connected ever. My Mac has entries that date back several years across several machine migrations. Some ecosystems sync access, too, so when you join the network on one device, all your other phones, tablets, and computers now can join without additional effort.
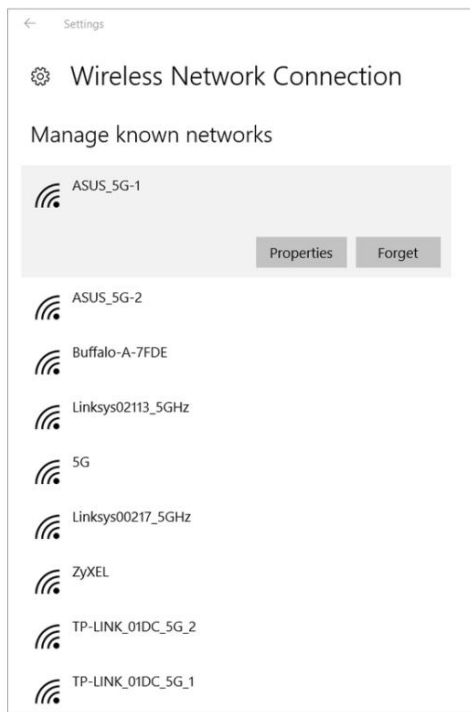
Windows 10's Manage Known Networks setting will show you every network your computer has ever joined (unless you've told it to forget some of them). If you know there are networks you'll never need to connect to again, click on each one and select Forget.

If you find a flaky network in a place you work or visit routinely that you've joined once, you might have tried to forget it, but it remains. I've seen this and heard from readers that deleting a network connection doesn't fully remove it, because a synced copy elsewhere gets copied back to your device! The trick is persistence: keep deleting it from every device you're using so the syncing finally syncs up.

You can manage networks in each OS after navigating to these locations:

Android: Settings > Wi-Fi, tap the Customize button and choose Saved Network.
iOS: In Settings > Wi-Fi, you can only forget the currently connected network.

Windows: Click the Network icon, choose Manage Wi-Fi Settings, and then choose Manage Known Networks.

macOS: Open the Network system preference pane, click the Wi-Fi adapter in the list at left, click Advanced, and then click the Wi-Fi tab.

YOUR ADAPTER COULD JUST BE DEAD

Wi-Fi adapters can just die, no matter what kind of device they're embedded in. Before giving up, reinstalling the OS can be a final ditch way to see if it's a corrupted driver rather than broken hardware.

With a computer, you can purchase a cheap USB nub that plugs in and offers compatible service. With mobile phones and tablets, they may be unrepairable. As I was writing this article, a friend had just returned from the Apple Store with a phone that had its Wi-Fi access go flaky and then fail: the store said it couldn't be fixed, only replaced. ⏻

Excel functions: 6 ways to use Text functions to manage data

How to replace words; extract first and last words, matched or a specific word in a string of text. **BY JD SARTAIN**

Excel's Text functions are a major time-saver if your job entails managing massive data, especially data that's imported from other sources. Fortunately, all ASCII data is easily imported, but the format of that imported data can vary drastically from one source to another.

For example, fields may be delimited, such as with tabs, spaces, commas, or periods. Any other characters are all preferable to spaces. That's because spaces not only exist in between fields, they also separate words within the fields, which makes sorting out the fields a real challenge. That's where the following Text functions are helpful.

1. USE THE SUBSTITUTE FUNCTION TO REPLACE ONE STRING OF TEXT WITH ANOTHER

Function syntax: The syntax (or sentence structure) of the SUBSTITUTE function is this: =SUBSTITUTE(text, old text, new text, [Instance Num])

Note: If you don't specify an Instance Num, every occurrence of the Old Text is changed to the New Text. If you specify the Instance Num, only that occurrence of the Old Text is replaced. For example, entering the number '1' means you want to change only the first occurrence of that word in the string.

1. Enter some phrases in column A (from A2 through A13).
2. Enter the word or phrase you want changed in column B.
3. Enter the word or phrase you want to replace the old text with in column C.
4. Enter the following formula in cells D2 through D7 (or half the database): =SUBSTITUTE(A2, B2,C2,1)

This changes/replaces only the first occurrence of the Old Text to New Text.
5. Next, enter this formula in the remaining cells (in our case, D8 through D13): =SUBSTITUTE(A2, B2,C2). This changes/replaces all occurrences of the Old Text to New Text.

Note: This function is case-sensitive, so if

Use the SUBSTITUTE function to replace one string of text with another.

your results aren't working, change the text to all the same case.

2. EXTRACT THE LAST WORD IN A STRING OF TEXT USING TRIM, RIGHT, AND SUBSTITUTE

For this example, the object is to extract the last word—that is, the last name, from a string of text (the full names of a list of clients).
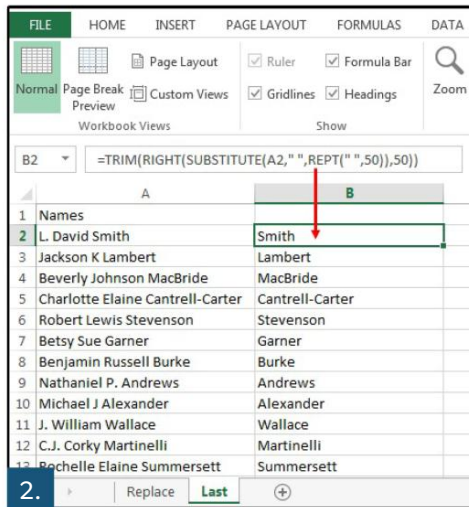
Use the SUBSTITUTE function to replace one string of text with another.

1. Enter some names in column A: first, last, and middle names or initials.

2. Enter this formula in B2: =TRIM(RIGHT(SUBSTITUTE(A2," "," ,REPT(" ",50)),50))

3. Copy the formula from B2, down to B3 through B1000 (or the end of your database). For this example, we're assuming your database has 1,000 records.

4. This formula works because the SUBSTITUTE function locates all the spaces in the string of text, and then replaces each single space with 50 spaces. The RIGHT function removes 50 characters (from right to left), and the TRIM function deletes all the excess leading spaces leaving just the single,

last word. If you have longer strings of text, try substituting 100 or more for the 50 values in the above formula.

3. EXTRACT THE FIRST WORD/NAME IN A STRING OF TEXT USING LEFT AND SEARCH

This formula works when you need to separate the first name from the middle and last name of a list of clients.

1. Enter some names in column A (or use the same names from the previous exercise).

2. Enter this formula in B2 through B1000: =LEFT(A2,SEARCH(" ",A2)-1) to extract the first name of each client into a separate column.
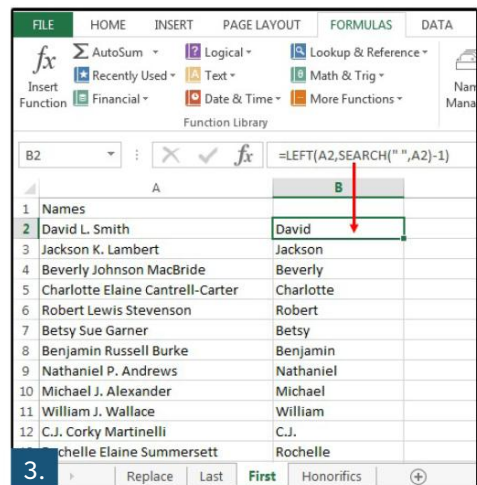
Extract the first word/name in a string of text.

4. EXTRACT EVERYTHING EXCEPT THE FIRST WORD IN A STRING OF TEXT USING TRIM, RIGHT, REPT, AND SUBSTITUTE

The purpose of this exercise is to remove the honorifics from a list of client names. These clients are providing confidential survey information, so the company does not want the titles and salutations of each individual to influence the surveyors.

1. Enter some more names in column A (or use the same names from the previous exercise). Enter some honorifics before each name; for example, Mr., Miss, Ms., Mrs., Dr.,

Sir, Lord, Lady, Capt., etc.

2. Enter this formula in B2 through B1000: =TRIM(RIGHT(SUBSTITUTE(TRIM(A2)," ",REPT(" ",60)),180)) to extract the full names of all the clients minus the honorifics.

3. And, if you wanted to extract the honorifics (for some reason), enter this formula in C2 through C1000: =LEFT(A2,SEARCH(" ",A2)-1).

5. EXTRACT NAMES FROM EMAIL ADDRESSES USING LEFT, FIND, AND SUBSTITUTE

The worst job of the day is to spend hours manually retyping client names or domain names from email addresses, especially when the list is over 5,000 names. Use the following formulas to complete this task in minutes.

1. Enter some email addresses in column A.
2. Enter this formula in B2 through B5000: =LEFT(A2,FIND("@",a2)-1) to extract the full names of all the clients.
3. Enter this formula in C2 through C5000 to remove the underscore between the first and last name:


Extract everything EXCEPT the first word in a string of text.

=SUBSTITUTE(B2," ","_").
4. Move to cell F2. Select Formulas > Text. Type C2 in the Text field box on the Functions Arguments dialog screen, or click cell C2, and then click OK. This formula converts the names to Proper Case (that is, first letter of the first and last name capitalized, all other letters in lowercase).
5. Copy the formula in F2 to F3 through F5000 and press Enter.
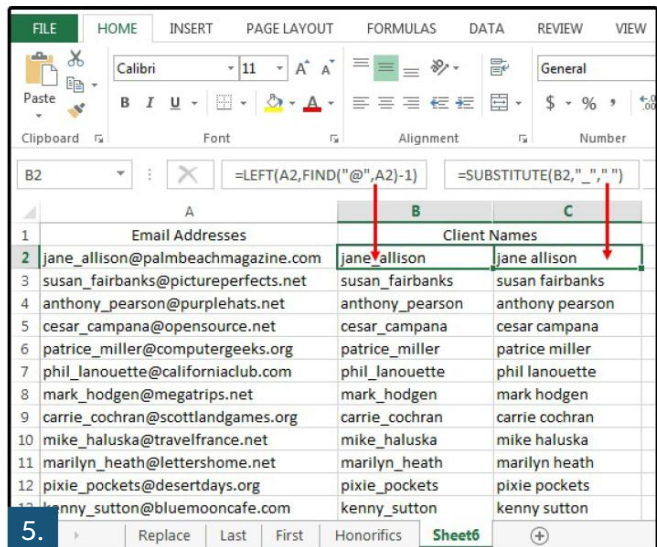
Extract names from email addresses.

6. EXTRACT DOMAINS FROM EMAIL ADDRESSES USING TRIM, LEFT, SUBSTITUTE, MID, FIND, LEN & REPT

1. Enter this formula in D2 through D5000 to extract the domain names from the email addresses:
=TRIM(LEFT(SUBSTITUTE (MID(A2,FIND("@",A2), LEN(A2))," ",REPT(" ",100)),100))
2. And last, enter this formula in E2 through E5000 to remove the @ signs from the extracted domain names: =SUBSTITUTE (D2,"@","") ⏻
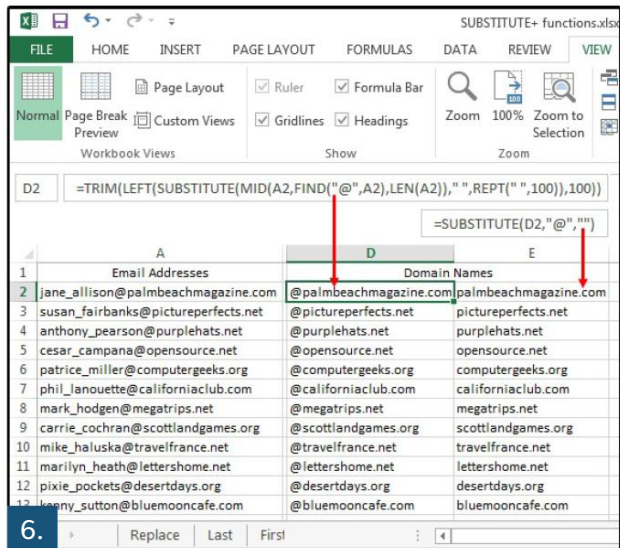
Extract domains from email addresses.

THE CLOSER WE GET, THE MORE WE SEE

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Tech Spotlight

Watch the video at go.pcworld.com/hm10

Huawei Mate 10 Pro Review

⟶ The Huawei Mate 10 Pro is the kind of flagship phone you'd expect from Samsung and Google, packed with premium features, and oozing power. While it will no doubt struggle to compete with the likes of the Galaxy Note 8 and Google Pixel 2 XL once it releases in the U.S. (mainly due to a lack of carrier support), Huawei has nonetheless proven that it's worthy of its No. 2 position on the smartphone charts.