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APRIL 2020

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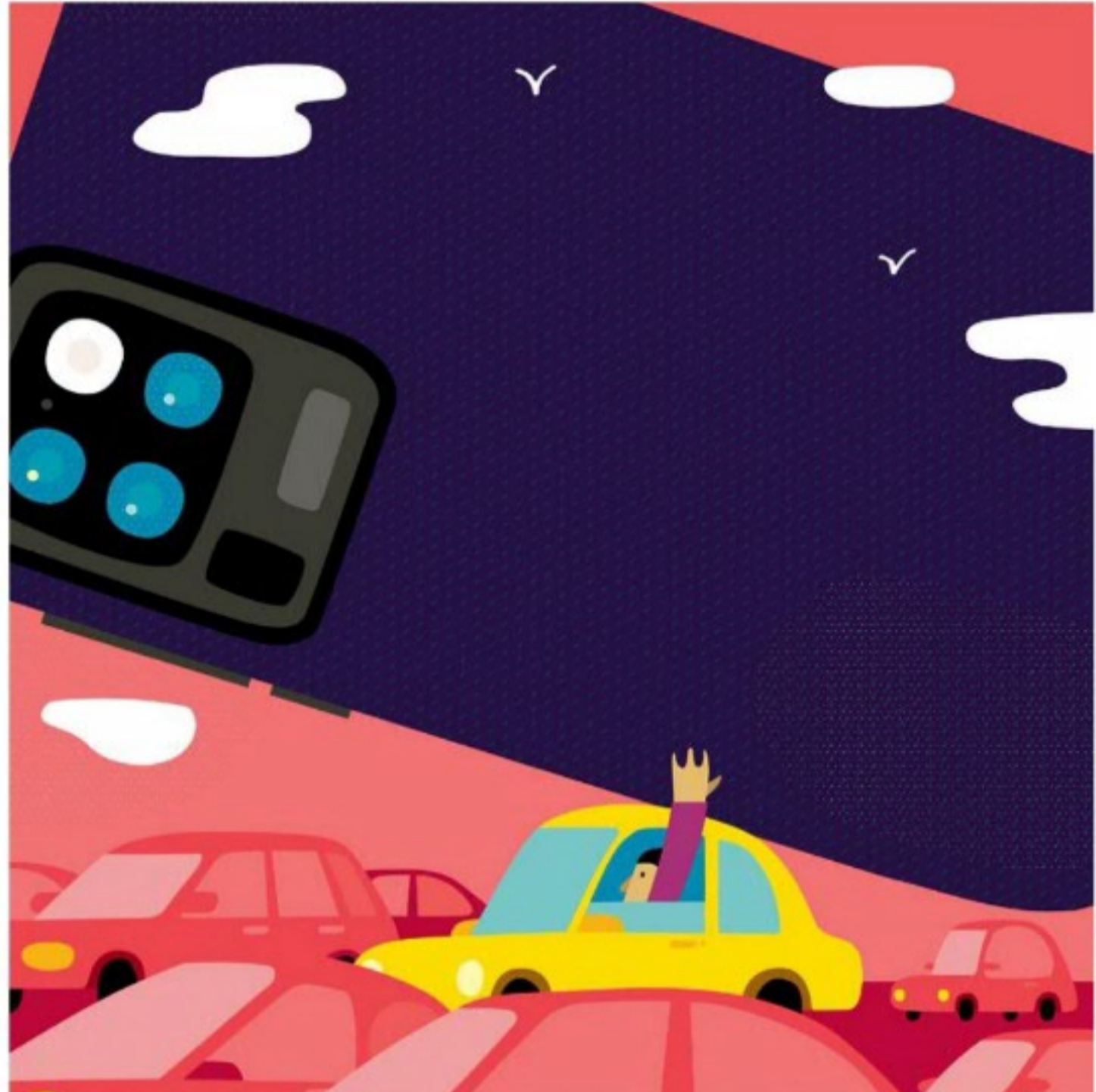


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LOGAN RYAN WITH LEO AND JULIUS: ADOPTED 2014 AND 2018.
They're a little bit of a lot of things, but they're all pure love.



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AMD talks PC GPU ray tracing as it looks to the future of Ryzen and Radeon

At long last, its next-generation RDNA 2 graphics architecture will include hardware ray tracing. **BY MARK HACHMAN**

AMD confirmed recently that its next-generation RDNA 2 graphics architecture will be its first to include hardware ray tracing, and that it will advance performance-per-watt improvements by an additional 50 percent over its current designs. The company also plans to add a compute-specific version of its GPUs, dubbed "CDNA."

AMD has traditionally used its financial analyst meetings to provide insight into its

future strategy in the CPU and GPU markets, especially with regard to the PC, mobile, and server spaces. It's the latter market in which AMD is driving hard, as enterprise and scientific markets are willing to pay top dollar for a high-margin Epyc processor—the sort of boon financial analysts like to hear about.

AMD habitually offers more insight into its server road maps as a way of building credibility with customers, chief marketing officer John Taylor said in advance of the call. In this case, however, the company is sharing

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AMD teased what it has coming down the pipe in terms of CPU and GPU revisions. Note that AMD's not saying what the "advanced node" means.

details on key technologies that will benefit the PC as well as other segments: a new "X3D" packaging technology that will complement its existing "chiplet" designs; a "CDNA" compute-intensive version of its GPUs; and RDNA 2 and 3, the evolution of the "Navi" GPU architecture that should include hardware ray tracing.

Lisa Su, AMD's chief executive officer, began by noting that, first and foremost, AMD is playing to its strengths: high performance in graphics, CPU, and solutions that include the two. "This is the fundamental DNA of our company," she said.

RYZEN INVESTMENTS ARE PAYING OFF

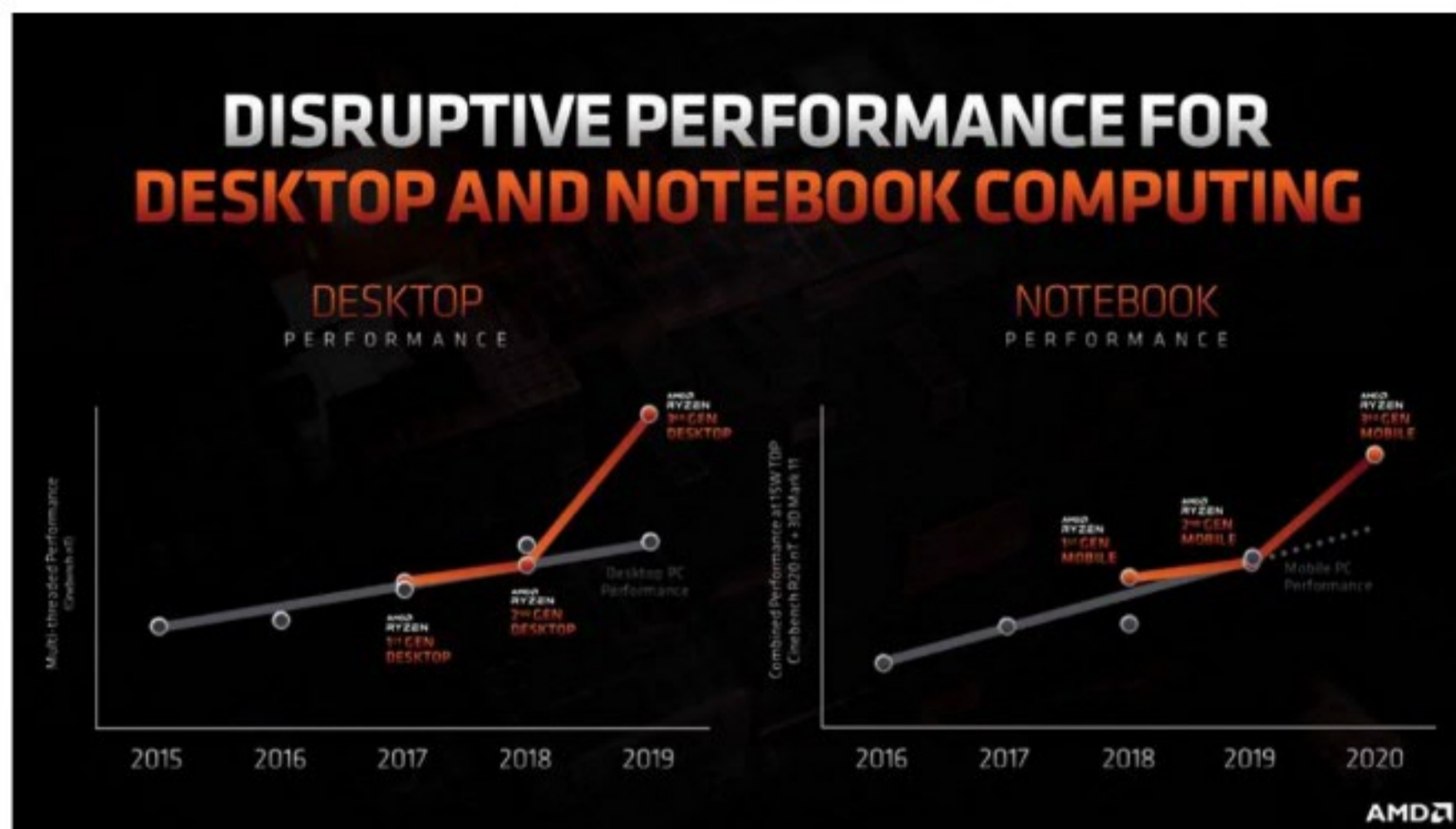
Over the next five years, AMD will continue to build upon its Zen road map, its RDNA architecture, and 7nm and future process

technologies. AMD changed the game with Ryzen, and it's paid off, Su said: Fully half of premium desktop PCs use Ryzen, and it's consistently gained share over the last few quarters. AMD also continues to invest in graphics, exclusively supplying the Apple Macintosh, and

shipping over 150 million units in the game console business since 2013. But, Su added, AMD is still "underrepresented" in the PC market.

Now, AMD is looking for new ways to leverage the technology it already has in house. "We actually see more opportunities to combine our CPU and GPU solutions," Su added. AMD has used techniques such as "chiplets" to improve the flexibility of its processor and graphics design. AMD will have to build on those with new packaging and interconnect techniques to keep pushing performance forward, Su said.

Su was so confident that the company can make it happen that AMD now predicts that it can deliver 20-percent compound annual growth in revenue over the next four years—aggressive numbers for a company that was struggling just a decade ago.



AMD's performance took off with its Zen architecture.

WHAT'S NEXT? ZEN 4 AND 5NM PROCESSORS

According to Mark Papermaster, AMD's chief technical officer and executive vice president of technology and engineering, in each of the product segments AMD serves, there's a common thread: incredible amounts of compute power.

Papermaster noted that AMD has now switched to a "chiplet" architecture, where various products are developed as modular parts that can be fitted together. A modular approach didn't just change the design of AMD's products, it changed the company culture—it forced various

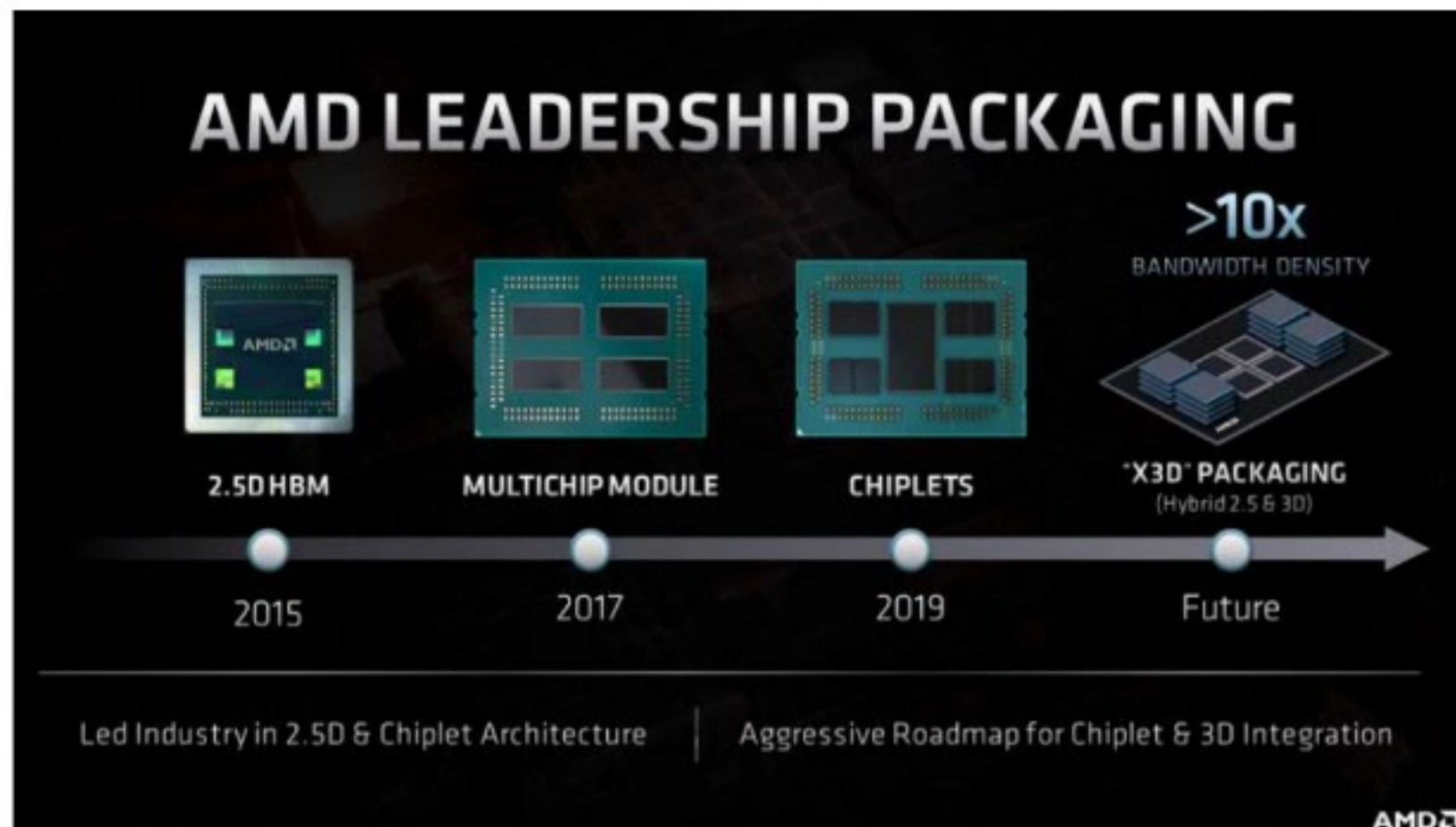
teams at AMD to work together, Papermaster said. Likewise, it made validation simpler, allowing AMD engineers to determine whether chips were viable in hours, not days. "This is the new normal at AMD," he said.

As an example, Papermaster said that AMD developed a single NUMA domain within its Epyc chips, organizing 7nm CPU cores and connecting them with a 12nm Infinity Fabric I/O.

Papermaster said that AMD is planning to bring "Zen 4" and 5nm processors into the market by 2022, without specifying which



AMD's Zen architecture road map now extends through 2022. Remember, this includes both Epyc products in the datacenter as well as the PC.



AMD's X3D is an extension of its chiplet approach, combining stacking and a modular approach.

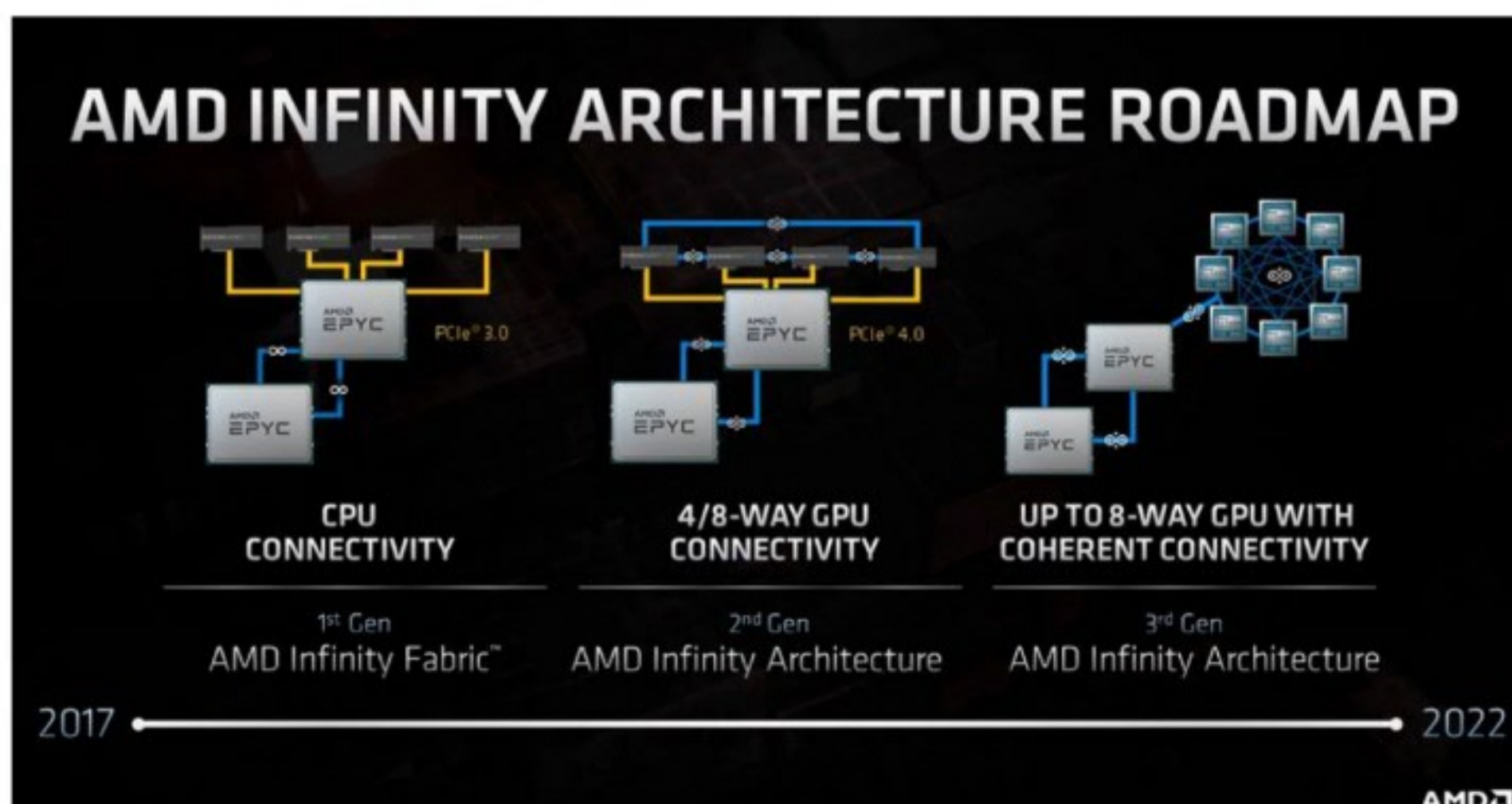
markets would be addressed first. (Taylor indicated that AMD's rollout strategy isn't expected to change: server first, then desktop, then mobile, with all rolled out by the end of 2022.) Papermaster also said that he expects AMD's chief competitor, Intel, will solve its manufacturing problems and accelerate its

manufacturing technology.

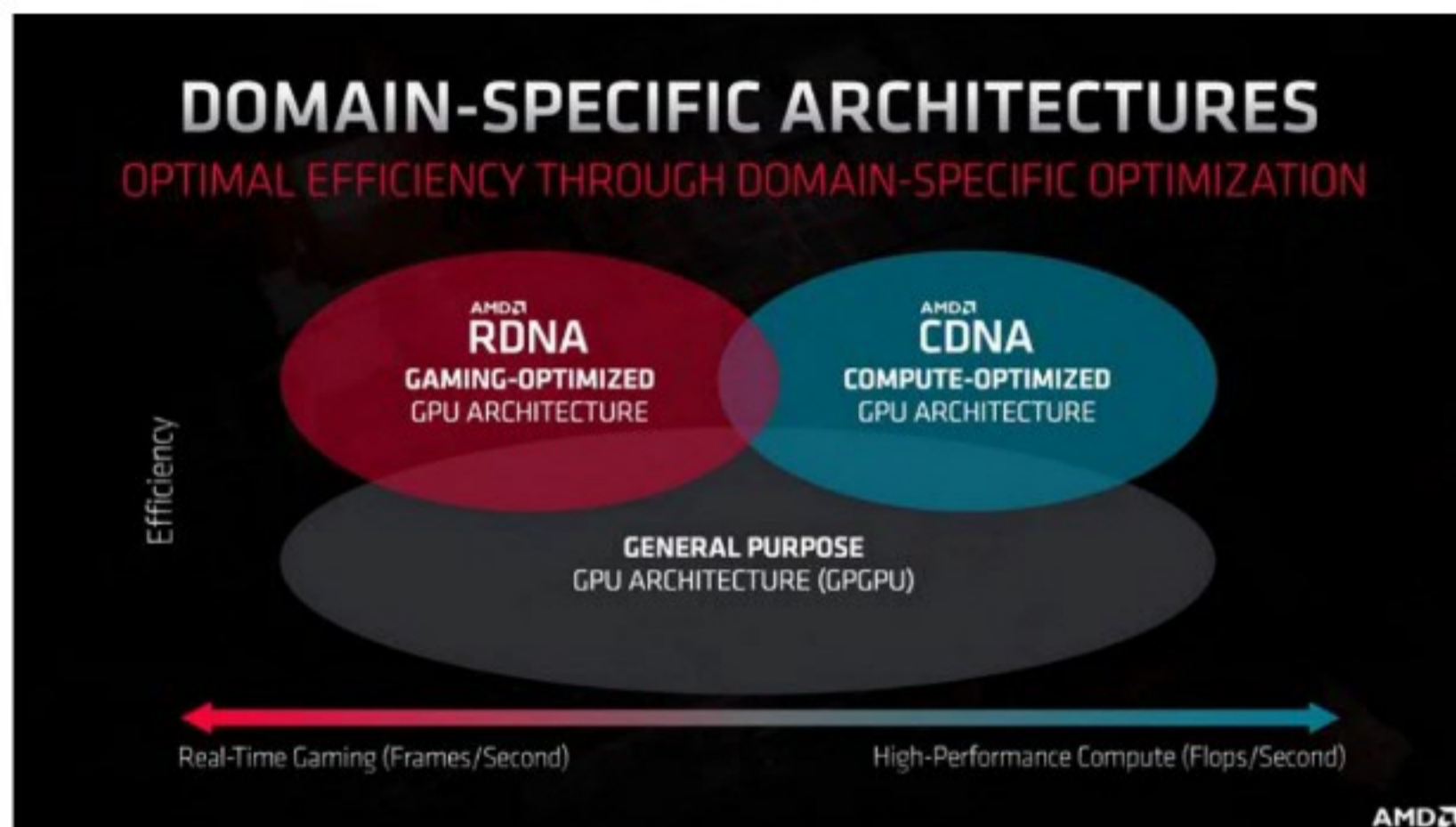
"Once you have that level playing field, it is about how you put these solutions together," Papermaster said.

The X3D packaging technique will be used to combine chiplets and 3D stacking, all connected with its Infinity Fabric

architecture. That Infinity Architecture will also improve, with 3rd-gen products rolling out by 2022 with up to 8-way GPU and coherent connectivity. "What does this mean with these types of improvements? Look at machine learning...they demand this type of connectivity," Papermaster said.



AMD' Infinity Architecture will likely be largely confined to servers, but not altogether.



AMD will be offering different versions of its GPUs for different markets, though it's not exactly clear how profoundly they'll differ from one another.

BIG CHANGES IN AMD'S GPU DESIGNS

Perhaps the most significant news of AMD's financial meeting was the fact that AMD would be moving from a single GPU architecture to multiple, domain-specific architectures.

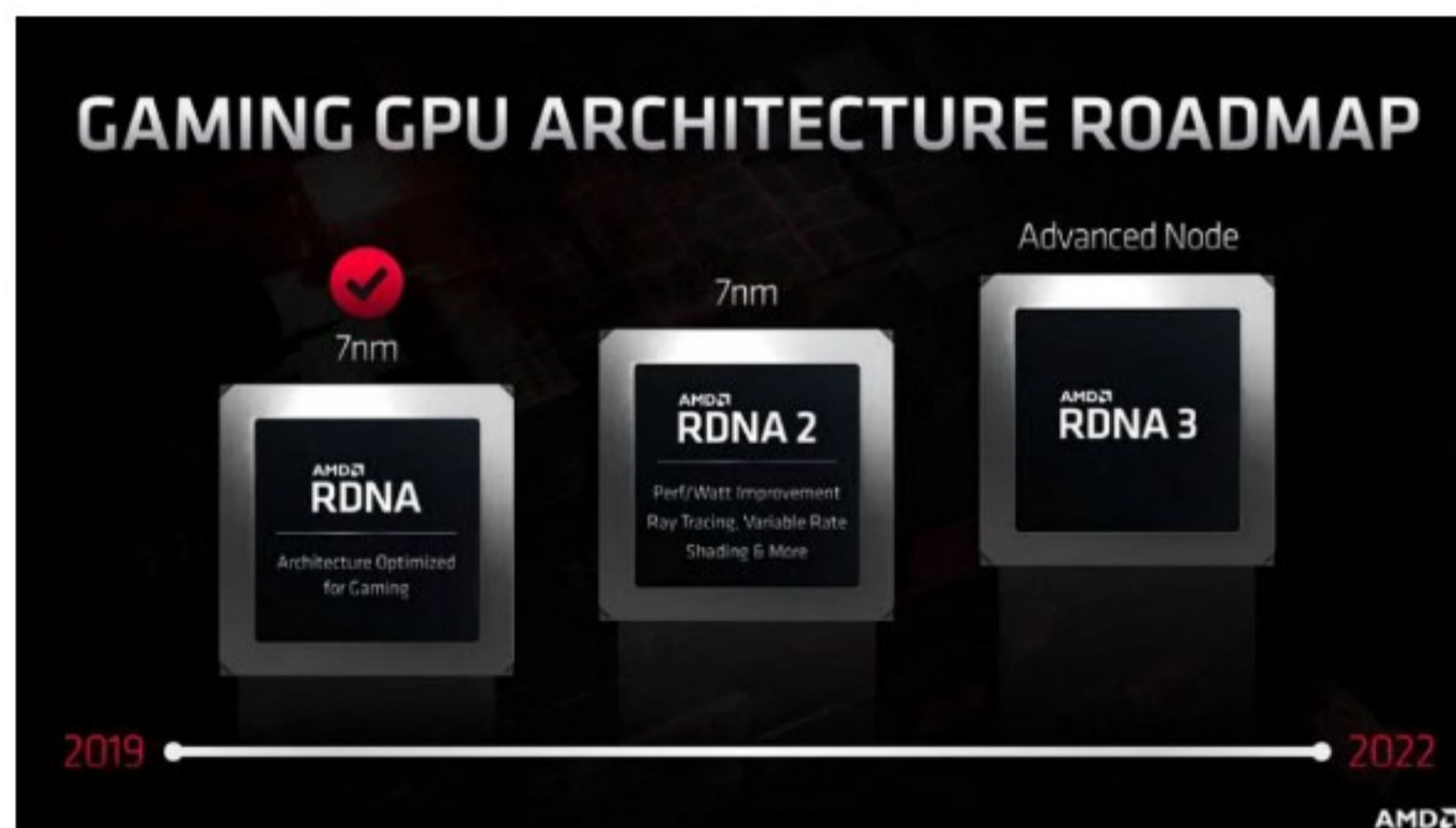
Related and also significant will be the long-awaited release of hardware ray tracing within the upcoming RDNA 2 GPU architecture.

AMD is developing specific versions of the architectures for different markets, such as the data center, because it has become increasingly difficult to develop a general GPU architecture as Moore's Law slows

down, said David Wang, senior vice president of the Radeon Technologies Group at AMD.

AMD's PC GPU architecture is known as RDNA, and it's been the foundation of recent Radeon cards. Before the end of the year, however, AMD will ship RDNA 2 cards, which—

hurray!—will include hardware ray tracing, optimized both for the game consoles based upon the RDNA 2 architecture as well as PCs. AMD sometimes refers to RDNA 2 as Navi 2X, with Navi 3X to follow. (The rumored "Big Navi" [go.pcworld.com/bnvi] codename wasn't used.) AMD already delivered a 50



AMD is now beginning to chart its PC GPU architecture, known as RDNA, out several years. And there's ray tracing!

percent performance-per-watt improvement with its first-generation “Navi” GPU—now it’s aiming to do it again with the upcoming Navi 2X. That’s crazy!

As for the data center, AMD’s plan is to design a compute-specific version of RDNA, also known as compute DNA, or CDNA. CDNA will be scalable for multi-GPU for exascale computing and machine learning. AMD also confirmed CDNA 2, with the 3rd-generation AMD Infinity Fabric Architecture.

“This is a good move as datacenter GPUs don’t need many of the features a consumer graphics card needs,” said Patrick Moorhead, principal analyst at Moor Research, in an email. “[CDNA] includes elements like display and pixel rendering engines, and ray tracing. This means AMD can save cost by removing those elements and add more gates that help datacenter performance like tensor OPS. AMD hadn’t done it until today because it couldn’t afford to have

two architectures. I believe AMD can field a high performance datacenter GPU, but it will need to invest at least as much in software to complete the solution.”

WHAT IT ALL MEANS FOR THE PC

AMD created an “execution machine” in processors, did the same with GPUs, and combined the two into an APU. Now, there’s a \$32 billion PC market waiting for what’s next, said Rick Bergman, executive vice president of Computing and Graphics for AMD. Before the end of the year, we’ll know: the fourth-generation Ryzen processor.

Having secured desktop PC share of about 17 percent, AMD also has its eye trained on the mobile space, with its mobile Ryzen chips aimed squarely at the notebook space and especially commercial PCs. A key technology is Modern Standby, with five times the number of

laptops now supporting the technology versus the prior generation, Bergman said. AMD is also claiming that versions of the 3rd-gen mobile Ryzen will deliver up to 18 hours of battery life. (That number typically varies quite a bit in the real world.)

HARDWARE-ACCELERATED RAY TRACING
ECOSYSTEM ENABLEMENT FOR PCs AND CONSOLES

AMD
RDNA 2

Common Architecture for
PCs and Consoles

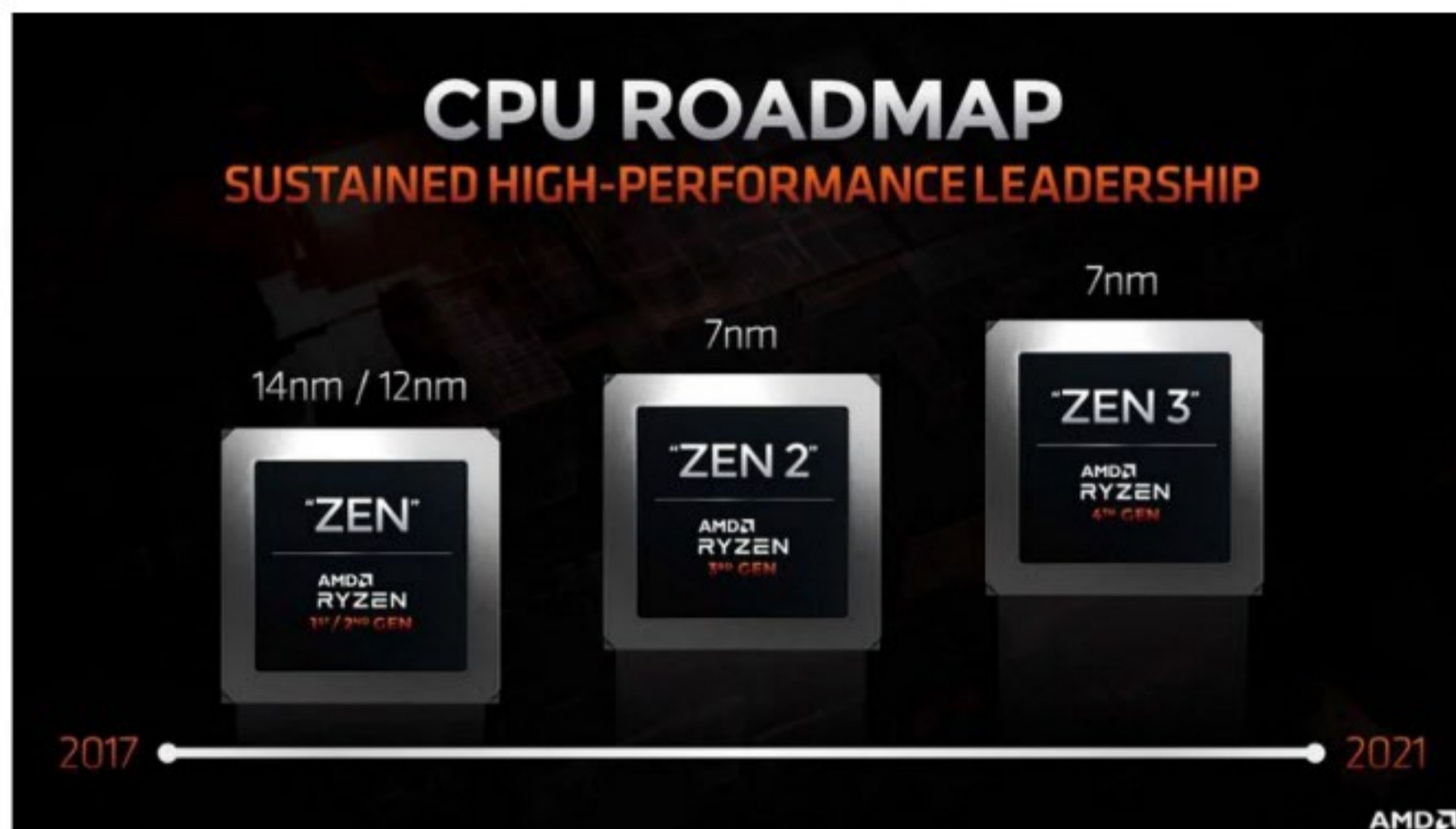
Simplify Development
and Speed Adoption

Maximize Performance
with Lower-Level API

Microsoft DXR 1.1 on AMD RDNA 2 Silicon

AMD

Here’s what AMD is saying about hardware ray tracing.



AMD's Zen architecture road map, through 2022. Zen forms the foundation of the Ryzen processors. Note that we'll be seeing Zen 3 chips by the end of the year.

"We want our customers to love that experience, from the time they open up the box to the lifetime of that experience," Bergman said.

Bergman said that AMD has already secured more than 70 designs in the commercial PC space, and that's before Ryzen Mobile or the related Ryzen Mobile Pro debuted. "We're expecting a lot more," he said.

In a surprise, Bergman showed off a slide indicating that 4th-gen Ryzen chips would begin to ship before the end of 2020, just a few months after the expected ship date of 3rd-gen mobile Ryzen parts. (PCWorld asked for more specifics

about which 4th-generation products would ship first, but AMD did not comment further.) That's not all: AMD will ship the next-gen RDNA 2 cards before the end of the year, "with uncompromised 4K performance," Bergman said.

These will be the first cards with hardware based ray tracing and variable-rate shading, he added.

Granted, AMD is revealing scant detail about its Zen 2/RDNA 2 cards, its next-gen fourth-gen Ryzen processor, or anything else. But we know they're coming, and AMD will fill in the blanks as we get closer. 🔌



AMD's winning designs in GPU add-in cards, too.



LG V60 ThinQ 5G with Dual Screen: An awfully long name for a phone short on innovation

For better or worse, LG has a formula, and it's sticking to it. **BY MICHAEL SIMON**

You don't actually need to see the LG V60 ThinQ 5G with Dual Screen to know what it is. Based on our experiences during a recent briefing and hands-on opportunity in New York, the V60 clearly looks like LG's V50, V40, G8, and G7. It has a few gimmicks and some unnecessary carrier compromises. And it has a headphone jack.

In short, it's an LG phone. It's not entirely clear whether it will be the only flagship of 2020 from LG, but if there is a G9 in the works, my guess is that the only difference will be screen size. For better or worse, LG has a

formula, and it's sticking to it. I'm not really sure what, if anything, the ThinQ surname even means at this point, but you won't find the G8's 3D face unlock or touch commands, nor the V50's tailored intelligence services in this iteration.

That said, the LG V60 ThinQ 5G is a perfectly fine 2020 phone. With a 6.8-inch screen and more bezel than the Galaxy S20 Ultra has, it's a bit too big for my tastes, but LG is merely following the big-screen trend line. The Dual Screen case that we first saw on the G8X (go.pcworld.com/lq8x) has some useful features, but it still feels like a very cheap

imitation of the Galaxy Fold.

But if you're looking for an Android phone with premium specs, the V60 checks off most of the boxes. We don't know yet how much all of those components will cost—one of LG's irksome carrier capitulations—but it's certainly ready to go head to head with the S20 on paper:

Dimensions: 169.3 x 77.6 x 8.79mm

Display: 6.8-inch Full HD OLED

Processor: Snapdragon 865

RAM: 8GB

Storage: 256GB

Rear camera: Dual 64MP, f/1.8, OIS + 13MP Ultra Wide (117 deg), f/1.9

Front camera: 10MP, f/1.9

Battery: 5,000mAh

OS: Android 10

Colors: Classy Blue, Classy White

Those are all perfectly fine specs, though the 1080p 60Hz display will certainly show its inferiority alongside the S20 and upcoming OnePlus 8. LG has lagged somewhat with its smartphone displays, having only recently made the switch to OLED—so the V60 feels a bit behind the times, even with a screen size nearly as big as the 6.9-incher on the Galaxy S20 Ultra.

The same can be said of the design. While the corners are a bit more rounded, the V60 follows the same basic language LG introduced with the G7 (go.pcworld.com/g7tq), and it very much looks like it's stuck in 2018. The camera cutout at the top of the



The Dual Screen's second display perfectly mirrors the one on the V60 itself, notch and all.

display is significantly smaller than the G8X's, but the V60's sizable top bezel doesn't do it any favors. The chin is just as large, and the side bezels, while not as big as the top and bottom, are still distractingly thick.

Speaking of thick, the phone is pretty chunky at nearly 8.8mm, though its slight teardrop shape does well to hide it. At 218 grams, it's a bit lighter than the S20 Ultra (222g), though it's less top-heavy due to the horizontal camera array. When you add the Dual Screen case, however, it tips the scales at nearly 350 grams.

Around the back, LG has ditched the V50's telephoto camera (go.pcworld.com/lv50) and brought back the bump, two decisions I'm not all that happy about. The lack of a telephoto lens is particularly



The V60 is the biggest V phone so far.

head-scratching for a phone in 2020, but I'm more perplexed by the bump. The V50's most unique design element was its flush, smooth camera array that was completely encased under the glass, so the bump on the V60 feels like a step backward.

I don't quite understand the decision—it's not like the phone isn't thick enough—but such as it is, the V60 has very little to set it apart from other phones in its class. LG says the V60 has "a sleeker quality to it" with "a little more elegance," but the return to the camera bump says otherwise.

The lack of a telephoto lens aside, the V60 will record in 8K, and LG has beefed up its night

mode using AI as well. We didn't get a chance to test it in the well-lit briefing room, but low-light photography is an area where LG has lagged Apple and Google, so we're anxious to try the V60 at night.

THE SECOND SCREEN TELLS THE STORY

The V60's claim to fame, as with the G8X, is its dual-screen accessory. LG still hasn't committed to going all-in on the case, so it may or may not come with your purchase, a choice that will "depend on the carrier." In fact, LG won't be offering an unlocked version of the V60, so whatever bundles are offered will be entirely at the carriers' discretion.

But my guess is the Dual Screen will come with all V60 purchases because it's so central to the experience. When attached, the Dual Screen supplies a second 6.8-inch Full HD display that mirrors the V60's, notch and all. Based on my experience with it on the G8X, it's not nearly as well-conceived as the Galaxy Fold or even what we've seen of the Microsoft Surface Duo. It's still easily the V60's most



The V60 has fewer cameras and a bigger bump than the V50.

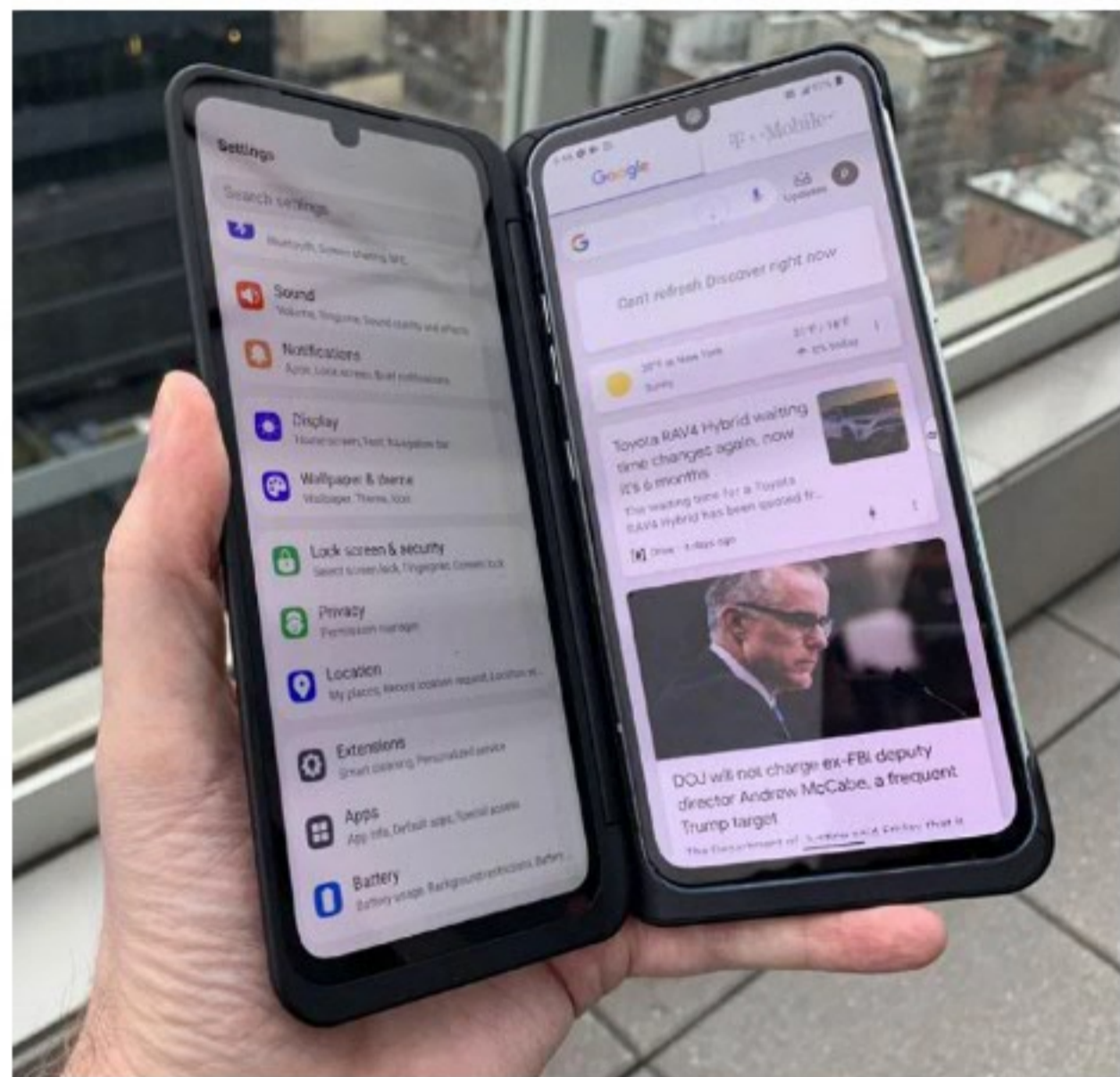
compelling feature, especially since LG has added the ability to use one screen as a full keyboard like a mini-laptop.

With 5G and a second screen to power, the V60 is going to need a lot of battery life, and it certainly has the capacity at 5,000mAh. That's a thousand more milliamp-hours than the G8X, resulting in an additional eight hours of use, per LG. In my G8X testing, I got around 9 hours, which is acceptable, but 17 hours would be mind-blowing. LG also claims that a 30-minute charge will deliver 18 hours of use, but we'll need to test these claims, especially with 5G on board.

Speaking of 5G, LG is using the newest Snapdragon X55 modem, but the experience will differ across carriers. On Verizon models of the V60, you'll get mmWave and sub-6GHz support. AT&T, Sprint, and T-Mobile subscribers will only be able to tap into sub-6GHz networks.

When all is said and done, the main reason why most people will choose the V60 over the S20 or the iPhone 11 is the headphone jack. LG is one of the only premium Android phone makers that hasn't gone all-Bluetooth. The 32-bit Quad DAC will be a breath of fresh air for anyone clinging to their wired headphones.

For audio purists, LG has also added four "brand-new, high-performance microphones," along with a feature called



The Dual Screen can show two apps side by side, but interaction between them is limited.

Voice Bokeh "that minimizes background noise and boosts the user's voice, allowing content creators to place more focus on the subject while reducing excess noise."

What we don't know about the V60 is how much it will cost. LG did say that the V60 will come in "under the cheapest Galaxy S20 with the Dual Screen included," so assuming that means \$950 or so, that's a good deal cheaper than the \$1,400 Galaxy S20 Ultra and one of the cheapest 5G phones you can buy. That's even cheaper than the V50, which started at \$1,150 without the Dual Screen accessory, so LG is definitely pushing value with the V60. Whether it's worth it, however, might be a tough sell. 🔌

TCL bursts onto the Android scene with folding and rollable screens you'll flip over

But don't expect to buy one anytime soon. **BY MICHAEL SIMON**



TCL isn't exactly a household name when it comes to smartphones, but the BlackBerry (go.pcworld.com/bky2) and Palm (go.pcworld.com/palm) phone maker is looking to change that in 2020. Ahead of the launch of its own phones later this year, TCL is piquing our curiosity with a couple of wild concept phones that make the Samsung Galaxy Z Flip

(go.pcworld.com/szfl) and Motorola razr (go.pcworld.com/mraz) look like old news.

To be clear, these are concepts in every sense of the word. They have no names, no specs, and no chance of being sold anytime soon. The models we saw were basically movie props with few working parts, but they're certainly intriguing. And if they're an indication of what TCL has in store for future

phones, it won't be an unknown name for very long.

While we're somewhat accustomed to folding screens at this point, TCL doesn't think simply folding in half is enough. To be fair, the company does have a single-folding phone in development that folds completely flat with "zero gap," but TCL is staking its reputation on two moonshots: a tri-fold display that opens like an accordion and a rollable display that slides out like sideways window blinds.

If it can actually be mass-produced at a reasonable price, the rollable display could be a game-changer. The idea is that most of the time, the phone looks like any of today's smartphones, but behind its 6.7-inch display is another inch-plus of display stored around the backs and rolls out to expand to 7.8 inches. The mechanism is powered by "a very simple pushrod motor that works with gesture controls," and even seeing it in action without a working motor or screen, it was kind of magical.

It's very much a now-you-see-it-now-you-don't kind of thing and it presents a unique new direction for foldables that solved the biggest issue: the hinge crease. Of course, it raises numerous interface and multitasking questions that TCL isn't prepared to demonstrate just yet, but it contends that extending display is easier "from a UI/UX



TCL's folding phone concept lies flatter than the Galaxy Fold.

perspective" than folding the display.

"Because you're not taking the screen and then holding it this way or holding it this way, but you're just extending," TCL said, "so it's keeping a standard aspect ratio, kind of like when you do a screen share from your computer."

THREE FOR THE SHOW

If TCL's rollable phone is "standard," however, its tri-fold tablet is anything but. TCL has combined two different hinges to create a display that unfolds like a pamphlet, with three panels becoming one. The demo unit we saw technically worked, but like the rollable phone, it was far from a finished product. TCL's vision is to once again turn a normal-sized 6.5-inch phone into a 10-inch tablet. To accomplish the dual-fold, TCL uses two different hinge technologies, Dragon Hinge and Butterfly Hinge, to "ensure smooth folding inside and out with a minimal gap."



TCL's rollable display is a tablet when you need it and a phone when you don't.

When closed, the tri-fold phone is quite thick and the whole package was very heavy and clunky. The screens looked and felt like plastic, and the mechanism was creaky. In all honesty, it felt a lot like Royale's early Flexpai prototype (go.pcworld.com/flxp). But TCL wasn't showing off a polished phone. It's all about the potential of what a smartphone display can be. When TCL launches its first phones later this year, they'll look much more like traditional handsets, but down the line, TCL is hoping to become an innovator in the

smartphone space with its outside-the-box displays.

And it might be able to do it. For years, TCL has made some of the best budget TV sets in the business, including a partnership with Roku, as well as the BlackBerry Key2 and tiny Palm phones. But with these displays, it's looking to combine innovation with aggressive pricing to give Android fans another option in an ever-shrinking field.

Of course, interesting ideas don't necessarily translate into building a good smartphone, and the prototypes we saw gave little indication of how—or if—they'll

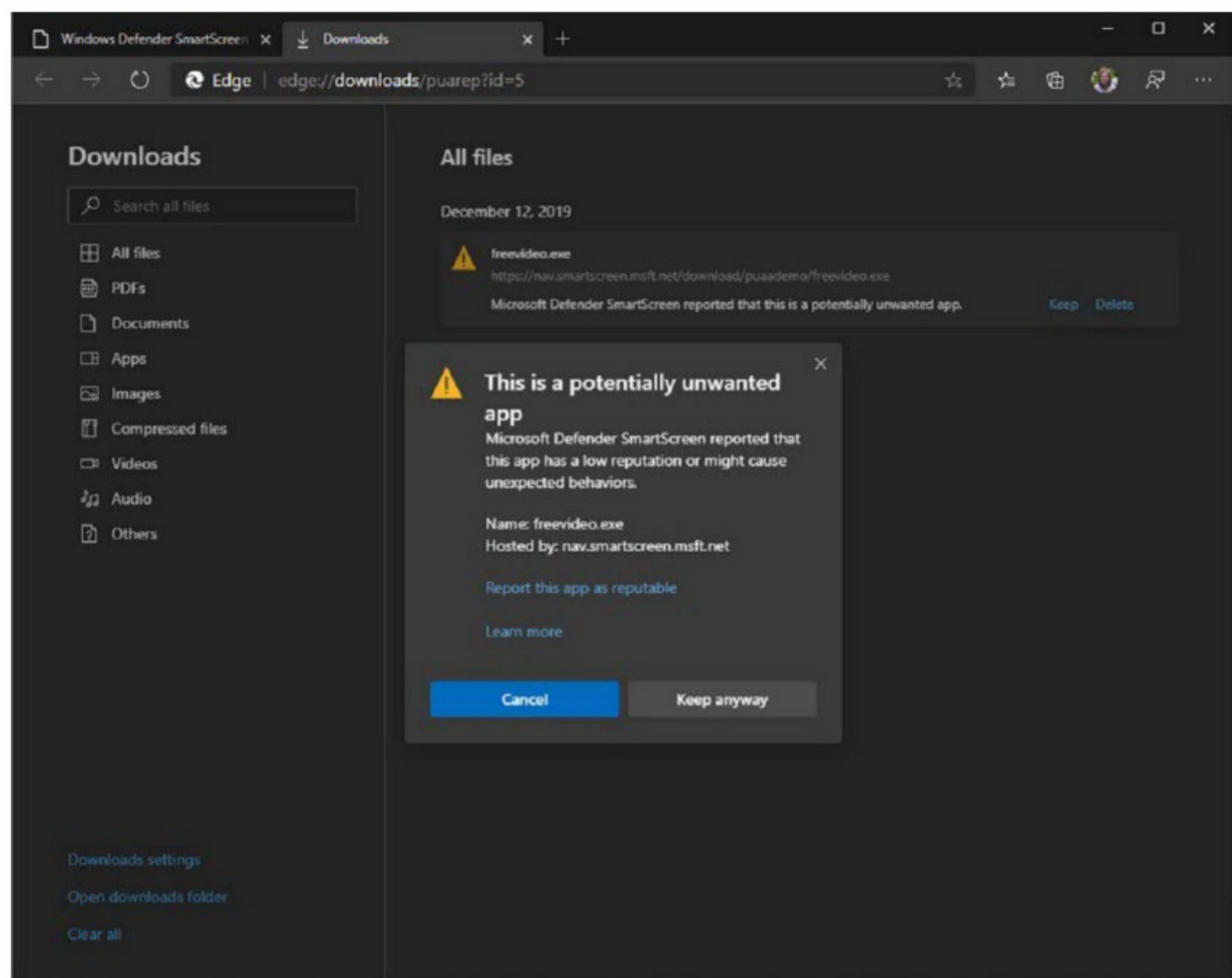
work, so we'll have to wait and see how TCL's first devices stack up to their peers. But if TCL's concepts are any indication, we're in for a wild ride. 🔌



When unrolled, TCL's prototype phone opens to a 7.8-inch tablet.

Microsoft begins blocking 'unwanted applications' like adware, using Edge

The new anti-PUA feature must be manually toggled on, however. **BY MARK HACHMAN**



Beginning with the current version of Microsoft Edge, Microsoft will start blocking adware, Bitcoin miners, and other unwanted apps that sometimes accompany apps that users

download from the web.

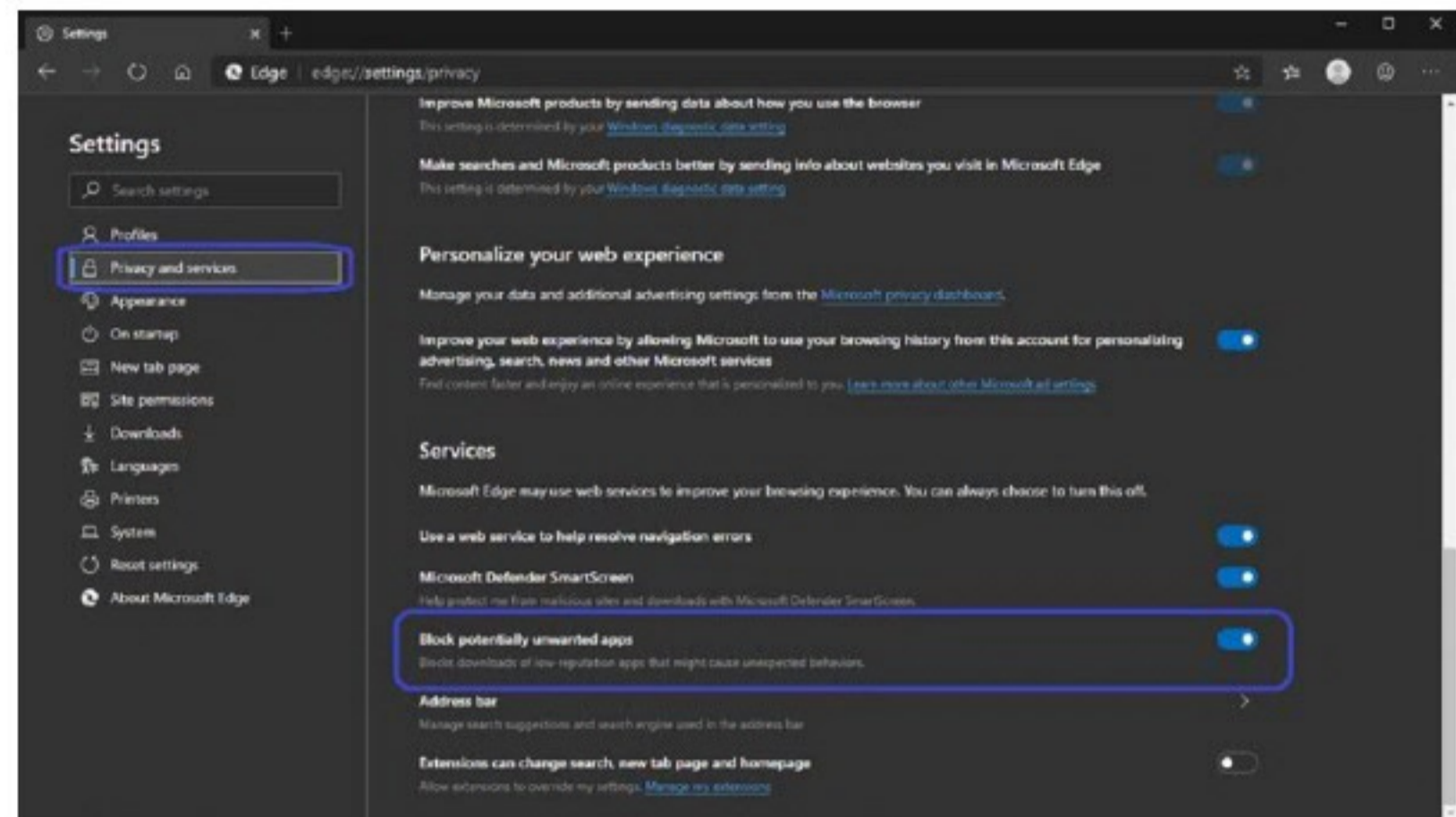
Microsoft Edge version 80 contains a new Settings menu with the option to Block Potentially Unwanted Apps, which works in conjunction with Windows' Microsoft

Defender SmartScreen to detect and warn against what Microsoft calls PUAs, or Potentially Unwanted Apps. (Microsoft has listed what it considers to be common PUAs here—go.pcworld.com/puas.)

If turned on, Edge will block these apps by default, though you'll have the option to override Microsoft's decision and allow the app to download and install.


The new option takes Windows' own built-in protection in a different direction. To date, Microsoft's efforts have been focused primarily on malware. The company's answer to that has been the Microsoft Store, which has a list of curated apps that Microsoft has already approved. But far more applications can be downloaded from third-party app stores or from the web itself, where users must depend on the trustworthiness of the app's author.

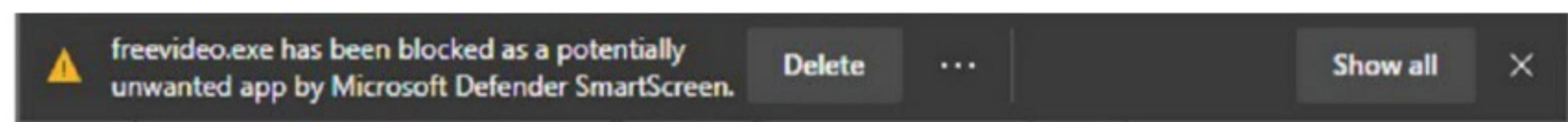
Microsoft makes clear, moreover, that PUAs are not malware, per se. Adware or cryptominers don't necessarily harm your PC; they simply slow it down. Some anti-malware



Microsoft's new PUA protections live in the Settings menu.

applications already identify applications like cryptominers and block them. Microsoft's code now attempts to sniff out piggybacked applications that come bundled with apps that are otherwise harmless.

Edge's protections against PUAs are off by default, though they can be turned on by going to Edge's Settings menu, then to Privacy and Services > Services > Block potentially unwanted apps. If a PUA is detected, you'll see a notification, like the images shown in this article. You'll then have the option to reject the app entirely, or let Microsoft know that it's okay to download. Microsoft will take this feedback and incorporate it, Microsoft said in a blog post (go.pcworld.com/uwnt). 

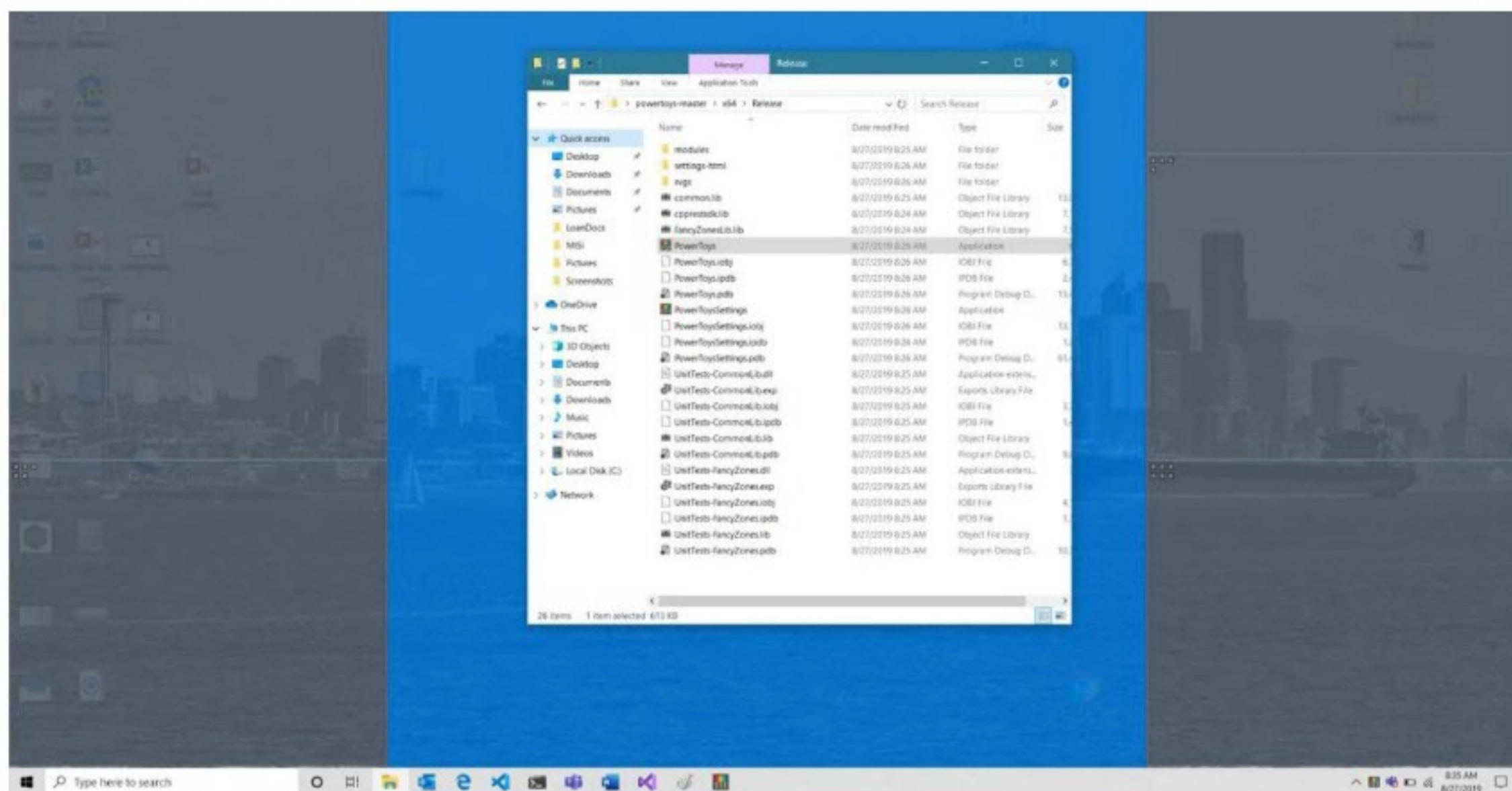


If Edge detects a PUA, it will pop up this notification. You can click the ellipsis menu to whitelist it.

Windows 10's first PowerToys app allows custom Snap resizing and looks amazing

Download the installer to get started with the revamped PowerTools for Windows 10.

BY MARK HACHMAN



If you're a fan of Windows 10's Snap feature, you've been waiting and hoping for Windows to allow you to design your own custom Snap layouts. Now you can! One of the first Windows 10 PowerToys apps, FancyZones, does just that—and it looks incredible.

If you don't know what Snap does, head to a PC and open any window there—this story will do. Then press the Windows key and one of the directional arrows. If you hit

Windows + the left arrow, for example, Snap snaps a window as a column attached to the left side of the screen. If you drag it toward any corner, the window will snap to that corner, allowing you to create a 4-window tiled effect.

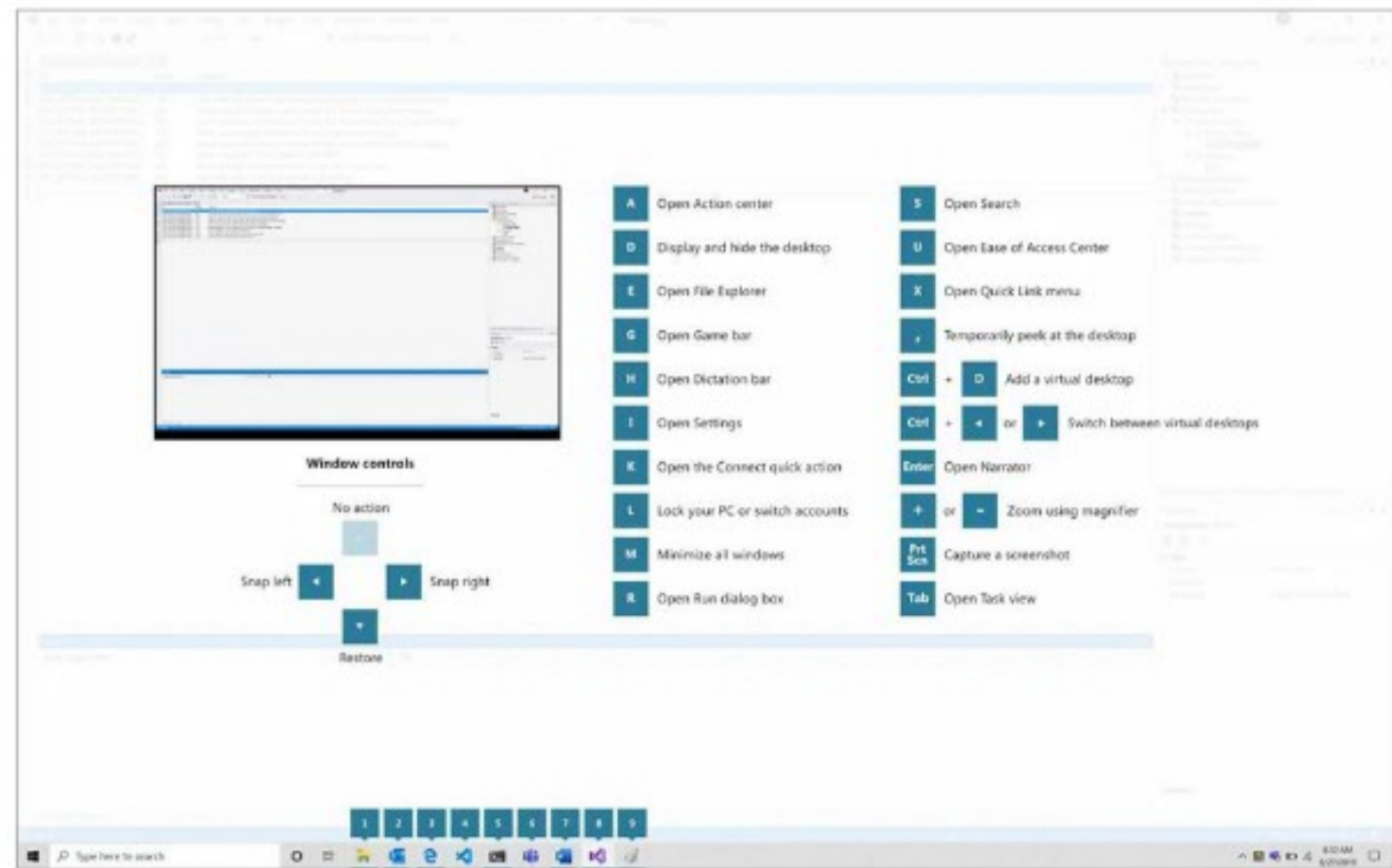
But if those windows are a little smaller than what you want? Or if instead of two columned windows, you want three? Until now, you'd have had to create your own, dragging and resizing windows manually.

Now you don't have to.

Microsoft's PowerToys were a beloved staple of the Windows 95 era, allowing users to add vetted extensions to the basic operating system. Others, like SyncToy's tool for syncing folders (go.pcworld.com/stot), emerged as PowerToys for Windows XP and Vista. Now, PowerToys is

back, and each app even has the code available on GitHub for suggested modifications. There are two initial PowerToys apps: a Shortcut Guide, and the FancyZones app. You'll need to download the PowerToys installer (go.pcworld.com/ptin), then select which apps you'll want to install. You don't even need to be on a Windows 10 Insider build to get it—this is open to anyone.

The Shortcut Guide is basically a cheat sheet to what's going on in your Windows screen. With the Shortcut guide enabled, depressing the Windows key for more than a second will turn on the available Windows shortcuts for what you're currently seeing on your screen. The implication is that Shortcut Guide is somewhat context-aware, and will display what action those shortcuts will take given the current state of the desktop and



Windows PowerToys' Shortcut Guide.

active window. If, after you've triggered an action, you still hold down the Windows key, those shortcuts will adjust to reflect what you're seeing.

FANCYZONES INCLUDES SNAP TEMPLATES, OR YOU CAN CREATE YOUR OWN

When you Snap a window to the side or corner of the screen, what you're doing is telling the window to shrink (or expand) to a predefined region of the screen. What FancyZones does is allow you to select from a list of templates of predefined zones, or you can create your own.


In effect, it allows you to create your own version of Windows Snap, so that you can snap apps to cascading windows, or to regions on the screen.

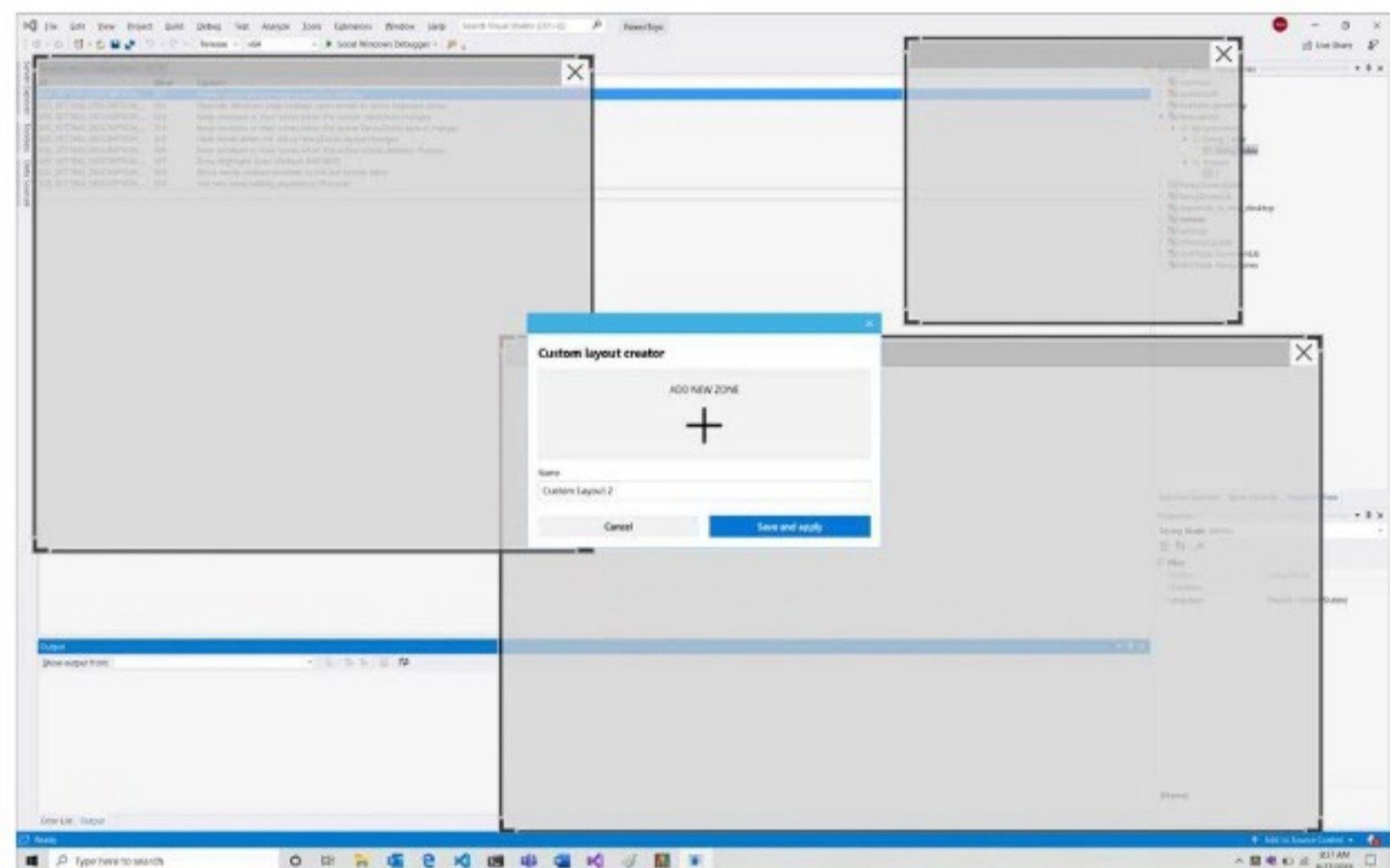
What's great about the predefined

templates is that it creates useful layouts right away: three columns of text that might be well suited for a widescreen monitor, for example—or, alternatively, a “priority grid” that widens the middle column.

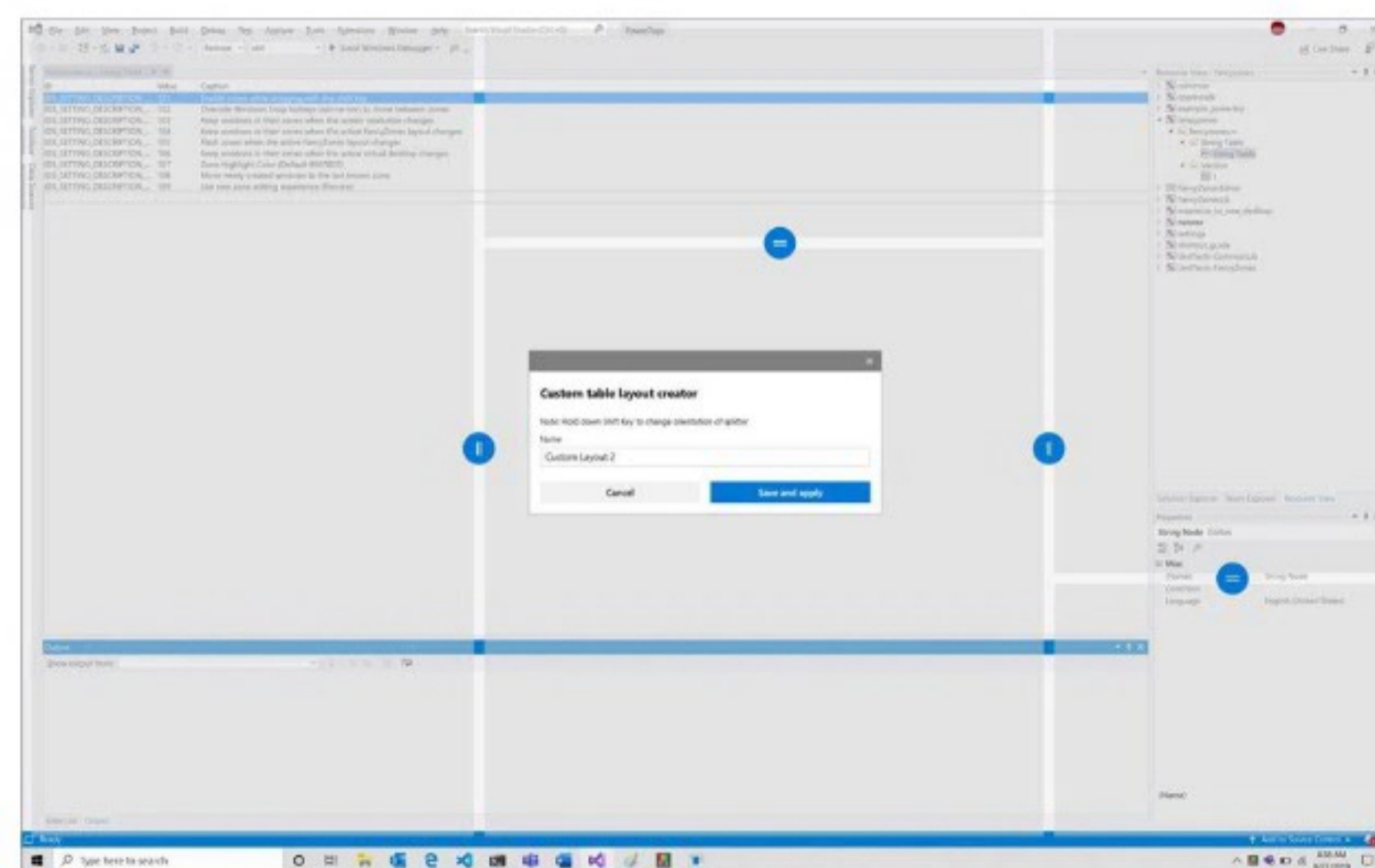
If none of these work, you can also create your own zones. FancyZones allows you to do this either additively, by creating zones that can be resized; or via subtraction, where a number of predefined zones can be removed or adjusted. If you’re looking for a way to quickly and easily rearrange windows for Windows’ Snap feature, FancyZones definitely is worth a look.

When we originally wrote this story, there was just one catch: it only worked on a single display. Now, that’s changed, and FancyZones works on multiple monitors. It’s still a little awkward: there’s a toggle switch in the FancyZones

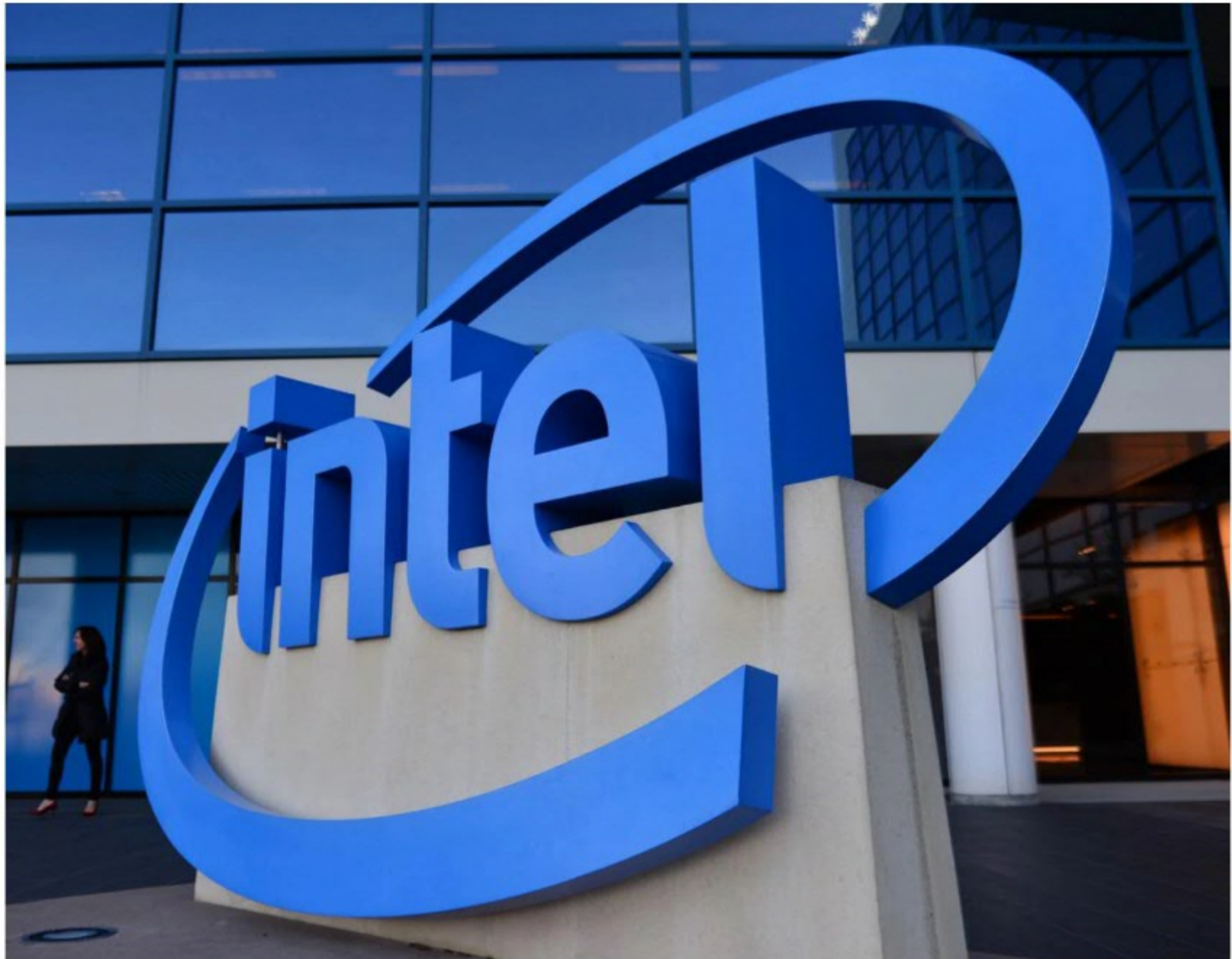
Settings that allows the app to “follow mouse cursor instead of focus when launching editor in a multi screen environment”. I’d suggest flipping that to “off,” dragging the zone configuration screen to the appropriate monitor, and setting up the Zones that way. 



You can create FancyZones from scratch, creating and resizing windows...



...or you can “subtract” them from existing predefined regions.



This insightful Intel video explains how CPUs are made, in words you can actually understand

From the concept stages all the way to store shelves. **BY BRAD CHACOS**

Yes, computer processors work. But have you ever wondered how they work? Recently, Intel published a fascinating animated video outlining “key concepts and their roles

in chip manufacturing.” The chatty “Chip” spokesperson that walks you through the video brings up memories of the cringeworthy Clippy introduced by Microsoft in Office 97 (go.pcworld.com/clpy); and



killed in 2014 [go.pcworld.com/k114], nevertheless, it's well worth spending five minutes to watch it if you've ever been interested in how the brain of your computer comes to life.

PC enthusiasts often toss around terms like transistors, silicon wafers, photolithography masks, interconnects, and substrates. Intel's video provides a great high-level overview of what all that really means. Better yet, it does it in a friendly, approachable manner that you can actually wrap your mind around even if you don't have an engineering degree. After watching it, you'll better appreciate all the hard work that goes into the badass CPU at the heart of your gaming rig (go.pcworld.com/gmrg).


Check it out!

Want to dive even deeper down the rabbit hole? Intel also published a video diving deeper into transistor technology (go.pcworld.com/sns1) specifically, though it's not quite as accessible for non-technical types. "Learn more about how we turn sand

into the silicon chips that power the world," it promises.

Intel's been pushing more helpful information recently. Earlier this year, the company threw open the doors to its secretive overclocking labs, revealing what Intel engineers use to push CPU clocks to 11 (go.pcworld.com/cp11).

If you're interested in more nuts-and-bolts looks inside how your PC's components are made, several factory tours have shed light on various pieces of hardware. These aren't as high-level as Intel's chip video—they don't explain basic concepts, just show you how the sausage is made—but they're nevertheless illuminating.

We've taken our cameras inside a Gigabyte motherboard factory, while Gamers Nexus (go.pcworld.com/gmns) provided deep dives into the manufacturing of AMD's Ryzen coolers, Cooler Master and DeepCool liquid coolers, NZXT cases, tempered glass, and copper heatpipes. We've embedded them all below for your viewing pleasure. 



Call of Duty's free Warzone spinoff is the newest (and maybe last) magnificent battle royale

A tense one-on-one respawn mechanic and excellent level design make for the best battle royale since Apex Legends. Now all it needs is a solo mode. **BY HAYDEN DINGMAN**

When *Call of Duty: Black Ops 4* ([go.pcworld.com/bop4](https://www.pcworld.com/bop4)) launched in 2018, I thought its “Blackout” mode would become the third big battle royale game. Splitting the difference between Playerunknown’s *Battlegrounds* and *Fortnite*, between hardcore and cartoony, Blackout felt like a more refined take on those already well-trod ideas, with snappy gunplay and a

streamlined interface.

Problem was, you had to buy *Black Ops 4* to play it—and then Apex Legends released a few months later, for free, and took all the wind out of Blackout’s sails (and sales).

Activision’s back for round two though, and this time it’s being smarter about it. *Warzone* ([go.pcworld.com/wrzn](https://www.pcworld.com/wrzn)), released on March 10, is the next evolution of *Call of Duty*’s battle royale—but this time it’s

free-to-play. *Modern Warfare* owners can launch it from within the usual client, but anyone can download *Warzone* direct from [Battle.net](https://battle.net).

And you should, so long as you're still interested in a battle royale circa 2020—and have friends who are interested as well.

HURRY UP AND WAIT

Be warned, it might take a bit to download. It's been a long time since I played *Call of Duty: Modern Warfare* (go.pcworld.com/mdwf), and so while I'd heard the griping about enormous patch sizes, this is the first time I've come in direct contact. As it turns out, I could have downloaded the standalone version of *Warzone* just as easily as updating *Modern Warfare*. Total update size? Over 115GB.

This is absolutely ridiculous. That's a tenth of my monthly bandwidth cap, not for a new game but for a single update. Even if I'd kept *Modern Warfare* up-to-date, *Warzone* still would've necessitated a 22GB install. Apparently *Modern Warfare* now takes up 163GB of my 1TB SSD, an entire fifth of the drive. I don't know what's up with this engine, that it requires such absurd patch sizes, but it's

unsustainable.

And what's even more frustrating is that *Call of Duty's* gotten worse over the years. I wrote about the problem of ballooning installs in early 2017, and specifically cited *Call of Duty* as a model for the future. Back then, the games were still on Steam and you could easily install and uninstall pieces of it at will. Only playing *Warzone*? Keep that, and jettison the campaign. Team Deathmatch and nothing else? Launch the rest into the void.

That's how it should be, but unfortunately that quality-of-life feature disappeared with the move to [Battle.net](https://battle.net). I've got plenty of storage space, but not infinite.

WOLF AMONG WOLVES

Anyway, once I'd waited for the 115GB install—and then an additional ten minutes after the game launched, while it sat and installed shaders—I hopped into *Call of*



...And then waiting for the shaders to install as well, after I'd already launched the game.

Duty: Warzone.

As I said, bring your friends. My biggest disappointment with *Warzone* so far is the lack of a Solo or even Duo mode. I've long since tired of playing battle royale games with strangers, and *Warzone* hasn't changed that.

Warzone isn't even as stranger-friendly as *Apex Legends*. It does adopt the latter's excellent "ping" system to call out targets and loot, but neglects to group teams together when they jump out of the plane at the start of a match. Every time I've played with strangers, the match started with us spread across a half-mile stretch of buildings desperately trying to group back up. The only person I've heard on comms so far was talking to his Twitch viewers, not to me, and that about sums up the experience of playing *Call of Duty: Warzone* with strangers.

You can elect to enter a match without a team, but you're only hurting yourself. Your opponents will still be three-person squads,

and while *Call of Duty's* faster time-to-kill makes these matchups a bit more even than they would be in *PUBG* or *Fortnite*, it's still borderline suicidal to go it alone.

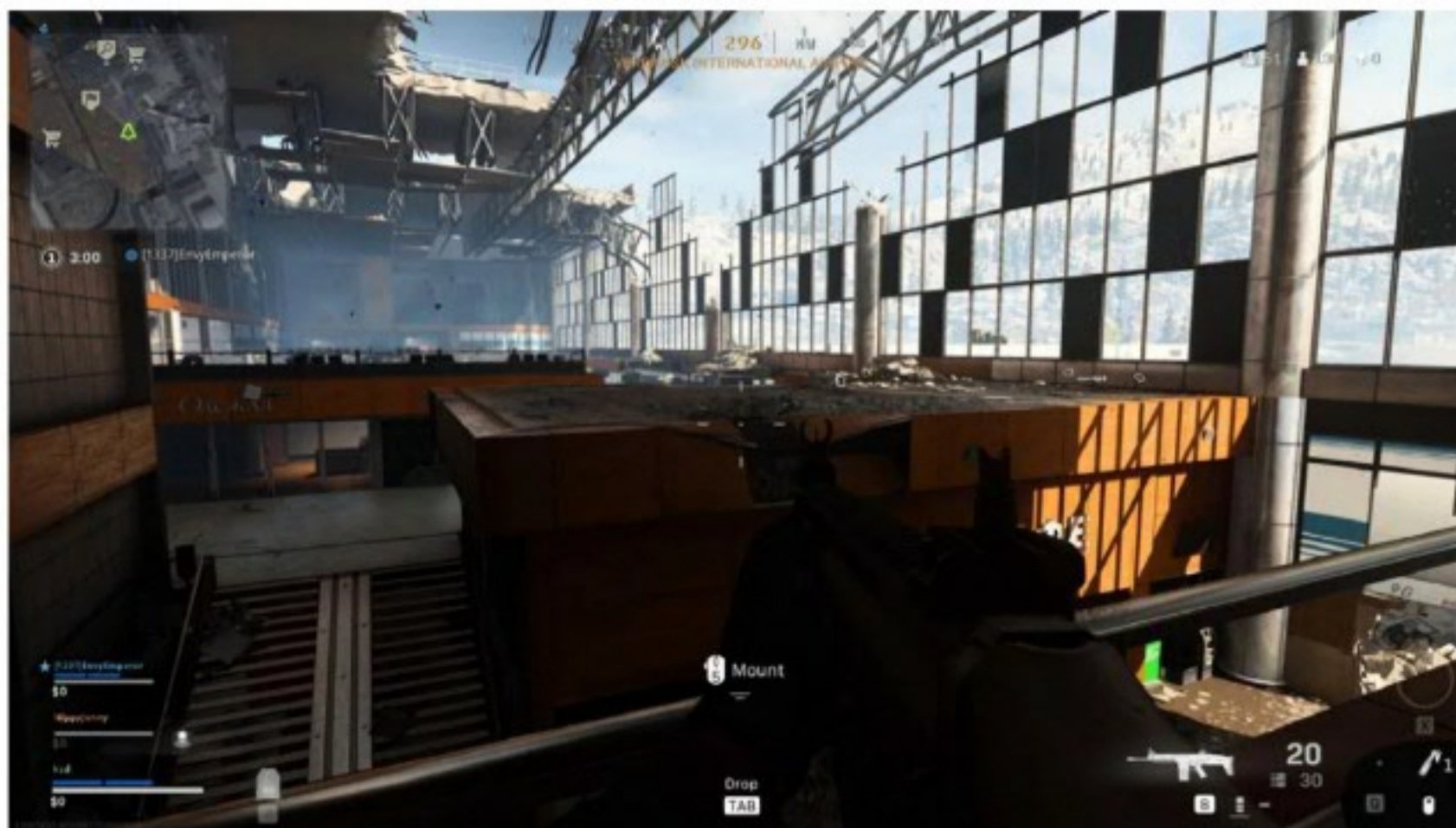
It's weird because unlike *Apex*, *Call of Duty* doesn't have any hero-specific skills or whatever that necessitate (or at least encourage) squadding up. My gut tells me this is a marketing ploy, a way to get players to coerce friends into giving *Call of Duty: Warzone* a shot, but in my case it's more likely to get me to stop playing.

The long, lonely wait for a Solo mode begins, I guess.

It's a shame I'm so put off by playing with randoms, because otherwise I love *Warzone*. It's *Blackout*—which I already loved—but bigger and better. It's paced like *Fortnite* but skinned like *PUBG*, and it turns out that's exactly what I want: A semi-serious battle royale game with minimal downtime.

PUBG had hotspots, but it never really felt

(at least when I used to play) like it was set up to support them. People would drop into Pochinki, but decent loot was so hard to come by that a lot of those early encounters turned into slugfests, and if you didn't drop in hot you might go



the entire game without seeing another player.

In *Call of Duty: Warzone*, loot is abundant from the get-go. A single two-story building might have three or four guns inside, which facilitates those early-game skirmishes. It felt like I was always in the

action, no matter where I landed. *Warzone* also lets players buy their custom loadouts instead of relying on random loot, which is a neat addition, and looting is just as intuitive as it was in *Blackout*. No digging through menus to drop a single bandage. Grab what you want and leave the rest. It's easy.

And since, at its heart, this is *Call of Duty*, the guns are a joy to use in close- to mid-range shootouts, the beating heart of *Warzone*. The (enormous) map is basically cobbled together from a dozen existing *Call of Duty* levels with some filler areas. "Terminal" is here, as are "Scrapyard" and "Broadcast." On the one hand it makes the map feel less like a real Russian city and more like a cartoon as you stumble from setpiece to setpiece. On the other, these are legendary levels with excellent competitive flow. Every individual section feels like a miniature *Call of Duty* match, with a handful of people trying to get an angle on each other as the circle



shrinks and the killstreaks get more intense. You can play long-range sniper battles if you'd like, but that's not really what *Warzone* is geared around.

It takes some getting used to, moving from zone to zone without getting picked off. I've come to love it though. The environments have a lot more character than your average battle royale, and if you're already good at *Call of Duty's* traditional multiplayer then many of those skills map onto *Warzone* as well.

And when you do die, *Warzone* throws you into probably my favorite battle royale respawn mechanic so far: The Gulag.

You go to prison. You die, and then you awake in a dimly lit cell, looking down on the Gulag Showers map—itsself a recreation of a scene from the original *Modern Warfare 2* campaign (which itself is an homage to *The Rock*). When it's your turn, you're teleported into the showers with a random gun, then forced to fight the other player one-on-one in



under 15 seconds. Win? You get sent back to the main fight. Die? You're dead.

Okay, in the latter case you can still get resurrected by a teammate at specific points on the map. It's a hassle though, and the thrill of winning a Gulag match is second only to winning Warzone, I imagine. The two-on-two Gunfight mode was already my favorite version of *Modern Warfare* multiplayer. This is even more tense, a high-stakes purgatory that takes the sting out of an early death, the catch being that the Gulag disappears once a Warzone match is down to around 50 players (from the max of 150).

BOTTOM LINE

The Gulag is easily *Call of Duty: Warzone's* standout feature, but I'm enjoying the whole

package. I'd admittedly enjoy it a hell of a lot more if there were a Solo hopper, and I hope Infinity Ward adds one soon, but we'll see.

Regardless, it's the first time I've cared much about a battle royale since *Apex Legends* first launched last year. Will *Warzone* recapture the third place position? Hard to say, but I think it deserves a shot. Once upon a time I scoffed at the idea of a *Call of Duty* battle royale mode, and then *Blackout* proved sanding off some of *PUBG's* rough edges could actually make for a better game. (Shocking, I know.) Now that *Warzone* is free—and presumably divorced from the annualized *Call of Duty* games—it feels like it has a real chance at winning people over. It's just a shame Activision didn't go this path the first time. 📺

Owl Cameras is dead and users who bought its expensive dash cam are in limbo

The company that acquired its assets is looking for someone to help bereft customers.

BY MELISSA RIOFRIO



Owl Cameras is dead. The startup made a splash in 2018 with the Owl Car Cam, a dash cam that plugged into a car's OBD-II port and recorded both inside and outside the vehicle, uploading those videos to a cloud service via LTE. But now, two years

later, the company's employees are scattered, and its assets have been sold. The story might have ended abruptly right there, but this tale holds a glimmer of hope for existing users.

PCWorld reviews dash cams ([go.pcworld.com/dcam](https://www.pcworld.com/dcam)), including both the debut 2018 Owl Car Cam ([go.pcworld.com/ow18](https://www.pcworld.com/ow18)) and

the improved 2019 Owl Car Cam (go.pcworld.com/ow19). Even though the camera's \$350 price was very high for its competitive set, it received largely positive reviews, and some people bought the Owl Car Cam—though, apparently, not enough people to keep the company afloat.

Things started looking alarming earlier this year when *PCWorld* dash cam reviewer Jon L. Jacobi began receiving emails from readers who were unable to reach Owl Cameras for support. As we began to investigate the Owl Cameras communication blackout, we found a company that looked alive on the surface, but seemed very much dead upon closer inspection.

THE LIGHTS ARE ON, BUT...

If you had looked at Owl Cameras' website (go.pcworld.com/oweb) in early February, all would have seemed normal, at least at first glance. Its slickly designed pages were up and running. The About page listed the executive team and a Board of Directors. A Careers page showed a long list of job openings. Now in early March, the site greets you with a pop-up stating new purchases are being "temporarily suspended while

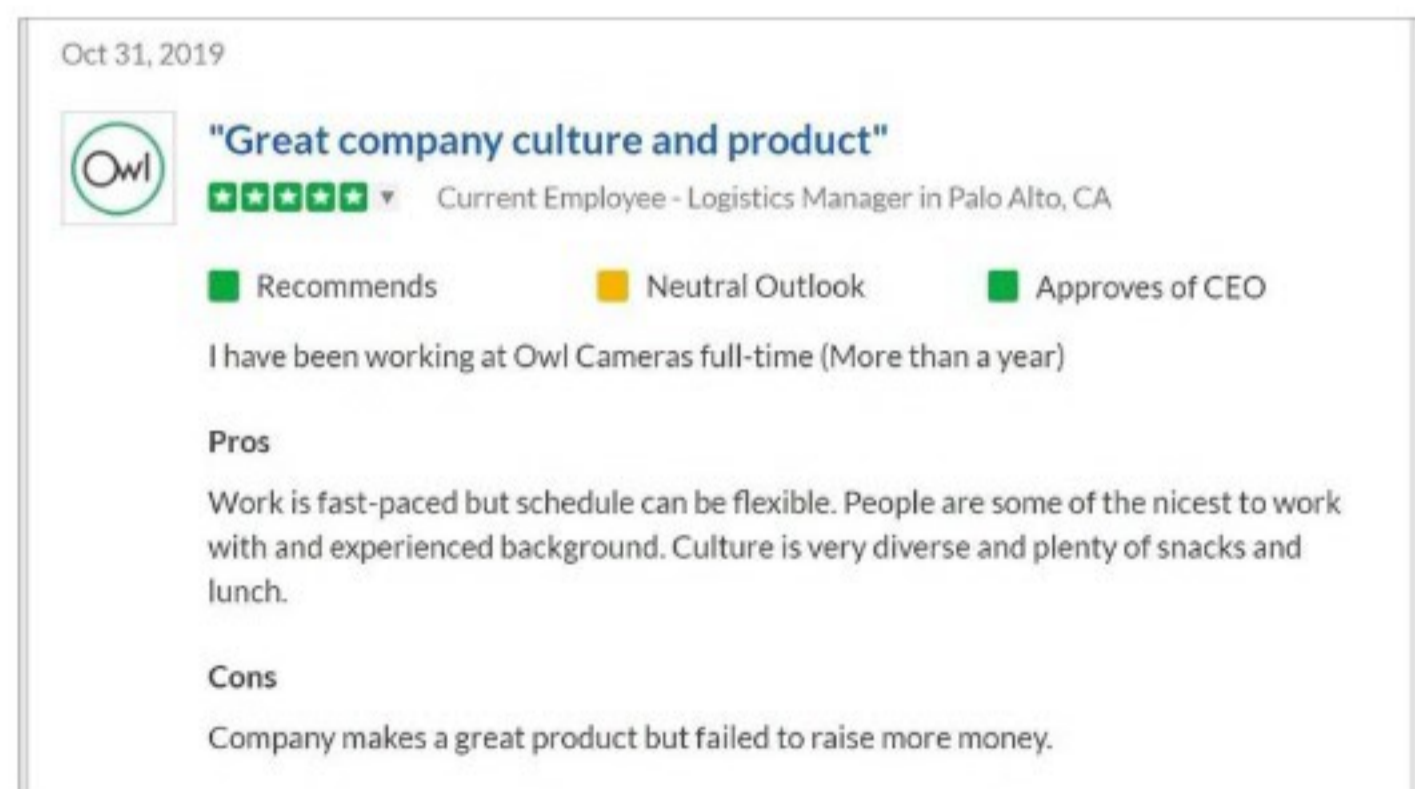


Owl Cameras, Inc., co-founding CEO Andrew Hodge still says "we're hiring" on LinkedIn in early March, long after the company had closed its doors.

the next steps are being determined," but just a few weeks ago, nothing seemed amiss.

Other signs of life could be found on LinkedIn, where the founding executive team was still listed as employed by Owl Cameras, Inc. The LinkedIn profile pages of co-founding CEO Andrew Hodge and co-founding CTO Nathan Ackerman went so far as to proclaim, "we're hiring!"

Other signs of health: Job postings on Glassdoor looked recently refreshed, and



The last review of Owl Cameras, Inc., on Glassdoor, dated October 31, 2019, ends with an ominous "cons" comment.

employee reviews were generally glowing. Some reviews mentioned typical startup perks, like plentiful free snacks. But one hint of a different story came in the final Glassdoor review, dated October 31, 2019. It was a favorable review, but it ended with a foreboding sentence: “Company makes a great product but failed to raise more money.”

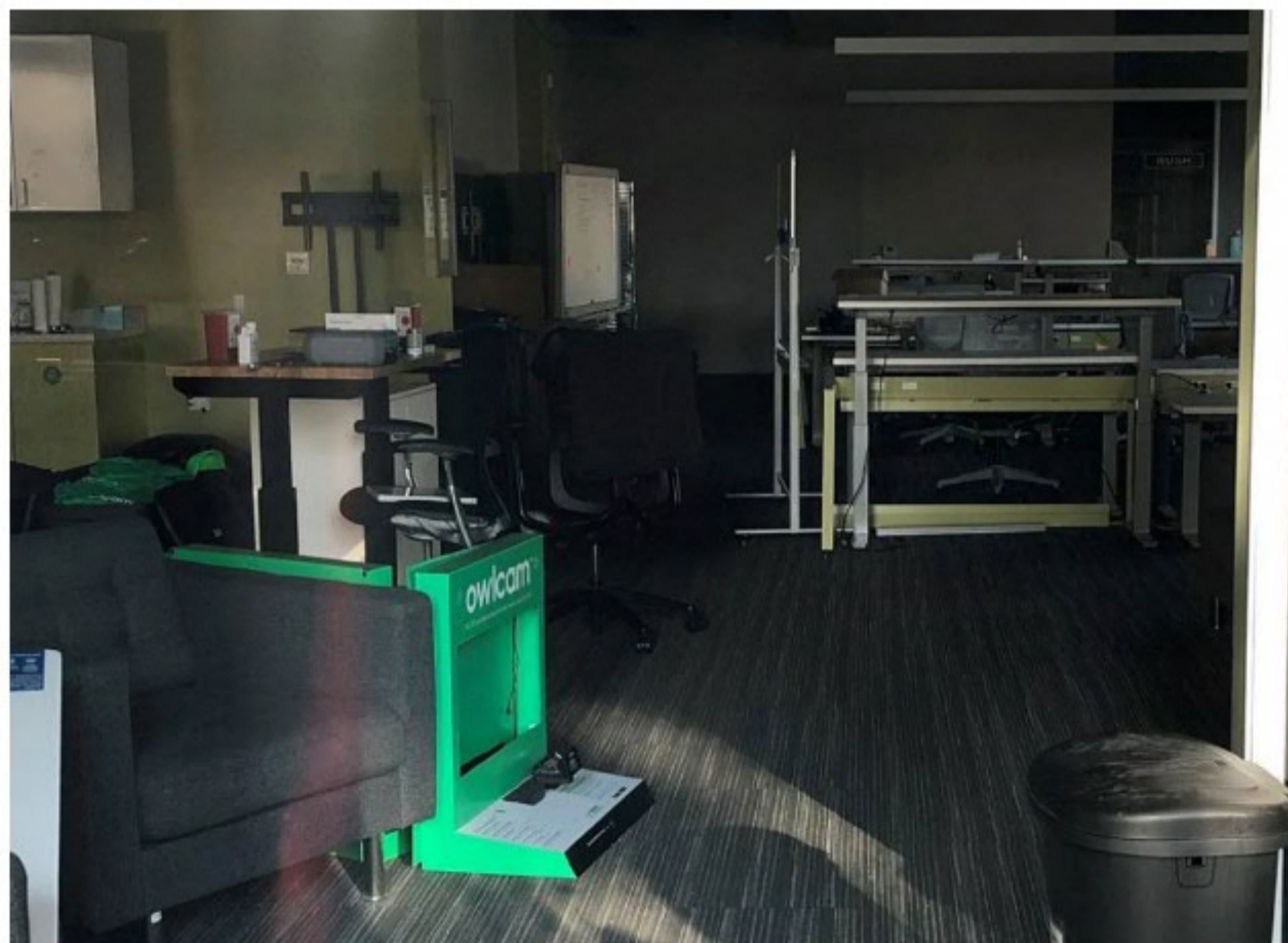
NO ONE IS HOME

The more we pulled at Owl Cameras’ strings, the more it became clear that the company was either on life support or completely dead. We reached out to Owl’s public relations firm and learned it was no longer working with Owl. We also noticed Owl Cam products were unavailable to purchase on the company’s website and Amazon. And, after failing to reach anyone on Owl’s customer support line, we visited the company’s Palo Alto, CA, headquarters to find offices gone completely dark. Inside, we could see office furniture and some scattered paraphernalia. But there were no people, no PCs, and no signs of free

snacks.

Most tech startups fail. From that perspective, the death of Owl Cameras is hardly a surprise, and neither is the reason—as that Glassdoor review stated, it simply ran out of money. A person closely associated with Owl Cameras who wished to remain anonymous described a downward spiral that began last September with a major layoff and executive reshuffle, and concluded in January with a full shutdown of the company.

Other than that single anonymous source, *PCWorld* has been unable to find anyone else willing to describe what happened. We reached out to founders Hodge and Ackerman for comment, but received no responses as of this writing.



***PCWorld* visited Owl Cameras, Inc., mid-afternoon on February 19, 2020, and found dark, empty offices, devoid of people and PCs.**

Nonetheless, we've been able to piece together a chronology of troubling events. Owl Cameras' Twitter feed went silent after August 29, 2019. A scan of the LinkedIn profiles of former Owl Cameras employees showed many of them exited around September 2019, including founding CEO Andrew Hodge. The company filed a Statement of Information with the State of California dated October 28, 2019, listing a new CEO (Gary Clayton), and designating co-founder/CTO Nathan Ackerman as Secretary and Chief Financial Officer. Gary Clayton's LinkedIn profile now shows he was CEO of Owl Cameras from October 2019 to January 2020, while Nathan Ackerman's profile shows him as a current employee of Owl Cameras, Inc.

And let's not forget the users who bought Owl Car Cams and suddenly lost all technical support. Owl Cameras also abandoned two business partners, Best Buy and the AAA automotive insurance company. Best Buy was still selling the Owl Car Cam in February, long after the company began showing signs of failure. AAA had inked a deal last June to work with Owl Car Cams on behalf of its customers, and was still promoting the deal in February.

It appears both companies learned of Owl's demise not from Owl itself, but rather from *PCWorld* when we contacted them for this story. Neither responded to our



Owl Cameras, Inc., co-founding CTO Nathan Ackerman still says “We’re Hiring!” on LinkedIn in early March, even though the company closed down in January.

communications directly, but we noticed that the Best Buy retail page and AAA information related to Owl Car Cams disappeared soon after we contacted the companies.

AN ANSWER, AND A LITTLE HOPE

So would anyone share clear information on the fate of Owl Cameras, and where its customers can seek support? We finally got a response (albeit a vague one) from Xirgo Technologies (go.pcworld.com/xirgo), a company that provides IoT solutions for enterprise customers. A source within the company confirmed that Xirgo had acquired the assets and technology of Owl Cameras, Inc. The purchase occurred in early February, but has not yet been publicly announced. Our source says the company is exploring solutions for servicing existing Owl Car Cam owners. At least Xirgo seems to care a little more about these early backers than Owl Cameras did. 🛑

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Samsung Galaxy S20 Ultra: Too much more for most

The influencer phone. **BY MICHAEL SIMON**

I feel like I need to give Samsung's Galaxy S20 Ultra two scores. If I'm reviewing it solely on the merits of its components and what it can do, it's easily a five-star device, with only the smallest of perceptible flaws.

The 6.9-inch display is remarkably bright and incredibly smooth when the 120Hz

refresh rate is switched on, and the 40MP hole-punch selfie camera is much more discreet than it was on the S10. The RAM, storage, and processor are all the fastest you can get in a smartphone, and the 5,000mAh battery both lasts all day and fills up incredibly quickly. And yes, the 100X Space Zoom camera is cooler than any other telephoto



You won't find the S20 Ultra name anywhere on the phone, but everyone will know what it is.

lens I've used.

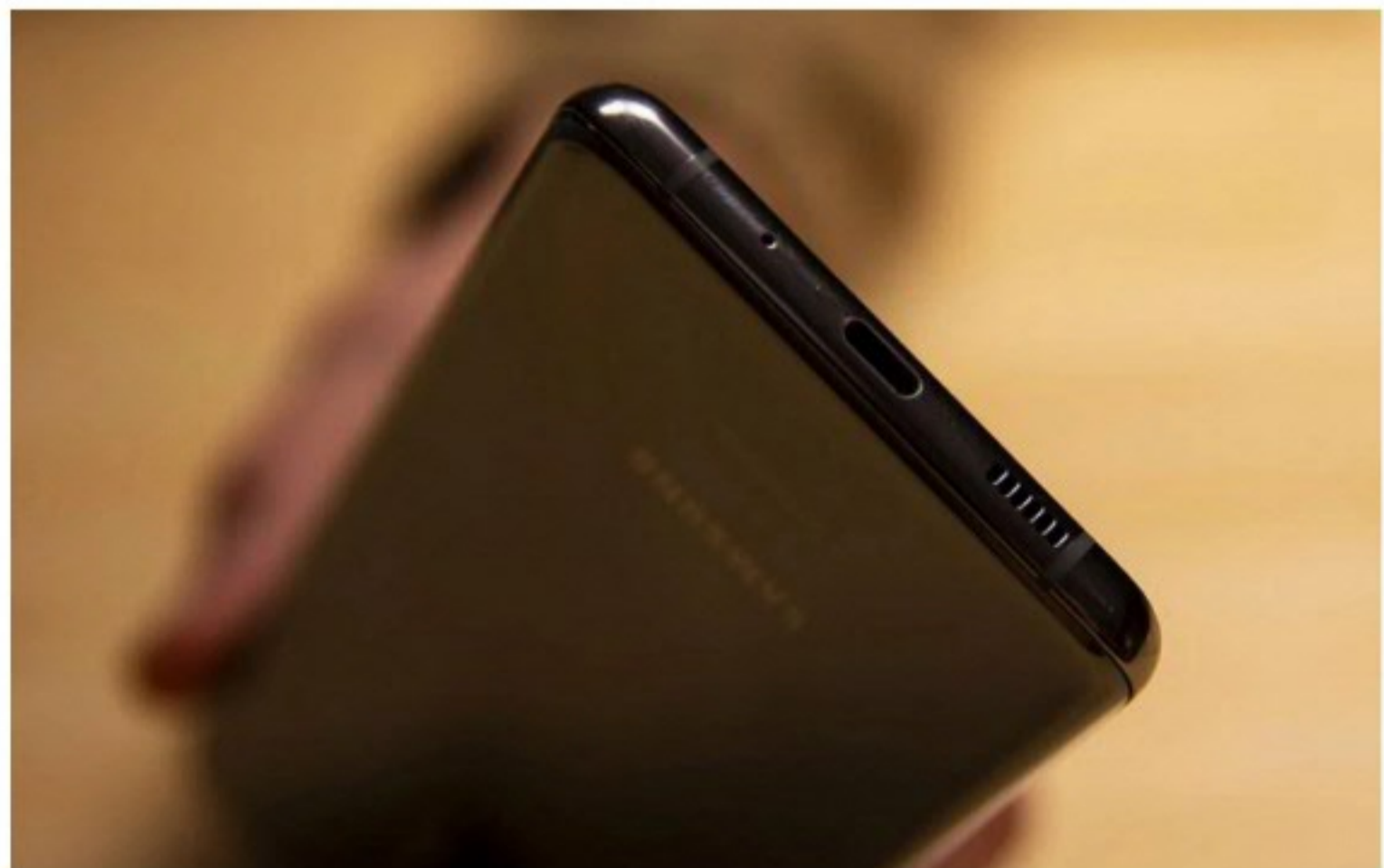
But if I were to score the Galaxy S20 Ultra on usability and cost, I'd give it closer to 2 stars (hence the 3.5-star final score). Even if our review model didn't start at \$1,400, a price high enough to make Apple blush, the Galaxy S20 Ultra would still be far too much phone for most people. Everything feels extreme, especially its size. Samsung's push to make the ultimate device has created a gorgeous and awe-inspiring superphone that is far beyond what most people need. Or even want. (Curious about the

lower-cost S20 models? Check out our comparison of the Samsung Galaxy S20 vs. the S20+ (go.pcworld.com/s20c.)

BIG, HEAVY, AND AWKWARD

For several generations now, Samsung has established that its "plus" phones are essentially larger versions of base models with better cameras. On paper, that's true of the S20 Ultra as well, but in reality, it's much more than a super-sized Galaxy S20+.

I don't usually spend much time thinking about the weight of my phone, but it's hard to ignore the S20 Ultra's mass. At 222 grams, it's significantly heavier than S20+ (188g) and the S10 5G (198g). It's actually a bit lighter than the iPhone 11 Pro Max, which clocks in at 226 grams, but you wouldn't know it from holding it. With such a massive camera bump in the top left corner, the S20 Ultra is both top-heavy



The S20 Ultra's USB-C port is perfectly centered on the bottom edge.

and side-heavy, so it requires a slightly different grip, lest it slide and slip out of your hands.

You can forget about one-handed operation. While the new, higher placement of the in-display fingerprint sensor has drastically improved the accuracy and reliability of the scanner when picking it up and unlocking with my thumb, the size of the S20 Ultra makes it difficult to do much else without using all 10 of my fingers. It was hard enough to use the 6.8-inch display on the Note 10+, but the S20 Ultra's 6.9-inch screen, coupled with the weight and near-9mm thickness, is simply too much for one hand to bear.

The S20 Ultra is the only phone I've used that I could actually feel sliding down my hand as I held it. It's a weird phenomenon, caused by a combination of the size, weight, and polished aluminum edges. Eventually, I settled on a grip that either contorted my pinkie finger under the bottom or used my off-hand thumb to keep it steady. I still had to adjust my grip every so often. Long stretches with the Ultra were downright uncomfortable.

Even if you have fingers long enough to comfortably reach the upper corners of the screen, the bulbous camera will complicate your grip. While giant geometrical camera arrays are all the rage, the S20 Ultra takes it to



The S20 Ultra absolutely towers over the Galaxy S10+, which isn't exactly small.

almost comical proportions, with a bump that protrudes some three millimeters from the back. Because it's such a broad bump, taking up about an eighth of the rear case, your fingers will inevitably butt into it.

The giant camera bump also makes it tricky to use on a table, especially when tapping the upper left side of the screen. It's wobblier than the S10 and the Pixel, and when a notification comes in, the haptic vibration is downright startling. All said, it's the first phone I wanted to put in a case, which is a shame, because the glass repels fingerprints surprisingly well.

Elsewhere, it's easier to raise the volume,

as the rocker has been moved to the right side above the power button. That leaves the left side completely smooth, because Samsung has dumped the Bixby button once and for all.

Gone, too, is the headphone jack, which we expected after the Note 10+ dropped the port last year. Samsung is offering a pair of USB-C earbuds in the box and selling a set of Bluetooth Galaxy Buds+ earbuds for \$150. It's still a bummer that Samsung couldn't find 3.5 millimeters of free space on a phone this big.

PIXEL PERFECTION

Samsung has delivered its most impressive display yet for the S20 product line—and that's before you even touch it. The weirdly off-center camera cutout of the S10 product line has been repositioned in the S20 so it's smack-dab in the center of the top of the screen. While the hole is still a little too low to center itself inside the status bar, its new position still improves the look of the phone.

I can't really find a fault with the image quality. It's impressively crisp at 1440p and still very nice at the default 1080p resolution. I was able to crank it all the way up to 650 nits' brightness manually, and it

reached an eye-piercing 1,350 nits with auto-brightness enabled. Its ability to transition automatically between low and bright light is excellent. Colors are vivid without being too saturated, whites are natural, blacks are impressively deep, and the whole palette is rich and robust. There just aren't enough superlatives for how incredible the S20's display is.

It's also not quite as curved as previous Infinity displays. It's hard to see without putting it next to a Note 10 or S10, but the S20 screen is decidedly "flatter" than those of previous generations (though definitely more curved than the S10e's). That's a good thing: It helps cut down on accidental palm touches and still does well to hide the side bezels. I vastly prefer it to the extreme "waterfall" displays that Oppo and Vivo are pushing.



The front camera in the S20 line has moved to the middle of the top of the screen, a positive change from the awkwardly off-center hole of the prior generation. (As shown in the S20 and S20+, above)



That's no moon, that's the 100X Space Zoom camera bump.

Samsung has once again gone with an ultrasonic in-display fingerprint sensor on the S20 family. While a thousand-dollar-plus phone should really have 3D facial recognition, this implementation of the fingerprint sensor is much improved over what we had with the S10. The position of the scanner is higher on the screen and the target is a bit bigger, so I didn't need to alter my grip or flex my thumb to hit it. It's still not quite as consistently fast as the hardware sensor on the S9 and probably never will be, but it's plenty accurate and reliable now.

The best feature on the S20 display is actually switched off by default (and I'm not talking about the usual WQHD 1440p resolution). The S20 is Samsung's first

product line to feature a high-refresh display, and it's gone for the gusto, opting for a full 120Hz, twice as fast as the standard 60Hz. It's glorious. Compared to the standard 60Hz setting, scrolling, animation, and gaming are fantastically smooth, well worth the serious hit to battery life when it's switched on.

When pitted against the Pixel 4's 90Hz Smooth Display, however, the difference is not nearly as obvious.

Samsung could easily have gotten away with 90Hz, saved some battery life, and offered it for 1440p resolution as well, but as it stands the 120Hz setting is available only with Full HD 1080p resolution. Fast refresh with WQHD would have been nice, especially on a screen this size—I'm holding out hope that Samsung will unlock it with a future update.



You can fit an awful lot of app icons on the Galaxy S20 Ultra's screen.

Despite that limitation, however, the 120Hz screen is one of the best reasons to buy any S20 phone.

SPEED TO SPARE

Galaxy phones have been fast enough since the Snapdragon 820 processor in the Galaxy S7, but the Snapdragon 865 in the S20 line is on another level. Snapdragon 855 Plus-powered phones had already broken the 10,000 threshold on the PCMark Work 2.0 benchmark, the S20 crushes expectations with a score of 12,350.

While the speed boost is palpable, Qualcomm doesn't deserve all of the credit. Samsung is using entirely new RAM modules inside the S20, and every handset is packed with at least 12GB of LPDDR5 memory. Plus you're able to keep three apps open for faster switching, so launching games with lengthy startup times

are lightning-quick. To give you an idea of how it feels to have this much RAM: I stopped counting the apps on my Recents screen at 50.

Even the SSD has improved. It's not just the 128GB capacity—once again, twice as much as the Pixel and iPhone—but the speed: Samsung is using UFS 3.0 storage on all S20 models. While it's not quite as fast as the UFS 3.1 storage that will probably debut in the Note 20, it's a huge jump over what you got with the S10, and it even bests other UFS 3.0 phones (though I'm not sure what's going on with random write results):

S20 (UFS 3.0)

Sequential read: 1,592.46 MBps

Sequential write: 662.75 MBps

Random read: 45,172.27 IOPS

Random write: 33,764.08 IOPS



Compared to the S10, the Ultra's camera is a monster.

S10 (UFS 2.1)

Sequential read: 802.13 MBps

Sequential write: 188.34 MBps

Random read: 34,612.61 IOPS

Random write: 7,383.57 IOPS

OnePlus 7T (UFS 3.0)

Sequential read: 1,436.19 MBps

Sequential write: 210.4 MBps

Random read: 44,158.73 IOPS

Random write: 7,189 IOPS

Add up the chip, RAM, and storage, and you've got a downright monster of a phone that's faster than most Chromebooks and can even give some PCs a run for their money. It's so powerful, Samsung could probably rest on its laurels for the next two generations and still keep pace with its competitors.

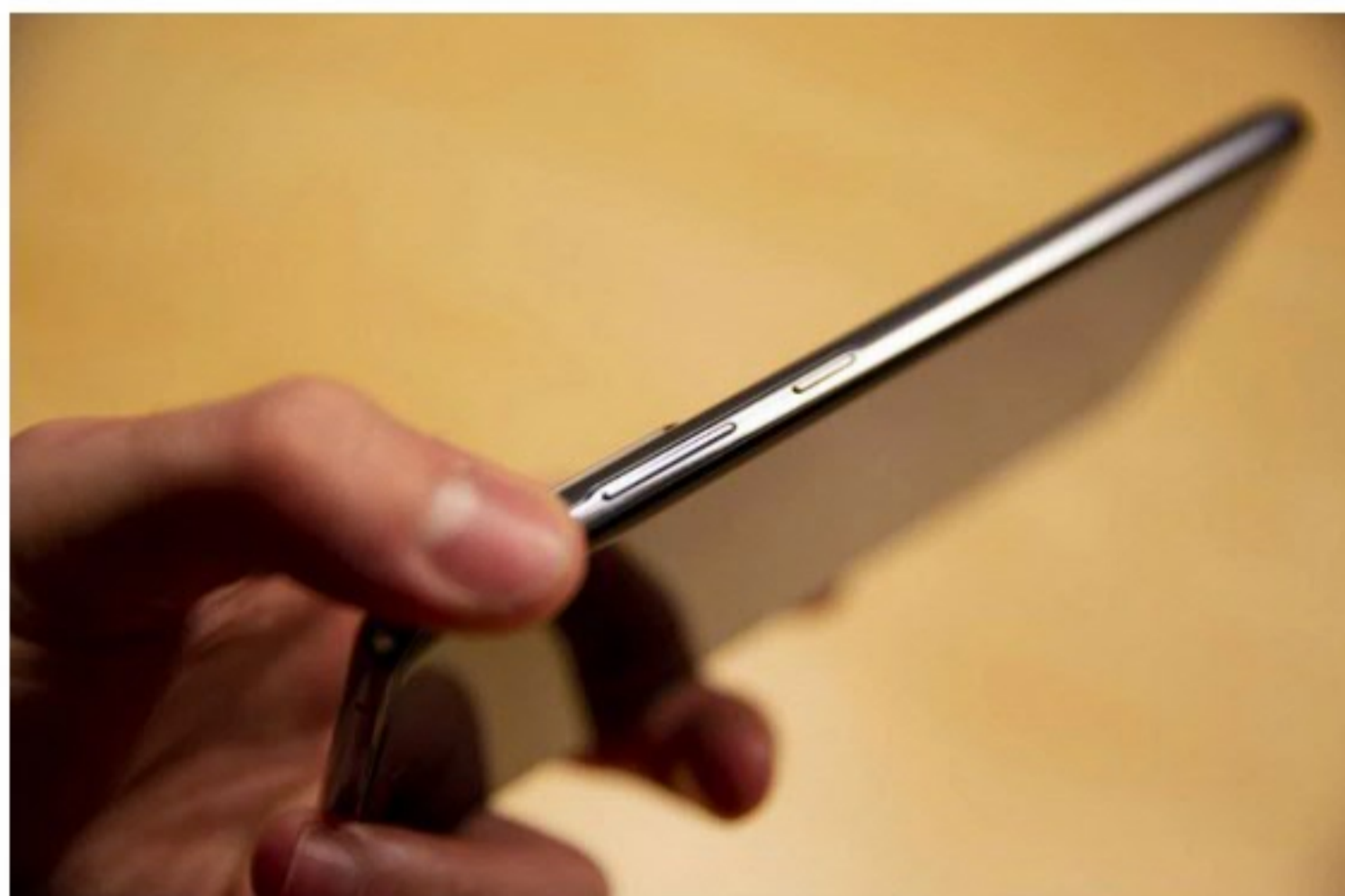
GREAT BATTERY, SO-SO 5G

Samsung has loaded the S20 Ultra with a 5,000mAh battery—its biggest ever, and a sign that it's finally ready to push the limits of battery capacity after the Galaxy Note 7's exploding-battery debacle (go.pcworld.com/xpbt).

The S20 needs it. With 5G active and 120Hz motion smoothness flipped on, I was

barely able to make it through a full day of heavy use. With the 120Hz refresh off, WQHD on, and 5G enabled, I was able to last a good part of a second day, which is iPhone 11 Pro Max territory. Benchmarks topped 10 hours in both cases, but 120Hz zapped more than three hours of use, so you'll definitely want to consider whether it's worth it to you. The bundled 25W charger fills up the Ultra in about an hour and a half, but it also supports 45W charging—if you have the right charger. I tested numerous 60W chargers and none of them worked, so you'll probably need Samsung's proprietary one (go.pcworld.com/schr).

The same goes for 5G. While all S20 phones sold in the United States will have a 5G modem, you can opt to turn it off in settings, which will give battery life a slight uptick. That's obviously something you'll want



The buttons on the S20 Ultra have all been moved to the right side.

to do if you're under an LTE plan, but even if you have subscribed to T-Mobile's or Verizon's 5G plan, the benefits might not be as great as you've been led to believe.

While it's well-documented that Verizon's mmWave 5G speeds are stupid fast, they're limited to very small pockets around the United States. I tested the S20 Ultra using T-Mobile's network in Connecticut, and my mileage varied. Even when my S20 Ultra said it was connected to a 5G network, my speeds were often lower than my Pixel 4's on Verizon's LTE network. Occasionally I topped 100Mbps, but none of it felt transformative or any better than LTE.

Even if you don't take advantage of the 5G modem now, you can be assured that the S20 Ultra will be as future-proofed as it can be, for as long as you hold onto it. With support for both mmWave and Sub-6GHz 5G, 12GB of RAM, a fast processor, speedy

storage, and an insanely great display, the S20 Ultra is primed for years of solid performance.

AN ANDROID SKIN WORTHY OF PRAISE

It's not just the hardware that's future-proofing the S20. For the first time since I've been testing Galaxy phones, I'm confident that Samsung will keep the S20 line as fresh as possible with regular and timely updates. Exhibit A: It's March 3 as I'm writing this, and my S20 Ultra already has the March Security Update, the third straight month that one of my Samsung phones has gotten an Android update earlier than my Pixel 4 has. That's a huge accomplishment and hopefully a sign of things to come with Android 11 later this year.

One UI has completely transformed the Samsung smartphone experience from a so-so skin to one of the best user interfaces

Android has to offer. The S20 family ships with One UI 2, and while it's very much an iterative update, the new features it brings—including an expansion of dark mode and the adoption of a proper back gesture—are as smart and thoughtful as they are on the Pixel 4.

One UI 2 is a bona fide contender for the best Android overlay of the year, and far and away the most creative in the



The S20 Ultra isn't available in any funky colors, but even in gray, it cuts a striking figure.

Android world right now. If Samsung can deliver One UI 3 at or around the time Android 11 drops, there will be very few remaining reasons to buy another Android phone.

A GREAT CAMERA WITH CAVEATS

While there are plenty of reasons above to justify the S20's Ultra surname, the camera is the biggest. Inside that huge bulge is an array of large, powerful sensors and lenses that can do more than any other smartphone camera ever made.

Like the rest of the S20 Ultra, the camera is on the absolute cutting edge of available components. You're unlikely to find another smartphone that bests it on paper. Like the S20+, the Ultra has four rear cameras, and they're all different:

S20 Ultra

- Camera 1:** 12MP Ultra Wide, f/2.2
- Camera 2:** 108MP Wide-angle, f/1.8
- Camera 3:** 48MP Telephoto, f/3.5
- Camera 4:** DepthVision (time-of-flight)

S20+

- Camera 1:** 12MP Ultra Wide, f/2.2
- Camera 2:** 12MP Wide-angle, f/1.76
- Camera 3:** 64MP Telephoto, f/2.0
- Camera 4:** DepthVision (time-of-flight)



The S20 Ultra's zoom isn't quite DSLR-quality, but it's the closest a smartphone has ever been.

Whether those S20 Ultra specs actually make a difference in your day-to-day picture-taking is another story. There's a 108MP sensor that most people will never turn on. There's a 100X zoom that most people will never need. And it can record in 8K, which most people will never—well, you get the idea.

While the 108MP sensor obviously stands out on the Ultra, the telephoto lens is the real star. Samsung's claims are true—it can reach up to an insane 100X—but you're unlikely to use it at that distance very often. As you can see above, the pictures it captures aren't really ones you'll want to display. Plus there's the creep factor: I was able to see clear across my wide yard into my neighbor's kitchen window. Still, when you see just how far it can go, it's pretty mind-blowing.

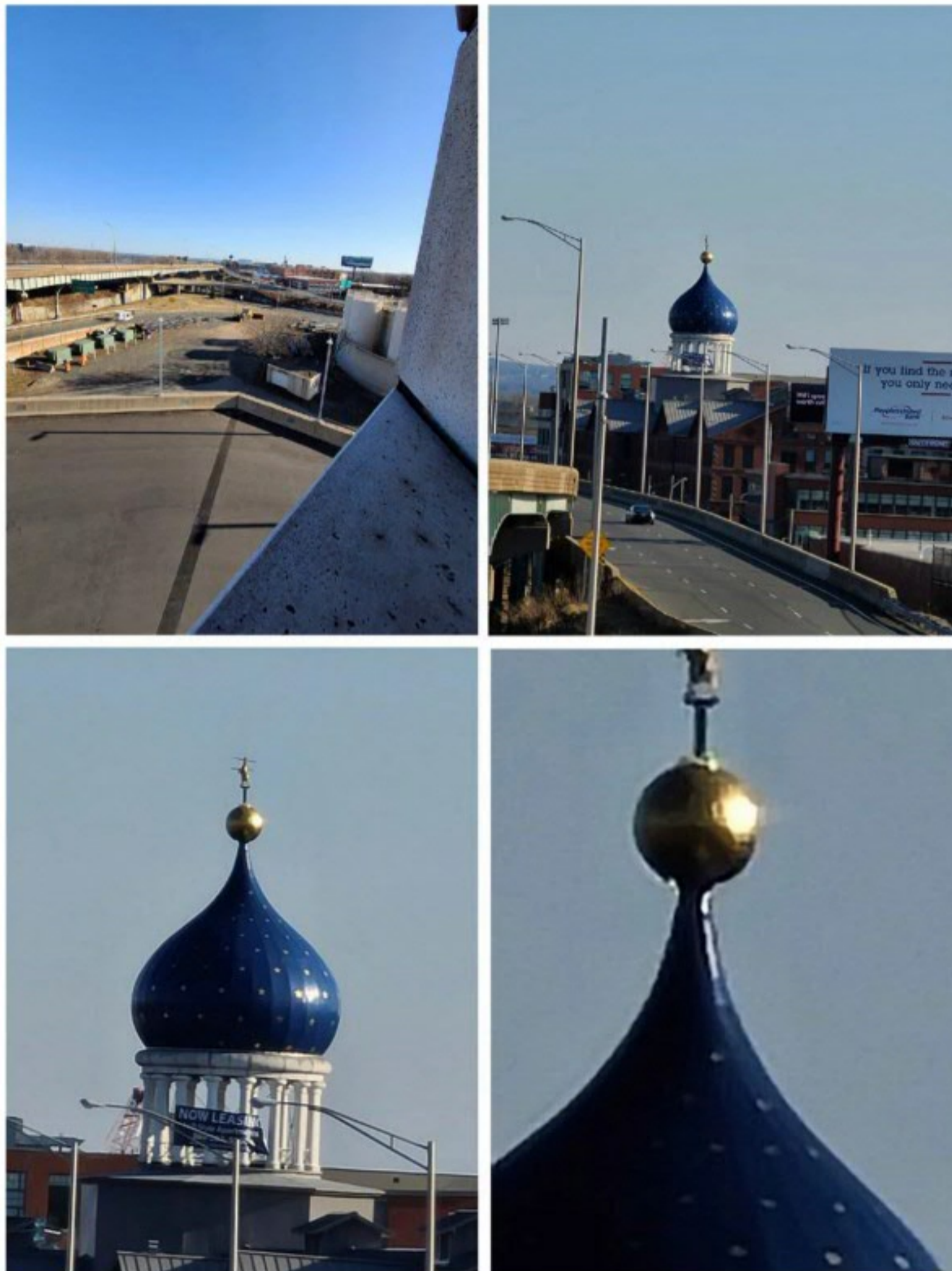
The S20 Ultra is even more impressive when you zoom out. While 2X or 3X optical zoom is pretty standard for premium Android phones, Samsung says the S20 Ultra has a 10X “lossless” zoom that combines 4X optical and 6X digital zoom with AI to reduce the noise you’d normally get with digital zoom.

It’s quite good: Photography purists will still see some telltale digital smartphone artifacts at 10X, but it’s an excellent first step, and the quality should improve with steady updates.

Speaking of improvement, Samsung has put a good deal of work into its night mode, and the effort shows on the S20 Ultra. Most of

the heavy lifting is done by the ISOCELL Bright HM1 image sensor that powers the 108MP lens—night mode shots are using 9-to-1 nona binning to turn 0.8 μ m pixels into 2.4 μ m—but Samsung’s maturing algorithm deserves some credit too. On the S10, night shots were largely overexposed, but there’s much more nuance on the Ultra. Shadows and highlights are preserved, and in some shots, I actually preferred the S20 Ultra’s night mode to the Pixel 4’s. The new countdown interface that’s built into the shutter is extremely clever and the best implementation I’ve used so far.

Samsung also continues to make strides



The various preset zooms on the S20 Ultra, clockwise from top left, 1X, 10X, 30X and 100X, show how incredible the telephoto lens is.



These three photos taken by the S20 (left), iPhone 11 (center), and Pixel 4 XL (right) are so similar, I had a hard time remembering which was which.

with portrait mode. Even without a second selfie cam like the S10+, edges are crisp, and wisps of hair are recognized. The rear camera excelled thanks to the time-of-flight sensor, though the aggressive AI tended to smooth faces a bit too much with the selfie cam.

The S20 Ultra camera's other claim to fame is 8K video recording, which you can capture at 30 fps. You'll need a lot of space for it—every minute will eat up about 600MB of storage—and some of those clips might need to be reshot. That's because of a bug



In challenging lighting, the S20 Ultra (left) performed admirably, retaining detail that the Pixel 4 lost (right) and preserving low lights that the S10 blew away (center).



The S20 Ultra's rear camera does an excellent job with portraits (left), but the selfie cam tends to smooth over perceived blemishes, like my son's freckles in this shot.

that messes with the S20 Ultra's autofocus. Samsung has supposedly rolled out a fix for it in Korea, but my device, which has already gotten the March update, hasn't received it

yet (or if it has, it's not fixed). The autofocus issue affects photos as well, but it's more apparent in videos, where tapping the screen to focus manually is more of a nuisance.

I hope a fix will be available soon, because it's a nagging issue on an otherwise amazing camera that can take truly excellent photos. Pictures were constantly a bit more saturated than on the iPhone or Pixel, as is

Samsung's tendency. Despite the autofocus issues, however, more often than not I snapped a great pic with the Ultra. I particularly liked Samsung's new Single Take



The S20 Ultra's 108MP lens handles color and detail remarkably well, even if you're not shooting with every pixel.

feature, which uses Ai to offer up a smattering of different shots and compositions. It's downright delightful at times.

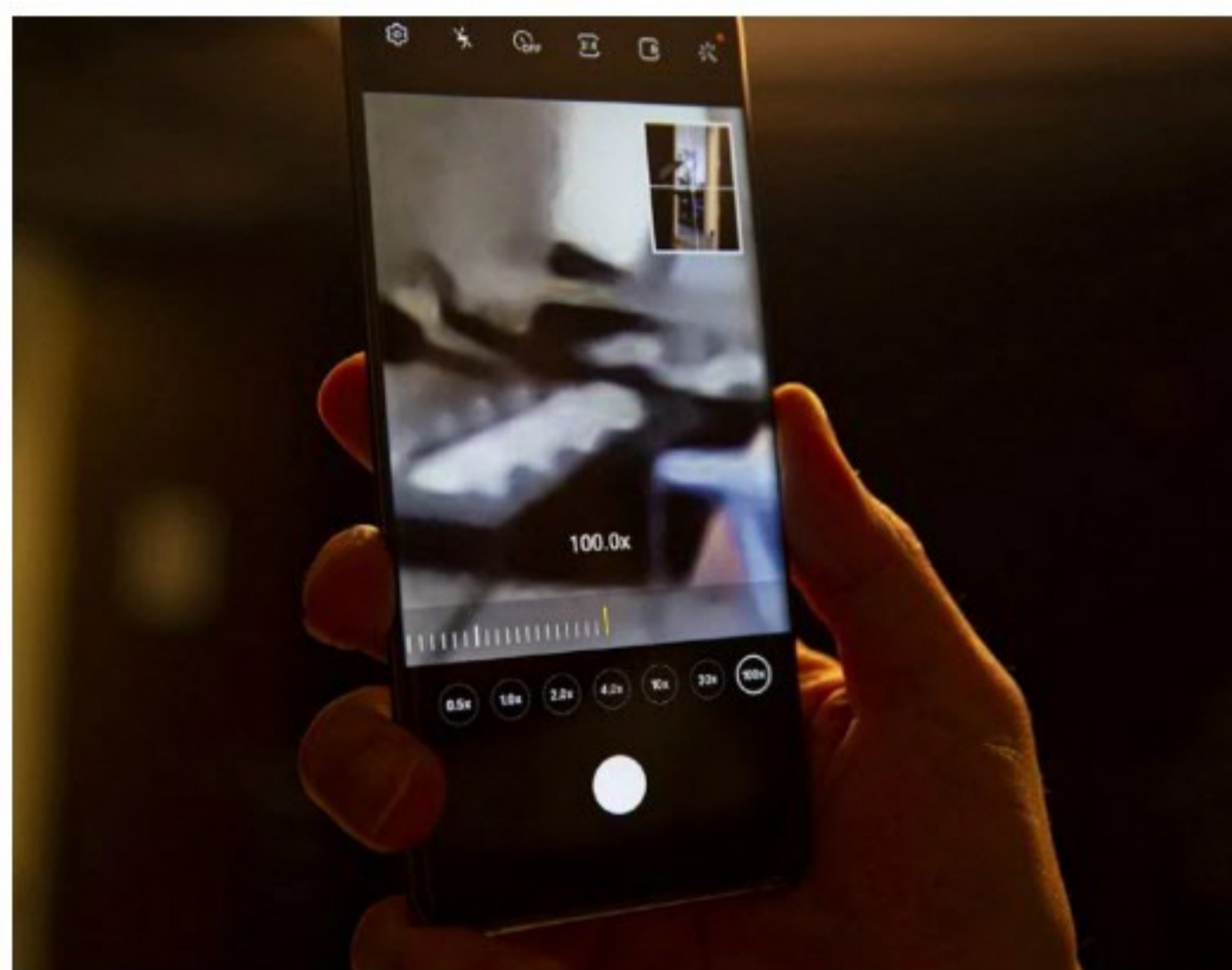
Far more concerning is how the S20 Ultra's size affects the photography experience. The S20 Ultra is so big that taking it out of my pocket, launching the camera, pointing it at my subject, and tapping the shutter button took several seconds longer than it did on other phones, simply due to the phone and the bump's tremendous size. It's a fact that people who really want a 108MP camera and 100X zoom are going to have to deal with, and it should definitely factor into your buying decision.

BOTTOM LINE

There are three types of people who should spend \$1,400 or \$1,600 on the top-of-the-line Galaxy S20 Ultra:

1. Samsung fans who will pay anything to have the latest and greatest handset.
2. Smartphone photographers who need the latest and greatest camera.
3. Influencers who have enough money to afford this phone

That's basically it. Anyone else should look at the S20+, which has many of the same features and specs minus some of the camera stuff, or even the S10+, which received a permanent \$150 price cut.



Space Zoom on the Galaxy S20 Ultra is far out.

Don't get me wrong: The S20 Ultra is a great phone, definitely in contention for the best Android phone ever made. But for most people, it's just too much phone for too much money. 🛑

Samsung Galaxy S20 Ultra



PROS

- Incredible processor, battery, and RAM.
- Absolutely gorgeous display.
- One UI has become one of Android's best overlays.

CONS

- Big, heavy, and awkward to hold.
- Extremely expensive.
- Camera is excellent but has some annoying bugs.

BOTTOM LINE

The Galaxy S20 Ultra is a technically superior phone with an incredible camera, but its size, price, and overkill make it hard to recommend.

\$1,399



Lenovo Yoga C940 14: A 2-in-1 convertible laptop that's just right

A plus-sized screen and all-day battery life help it stand out **BY JARED NEWMAN**

PCWorld
EDITORS'
CHOICE

Lenovo's C940 Yoga 14 just might be the laptop Goldilocks would pick if she found it in the Three Bears' house (go.pcworld.com/3brs). It's neither too much nor too little of what most people need in a 2-in-1 convertible laptop—it's just right.

Think about other popular convertible

2-in-1 laptops playing in this space, such as HP's Spectre x360 13t (go.pcworld.com/sp36), or Dell's XPS 13 2-in-1 (go.pcworld.com/dlxp). The Yoga C940 14 has the bigger display size compared to either, obviously, but it still stays just under the 3-pound mark that suddenly makes a laptop more of a luggable (and don't even ask about the weight of most 15-inch convertibles). It

doesn't sacrifice keyboard travel in pursuit of thinness, and its speakers aren't godawful like those of the LG Gram 2-in-1 (go.pcworld.com/lgrm). It even has a holster for its included stylus.

Of course, even Goldilocks had character flaws—sneaking into a house and messing with everyone's stuff is fundamentally not cool—and so does the C940 Yoga 14. The port selection is on the skimpy side, the trackpad is too rigid, and the display, while vibrant, is highly reflective. But if you're looking for a convertible that makes no major sacrifices, the C940 Yoga 14 is well worth considering.

TECH SPECS

Our Lenovo Yoga C940 Yoga 14, which we purchased, lists for \$1,430 from the Microsoft Store (go.pcworld.com/byyg), and has the following specs:

- 10th-generation Intel Core i7-1065G7 processor with Intel Iris Plus graphics
- 14-inch 1080p IPS touchscreen
- 12GB LPDDR4 RAM
- 512GB SSD
- USB 3.1 Type-A port,
- Two USB-C ports with Thunderbolt 3
- Headphone jack
- 720p webcam with privacy shutter

- Fingerprint reader
- Wi-Fi 6 support
- Stylus with 4,096 pressure sensitivity levels
- Windows 10 Home
- Dimensions: 12.61 x 8.49 x 0.62 inches
- Weight: 2.98 pounds (3.67 pounds with charger)

The same configuration is also available for \$1,300 at Best Buy (go.pcworld.com/b129).

Lenovo's website offers additional configurations, starting with a 10th-generation Intel Core i5-1035G4 processor, 80GB of RAM, and 256GB of storage. You can also upgrade to a 4K HDR display, 16GB of RAM, and 512GB of storage with 32GB of Intel Optane memory (go.pcworld.com/mh10) for \$1,600 at Best Buy (go.pcworld.com/32ln).

The only glaring tech spec issue is the port



The Lenovo Yoga C940 14 has a USB-A 3.1 port and two USB-C Thunderbolt 3 ports, but they're all on one side.

arrangement. Every USB port is on the left side, so you can't plug in the included USB-C charger from either direction, and there's no MicroSD card slot.

Also note that the Lenovo C940 Yoga 14 isn't really upgradable. The RAM is soldered to the motherboard, the bottom panel is held in place with T5 Torx screws, and the rear rubber foot (which hides a few of those screws) is glued on. You might be able to pry the laptop open for a battery replacement, but only as a last resort.



The Yoga C940 14 looks slick without being flashy.



The Yoga C940 14 folds into a tablet and has a built-in stylus.

DESIGN AND DISPLAY

Lenovo has a knack for designs that are unique without being excessively gaudy, and that's also the case with the C940 Yoga 14. The case is aluminum throughout, with no discernible flex anywhere along the bottom portion. The off-center placement of the lid's etched "Yoga" logo helps give the laptop a monolithic look. It's available in either a deep "Iron Gray," or a lighter, silvery gray that Lenovo calls "Mica."

The design includes a couple of clever

flourishes as well:

While the laptop's lid juts out at an angle when closed, the center portion faces straight down to form an extra lip, which both houses the webcam and gives your thumb a place to lift up the screen. Lenovo also built the speaker grille into the laptop's hinge, allowing sound to project outward even when the Yoga is folded around into tablet mode.

Lenovo went with a 16:9 aspect ratio for the C940 Yoga 14,

which for web browsing and document editing isn't quite as practical as the taller 16:10 ratio found on the MacBook Air and Dell's XPS 13 2-in-1. Having the extra space of a 14-inch screen helps mitigate this, but the larger the screen gets, the more you're going to notice individual pixels. Compared to 13-inch laptops, the Yoga 14's 1080p panel doesn't look quite as sharp.

It is plenty bright, though, with an advertised peak brightness of 400 nits for the 1080p version and 500 nits on the 4K HDR panel. (We actually measured an even higher than advertised brightness of 463 nits, but display brightness can vary by panel and we set a mid-range brightness of 250-260 nits for all laptop battery testing.). You'll have no problem using the Lenovo C940 Yoga 14 opposite a sunlit window or outdoors, though the glass touchscreen does create a lot of glare if it's angled straight at a light source.

Just one nitpick here: Out of the box, the display seemed overly cool and somewhat harsh, while also looking undersaturated. If this is something you'd notice, you can fiddle with Intel's Graphics Control Panel or even install an alternative ICM color profile, but that's obviously not ideal.

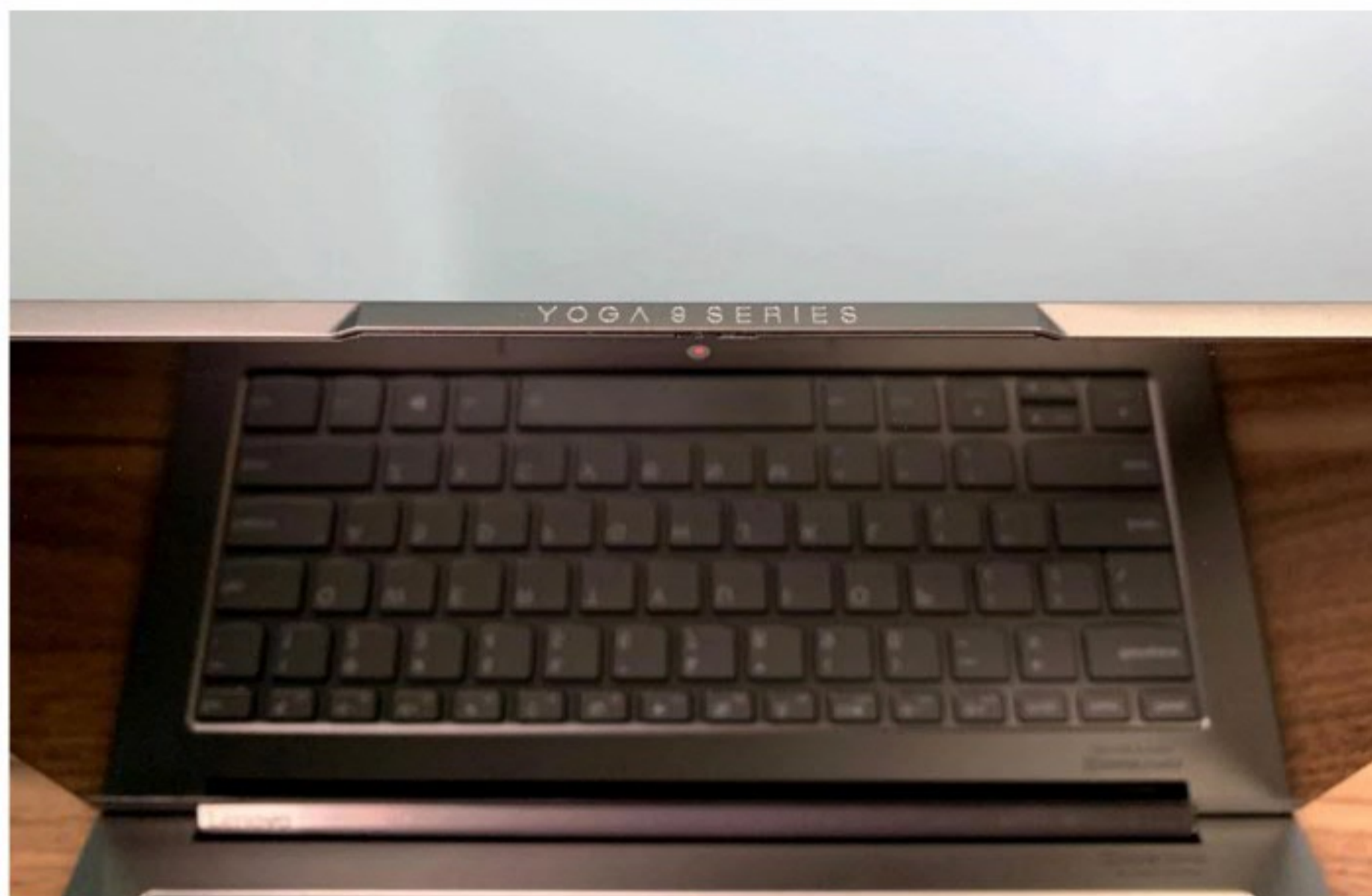


For a non-ThinkPad, the Yoga C940 14 keyboard has plenty of travel and provides a satisfying typing experience.

KEYBOARD AND TRACKPAD

While Lenovo's ThinkPads tend to get all the keyboard credit, its consumer laptops often hold their own without being so aggressively chunky. And if you like a keyboard that's a little on the louder side, you might be smitten with that of the C940 Yoga 14. These shield-shaped keys are not mushy at all, with a strong tactile bump that kicks in immediately as you press them. They give off a faintly high-pitched pop on the way back up.

The trackpad is also top-notch in terms of smoothness—another example of where a 14-inch laptop can excel over 13-inch ones. As the latter are becoming more compact, their trackpads are becoming cramped vertically, as is the case with HP's latest Spectre x360 13t. The only downside with the C940 Yoga 14's trackpad is one that many



The webcam's privacy shutter is a nice touch.

Windows laptops share: As your finger moves upward, the click mechanism becomes uncomfortably rigid, and clicking at the very top is almost impossible.

AUDIO, WEBCAM, AND SECURITY

Windows laptops often have terrible speakers, but the Lenovo Yoga C940 14 doesn't. That speaker grille built into the laptop's hinge puts out surprisingly balanced audio, making it one of the rare PCs that sounds better than my iPad Pro from 2017. It's still not going to replace a dedicated speaker for music, but it does a decent job in a pinch, and it's great for watching videos on Netflix or YouTube.

The Yoga C940 14's webcam isn't nearly as exemplary, with the same 720p resolution

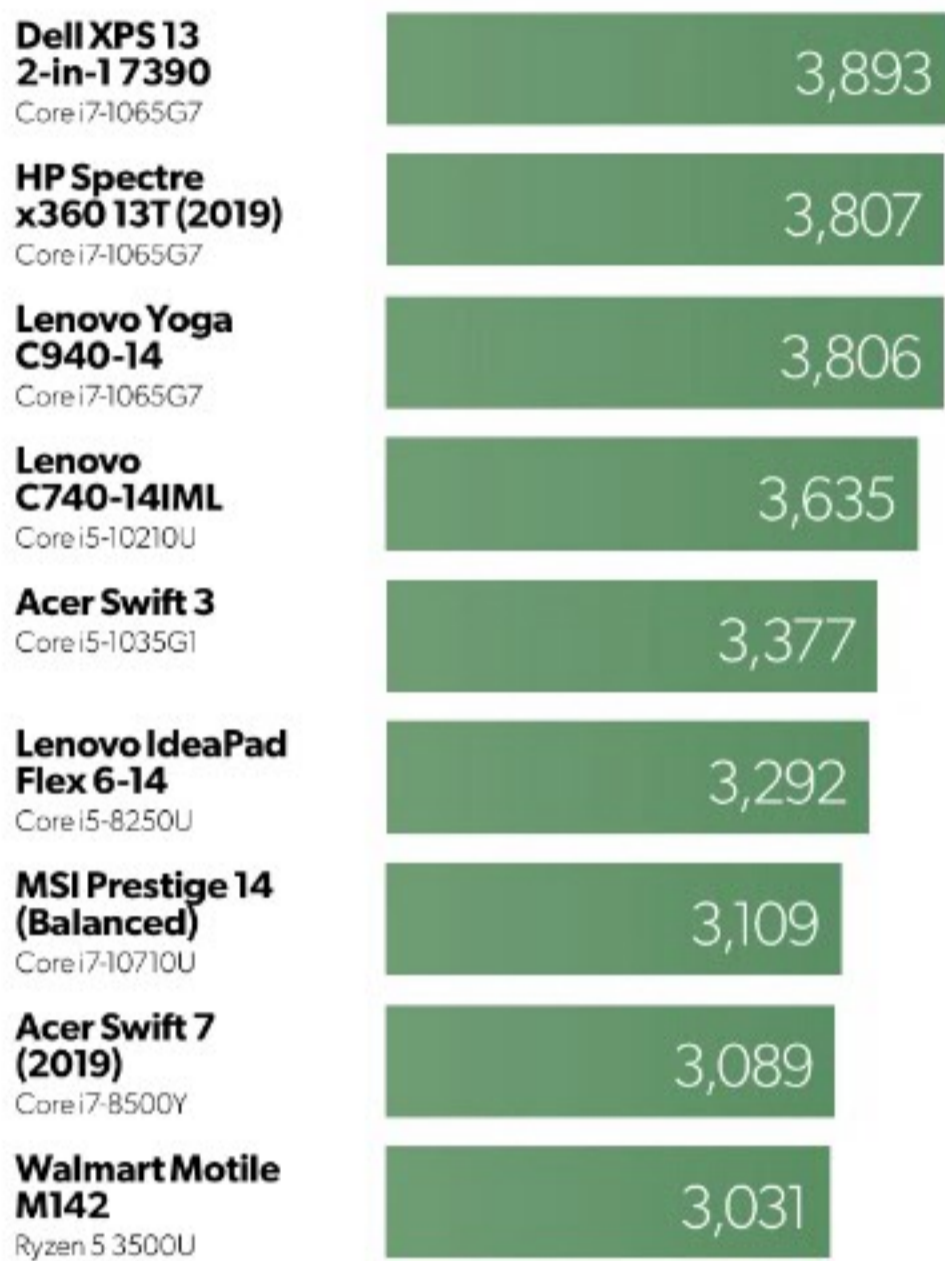
you'll find on practically every other Windows laptop. It does, however, include a nifty privacy shutter, which shows a red dot over the camera when you slide it into place. The camera doesn't support face recognition for Windows Hello, but there is a fingerprint reader underneath the keyboard, and it's fast and accurate enough.

PERFORMANCE

The Lenovo Yoga C940 14 launched late last fall among the first wave of laptops using Intel's 10th-generation Ice Lake processors. In many ways, Ice Lake is tailor-made for convertibles, allowing them to shrink down in size without sacrificing performance or battery life, while upgrades to Intel's Iris Pro integrated graphics provide a boost for light gaming.

PCMark 8 Work 2.0 Conventional

Native resolution



LONGER BARS INDICATE BETTER PERFORMANCE

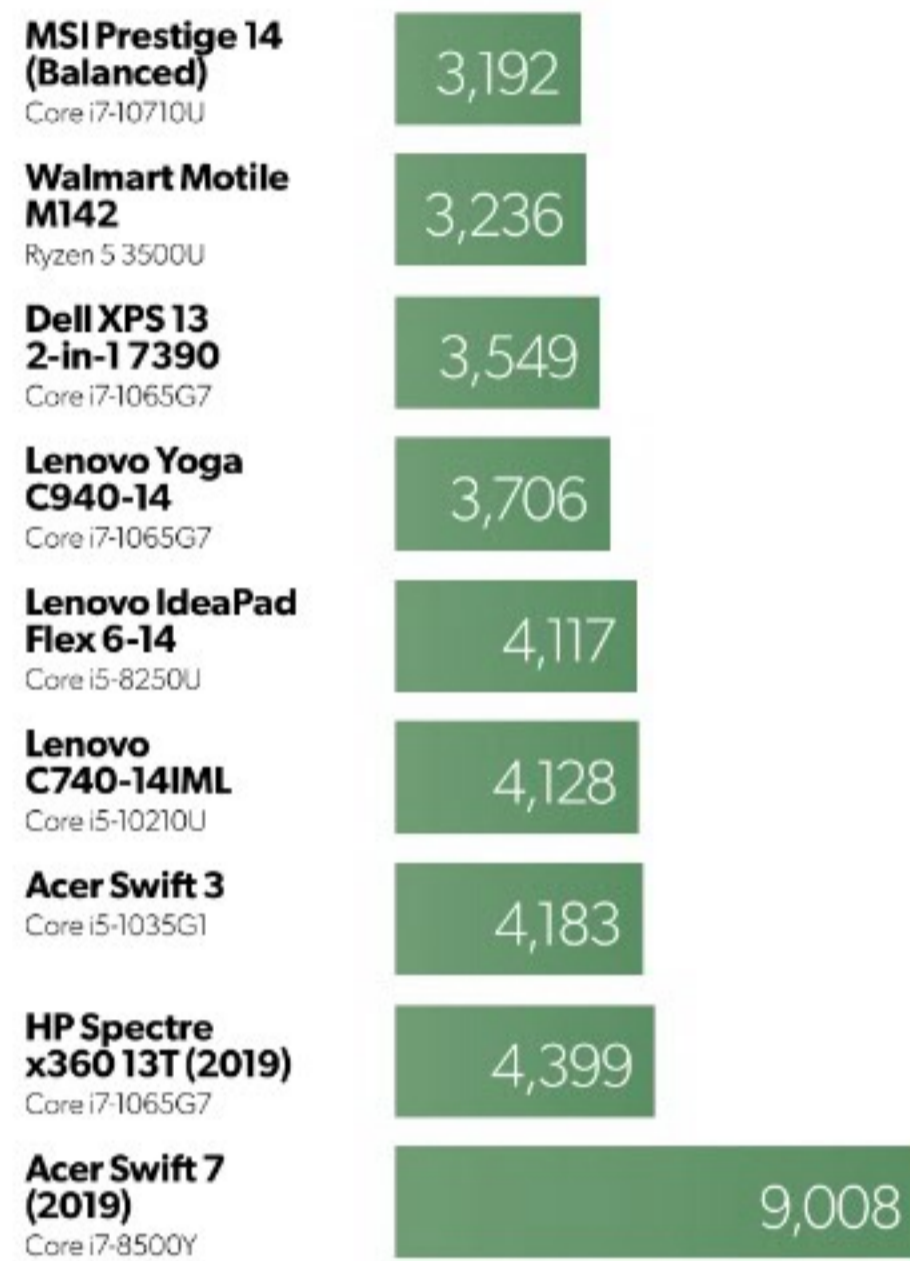
Productivity performance is a hair behind other premium 2-in-1s with 10th-gen Intel Core-i7 CPUs.

Benchmark testing bears this out. While the Yoga C940 14 is slightly behind some of its convertible competitors in raw performance, it's a clear cut above last year's 2-in-1 laptops and offers excellent battery life.

In PCMark's Work 2.0 benchmark, which simulates a gamut of productivity tasks, the Yoga C940 14 didn't score as well as Dell's XPS 13 2-in-1 or HP's Spectre x360 13t, both of which use the same Intel Core i7-1065G7

HandBrake Encode (Android Tablet)

Seconds



SHORTER BARS INDICATE BETTER PERFORMANCE

The Yoga C940 14 makes pretty quick work of video encoding, though again it's behind some of its direct competitors.

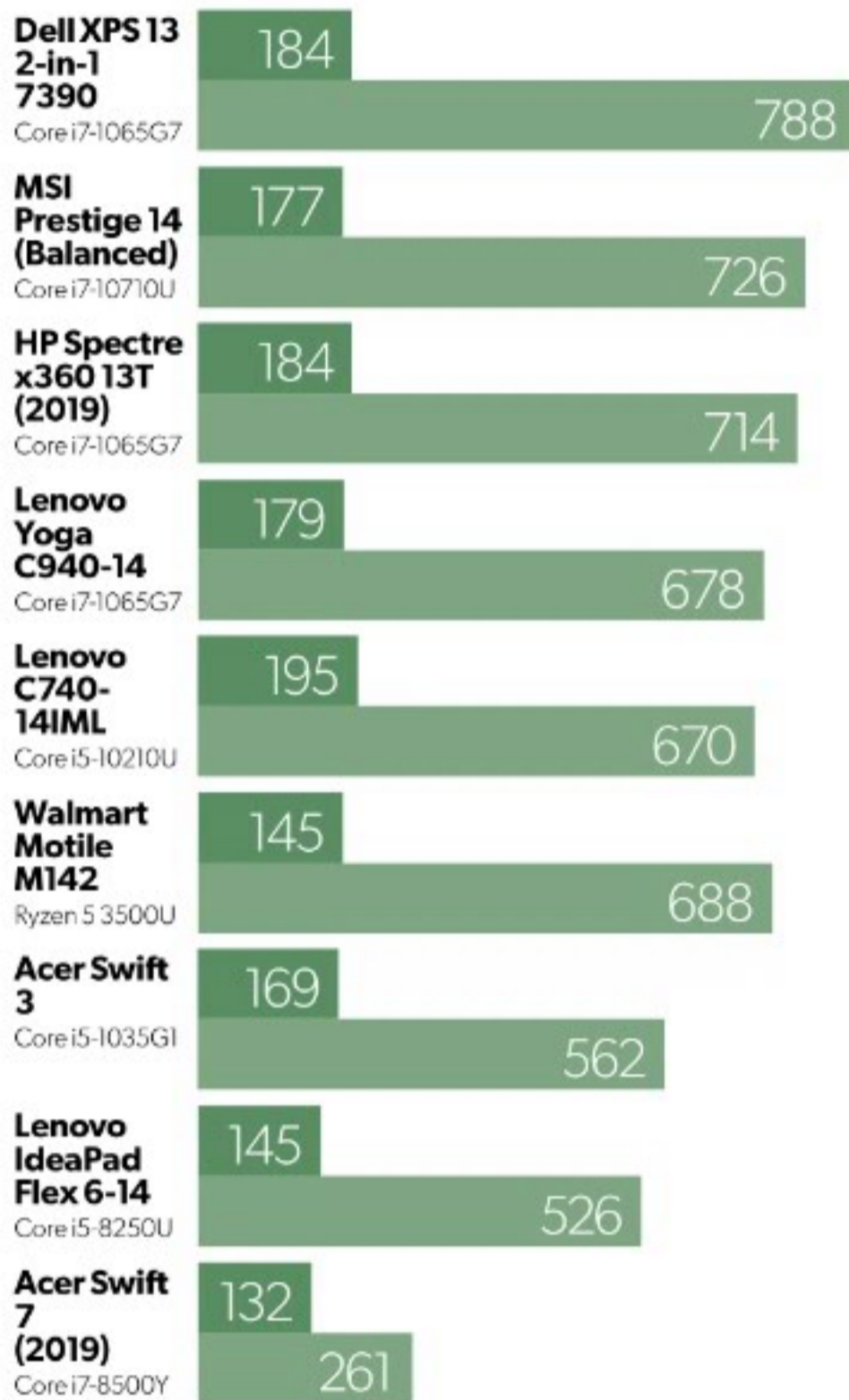
processor. Still, performance is in line with expectations, beating out Intel's 10th-generation Core i5 processors and last year's 8th-gen chips.

Our HandBrake test uses the popular free utility to encode a large video file, a good way to stress a CPU. As with the PCMark 8 test, The Yoga C940 14 didn't get the job done as quickly as the XPS 13 did—or the Ryzen 5-powered Walmart Motile M142, for

Cinebench R15.038

All threads

■ Single thread ■ Multi thread



LONGER BARS INDICATE BETTER PERFORMANCE

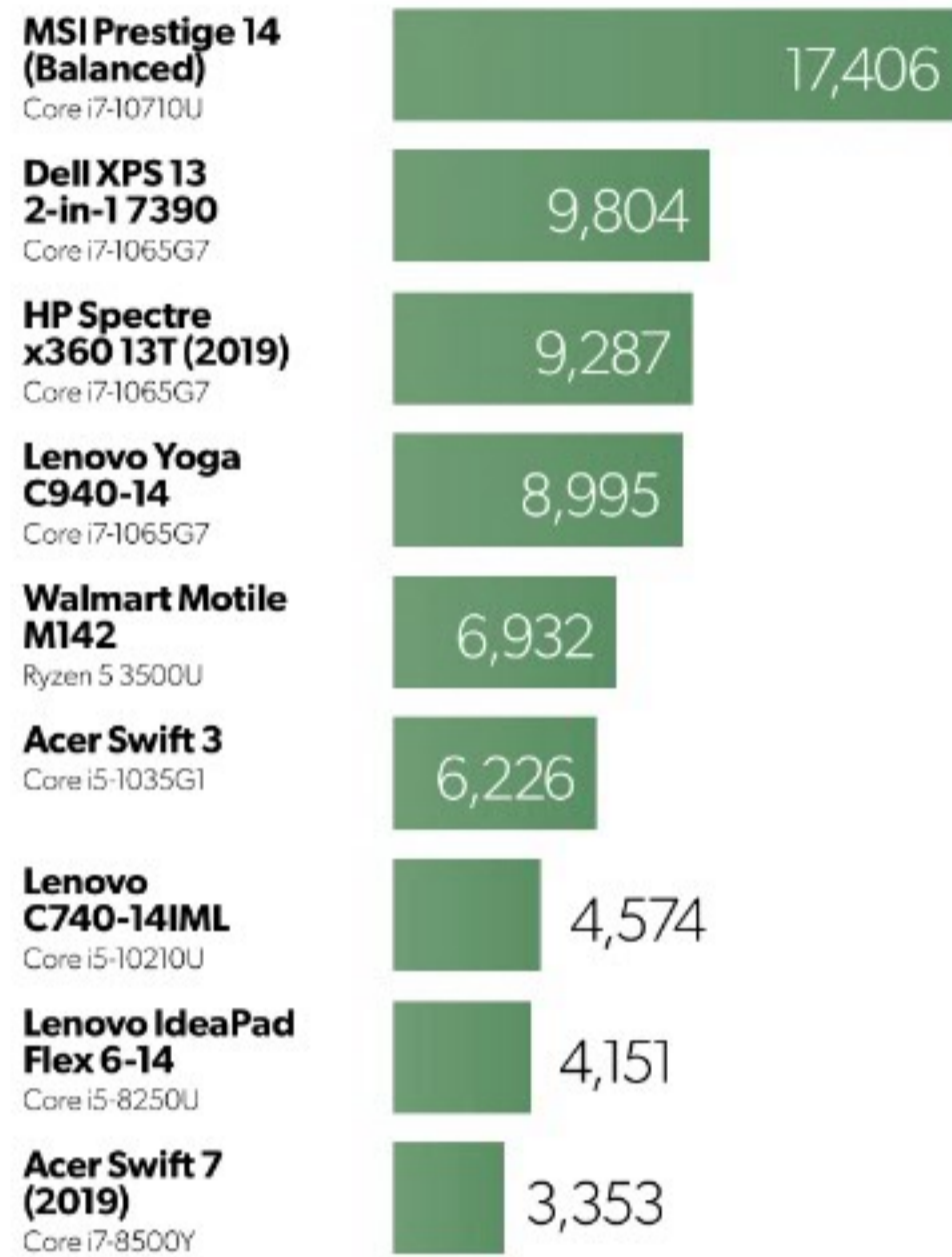
As Cinebench shows, the Yoga C940 14 doesn't rush to ramp up multi-threaded performance.

that matter—but it's way ahead of laptops with weaker chips. (The MSI Prestige 14's excellent performance seems like an anomaly here.)

Cinebench results are slightly murkier, if only because Dell's XPS 13 and MSI's Prestige 14 really stand out on multi-threaded

3DMarkSky Diver 1.0 Overall

Demo mode off



LONGER BARS INDICATE BETTER PERFORMANCE

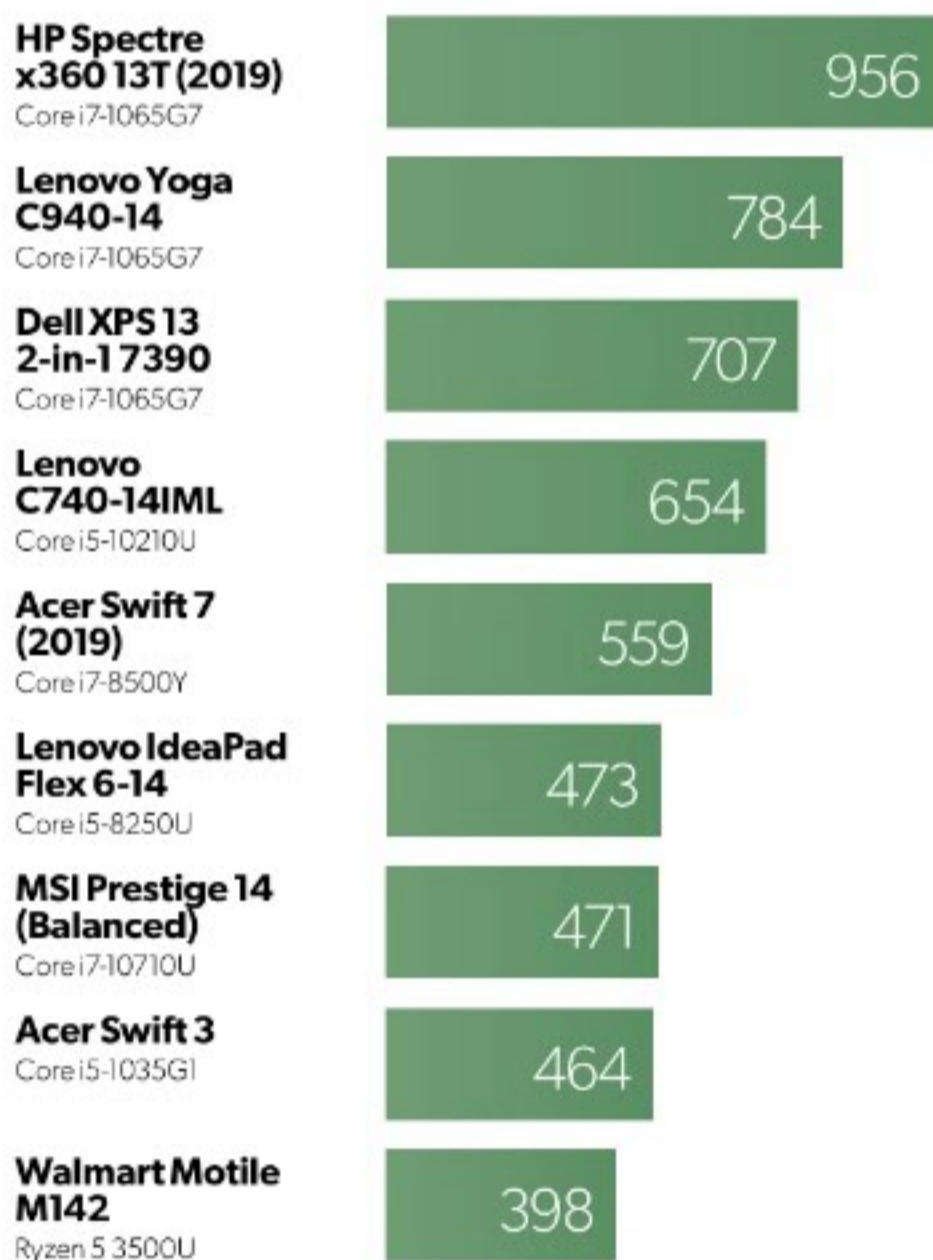
The Iris Pro graphics in Intel's 10th-gen Core-i7 CPU allow you to do a little more gaming than you used to.

performance. One theory: Based on actual use, the Yoga C940 runs cool and quiet nearly all the time, kicking its fans into high gear only under extremely heavy workloads. Given that Cinebench tests short, bursty performance, Lenovo may be slightly more reserved about cranking its CPU so quickly.

While the Lenovo Yoga C940 14 is not a gaming machine, Intel's Iris Plus graphics improvements in 10th-gen CPUs do make a

Battery life (Video rundown)

Minutes



LONGER BARS INDICATE BETTER PERFORMANCE

Battery life is one area where the Lenovo C940 14 makes no compromises.

clear difference. As with other thin-and-light laptops, you can play 2D indie games and older games on this machine without issue. I was also able to get a passable experience in the 3D shooter Deep Rock Galactic (go.pcworld.com/dprc) at 720p resolution with medium-to-low settings, which made me very happy.

Last but not least, there's battery life, where the Lenovo Yoga C940 14 really

shines. Our rundown test involves charging the battery to full, setting the display to 250 nits' brightness and connecting earbuds at medium volume, then looping a video offline. The HP Spectre x360 13t continues to lead strongly, as it has in previous generations, but the Yoga's 60Whr battery at least holds its own with roughly 13 hours.

The Lenovo Yoga C940 14's battery life ties into a broader theme: This laptop isn't a leader in any particular category—except perhaps audio quality—and it doesn't introduce any wild new ideas. But with a bright 14-inch display, strong battery life, and a great keyboard, it's solid in all the ways you'd want a premium 2-in-1 laptop to be. 🔌

Lenovo Yoga C940 14



PROS

- Great battery life without sacrificing screen brightness.
- Keyboard is satisfying to type on.
- Speaker quality is excellent for a laptop.

CONS

- Glass screen is highly reflective.
- Trackpad feels stiff.
- Display colors need some fine-tuning.

BOTTOM LINE

Lenovo's Yoga C940 14 is a 2-in-1 convertible laptop with a good-sized screen, snappy keyboard, and all-day battery life, all of which help it stand out among more famous ultraportable 2-in-1s.

\$1,429



MSI Prestige 14: Workhorse power in a thin-and-light shell

It packs a 6-core Comet Lake U and a GeForce GTX 1650 Max-Q into a 2.8-pound body.

BY GORDON MAH UNG

All laptops are a compromise in design and MSI's Prestige 14 is no different. Even so, there's a lot to love about what is likely the most powerful laptop in its class.

We're not exaggerating. The Prestige 14 packs a 6-core Comet Lake Core i7-10710U along with a GeForce GTX 1650 Max-Q

discrete GPU, all while weighing 2.8 pounds. That's basically the same weight as a Dell XPS 13 7390 (go.pcworld.com/xps7) or HP Spectre x360 13 (go.pcworld.com/hx36), which don't have discrete GPUs.

MSI does all this while also including a 4K screen and a reasonably sized 52-watt-hour battery.

THE COMPROMISE

But as we said, there is compromise to all laptops, and in with Prestige 14, it's the cooling. While competitors might use two fans or beefier heat pipes to keep all of that hardware cool, MSI tasks a single fan and a single heat pipe. That results in loud fan noise when pushed and yes, performance throttling at times.

For many people, the performance and weight of the Prestige 14 will be a godsend. For others, the compromise may be too much. Keep reading to learn more about the pros and cons of the Prestige 14.

SPECS

It's truly impressive that MSI was able to fit so many high-end parts into such a small and slender chassis. Here are the main features:

CPU: Our review model came with a Comet Lake U 6-core Core i7-10710U. Budget-minded folks can opt for the quad-core Core i5-10210U.

RAM: 16GB LPDDR3

Storage: Our unit had the 1TB NVMe SSD, and a 512GB SD is available in the lower-cost model.

Display: 14-inch 4K UHD (3840x2160) "IPS-level" LCD with 100-percent Adobe RGB color space support. We measured it at a blazing 565 nits of brightness. The



MSI's Prestige 14 is arguably the most powerful laptop in its weight class.

lower-cost version features an FHD "IPS-level" panel, rated to hit 100 percent of the sRGB color space, rather than the wider Adobe RGB gamut.

GPU: The Turing-based GeForce GTX 1650 Max-Q is a massive step up over the typical Pascal-based GeForce MX250 chips we see in laptops this size.

Ports: Two Thunderbolt 3, two USB Type A, microSD reader, combo audio jack.



The MSI Prestige 14's single exhaust fan pushes all of the heat out one side of the laptop.



The MSI Prestige 14 (middle) is between an HP Spectre x360 13 (top) and a Dell XPS 15 (bottom).

Size and weight: The laptop is 12.6 x 8.5 x 0.63 inches thick and weighs 2.8 pounds, 3.7 pounds with the included 90-watt USB-C power adapter.

Wireless: MSI uses an Intel AX201 2x2 WiFi 6 controller with support for Bluetooth 5.

Windows Hello: The laptop features both facial and fingerprint biometric readers.

Accessories: In a nice touch, MSI

includes a USB-C dongle with two more USB Type A 5Gbps ports, an SD card reader, a microSD card reader, and a Realtek-based Gigabit ethernet port. Oddly, the dongle has what we believe to be a supplementary cable you stretch to the USB Type A port on the right side of the laptop. We say oddly, because we had no issues running Gigabit ethernet, a mouse, keyboard, and an SD card in the dongle without the optional power

plug. MSI also includes a leather-like case for the laptop.

KEYBOARD, MOUSE AND SPEAKERS

The backlit keyboard action on the Prestige 14 is functional, but under hard typing can sound hollow and bouncy. It's serviceable for most except the picky-



MSI bundles a USB-C dongle with ethernet and USB ports along with a 90 watt USB-C power brick.



The keyboard features a white backlight and is hollow-sounding but functional. The trackpad is glass-smooth and despite its size, did not react to palm presses.

keyboard brigade (you know who you are).

The trackpad is oversized, with one corner occupied by the biometric fingerprint reader.



The speakers are bottom firing and we suspect made of the smallest kazooes ever produced. You can also see the generous portions of vents on the laptop's bottom to aid in cooling.

Despite its extra real estate, the palm rejection was excellent—we did not have issues with our palm causing the cursor to jump around. The surface of the trackpad is beautifully glass-smooth, with effortless finger-gliding.

There's nothing special about the speakers on the Prestige 14. Like most laptop speakers (especially in a design this slender), they sound thin and tinny.

BUILD QUALITY

“Build quality” is difficult to quantify. First, the Prestige 14 feels like a premium laptop, with its brushed aluminum finish and a hinge that lets you flip the lid open with one hand.

To get to this weight though, the shell is a fairly thin gauge. While the chassis feels sturdy, you can flex it by gripping it in each corner and twisting enough to see a slight gap open up at the trackpad. Unless you're preparing for some laptop-twisting competition this isn't a move you'd normally do, but it



Lifting the lid on the MSI Prestige 14 causes the bottom edge of the panel to tilt the laptop upward, increasing airflow.

demonstrates one of the challenges laptop manufacturers face in the quest for ever-thinner and lighter machines.

CPU PERFORMANCE

With so much hardware jammed into such a light laptop, the compromise was always going to be about performance. MSI tries to mitigate this by offering no fewer than four profiles for running the laptop: High Performance, Balanced, Silent, and Super Battery. Performance profiles in laptops are not new, but with the MSI they are critical to getting the most out of the laptop.

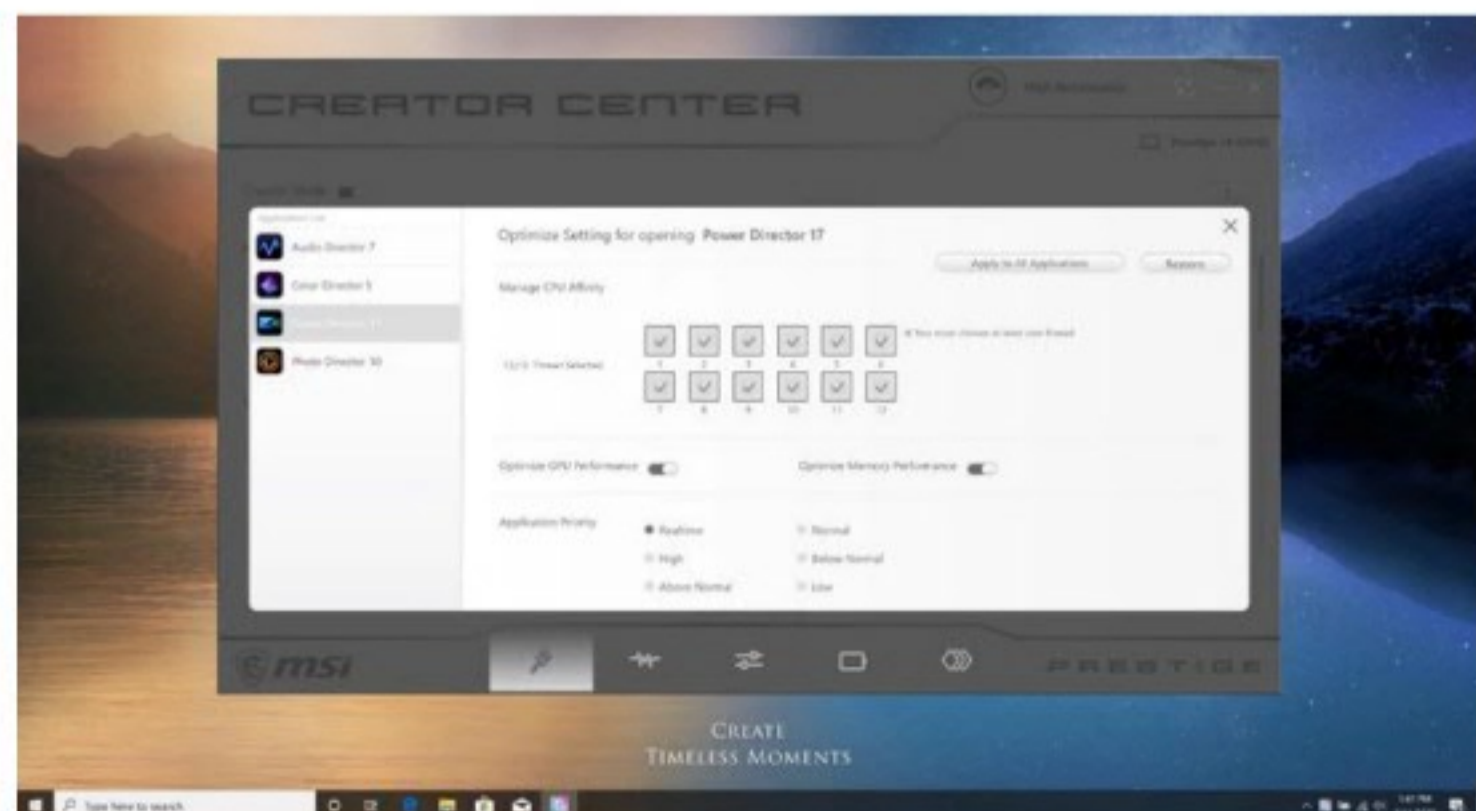
On its default setting of

Balanced, for example, the CPU's performance is essentially limited to that of a quad-core 8th-gen CPU. Set the laptop to its High Performance setting, and the CPU is now basically on a par with competing 6-core Core i7-10710U laptops.

To give you a better idea of just how the Prestige 14 performs, we ran Cinebench R15's multi-threaded test on all of the modes. The worst, not surprisingly, is Super Battery, which limits the

CPU's clock speeds to 400MHz—yes, 400MHz.

Silent lets it clock up to 2.6GHz and is more accurately quiet, rather than "silent." We say that because some may think silent means fans totally off and, uh, silent, but on silent they do spin—quietly. The default Balanced



MSI's Creator Center can automatically tweak approved applications for increased performance by changing affinity, GPU performance, and RAM performance.

Cinebench R15.038 on different power settings

Multi-core performance



LONGER BARS INDICATE BETTER PERFORMANCE

MSI's Prestige 14 features four power profiles as part of its Creator Center, each of which noticeably impacts overall performance.

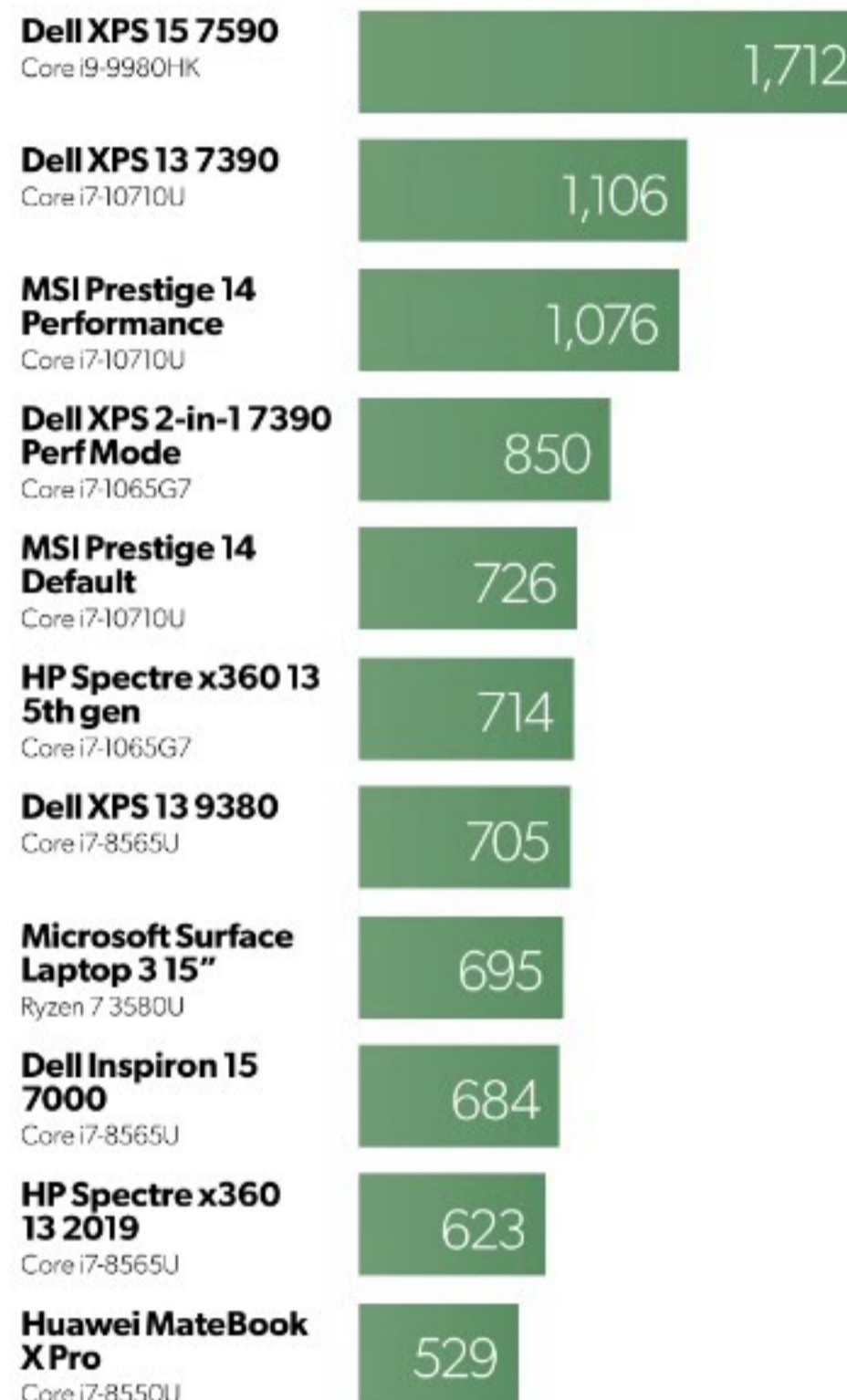
mode is also generally acceptable for fan noise, and a good compromise on CPU performance.

Setting the MS Prestige 14 to High Performance gives you the best performance, and also a near-constant running of the fans at full speed under loads. You can see all the modes compared in the chart below.

We have limited data for comparing the CPU performance to that of other laptops, because we've seen only one other Core i7-10710U laptop. We wouldn't normally include a much heavier, much faster 8-core Core i9-9980HK against laptops in this category, but those who are looking at a laptop with the performance promise of the Prestige 14 should know what they're giving up, and what they're getting, for the weight

Cinebench R15.038

Multi-core performance



LONGER BARS INDICATE BETTER PERFORMANCE

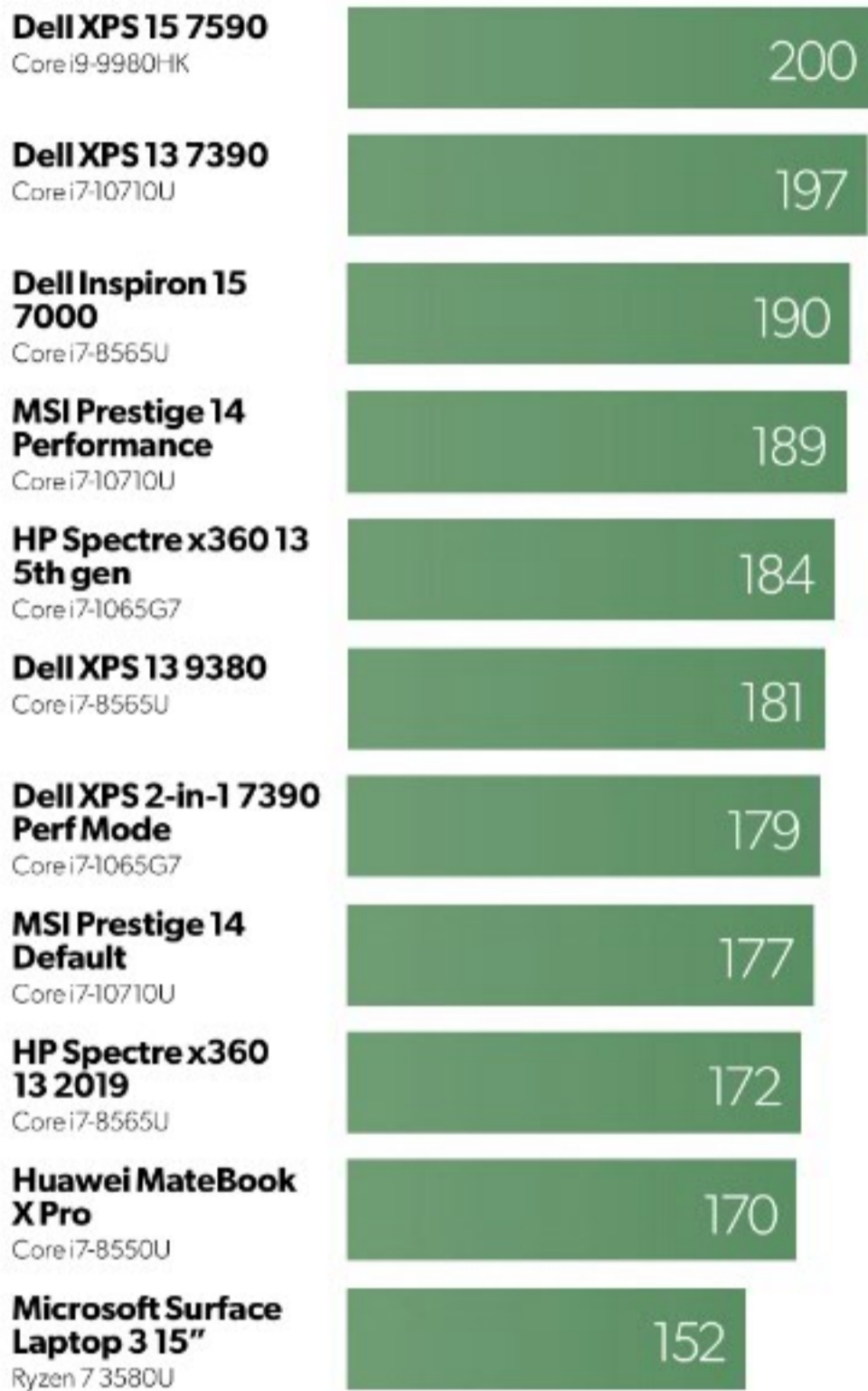
Make judicious use of the power profiles on the Prestige 14 to get the most performance out of the laptop.

differences. We can say performance is on a par with competing designs—when the Prestige 14 is set to High Performance.

We also test laptops using Cinebench R15 and a single thread. This gives us an idea of how well the laptop will handle the more mundane applications you might use. General performance for most tasks on

Cinebench R15.038

Single-core performance



LONGER BARS INDICATE BETTER PERFORMANCE

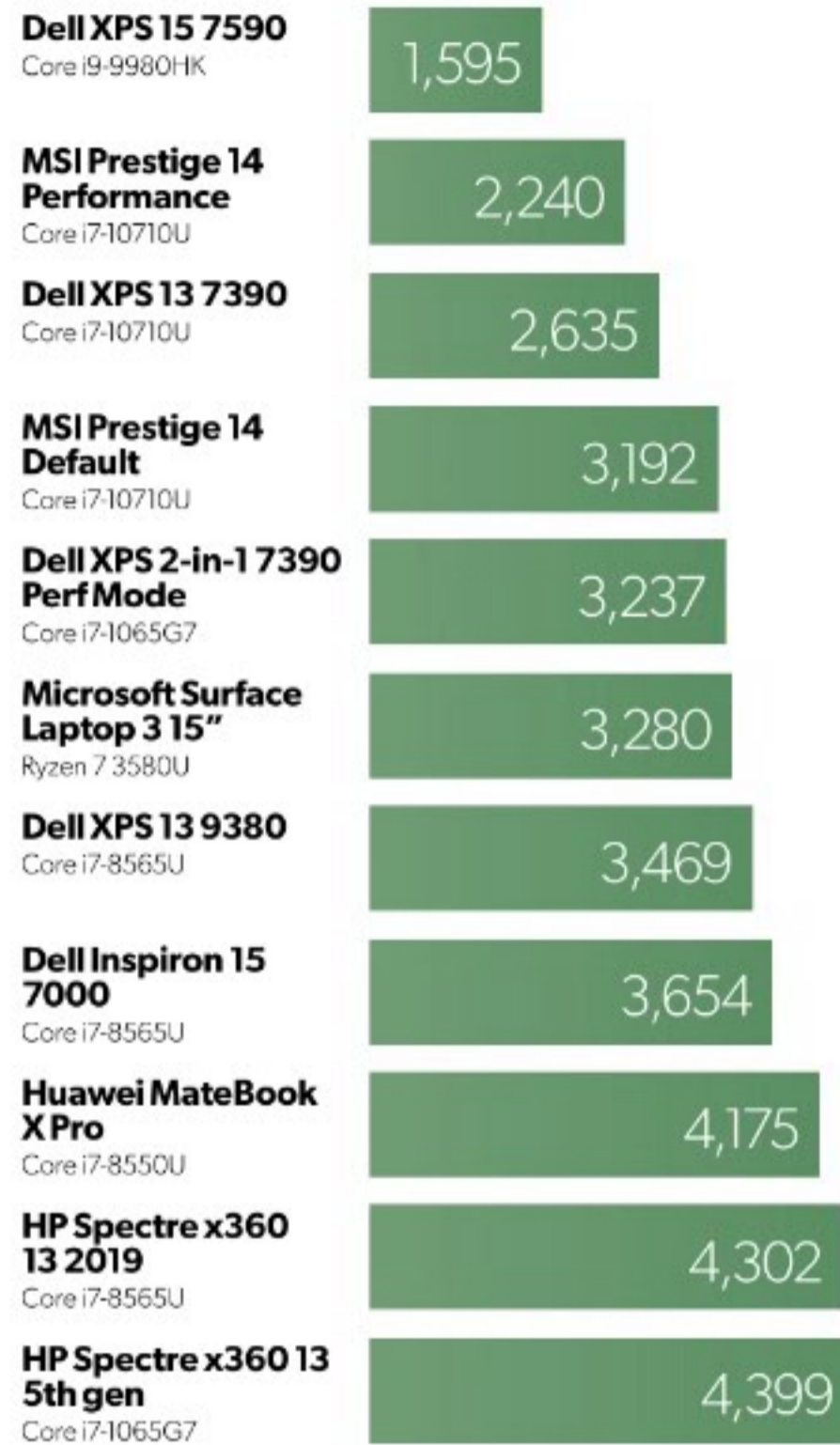
Single-threaded performance of the Prestige 14's Core i7 is fine even when set to its default Balanced mode. Just don't ask about Super Battery mode.

Balanced or High Performance is quite good—most people probably couldn't tell the difference.

We didn't include the performance of the laptop set to its Super Battery mode, because it's off-the-charts underwhelming at a mere 83. Set to Super Battery, the laptop feels like

HandBrake 0.99 Encode

Seconds



SHORTER BARS INDICATE BETTER PERFORMANCE

The Prestige 14 can be quite fast on CPU tasks when set to its High Performance mode.

an Atom-based CPU—sluggish.

One limitation to using Cinebench 15 as a gauge is its short run time. On modern laptop CPUs it might finish in a minute or so, which doesn't properly test performance under a longer load. For that, we use an older version of the free HandBrake utility to convert a

30GB 1080p file using the Android Tablet preset. It's a taxing, multi-threaded test which can take an hour to finish on many laptops. That's long enough that any Turbo Boost capabilities usually are burned off early, as the laptop settles down for a long marathon run.

As you can see, the Prestige 14's performance depends very much on which mode you're in. On its default of Balanced, performance is in the neighborhood of quad-core CPUs from Intel and AMD. Set it to High Performance, it actually outpaces the similarly equipped (by CPU) Dell XPS 13 7390 by a few minutes. So yes, performance of the CPU can be quite impressive when it's working alone.

For the record: Set to Super Battery, the MSI Prestige 14 took 12,472 seconds, or about 207 minutes, to complete the encode.

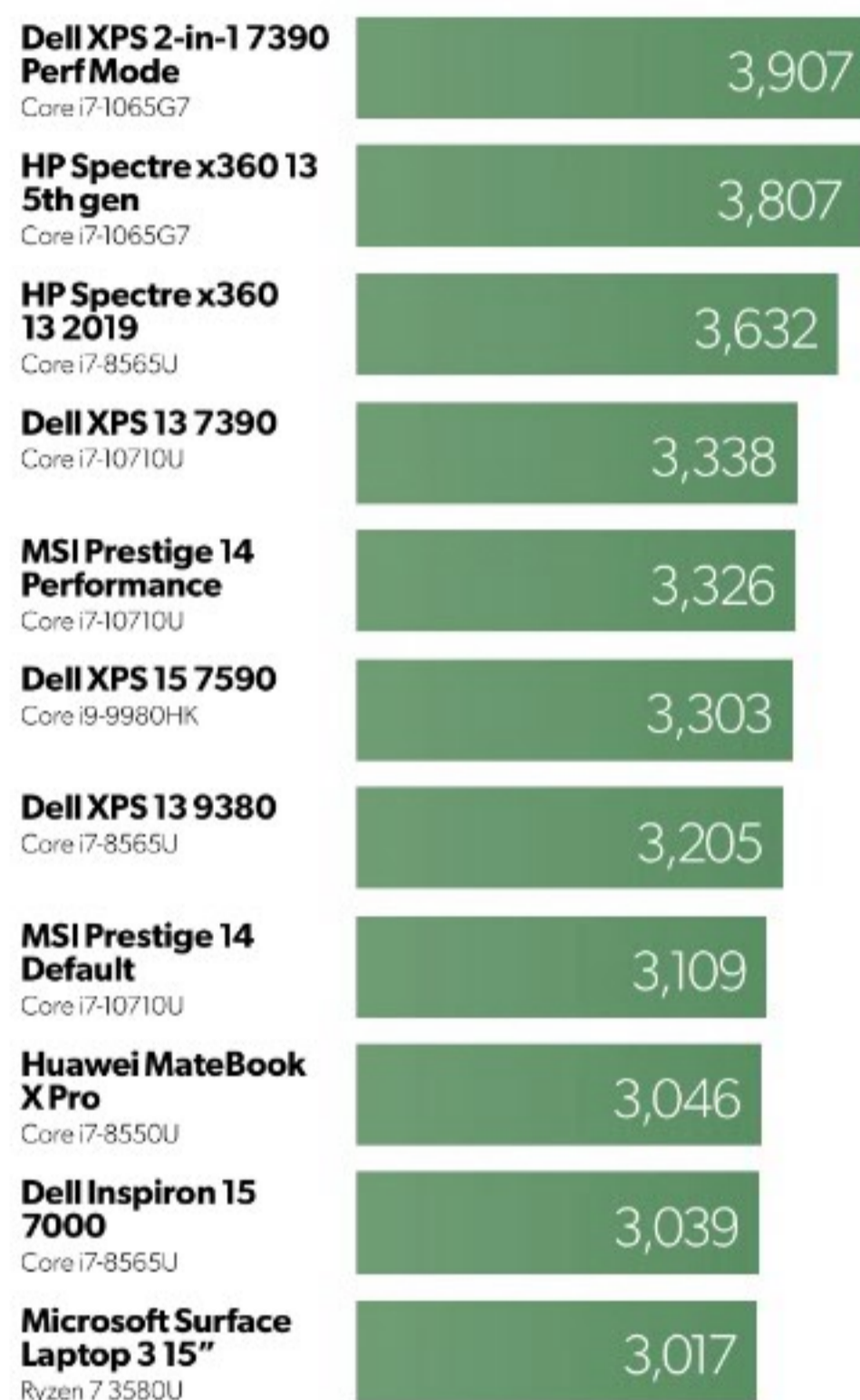
DOES IT EVEN MATTER HOW FAST IT IS?

One thing that you should always keep in mind when buying a PC is to pick the right tool for the job. If you have the need for a 6-core CPU and GTX 1650 GPU in a 2.8-pound laptop, rock on. But if all you really do is open up a few Chrome tabs, Word, and Outlook, and watch Netflix, do you really need a 6-core CPU and GTX 1650? Probably not.

One good measure we have for that is PCMark 8's work test, which simulates everyday productivity tasks. A score of 2,000 or more indicates your PC is up to the job. For

PCMark 8 Work 2.0 Conventional

Native resolution



LONGER BARS INDICATE BETTER PERFORMANCE

For the most part, if all you do is lift Outlook, PowerPoint and Chrome—almost any modern laptop is nearly indistinguishable from another to the normal person.

the most part, it doesn't really matter which laptop you pick for the job, as just about any modern laptop will do the job.

We did, for kicks, throw in the score from the laptop when set to its painfully slow Super Battery mode. The score of 2,086 just barely

squeaks by the 2,000-score threshold for acceptable performance. For reference, it's a little faster than the 1,717 score eked out by an Atom X7-z8700 CPU in a Surface 3. We can tell you that Surface 3 was painfully slow to use, too.

GPU PERFORMANCE

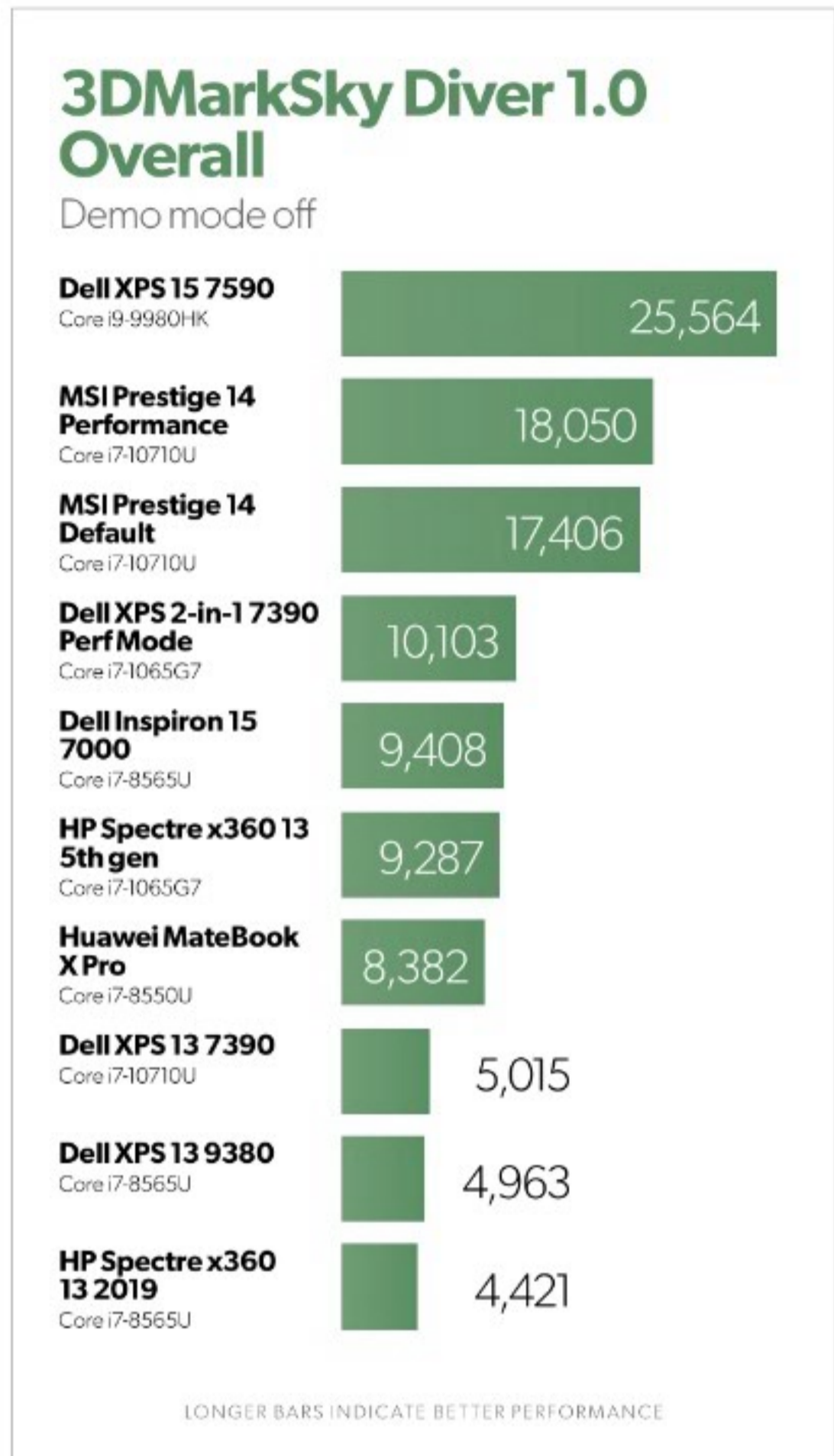
MSI has reiterated many times that although it includes a GeForce GTX 1650 Max-Q in the laptop, it didn't do that for gaming. Still, a discrete GPU should open the door to some play. Using the 3DMark Sky Diver benchmark, the Prestige 14 easily sweeps away all of the older Intel integrated graphics laptops, as well as those based on Intel's newer Ice Lake 10th-gen Core i7-1065G7. It also easily dispatches Nvidia's GeForce MX150 laptops, and AMD's current Ryzen APUs.

For reference, we also include the performance of the GeForce GTX 1650 inside of Dell's larger and heavier XPS 15 7590. As you can see, you do give up a hefty chunk of performance going with the Max-Q GPU—but you save on weight and size, too.

Overall, gaming should mostly be fine if your expectations are moderate.

CPU VS. GPU VS. IGP

If the GeForce GTX 1650 Max-Q isn't for gaming, then why have it? Well, one reason MSI likely picked it over the more practical GeForce MX250 is its capability in encoding. With its newer Turing chip, the



Although not pitched as a gaming laptop, the performance of the GTX 1650 Max-Q is a huge step over that of a GeForce MX150, and both Intel's and AMD's best integrated graphics chips.

GeForce GTX 1650 Max-Q supports Nvidia's NVENC hardware encoder and decoder. The older Pascal-based MX250 GPU doesn't.

With hardware support for NVENC, the Prestige 14 gives you a lot more flexibility than a laptop with an MX250 GPU. To see the

impact on performance we used the newest version of HandBrake and encoded a 4K file using the 1080p 30 fps H.265 preset. As you can see the GTX 1650 comes in a bit faster.

More important is the flexibility.

Application support for Intel's QuickSync and Nvidia's NVENC varies widely, so having it as an option at all is likely more important than just how fast it is.

BATTERY PERFORMANCE

Our last standard benchmark is a battery life test. For that, we loop a 4K video using Windows' Movies&TV app, with the laptop's display brightness set to 250-260 nits, Wi-Fi set to Airplane mode, and a pair of earbuds plugged in with volume set to its midpoint.

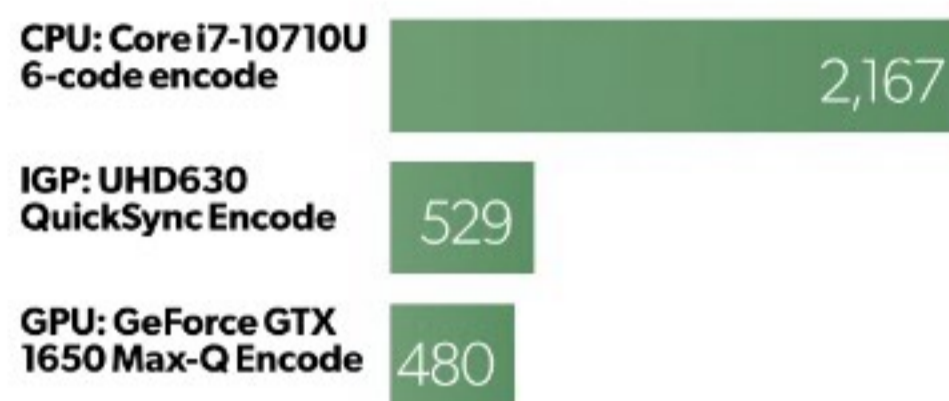
Overall, we'd rate the Prestige 14's run time as adequate. Don't blame the hotshot GPU and CPU; the 4K panel is the most likely culprit.

If you look at the results below, almost every laptop on the bottom of the list features a high-resolution display. Battery size matters, too: While the Dell XPS 15 7590 can produce better results using a 4K panel, it also has a massive 97-watt-hour "gas tank." The standout battery life numbers come from laptops with 1080p FHD screens.

The test is "realistic" because if you're trying to watch a movie on a train, plane or automobile, every minute counts. It's also fair to say that video playback performance on any modern laptop is essentially cruise

HandBrake 1.3.1

Encode of 4K Tears of Steel H.265 to 1080p/30

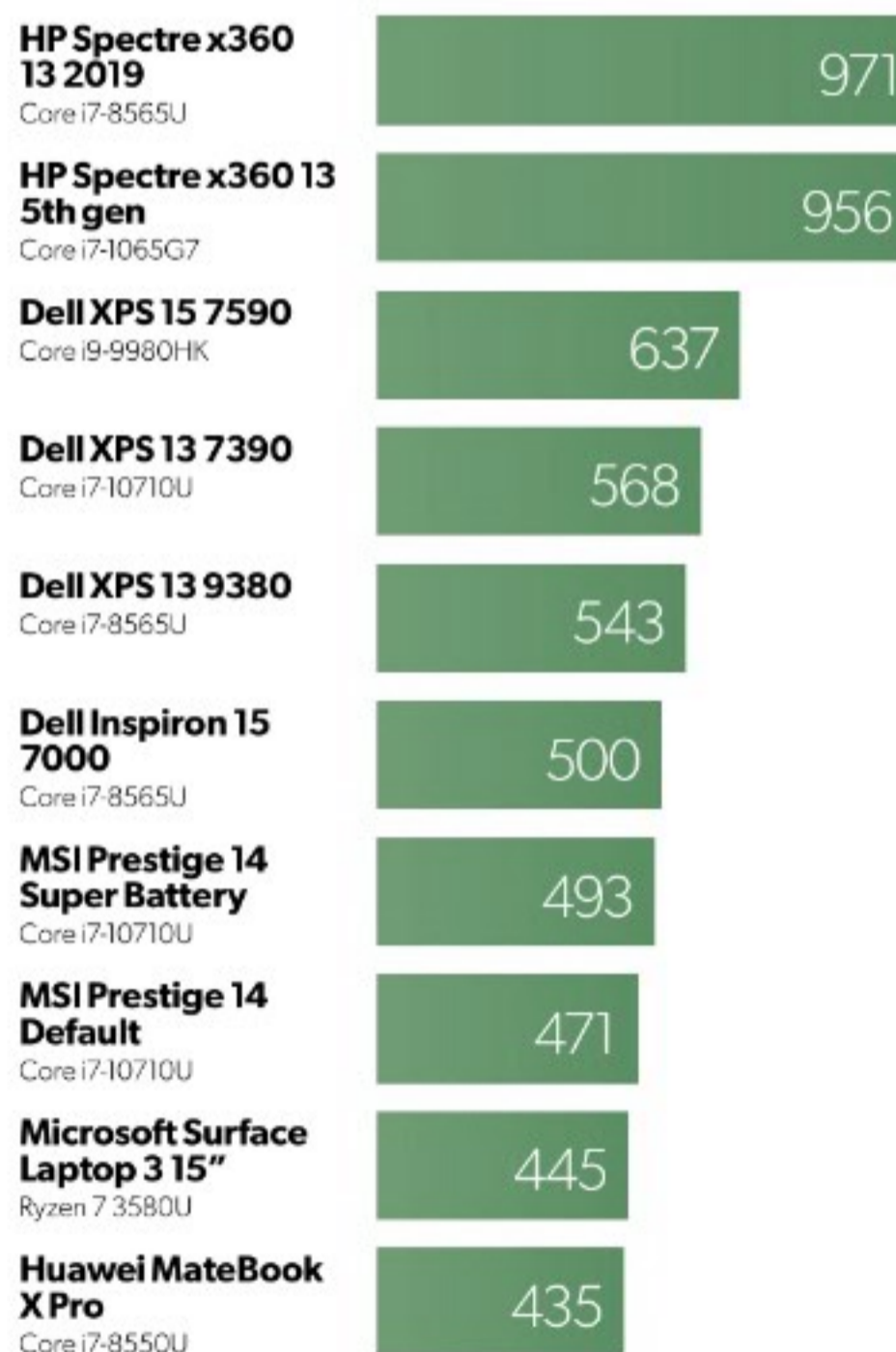


LONGER BARS INDICATE BETTER PERFORMANCE

You have the option of using Intel's QuickSync, Nvidia's NVENC or the CPU cores for encoding.

4K Video Playback Battery

Minutes



LONGER BARS INDICATE BETTER PERFORMANCE

Battery performance on the Prestige 14 is OK to meh—but what do you expect with a 4K panel?

control. Most of the video is handled with dedicated circuits in the integrated graphics, so the CPU and the accompanying GPU should be asleep and using minimal power.

If you were to do something much more battery-intensive like browse the web (yes, that's a battery drain) or run Photoshop, you can probably lop off a third to half of the battery life. If you're going to encode a video or push the GPU hard—you probably shouldn't expect more than an hour to an hour and a half at best.

MSI could have solved this, of course, by using a larger battery. But then the laptop wouldn't be as light.

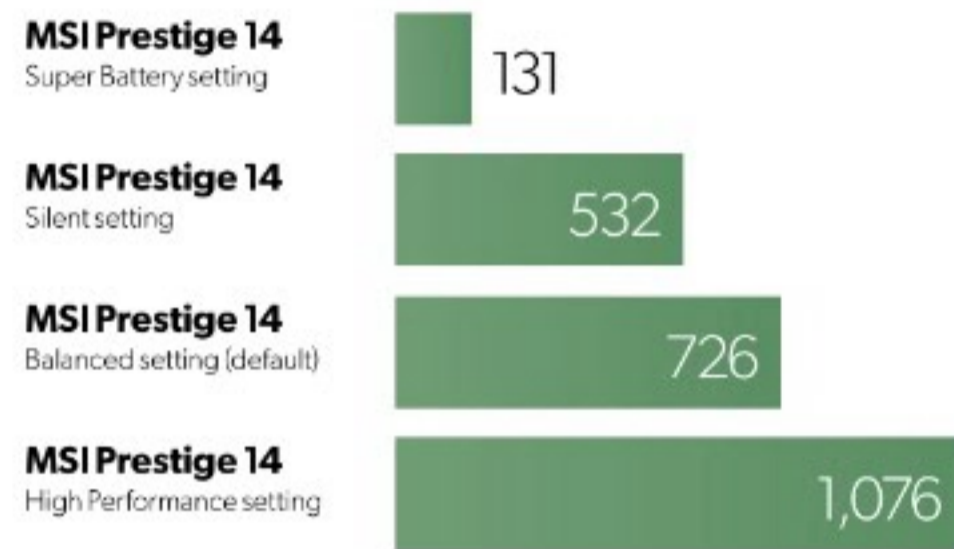
THERMAL THROTTLING

The testing above is isolated to either the CPU or the GPU. For most functions, that's fine. But for the times when you load up both chips, you could encounter some new problems. YouTube tech star Dave Lee ran into some with his Prestige 14 unit (go.pcworld.com/dvle), and we've seen this with Dell's XPS 15 under long simultaneous workloads (go.pcworld.com/dx75). No surprise, our Prestige 14 hits this wall, too.

For the first test, we ran OpenCL Luxmark 3 with the Luxball model. The test uses Open Compute Language to ray-trace an image. OpenCL can be run on CPUs and GPUs, so for the first test, we run OpenCL on just the Prestige 14's GeForce GTX 1650 Max-Q. We

Cinebench R15.038 on different power settings

Multi-core performance



LONGER BARS INDICATE BETTER PERFORMANCE

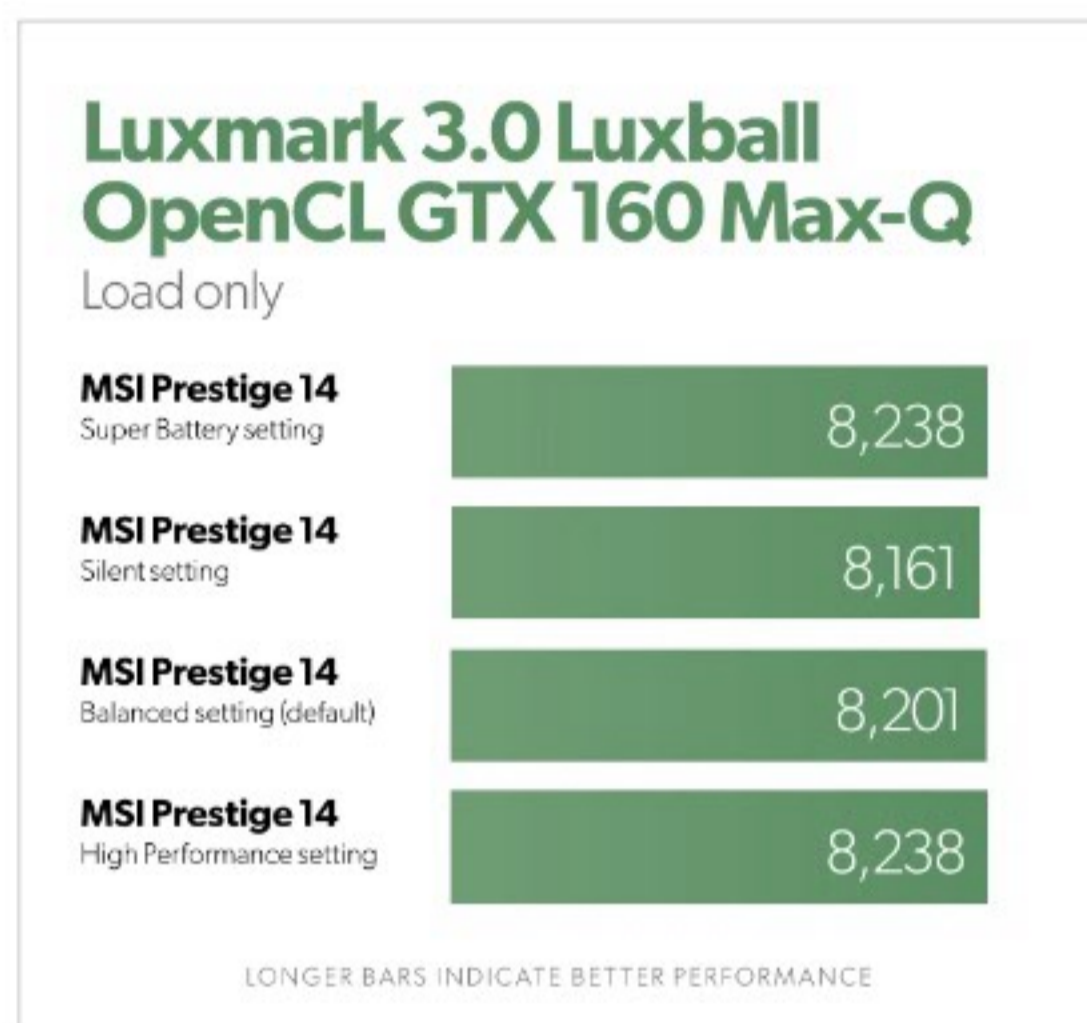
MSI's Prestige 14 features four power profiles as part of its Creator Center, and each greatly impacts overall performance.

also run the test using all four of the available power presets for the laptop. It's the first chart we ran, and here it is again.

As you can see, there are huge CPU performance hits depending on the profile selected on the Prestige 14. But what about the GPU? As you can see in the chart below, even when the CPU is basically locked at 400MHz, this GPU-based OpenCL test is essentially a tie.

This second result tells us MSI's power profiles don't gate GPU clocks as part of its power savings plan. It also confirms that LuxMark properly doesn't care how fast the CPU is running, because this particular test is supposed to be a GPU OpenCL load.

What happens when you stress both the



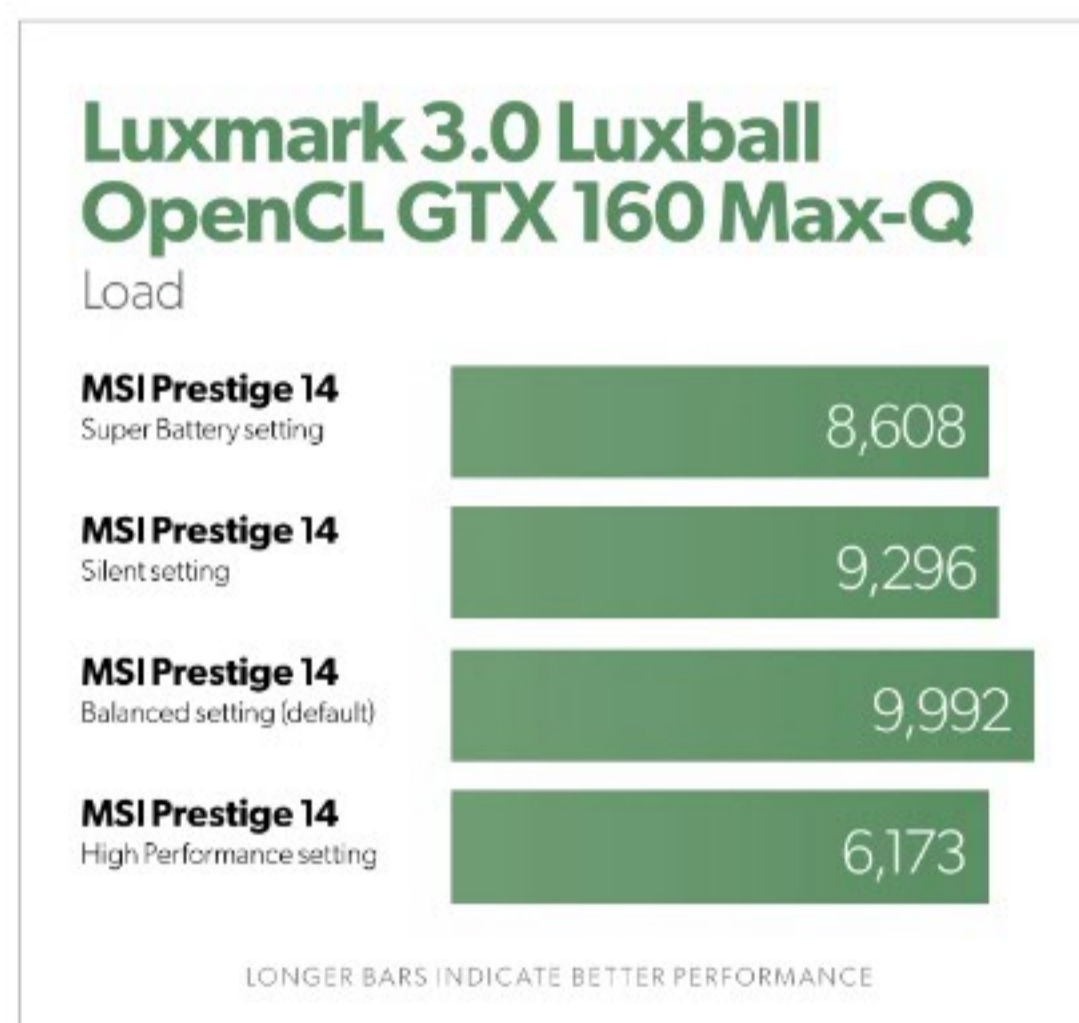
Using just the GPU on the Prestige 14, the performance is essentially the same on this OpenCL test when limited to the GPU.

GPU and CPU at the same time? We tasked the Prestige 14 with the same OpenCL load, adding the CPU's x86 cores too. Performance improves, even on the 400MHz Super Battery mode.

Everything is fine until you set the laptop to High Performance. Rather than scaling up the performance, the laptop hits a wall and actually drops below using just the GPU alone.

Why? We believe that loading up the CPU and the GPU simultaneously with such a heavy workload simply pushes the laptop beyond its cooling or power limits, which causes the slowdown.

During Luxmark, the GPU's clock speeds alone would stick to 1,500MHz for most of



You can see what happens when you push the MSI Prestige 14's CPU and GPU very hard simultaneously in Luxmark 3.0. Rather than seeing a higher score in High Performance mode, we actually see its score plummet.

the run. With the CPU also putting out heat, the GPU's clock speeds drop to 900MHz. That's enough to drop overall performance even with both working.

BOTTOM LINE

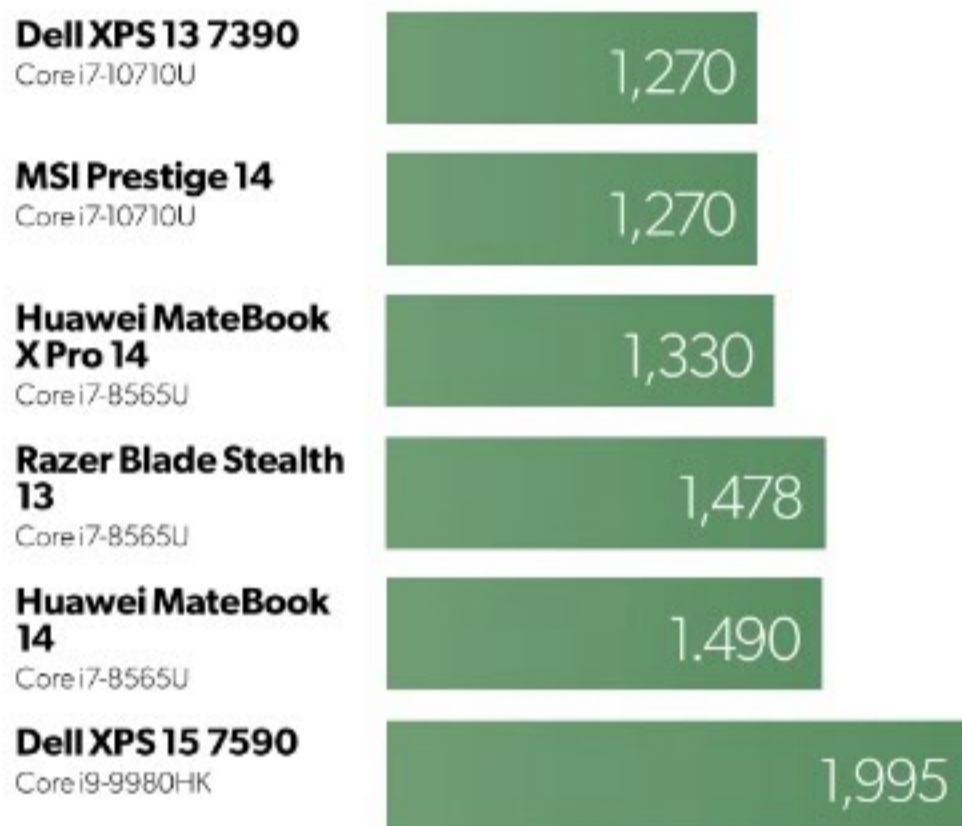
With so many layers of nuance, MSI's Prestige 14 is not an easy laptop to review. We basically think the main fact that sets the Prestige 14 apart from the pack is its weight and the potential performance of the components inside.

To help think about this, we made a chart with the weight of the Prestige 14 against those of other comparable laptops with discrete GPUs.

For reference, we also include a Dell XPS

Thin and light dGPU laptops compared

Grams



454 GRAMS = 1 LBS.

Though it has compromises, the MSI Prestige 14 essentially weighs as much as an XPS 13 while offering a GPU typically found in an XPS 15.

13 7390, which has a 4K touch screen. The 4K screen and touch adds a few ounces on the Dell but it has a 6-core CPU with only integrated graphics. Huawei's MateBook X Pro is similar in screen size, and heavier—but it tops out with an 8th-gen 4-core CPU and GeForce MX250 graphics.

The only real natural competitor to the Prestige 14 is the Razer Blade Stealth 13, which features the same GTX 1650 GPU and an Intel Ice Lake Core i7-1065G7 GPU. Although we haven't reviewed the latest Razer Blade Stealth 13, other reviewers say it's faster than the Prestige 14 when both CPU and GPU are working heavily. It's also heavier

by almost half a pound, mostly due to the thicker aluminum body, and the additional heat pipes and fans.

Of course, you could just step up to a 15.6-inch laptop, which would get you far more CPU and GPU performance—at the cost of a lot more weight.

So, the question you should ask yourself is how much every ounce matters to you. If you must have 6 cores and a GTX 1650 in as light a package as possible—and you're willing to accept the limitation of the platform—we can heartily recommend the MSI Prestige 14. If, however, you're ticked off by giving up any performance for "just" another 8 ounces, then you might want to look elsewhere.

But let's make sure to say it's still fairly amazing to get this much hardware in this light of a laptop. 🖱️

MSI Prestige 14



PROS

- Six-core Core i7-10710U and GeForce GTX 1650 Max-Q GPU.
- Very bright, 100-percent Adobe RGB panel.
- Amazingly light considering the CPU and GPU inside.

CONS

- Chassis can flex.
- Can hit performance wall under heavy CPU and GPU loads.
- Speakers sound like Kazoos.

BOTTOM LINE

MSI's Prestige 14 offers an impressive amount of hardware in a laptop weighing less than 3 pounds.

\$1,699



SanDisk Extreme Pro Portable SSD: Fast, tough and reasonably priced

The IP55 rating means it can fend off water and dust. **BY JON L. JACOBI**



Well, that didn't take long. A few short weeks after reviewing the Samsung T7 (go.pcworld.com/t7sd), SanDisk's Extreme Portable Pro SSD (1TB) showed up at our door and easily surpassed its rival for the top-performing USB 3.1 Gen 2 drive. SanDisk's drive doesn't offer the T7's handy and fun

fingerprint security, but it's about the same price and offers software-based password protection if security is a concern.

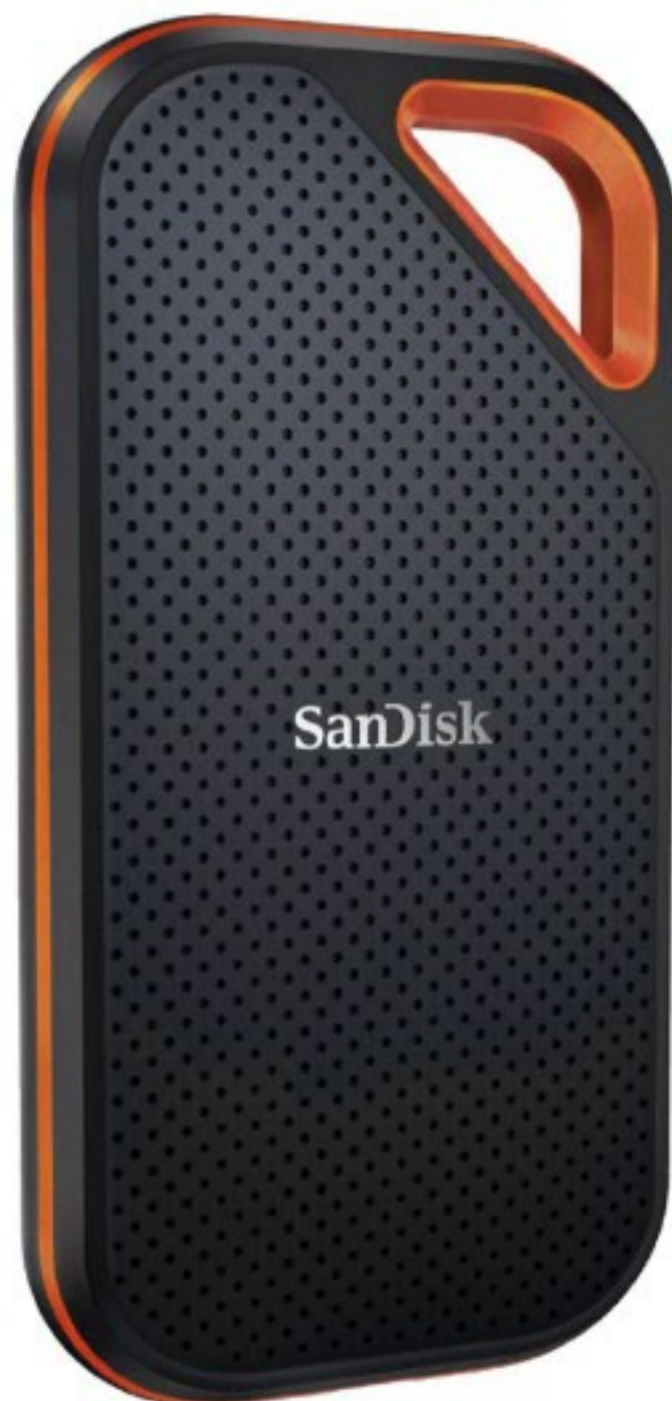
DESIGN AND FEATURES

The Extreme Pro Portable SSD is a bit larger than the previous iteration (go.pcworld.com/pitr), measuring approximately 0.4 x 2.25 x

4.34 inches, but it's still compact enough to reside comfortably in a shirt pocket. Unlike the Samsung T7 competition, there's an attachment point (a very large one!) for a lanyard or key ring.

The Extreme Pro Portable is designed with an aluminum chassis and ABS top, and is IP55-rated (Ingress Protection), meaning it will fend off dust and low-pressure water. The ingress weak spot with storage devices has historically been the connection port, but Type-C ports, such as the one on the Extreme Pro, are far better sealed than previous types.

Note that the IP rating indicates survivability when disconnected. With electricity flowing through a cable connection, fluid can short cable pins,



SanDisk's Extreme Pro Portable SSD has an aluminum (the orange parts) chassis with a dimpled ABS cover.

causing electronic damage.

The Extreme Pro Portable SSD lacks the fingerprint reader that graces the Samsung T7; however, it does come with SanDisk's own SecureAccess software security solution. It provides password protection for the drive's 256-bit AES encryption (when enabled), though it must, of course, be installed on any device or PC from which you wish to access your data—not as convenient. Neither drive is FIPS 140-2 certified (Federal Information Processing Standards security), which will limit enterprise interest and rule it out for conforming government agencies.

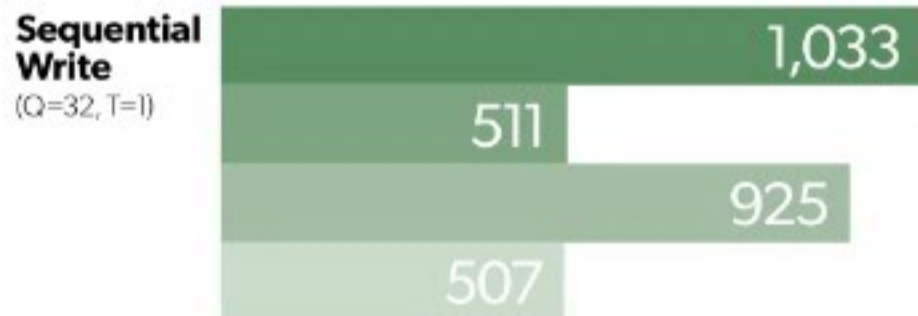
Why is the Extreme Pro Portable so fast? While it does transfer data via speedy USB 3.1 Gen 2 (10 gigabits per second), it's likely far more important that the internal storage uses the NVMe communications standard (go.pcworld.com/nvms), instead of the slower SATA standard used by its Extreme Portable SSD predecessor (go.pcworld.com/pitr). Beyond that, SanDisk offered no details, and I didn't want to destroy the drive to find out what's inside.

The WD store (go.pcworld.com/wdst) (SanDisk's parent company) sells the Extreme Pro Portable in three sizes: 500GB for \$120 currently, 1TB for \$230 currently (the size we tested), and 2TB for \$430 currently. We found the same prices on major online sites: 500GB for \$120 on Amazon (go.pcworld.com/500g) and 1TB for \$230 on Amazon (go.pcworld.com/b1tb). The five-year warranty is in effect no matter where you buy.

CrystalMark 6

MBps

■ SanDisk Extreme Portable Pro SSD ■ SanDisk Extreme Portable SSD
■ Samsung T7 ■ Samsung T5



LONGER BARS INDICATE BETTER PERFORMANCE

In CrystalDiskMark, the Extreme Pro was rated as far faster than its predecessor and Samsung's T5, but only marginally faster than Samsung's newer T7. Longer bars are better.

PERFORMANCE

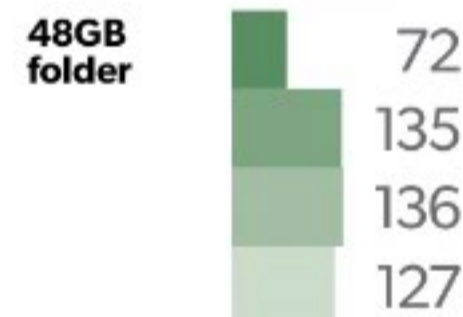
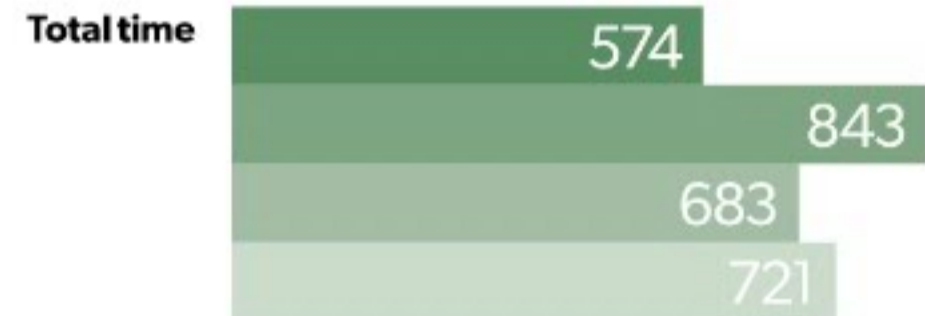
SanDisk squeezed a lot more performance across the board from the Pro version, so much so that it's the fastest USB SSD that we've seen to date. Burst performance is roughly on a par with the Samsung T7's, but it blows that drive out of the water during long writes. All the results shown below are from the 1TB version SanDisk sent us.

CrystalDiskMark 6 rated the Extreme Pro and Samsung T7 drives nearly equal, but as I just noted, real-world testing revealed a distinct advantage for the Extreme Pro during long writes. In the

48GB copies

Seconds

■ SanDisk Extreme Portable Pro SSD ■ SanDisk Extreme Portable SSD
■ Samsung T7 ■ Samsung T5

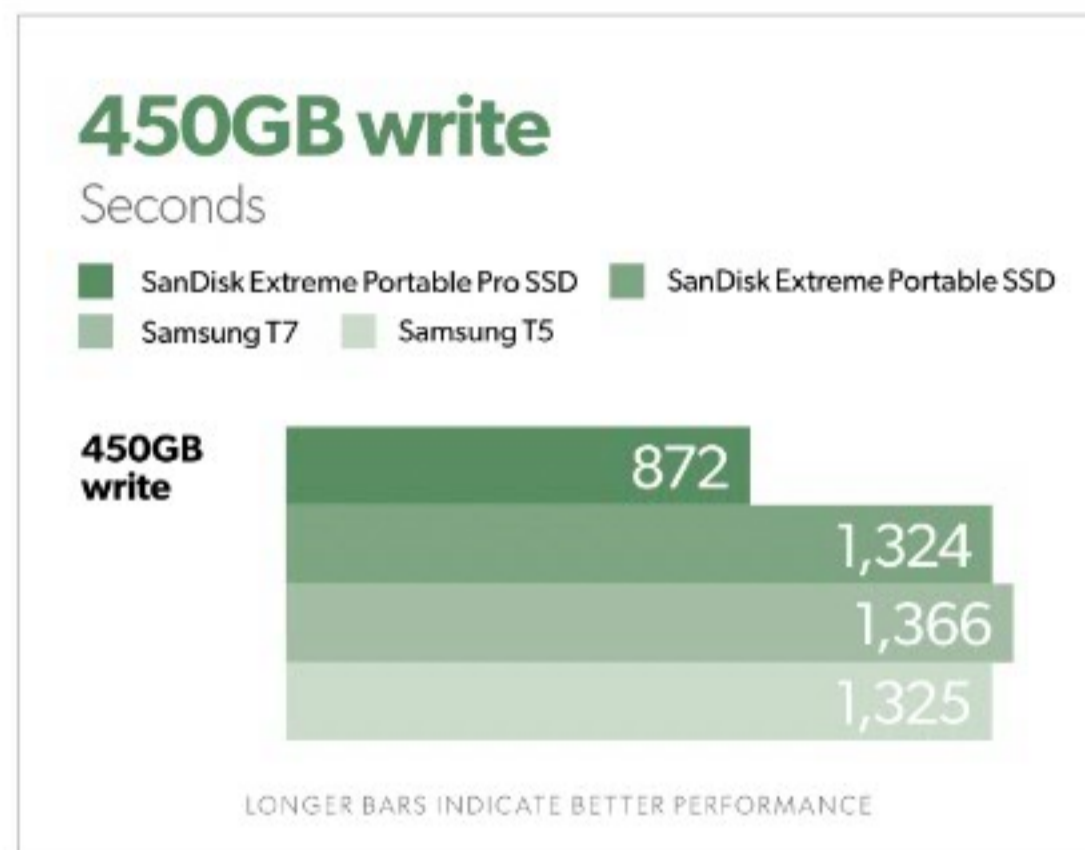


SHORTER BARS INDICATE BETTER PERFORMANCE

Though it was slightly slower than Samsung T7's reading, the Extreme Pro Portable blasted its rival when it came to writing.

48GB write tests shown below, this sway was apparent...

Those are eye-opening results, however, check out the 450GB write



The Pro version of the Extreme Portable rules when it comes to long sustained writes. No other USB SSD we've tested even comes close.

numbers below, where the advantage became overwhelming.

The primary reason for the landslide victory was that the Extreme Pro Portable wrote at a relatively steady 600MBps or so, while the T7 started at over 500MBps and dropped to around 300MBps when it ran out of cache. That occurred at around 4 percent of total capacity, or the 20GB mark with the 500GB T7 we tested. More capacious models of the T7 will run out of cache later in the process, narrowing but not eliminating the margin of defeat.

The Samsung T7 is a slightly faster reader, but being a distant second writing really hurt its conglomerate score in the 48GB tests. How much the slow writing will affect you depends on how you use your drive. For small amounts of data, the difference won't tell. However, the time you'll save on writes with the Extreme Pro

Portable will tell over the long haul.

Testing is performed on Windows 10, 64-bit running on a Core i7-5820K/Asus X99 Deluxe system with four 16GB Kingston 2666MHz DDR4 modules, a Zotac (Nvidia) GT 710 1GB x2 PCIe graphics card, and an Asmedia ASM2142 USB 3.1 Gen 2 (10Gbps) card. Also on board are a Gigabyte GC-Alpine Thunderbolt 3 card and Softperfect's Ramdisk 3.4.6, which is used for the 48GB read and write tests.

BOTTOM LINE

The Sandisk Extreme Pro Portable SSD is faster and only a bit larger than the Samsung T7. I admit that I enjoy the Samsung T7's fingerprint swiper, but otherwise, the Sandisk Extreme Portable Pro is the portable USB SSD you want when you're dealing with large amounts of data. 🚀

SanDisk Extreme Pro Portable SSD



PROS

- Overall fastest USB SSD currently available.
- Relatively affordable.
- IP55 rated against dust and mild streams of water.

CONS

- Slightly slower reading files than Samsung's T7.

BOTTOM LINE

The SanDisk Extreme Pro Portable SSD is the fastest writer we've seen by far. It's IP55-rated to fend off dust and water, affordable for its ilk, and we even like the looks. Unless you want the fingerprint security offered by its Samsung T7 rival, this is the drive.

\$229

NordVPN: Incredible speeds, and built for power users and newbies

NordVPN has excellent performance, and a set of features that will appeal to both novices and power users. Still, we'd like to see more transparency from the company. **BY IAN PAUL**



NordVPN

If there's one word that can describe NordVPN it has to be "impressive." This VPN offers incredible speeds, a high country and server count, and an excellent selection of VPN protocols, including Wireguard. It's also removing the hard drives from its servers to increase privacy and security. And in its aim to be more than just a VPN, it's expanding its data-privacy options to include a password manager and secure file storage. Indeed, it's only real shortcoming is its lack of transparency

regarding company ownership.

When you first open NordVPN on Windows, you get a very user-friendly interface. The left-hand rail includes a list of all available countries in alphabetical order. This section also has quick links to NordVPN's specialty servers, such as dedicated IP (for an extra cost), double-hop VPN, Onion over VPN, and P2P file-sharing servers. The rest of the app window contains a map that you can drag around to select a specific country.

Both the list and the map let you quickly

NORDVPN IN BRIEF

P2P allowed	Yes. Dedicated servers
Business location	Panama
Number of servers	5,500+
Number of country locations	57
Cost	\$84 (billed annually)
VPN Protocol	OpenVPN (default)
Data encryption	AES-256_GCM
Data authentication	TLS 1.2 with 4096-bit DH
Handshake encryption	SHA-512

decide where to connect. Two interface options are a bit redundant, but it makes space for both power users and novices.

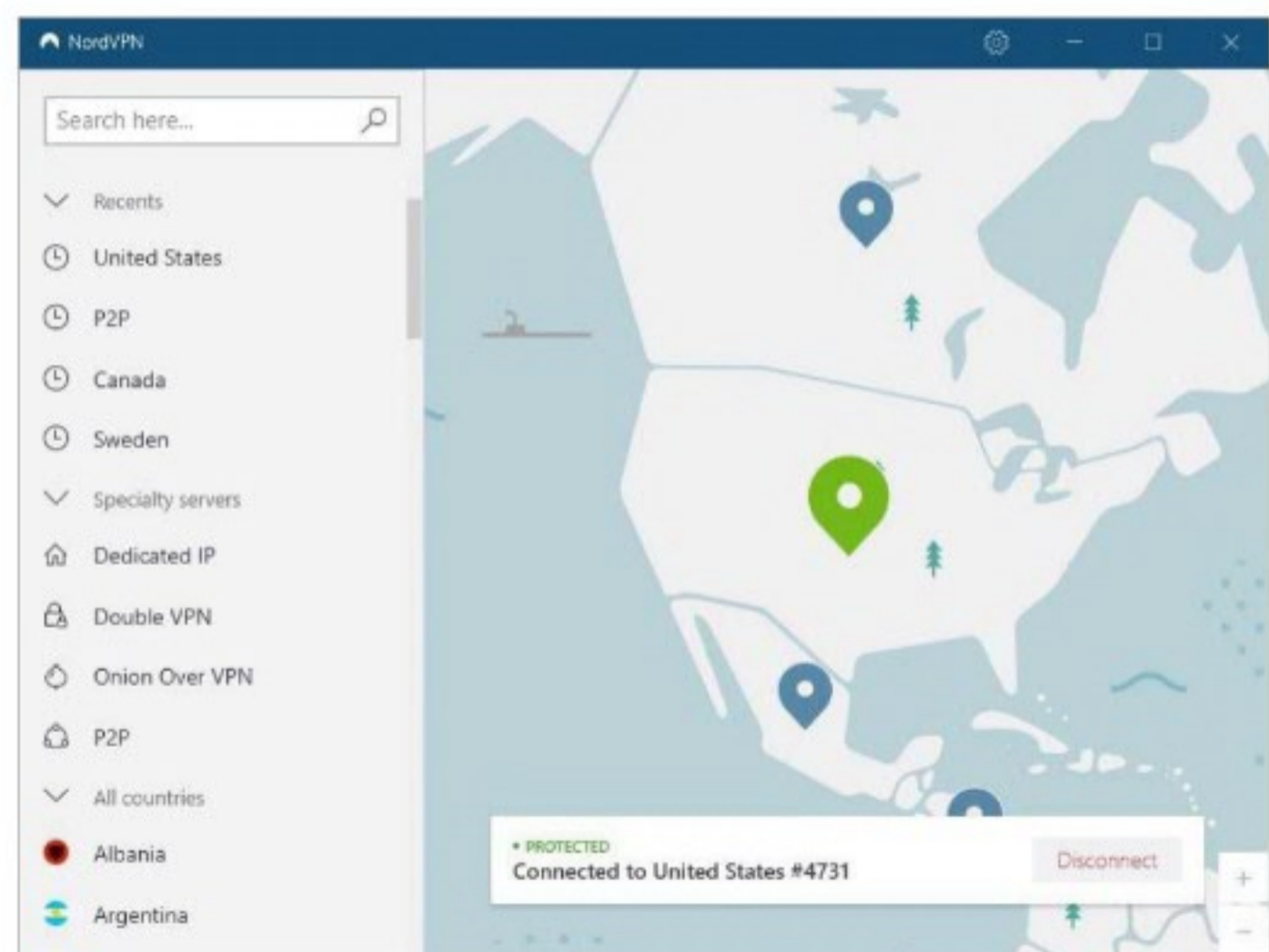
The list in the left-hand rail is where most of the power user advantages reside. Hover over a country listing and click on the three dots to the left of the country name. This reveals a pop-up window where you can choose the region of a country (if applicable), as well as any of the servers listed in that region.

If you choose to connect to the U.S., for example, you'd pick the "region," which is really one of a number of major cities such as New York, Los Angeles, Chicago, Denver, or Phoenix. Then you can pick any of the servers listed there, and each server in the list displays its current load. If you don't want to drill down that deep, NordVPN

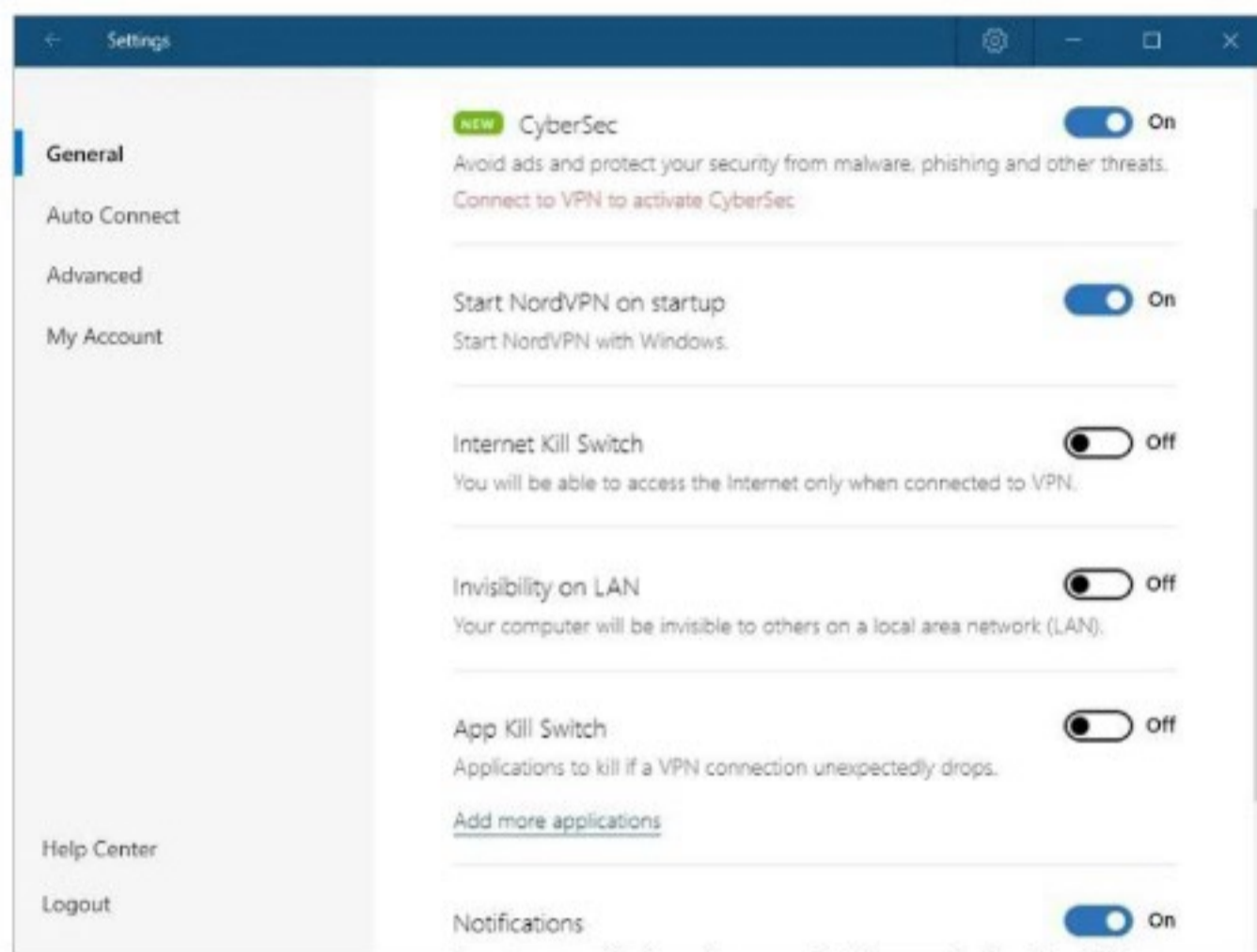
picks the fastest connection in the country of your choice.

The first time you use NordVPN it asks if you want to turn on the CyberSec feature. CyberSec blocks ads and protects against malware and phishing. If you ever want to turn it off you can do so in Settings > General. This section also has an internet kill switch, and an app kill switch. The latter stops any app from connecting to the internet if an active VPN connection drops, while the former does that for the entire PC.

There are also options to go invisible on the local area network, and a specialized auto-connect feature. Auto-connect not only connects you to the VPN automatically but lets you customize that connection. You can, for example automatically connect to a double VPN or a specific country. You can also choose whether to connect whenever the app starts or only on "insecure" wireless. The ability to



NordVPN with an active connection.



NordVPN's general settings.

customize the automated connection is an awesome little power user feature that you don't often see on other VPNs.

Finally, you can set your own DNS if you like, as well as use obfuscated servers if you're trying to use NordVPN in a place that blocks it.

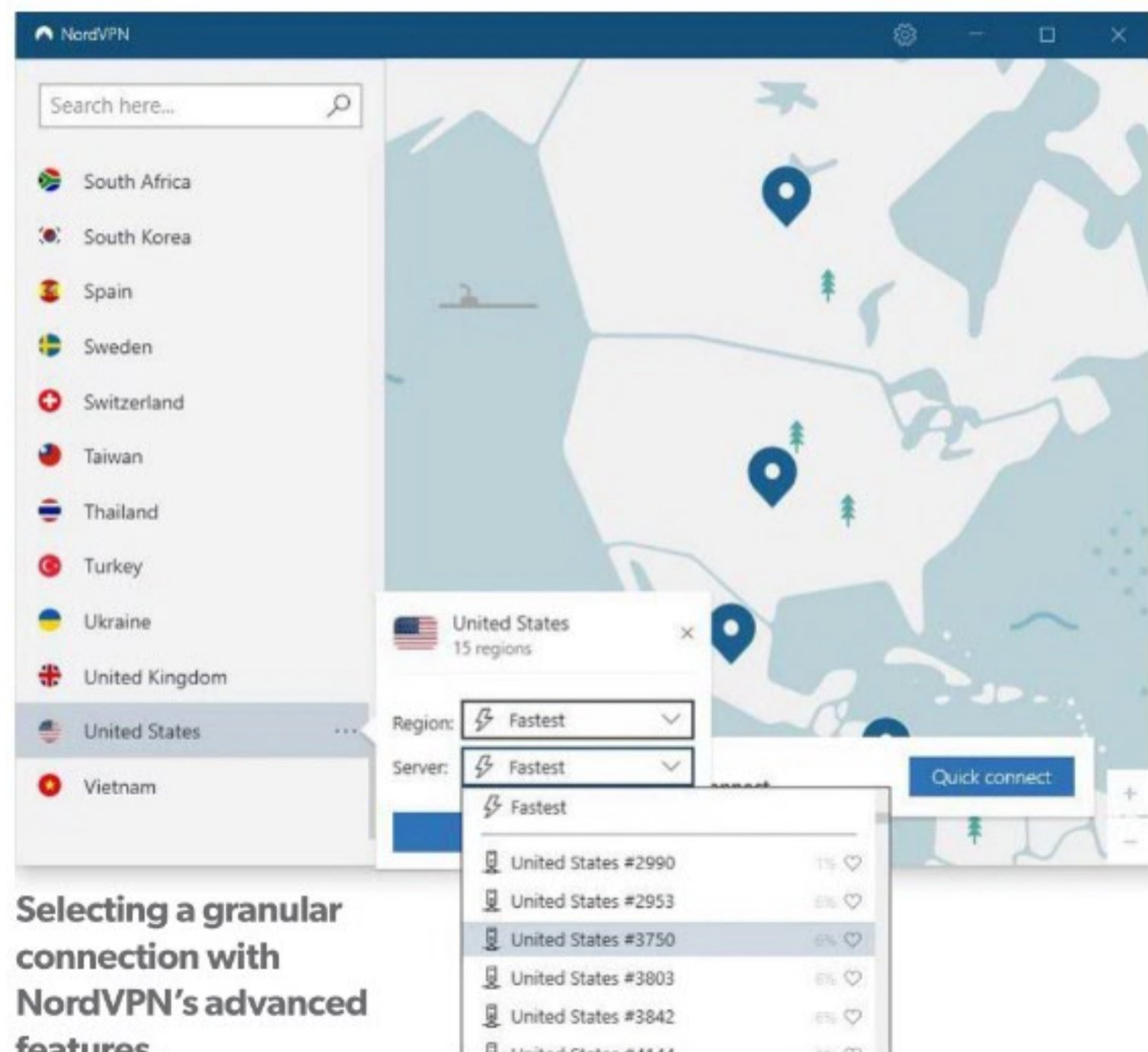
NordVPN advertises that it's compatible with Netflix, but in our experience it was hit or miss this time around. It seems the long arm of Netflix enforcement has, at least temporarily, caught up with NordVPN. I asked the company about this and a representative said there can be temporary issues due to the eternal cat-and-mouse game between VPNs and Netflix.

PRIVACY, ANONYMITY, AND TRUST

To create an account, NordVPN requires an email address. It accepts payments via credit card, Amazon Pay, and cryptocurrencies. NordVPN costs \$84 per year, or you can get two years for \$120, or three for \$125.64.

NordVPN is ostensibly based in Panama, and it appears there are a few employees who actually live there, according to LinkedIn listings

(go.pcworld.com/lkls). The rest of the team works remotely from various countries around the world.



Selecting a granular connection with NordVPN's advanced features.

NordVPN is owned by Tefincom S.A., which is a company based in Cyprus. Tefincom doesn't have a website, and may be little more than a shell. Multiple reference websites, including a whois listing, name a Marios Papaloizou as a representative for Tefincom. I asked NordVPN to confirm if Papaloizou was a founder or owner of NordVPN. The company said Papaloizou is a former director for Tefincom but is neither a founder nor the owner of NordVPN.

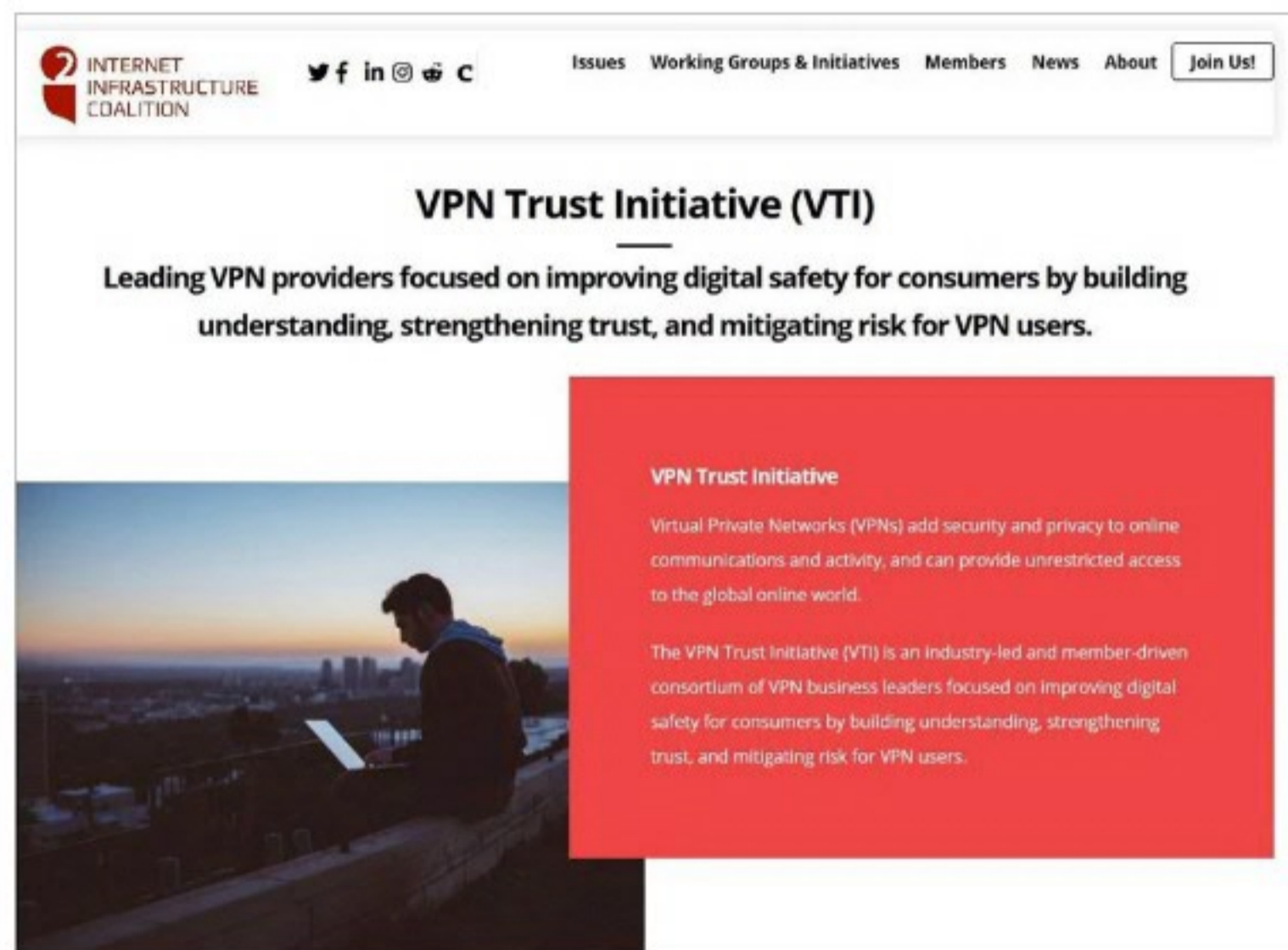
The company also told us that the founders can easily be found on LinkedIn (a claim we disagree with), and "at the moment they prefer to avoid public attention." The company also told us that transparency is a focus for NordVPN in 2020, and the situation with the founders will change in the coming months.

NordVPN's privacy policy says it has a "strict no-logs policy," meaning it does not store time stamps, session information, used bandwidth, traffic logs, IP addresses, and so on. A third-party audit in 2018 confirmed this, and NordVPN tells us another audit is planned for 2020.

NordVPN also plans to follow in the path of VPNs such as OVPN (go.pcworld.com/ovpn)

and ExpressVPN (go.pcworld.com/xvpn) by running diskless production servers. Currently, NordVPN has about half of its network running this way. Diskless servers don't store any information on them at all. They are controlled and booted from a remote server and everything then runs in RAM. That makes it mighty difficult to pull any user data from these servers. NordVPN says it plans to go diskless for its entire server infrastructure within three to four months.

Another step NordVPN took to increase trust is joining the VPN Trust Initiative, an effort that includes ExpressVPN, Golden Frog (of VyperVPN fame), SaferVPN, Surfshark, StrongVPN, and IP Vanish. The VPN Trust Initiative's (go.pcworld.com/vtrs) goal is to strengthen trust and mitigate risk for VPN users.



Landing page for the VPN Trust Initiative.

The company also recently published a blog post (go.pcworld.com/ndbl) detailing how it plans to prevent vulnerabilities like the one that occurred in 2018 (it was only reported in 2019). The new plan includes penetration testing, a bug bounty program, the new infrastructure audit, vendor assessments, and the aforementioned diskless servers.

That's a lot of effort to get users to trust NordVPN, but we'll feel a lot better once the founders and management go public. Anonymity for the people running a company that is supposed to be all about trust just doesn't sit well with us. Especially when the service has a poorly understood parent company based on the other side of the globe from NordVPN headquarters.


PERFORMANCE

Wow, is all we have to say about NordVPN's speeds. In our tests over multiple days, NordVPN was able to maintain 60.40 percent of the base non-VPN speed. That's still a little bit shy of our current speed champ, HotSpot Shield (go.pcworld.com/hshl). Nevertheless, NordVPN is fast enough that you can use its connections to do pretty much anything reliably.

BOTTOM LINE

So what do we do with a problem like NordVPN? It's a fantastic service that keeps getting better. The price is on the high side,

but you get a lot more for that money than with other services. Still, we can't bring ourselves to trust it as much as we do Mullvad (go.pcworld.com/mull) or OVPN given the secrecy behind it. Once this situation changes we will re-evaluate.

Nevertheless, NordVPN's excellent service can't be ignored. For that reason, we're creating a new category and calling NordVPN "the best full-featured VPN." If you want something that appeals to power users, has multi-hop, solid speeds, and hopefully works with Netflix, then NordVPN is a solid choice. If, however, you want to remain as anonymous as realistically possible with a VPN, we suggest you look elsewhere for the time being. 

NordVPN



PROS

- Excellent speeds.
- Enough features to appeal to power users and novices.
- No logs policy.

CONS

- Expensive.
- Still not transparent enough about management.

BOTTOM LINE

NordVPN offers a lot with its service. There are specialized servers for multi-hop connections, P2P file sharing, and dedicated IP addresses at an extra cost. It also offers a ton of country connections, and the ability to drill down to a specific server if you want. It also works with Netflix (though not consistently) and has malware and ad blocking, NordVPN is expensive, but you get a lot of options with this service.

\$84



Ori and the Will of the Wisps: A lively adventure in the shadow of the forest of death

Increased mobility and a bevy of beautiful environs carry the day, but Ori's second outing is a familiar adventure with some awkward middle-chapter pacing. **BY HAYDEN DINGMAN**

Skitter. Skitter skitter. It's time to move. Paws padding across the sand dunes, Ori scampers out from under the log, leaping up into the air and rebounding off the wall, grabbing a pole and flinging himself upward—and then movement. The owl turns its head. Ori freezes, pressed behind a scrap of fabric.

The owl looks away. Skitter skitter. Up and over this time, then leaping across a

gap—mere feet from the owl's head. If it turns around...best not to think about it. Clinging to a crumbling wooden log, Ori stops for a moment. The owl screams, frustrated it can't find its prey. It nudges the log, to no avail.

Again, it looks away. Ori sprints towards a small cave, a place where the owl can't follow. It was a ploy though. The owl hears him, turns, takes flight, its talons closing. Ori makes a last desperate dive for the entrance, and

finds it. Burrowing into the sand, he pauses, heart racing.

Or maybe it's my heart. Who can say, really?

PERFORMANCE

First, the briefest note on performance—and I'm only doing this because from what I've heard, the baseline Xbox

One version of *Ori and the Will of the Wisps* is pretty rough. Suffice it to say, the game ran great on my PC. I have an Nvidia GeForce RTX 2080 Ti which is admittedly overkill, but aside from one point where it was slow to load a cutscene, everything went fine. Assuming that bears out on lower-end GPUs, I wouldn't worry much.

A word of warning if you're planning to play on the Xbox though. Microsoft says there's a day one patch coming, but didn't know when that patch would be ready, nor was I all that concerned. This is *PCWorld*, after all.

In any case, back to the review.

REMEMBER THE MOUNTAIN BED

Ori and the Will of the Wisps is about speed. That's what I love most about it. Plenty of games have a double-jump and an air dash and a wall-climb, but there's a kineticism to Ori. Obstacles are almost never a single discrete hurdle for the player to overcome.



They're chained together, sometimes dozens in a row—double jump off the ledge into the wall, then leap towards the other side, air-dash, catapult yourself off an enemy mid-air, touch the other wall, run up it, use the incoming projectile to propel yourself higher, and so on, until finally, palms slick with sweat, you find a moment to sit and breathe.

It's instinctive, a force operating in the player's subconscious. It's that elusive "flow" state, and while Ori is hardly the only puzzle-platformer to induce this feeling, it's rare. (*Celeste* [go.pcworld.com/cste] has its moments, as do *Super Meat Boy* and the oft-overlooked *Rayman Origins*.) It takes an extraordinary amount of skill on the part of the developers, designing levels that are readable at a glance, the player hurtling through them as fast as they appear on-screen.

As such, the best additions to *Ori and the Will of the Wisps* are all movement-related. A grappling hook whips Ori along at high

speed, and can also yank him towards airborne enemies from a distance—a cousin to *Blind Forest*'s celebrated “Bash” ability, which still allows you to use enemies as a springboard up close.

And then there's the...I don't know. Tunneling? Burrowing? Shown in our E3 2018 demo (go.pcworld.com/e318), Ori has the ability to dive into sand dunes and explode out the other side, flying high into the air. This ability also works with snow drifts and—eventually—underwater, and it is a hell of a lot of fun. Easily the standout addition to *Will of the Wisps*, I'd say. The Windswept Wastes in particular revolve around burrowing through one sand dune, bursting out the far side, leaping over a gap, and then diving straight into the next one, a series of actions that never wore out its welcome no longer how many times I did it.

Not that I did it much. My main complaint about *Ori and the Will of the Wisps* is that it

takes a long time to get going, and then it's over. When I demoed *Will of the Wisps* last month I was told it's two to three times the size of *Blind Forest*, and in terms of land mass? That might be true. You move through it so damn fast though, and when credits rolled I found I'd finished *Will of the Wisps* with a 99 percent completion rate (I'm missing a few collectibles) in just under 10 hours.

That's precisely the same length as *Blind Forest*—which is fine. I don't mind a 10-hour runtime. I dreamed of an *Ori* the length of *Hollow Knight*, but honestly 10 hours is more than enough. It doesn't overstay its welcome.

The pacing is strange though. *Will of the Wisps* is more open-ended than *Blind Forest*, especially the middle chapter. You're given the option to visit three areas central to the story, plus two or three ancillaries filled with collectibles. Problem is, each zone tends to revolve around a single ability or gimmick.

Some of these are entertaining, as I said.

The Windswept Wastes introduces that sand-dash, while the snow-capped mountain of Baur's Reach teaches Ori to melt and freeze the local flora and fauna, and there's a darkened underground area (similar to *Hollow*





Knight's Deepnest) where every jump is near-blind until you unlock the ability to light your surroundings.

But because the developers can't guarantee you'll have these abilities in the other zones, they don't build on each other. You might occasionally miss a collectible for want of a skill, necessitating a second trip, but only very occasionally. Otherwise, the middle act feels like a series of tutorials, less like climbing a mountain and more like climbing a series of small hills. Having one skill or another unlocked already might let you approach problems differently, but by and large zones require only Ori's most basic skills and the one you unlock therein.

It's only in the final hour or two that the skills finally come together. The last act is

gated behind finishing the rest, in whatever order, which means *Will of the Wisps* can count on the player having Ori's full toolkit. And it really shines there at the end, with some incredibly creative platforming puzzles and memorable chase sequences. It's just a shame this section is over so quickly. I felt like I was just getting a handle on combining Ori's skills, and then I was done.

Merely finishing *Will of the Wisps* isn't the only challenge of course, and *Will of the Wisps* is built with speedrunning in mind. The open-ended nature actually seems more interesting for these players, as grabbing an ability early might help shave off seconds in another zone later. There are also a series of "Spirit Trials," or races through set obstacle courses, and an extensive "Spirit Shard"

system that mimics *Hollow Knight's* Charms. These give Ori modifiers, allowing players to triple-jump or grapple off enemies or reflect incoming melee damage, and so on. You can have three equipped to start, and unlock more slots as you go. Again, hundreds of potential combinations mean plenty of options for speedrunning.

For the one-and-done adventurer though? It feels a bit slight. I found a Spirit Shard setup I liked, and had little reason to stray from it, and definitely no incentive to hamper myself with Shards like "Enemies respawn faster." There's also a merchant that sells you additional combat skills—but again, since *Will of the Wisps* can't guarantee you'll buy them, none end up feeling necessary.

I don't think the open-ended nature is at

fault here, as *Blind Forest's* straightforward (almost entirely linear) design felt constricting at times. *Will of the Wisps* is too afraid to punish the player though, by which I mean too afraid to force them to make a second (or third, or fourth) journey to a zone with new skills unlocked. And isn't that what you want from these *Metroid*-style games? That feeling of returning to an earlier area and uncovering new secrets?

That said, I still had a good time with it. *Will of the Wisps* didn't have the same impact on me as *Blind Forest*, but Moon Studios has built an incredible world and a mythology, and they know when to layer on the swelling strings to give the story emotional heft.

If our review's spent less time talking about that aspect, it's only because I spent a





lot of time on it ([go.pcworld.com/time](https://www.pcworld.com/time)) mere weeks ago, and don't want to rehash it all here. Still, it's worth pointing out, as we give our final verdict. Moon Studios has an eye for the cinematic, a knack for taking the ordinary (i.e., "a door") and turning it into something extraordinary, be it a hibernating bear or a decaying watermill or a lost temple filled with sand.

Ori and the Will of the Wisps is at its best in these moments, when scenery and story and player skill all come together for a perfect escape sequence, or a fiendish platforming puzzle, or even just a quiet moment of contemplation in the wilderness.

Plenty of games nail the mechanics of *Metroid*. Few are able to disguise them so well.


BOTTOM LINE

It's really a wonder to behold, and as I said in our preview: *Ori and the Will of the Wisps*

is more than the sum of its parts. Is it just another *Metroid* homage, one among many? Absolutely. I think it's one of the best-playing, sure, but it's still well-trod territory of late.

I found myself gripped by it though. As I said earlier, I wish

it was longer. That's usually the sign (or at least one sign) of a good game, in my experience. I wanted one more environment, one more collectible, one more challenge, just one more reason to spend more time in that world.

I waited five years for a second outing with Ori. Now it's done and I'm right back to waiting. So it goes. 

Ori and the Will of the Wisps



PROS

- Gorgeous.
- Moving through the world is exhilarating.

CONS

- Doesn't build the difficulty early enough.
- Can feel a bit over-familiar.

BOTTOM LINE

Ori and the Will of the Wisps is more than the sum of its parts, but only barely. Increased mobility and a bevy of beautiful environs carry the day, but it's still a fairly familiar adventure with some awkward middle-chapter pacing.

\$29

BIG-SCREEN PHONES ARE BECOMING A PROBLEM

(& FOLDABLE DISPLAYS
AREN'T THE SOLUTION)

IT'S NOT JUST THE GALAXY S20 ULTRA.

BY MICHAEL SIMON | ILLUSTRATION BY ALEX EBEN MEYER





I have a confession to make: My favorite phone right now is the Samsung Galaxy S9 (go.pcworld.com/s9gl). Yes, the one from 2018. I'm testing the 6.9-inch Galaxy S20 Ultra (see page 39) and running Android 11 on the 6.3-inch Pixel 3 XL (go.pcworld.com/g3px), but when I want to kick back with my phone of choice, these days I'm reaching for the Galaxy S9 and its 5.8-inch screen. In short, I'm sick of big phones.

In just the past few months, we've gotten the 6.67-inch OnePlus 7T Pro (go.pcworld.com/1p7t), 6.8-inch Galaxy Note 10+ (go.pcworld.com/n10p), 6.8-inch LG V60 (go.pcworld.com/lv60), and 6.9-inch Galaxy S20 Ultra, all of which are extremely cumbersome. It's gotten to the point where the 6.5-inch iPhone 11 Pro Max (go.pcworld.com/11mx) is on the small side (which is probably why Apple is rumored to bump the size of its biggest flagship [go.pcworld.com/bgfl] to 6.7 inches this year).

But at least Apple makes an iPhone

that's under six inches. If you want a decent Android phone that can actually be used with one hand, your options are basically a 5.6-inch Pixel 3a (go.pcworld.com/gp3a) or a Galaxy S10e. The Galaxy S20 starts at 6.2 inches and goes up from there, nearly half an inch bigger than the Galaxy S9 from just two years ago.

Take a look at how phone sizes have increased over just the past three generations:

Galaxy S9: 5.8, 6.2

Galaxy S10: 5.8, 6.1, 6.4, 6.7

Galaxy S20: 6.2, 6.7, 6.9



Compared to even the Galaxy S10+ (right), the S20 Ultra is a beast.



Galaxy Note 10

LG G7: 6.1

LG V50: 6.4

LG V60: 6.8

Galaxy Note 8: 6.3

Galaxy Note 9: 6.4

Galaxy Note 10: 6.3, 6.8

OnePlus 5T: 6.0

OnePlus 6T: 6.4

OnePlus 7T: 6.6

Bottom line, premium Android phones have ballooned over the past two years and are just plain too big now, especially when you factor in the ever-taller screen ratios. The Galaxy S20 Ultra barely fits in my pocket, and its tremendous size makes it difficult to use—even with two hands. Case in point: I've been experiencing issues with autofocus that's at least partially due to my inability to keep it still while snapping a pic.

And I have fairly big hands. My wife wouldn't even consider the Galaxy S20 Ultra, effectively shutting her out of the best camera features just because she doesn't want a phone with a 6.9-inch display. Choosing between screen sizes is one thing, but forcing buyers to choose a phone that's downright unwieldy just to get the best features is just wrong. And beyond the fear of missing out, they're just too heavy, fragile, and awkward.

BIGGER ISN'T ALWAYS BETTER

I simply don't understand why Samsung dumped the 5.8-inch model with the launch of the Galaxy S20. For most people, it's the perfect size, big enough to get work done but not too big where you can't use it with one hand. But if you want an S20, you'll need to get a phone with a screen that's at least 6.2 inches with a noticeably larger body than the



Galaxy Z Flip



LG V60

Galaxy S10e.

A half an inch of screen size might not seem like much, but it makes a huge difference. Compared to the Galaxy Note 10+, the S20 Ultra is only 4.6mm taller, but for the impact it had on my grip and reachability, it may as well be a foot. By comparison, the Galaxy S20 is 9.5mm taller than the S10e, so by jumping from 5.8-inch

to a 6.2-inch screen you're getting a significantly bigger phone, too, which for many will cross the line from usable to unbearable.

But phone makers don't seem to care. I'm willing to bet that next year's Galaxy S30 will start at 6.4 inches, with the upper model inching ever closer to 7 inches. Usability has basically gotten lost in the race to be biggest,

and there's no signs of it slowing down. If anything, with the advent of folding tech, phones are going to push further into mini tablet territory.

THE UNCERTAIN FUTURE

Folding phones might still be novel and interesting, but we're a long way from mainstream use. The Galaxy Z Flip (go.pcworld.com/szfp) is certainly a big step in the right direction, but with so-so cameras, nascent UIs, and uncertain form factors, foldables are still in the experimental phase and likely will be for a while.

But even if foldable phones were to magically become durable and affordable, the only real problem they solve is pocketability. When you want to use the Galaxy Fold (go.pcworld.com/smfd), you're still stuck with a giant screen, and if anything, folded phones will quickly get just as big as today's non-folding handsets. This brings us to a crossroads: There's only so much bezel that can be trimmed, and if phone screens keep increasing in size, we're going to be looking at Galaxy Tab A-sized screens in just a couple more years, folding or not.

And it's all a big distraction from the truth: smartphone evolution has stalled. Folding displays and space-zoom cameras aside, we're at something of a lull in smartphone innovation, even as displays have gotten bigger. I'll admit that Samsung's Galaxy S20

120Hz panels are downright remarkable, but brightness and speed aside, my Galaxy S9's display is plenty good. As we all wait for the next big breakthrough, whether it's folding screens, everlasting batteries, or next-gen AI, phone makers are trying to convince us that bigger screens are the main thing we need, and power users will work harder and smarter with more pixels.

And as a result, small phones have gotten short shrift. Phone makers have reserved some features for its biggest phones due to space and battery limitations, but now, even 6.2-inch phones are missing out on features in their larger-screener counterparts, whether that's better screens, faster connectivity, or more powerful cameras.

Phones used to have so many new features people wanted to upgrade every year, but with the push into more screen, people are holding onto their phones longer. Part of the reason is the price, of course, but that's merely a consequence, not the cause. The larger issue is that phone makers are reserving their best features for phones with the biggest screens, essentially forcing consumers to buy more phone than they might want.

So they're waiting, which only leads to bigger phones. Phone makers are in such a race to one-up each other that none of them seem to be thinking about what can actually make them better. And a 7-inch display isn't it. 🛑

#DanceLikeaDad



fatherhood.gov

HOW INTEL IS CHANGING THE FUTURE OF POWER SUPPLIES WITH ITS ATX12VO SPEC



A MAJOR CHANGE WILL REJIGGER THE BALANCE OF POWER
IN PC POWER SUPPLIES FOR THE FIRST TIME IN 20 YEARS.

BY GORDON MAH UNG



We don't often talk about power supplies, but Intel's new ATX12VO spec—that's an 'O' for 'Oscar,' not a zero—will start appearing soon in pre-built PCs from OEMs and system integrators, and it represents a major change in PSU design.

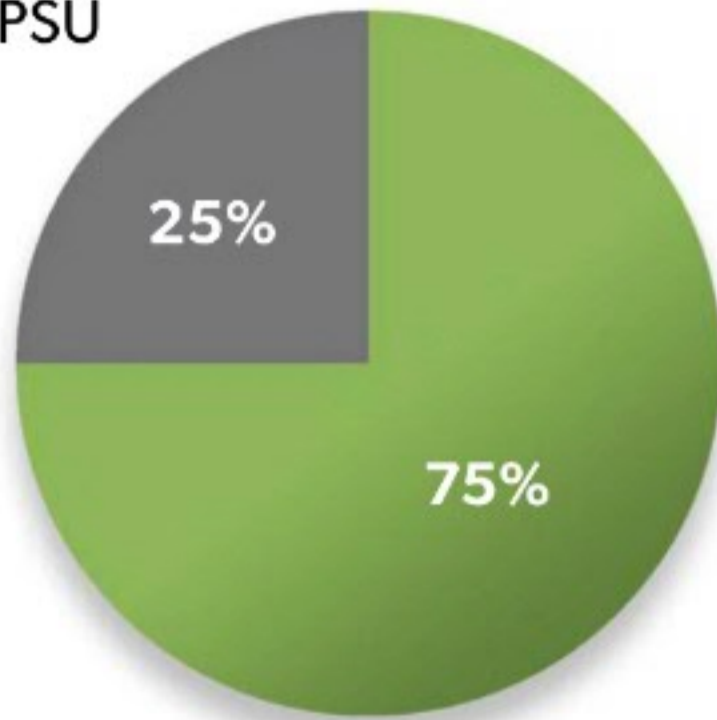
The ATX12VO spec removes voltage rails from the power supply, all in a bid to improve efficiency standards on the PC and meet stringent government regulations. But while the spec essentially removes +3.3-volt, +5-volt, and +12-volt and +5-volt standby power from the PSU, they aren't going away—they're just moving to the motherboard. That's the other big change, so keep reading to find out more.

DON'T TAKE MY ATX12V POWER SUPPLY AWAY!

Don't panic, DIYers: The PSU Enforcement Agents will not be coming to take away your 1,500-watt ATX PSU (there's no such thing as PSU police anyway). ATX12VO is currently aimed mostly at PC OEMs and system vendors—some of whom have already started down this path on their own.

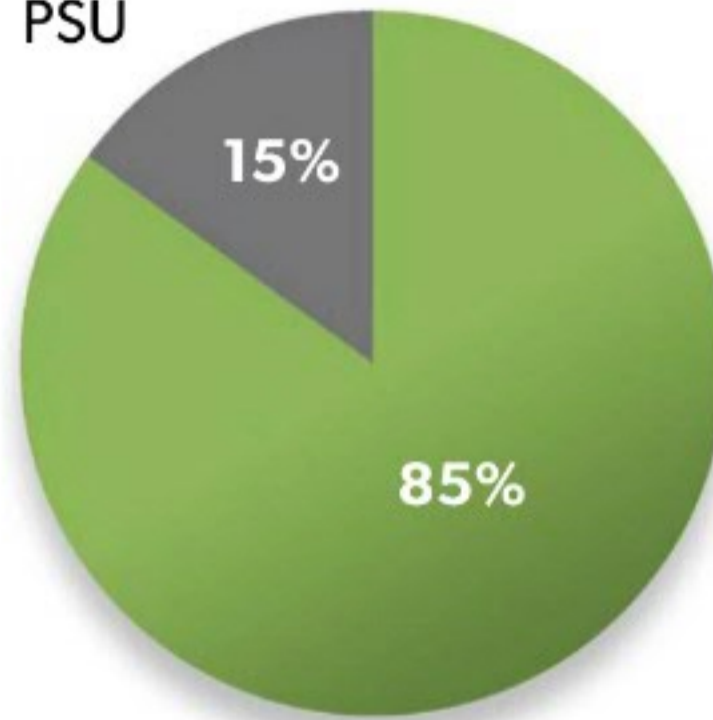
ATX12VO won't be replacing ATX12V for

2006-era 600 watt PSU



■ 3.3 Volt and 5 Volt rails ■ 12 Volt rail

2016-era 600 watt PSU



Comparing a 2006 PSU (left) with a 2016 version (right), we can see voltages have trended away from 3.3- and 5.5-volt use toward 12-volt.

individual PC builders. "Intel plans to continue to publish the ATX Multi Rail spec to maintain compatibility with existing motherboards and power supplies to provide the most options for our OEMs and customers," Intel officials told *PCWorld*.

WHY KICK 3.3 VOLTS AND 5 VOLTS TO THE CURB?

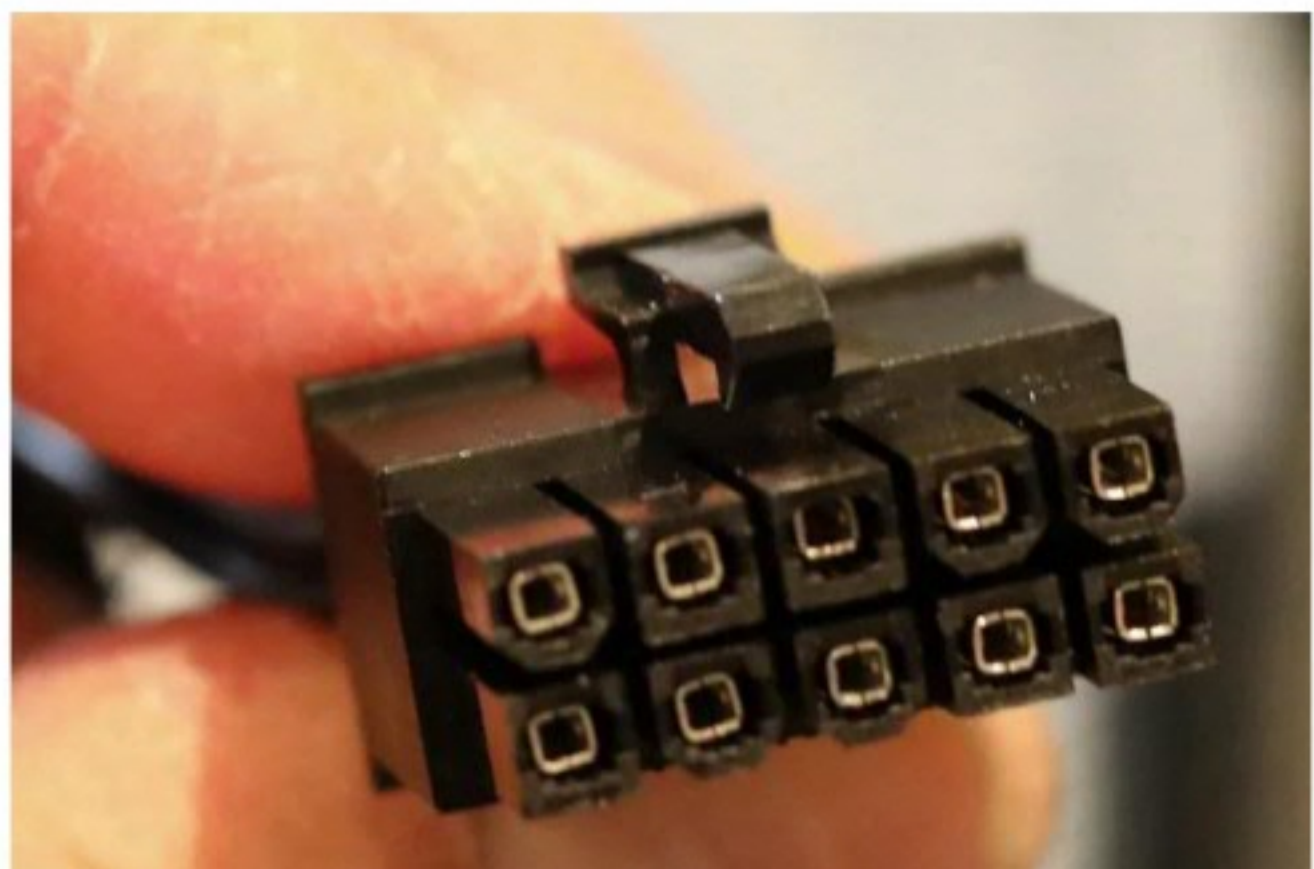
Still, eliminating the production of 3.3-volt and 5-volt power, or "rails," in the PSU itself is a major change. PCs originally ran mostly on 5 volts, but over time they've shifted mostly to 12-volt power. One PSU maker, for example, pointed to a circa-2006, 600-watt supply it made that had 25 percent of its power dedicated to 3.3-volt and 5-volt rails. Wind the

clock forward ten years, and a similar 600-watt PSU made by the same company now budgets just 15 percent for 3.3-volt and 5-volt power.

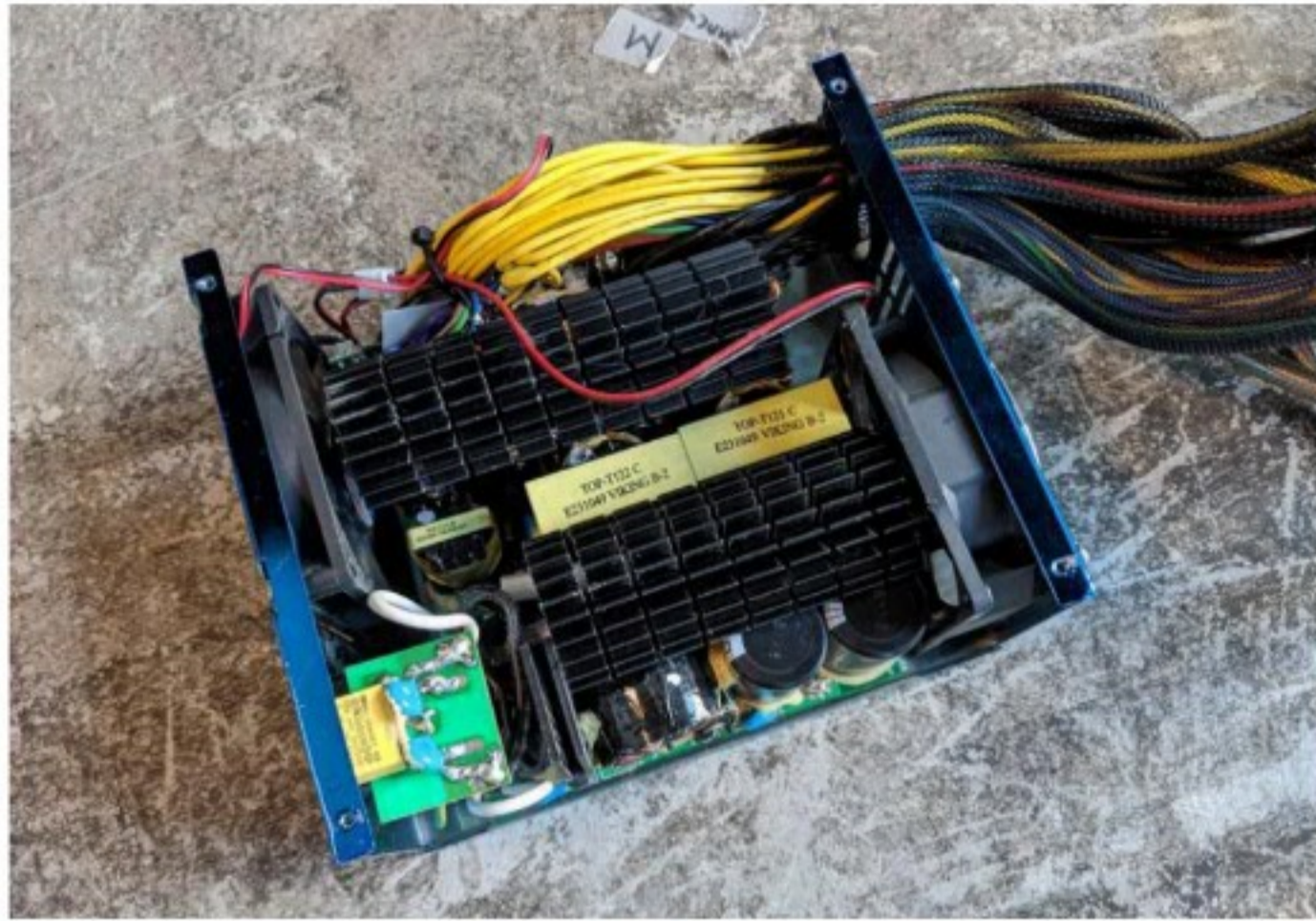
Efficiency (how effective the PSU is at converting the AC from the wall to DC that the PC needs) has evolved, too. The 2006 PSU operated at 78-percent efficiency, while the 2016 PSU has a

98-percent efficiency rating. That means the 2006 PSU would have to consume about 127 watts of AC from the wall to generate about 99 watts, while the 2016 PSU would consume about 100 watts to produce 98 watts of power.

Because ATX12VO removes so many rails,



Intel's new ATX12VO spec will feature a 10-pin connector similar to the Compute Element connector.



Vendors say it's difficult to reach increasingly stringent idle standby power requirements with power supplies that produce 3.3-volt and 5-volt power, so the new ATX12VO spec will move that support to motherboards.

the thick 24-pin Main Power Connector would drastically drop down to a tiny 10-pin connector, similar to what we saw with Intel's Compute Element (go.pcworld.com/cm1) earlier this year.

IT'S ABOUT THE EFFICIENCY

This efficiency gain is the main reason for the push toward ATX12VO. "As desktop computers continue to become more energy efficient, the power supply AC-to-DC conversion loss can be the biggest consumer of power in a computer at idle," Intel officials told *PCWorld*. "Existing ATX multi-rail power supplies (5V, 3.3V, 12V, -12V, 5VSB) are not very efficient at low loads of today's desktop computers when at idle," according to Intel. Because the multi-rail power supply is

sending very low current to all voltage rails, efficiency is just 50 percent to 60 percent.

The new ATX12VO spec significantly improves that efficiency. "By converting to a single rail power supply," Intel explains, "the conversion losses can be minimized, reaching up to 75 percent efficiency at the same DC Load levels."

While increased efficiency means less power used and less money going to the power company, PC vendors aren't making the move of their own

volition. They're doing it to comply with ever-tighter government regulations on power consumption by personal computers—specifically, California Energy Commission's Title 20, Tier 2 requirement, which goes into effect in July, 2021. "The most recent government energy regulations are requiring OEMs to extreme low system idle power levels to reduce desktop idle power consumption," Intel explained.

Although you might expect California's CEC to focus mostly on how much power a desktop or workstation burns under load, regulators are actually focusing on increasing idle and standby efficiency, which they believe yields the most benefit for power savings. The assumption is that desktops are idle far more than they are under load.

HOW ATX12VO COULD MAKE PSUS CHEAPER

ATX12VO means change, and change can be scary, but it's not all bad. One power supply maker told *PCWorld* that the move to ATX12VO should make PSUs "drastically" cheaper to build. Jon Gerow, director of research and development for another PSU maker, Corsair, agreed costs should go down while efficiency goes up.

But the power load isn't really going away, because people still need those rails. "5V is still largely used," Gerow explained. "It's what powers your SSDs, your USB ports and all of your RGB lighting." While 3.3V isn't used as widely, according to Gerow, he added that Corsair uses it to power the LEDs in the company's AIO coolers.

Instead, the power load is moving. Rather than being a small circuit board in a PSU, 3.3-volt and 5-volt power will be integrated into the motherboard.

There are pros and cons to this change. According to Corsair's Gerow, the move offers more opportunities for customization. "You can scale the +3.3V and +5V for exactly what the build needs and no more than that," Gerow said. On the downside, you're adding features to the motherboard, which means more cost and more demand on the limited

real estate of the board. And, of course, these circuits will need to be kept cool, making ventilation more of an issue.

PCWorld asked Gerow whether the motherboard or the PSU was better at power efficiency overall. Gerow said the answer depends. "Motherboards have to do it on such a smaller scale, so it's easier to regulate these smaller loads with smaller components," he explained. But as well all know, motherboards can be delicate creatures. "These smaller components are also more susceptible to damage from 'bad power,'" Gerow said, "so the PSU and motherboard really need to work together as a team."

WHAT MOTHERBOARD VENDORS THINK

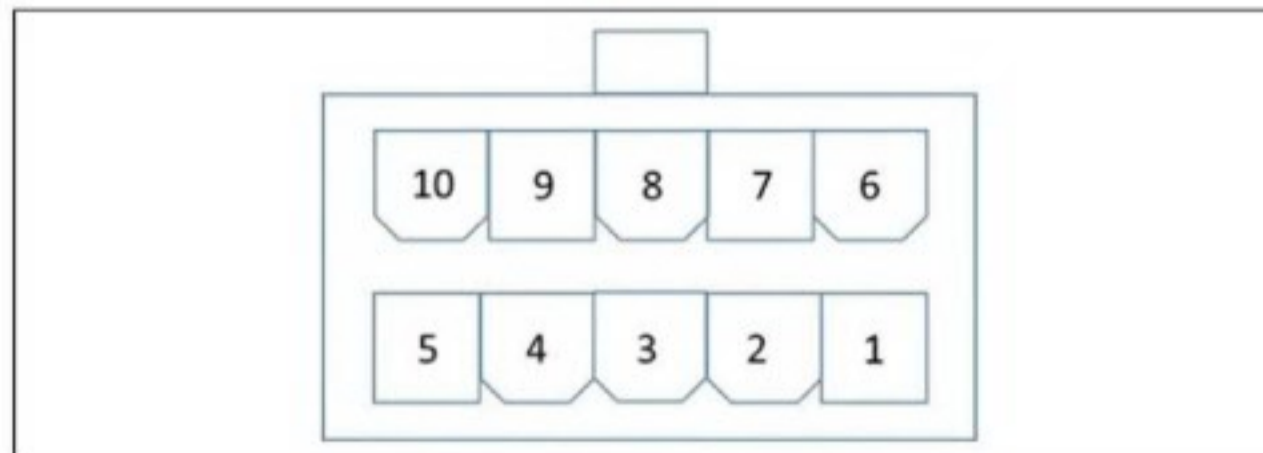
Motherboard vendors that *PCWorld* tapped for comment seemed largely optimistic about

4.2.2.1 Main Power Connector – REQUIRED

Main Power Connector for motherboard with control and standby rail connections. Smaller board sizes can only use this connector.

- Molex Mini-Fit Jr type of connector – Part numbers are with: CviLux Corporation
- Cable Connector: PN# CP-01110031-X22 (94V-0 black)
- Motherboard Connector Part Number: CP0131013E-HC-NH-X22 (94V-0 black)

Note: Connector color can be changed. Motherboard connector color is recommended to be white.



Intel's new ATX12VO uses a tiny 10-pin connector versus the typical 24-pin Main Power Connector used on most DIY desktops today.

ATX12VO. One told *PCWorld* the move would let a motherboard better manage the power sequence during boot-ups, which can get sticky when a non-standard PSU is used. With the motherboard in control of all three rails, it can better monitor and calculate power consumption, and it can reduce the risk from abnormal PSU power spikes.

Motherboard manufacturers interviewed also believed local control of the 5-volt and 3.3-volt rails could be more dynamic, potentially benefiting power-sensitive devices like USB and audio controllers. Vendors also said having the voltage on the board could lead to better over-current and over-voltage protection.

Still, our motherboard sources said, moving both the rails and the power connectors to the motherboard means a greater burden of components, a larger PCB, and more PCB layers, meaning more complexity and more cost. Also as you move to higher-wattage needs—say 1,500 watts—heat dissipation becomes an issue.

Another board vendor said ATX12VO was “interesting” and really could help with the internal aesthetics of a system. Today’s ATX12V Main Power Connectors are thick, awkward cables. ATXV12VO would make the connector smaller and the cables thinner, so they’d be easier to

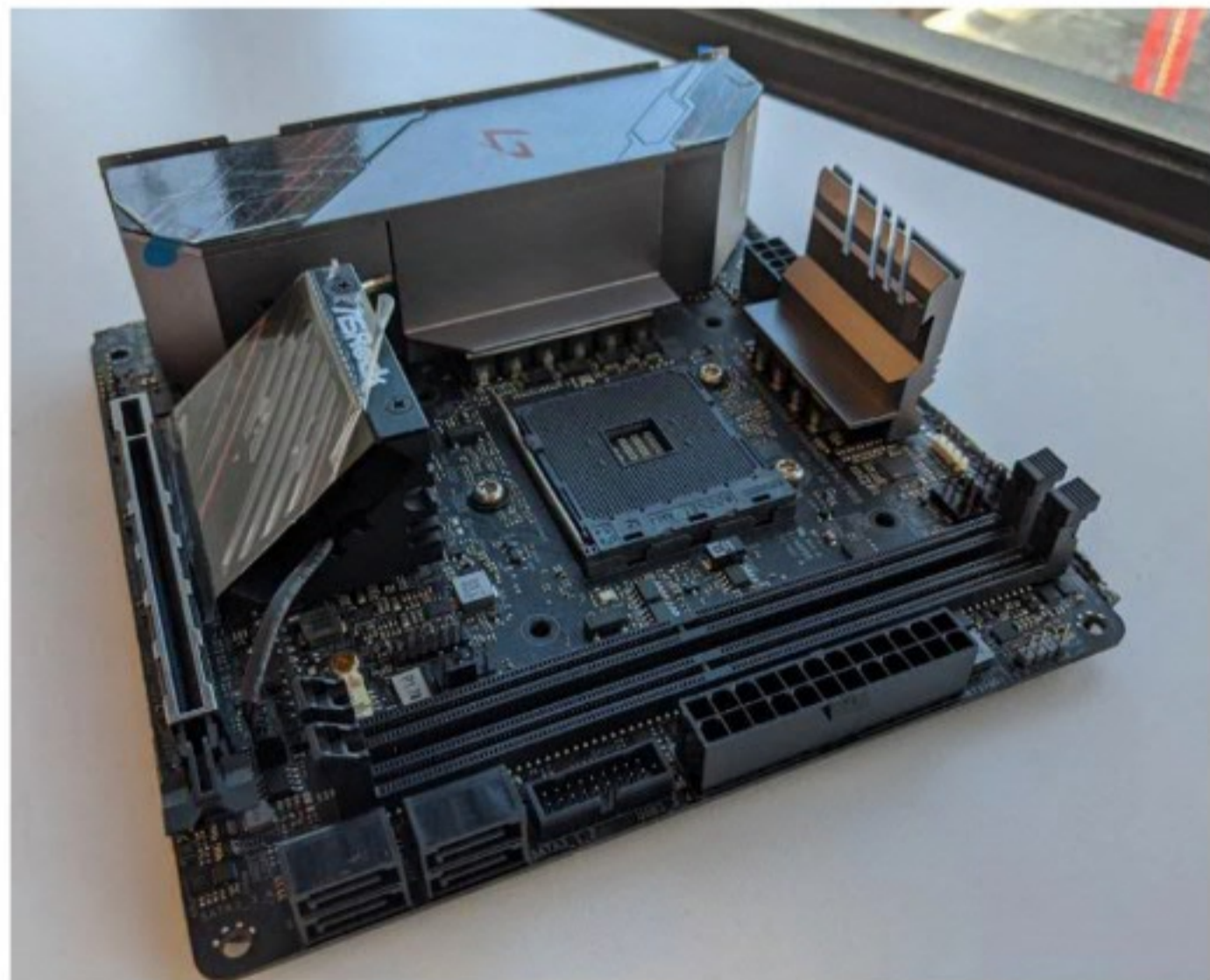
build with and easier to tie back or hide.

One vendor noted that controlling noise on the PCB could be a challenge, let alone performance. The first ATX12VO-compatible motherboard will likely be expensive as a result, but costs could come down as volume ramps up.

NOT FOR DIYERS JUST YET

Intel first released the ATXV12VO spec in July 2019, but there’s no set timeline for hitting the streets. Intel said it’s really up to the OEMs to introduce hardware based on it when they’re ready.

Most of this doesn’t apply to the DIY crowd, at least not yet. Not only do consumers tend to freak out if they’re suddenly required to get a new motherboard,



One faction that might benefit from ATX12VO are Mini-ITX boards, which can save space just in the connector itself. The only question is how much space will be needed to add the 3.3-volt and 5-volt rails to a board, as well as SATA power connectors.



Apple's Mac Pro tower routed power for the GPUs through the motherboard. A similar system will exist in ATX12VO—but only for SATA power connectors.

but supply and demand are stuck in what one vendor called “playing chicken.” PSU vendors don’t want to release ATX12VO products for DIY builders until there are motherboards that support ATX12VO. Motherboard vendors don’t want to create products until power supply makers support them.

WHAT MIGHT A FUTURE BUILD LOOK LIKE WITH ATX12VO?


We still don’t know what an ATX12VO motherboard will look like or what it will cost. The board itself is likely to be a little beefier, as the 3.3-volt and 5-volt power conversion will be handled by modules on it. From reading the spec and talking to vendors, however, a future DIY build with ATX12VO would likely be similar to today’s builds.

Your ATX12VO Main Power Connector would be far smaller, and the cable would be more flexible. If the board has enough power from the single connector, the board maker may not even require you to plug in the auxiliary 8-pin power connector. The spec does allow for auxiliary 12-volt power through the EPS12V connector.

One tricky part could be hooking up any SATA-powered drives, such as hard drives or 2.5-inch SSDs. Today, you’d plug

those directly into the PSU. On an ATX12VO build, you’d first plug a power cable into the motherboard and then into the drive. The spec allows for up to six power connectors, but it’s up to the motherboard vendor to determine how many power connectors there are. These same SATA power connectors would be used to power up your drives as well as your AIO/CLC cooler or RGB LEDs.

If you want to plug in an old-school Molex connector, the new spec allows PSU vendors to offer that directly from the PSU, but only with 12 volts, of course. If you’re hooking a really old 5-volt Molex device, you’ll need to get that from the motherboard power using a SATA-to-Molex connector.

For a DIYer, it really won’t be that different. The real question is how it’ll work with motherboards and PSUs. 

PREVENT WILDFIRES, FOR THE LOVE OF THE OUTDOORS.





Samsung Galaxy S20: 10 tips and tricks that will make your new phone even better

Get the most out of your new phone. **BY MICHAEL SIMON**

If you've already gotten your Galaxy S20 (go.pcworld.com/gs20), you've surely transferred over your apps, set up the home screen, and picked just the right wallpaper to show off your big beautiful screen. But there are a few settings you might have missed that will make your S20 experience that much better.

Here are 10 toggles, tweaks, and settings you need to learn:

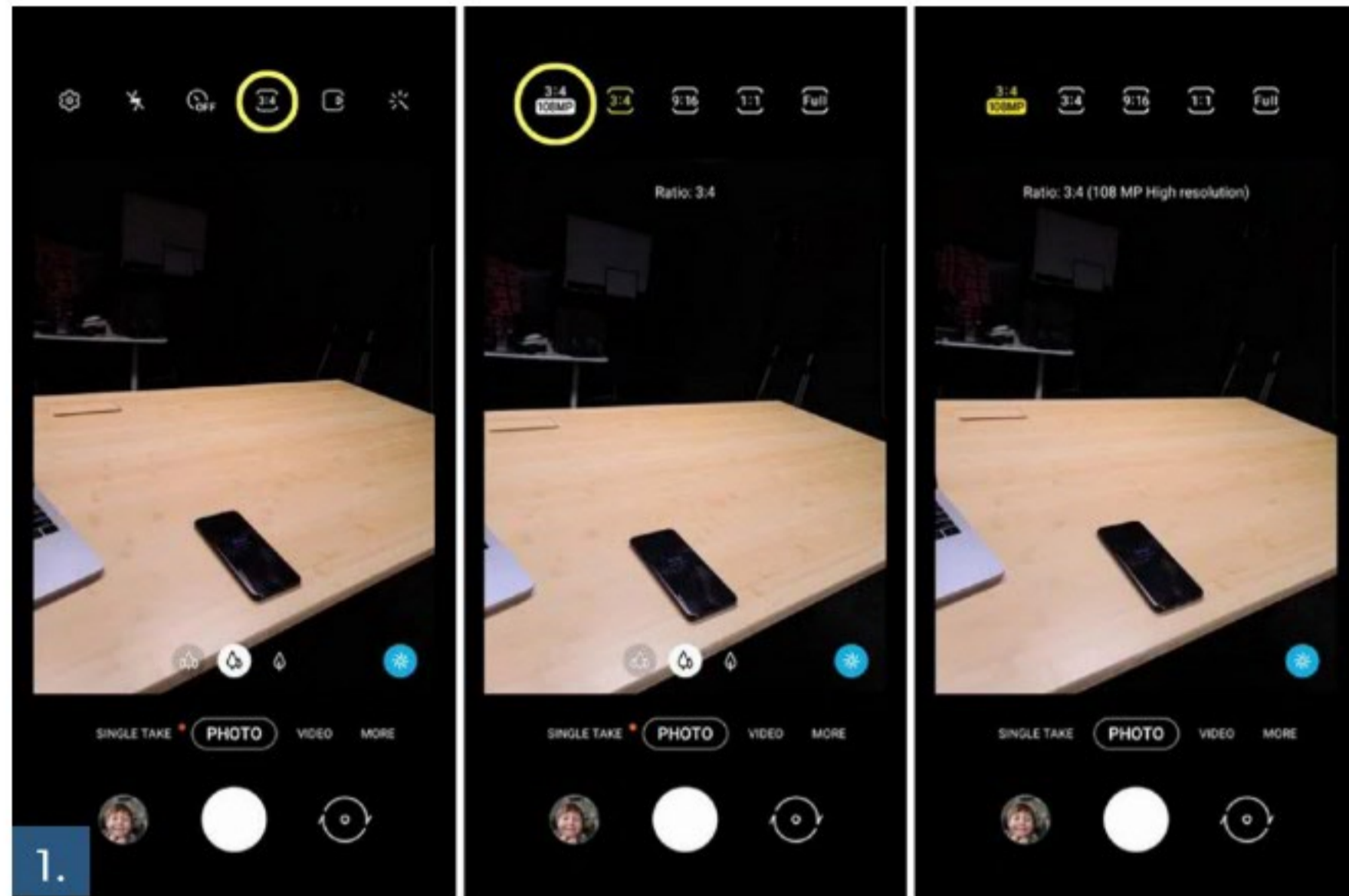
1. USE EVERY MEGAPIXEL IN YOUR PHOTOS

The S20 Ultra has the largest sensor ever crammed into a Galaxy phone: a whopping 108MP. But you won't take 108MP pictures

by default. Instead, Samsung uses pixel binning to bring the resolution down to 12MP and cram more detail into a smaller shot.

If you want to use all 108 megapixels (or the full 64MP in the S20+), you'll need to change

the ratio in the camera app. Tap the 3:4 button and switch it to the 3:4 108MP or the 3:4 64MP option. Just keep an eye on your storage, because every photo takes up a lot more space (about 30MB per photo using 108MP).

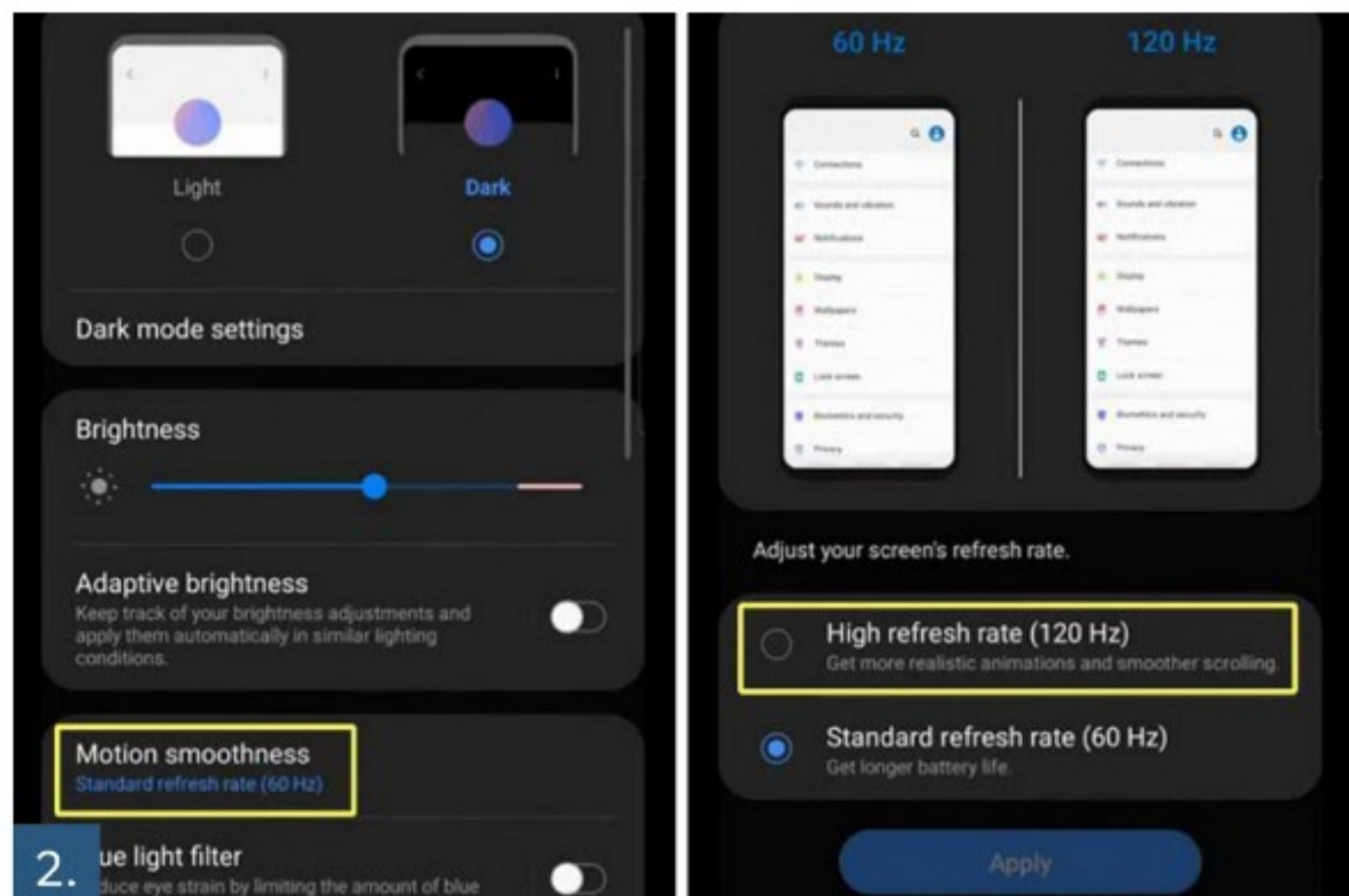


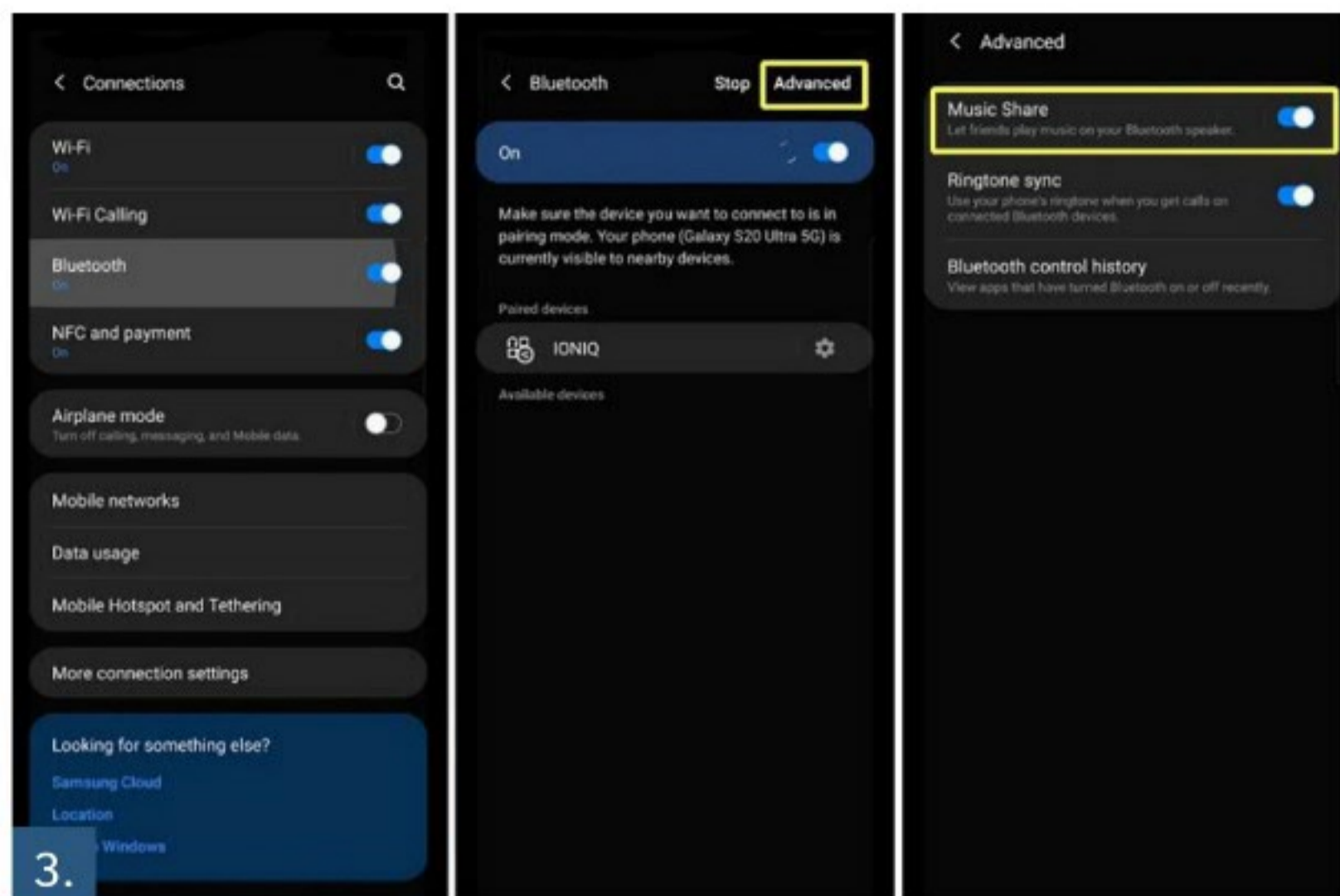
your disposal, your S20 actually has more than enough to handle it. And what a difference it makes when you switch in on.

To find it, head over to the Display tab in Settings, select Motion smoothness, and switch to 120Hz. Note that if you've already

2. MAKE THE DISPLAY BUTTERY-SMOOTH

The S20's display is awesome out of the box, but it's not all it could be. Samsung has motion smoothing turned off in an effort to preserve battery life, but with a minimum of 4,000mAh at





4. LAUNCH YOUR APPS INSANELY QUICK

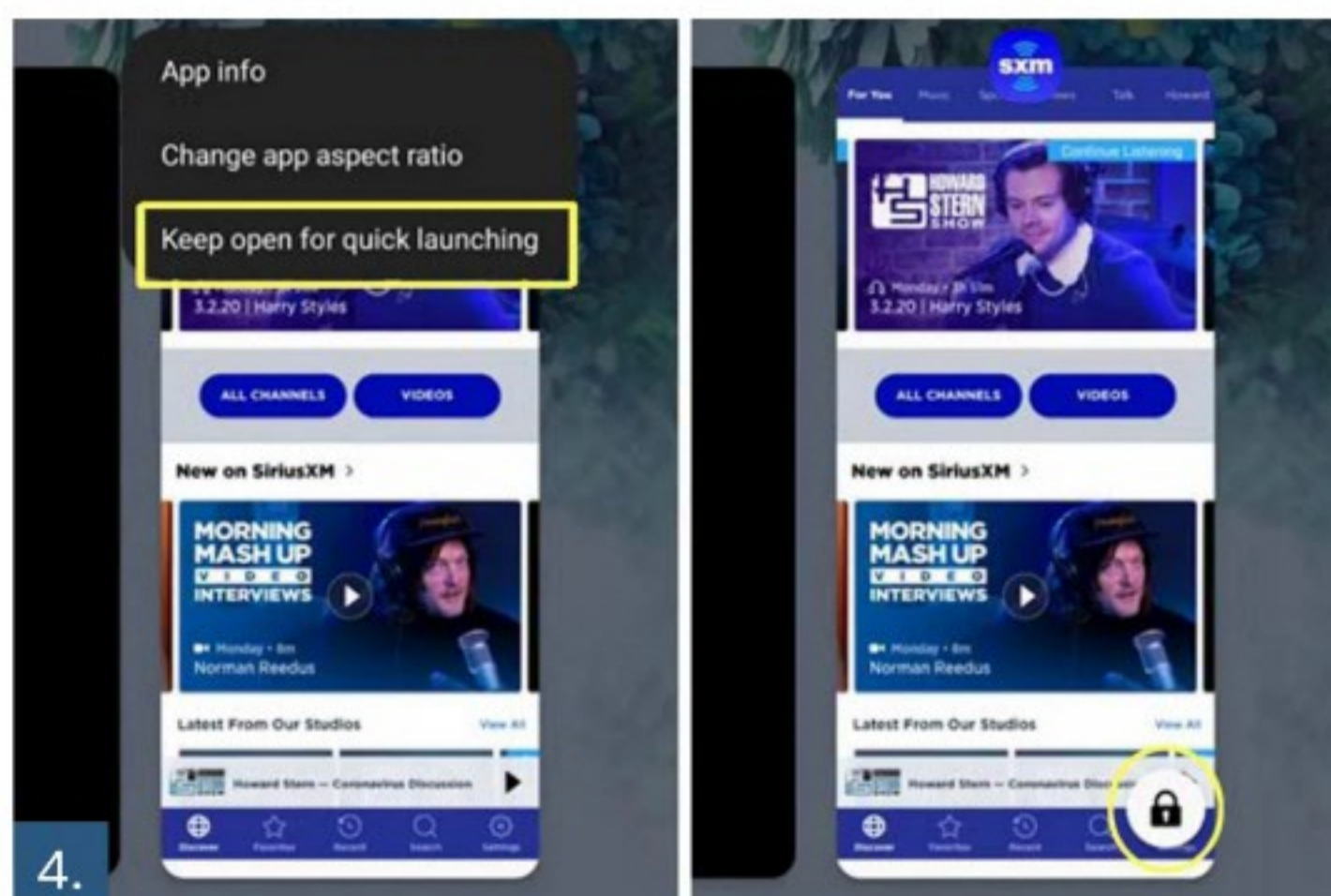
Every S20 comes equipped with at least 12GB of RAM, which is more than you'll ever need to keep your phone running at tip-top speed. But you can put all that memory to good use. Samsung

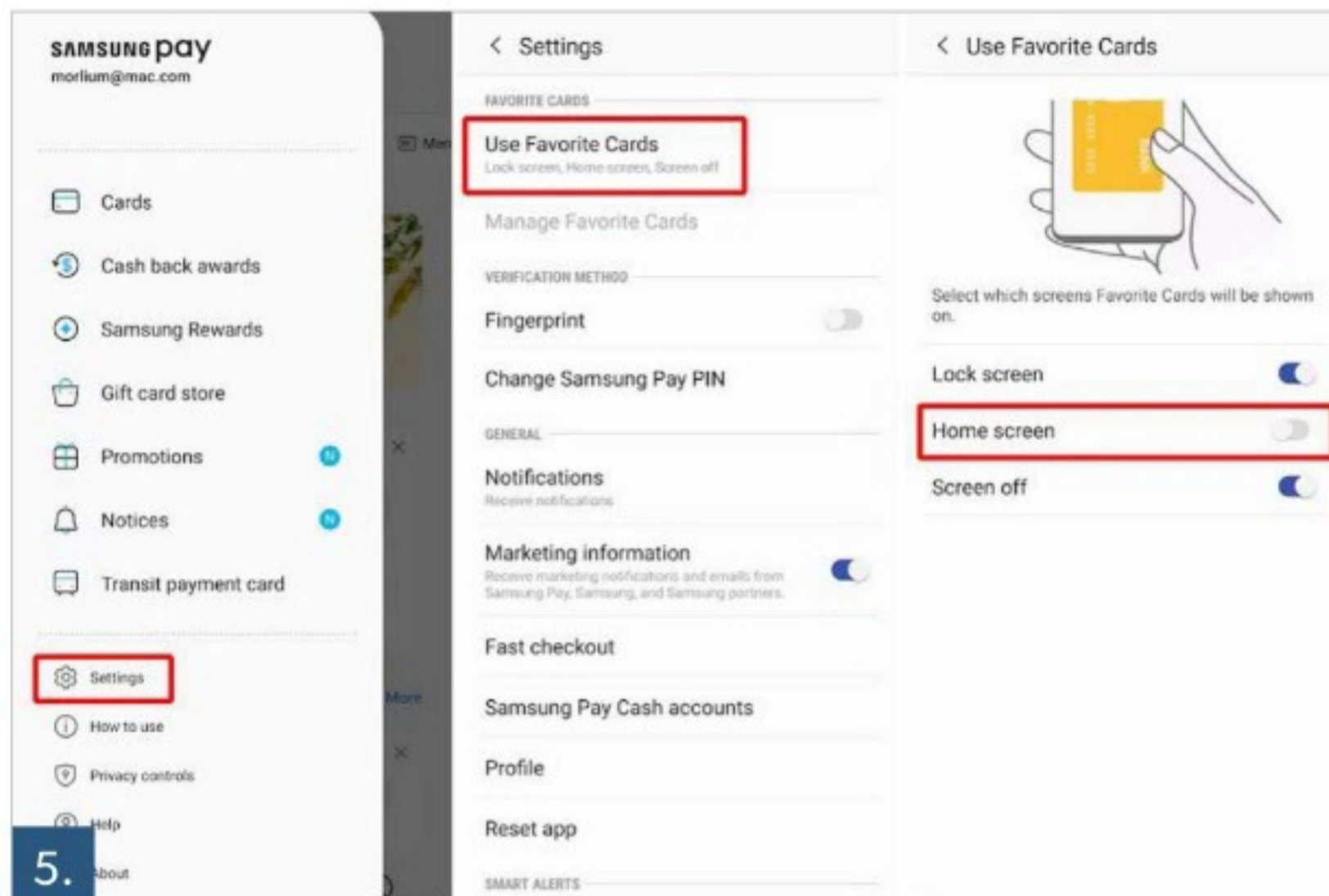
upped the resolution to WQHD, you'll need to go back down to Full HD, because Samsung doesn't allow both WQHD and motion smoothing.

3. TURN YOUR PHONE INTO A MUSIC STREAMING HUB

One of the more annoying facts of life is that if one device is already connected to a Bluetooth speaker, switching to a different one is a tedious process involving pairing and unpairing. But with Music Share, your friend can find your S20 on their own Galaxy phone and use it as a hub to play their music through your speaker. To turn it on, go to the Bluetooth settings, select Advanced, and flip the Music Share toggle.

lets you lock up to three apps to the RAM so they'll instantly launch whenever you call on them. You can find the setting on the Recents screen (where you find all of your open apps). Just tap the icon above the screen and select Keep Open For Quick Launching. You might see a slight hit on battery life, but for apps and games with lengthy load times, it'll be worth it.





accidentally launched it while trying to bring up the Recents screen or summon Assistant. It actually took me a while to figure out how to disable it. You'll need to go to the Samsung Pay app's settings, which you'll find in the sidebar. Select Use Favorite Cards, then toggle off the

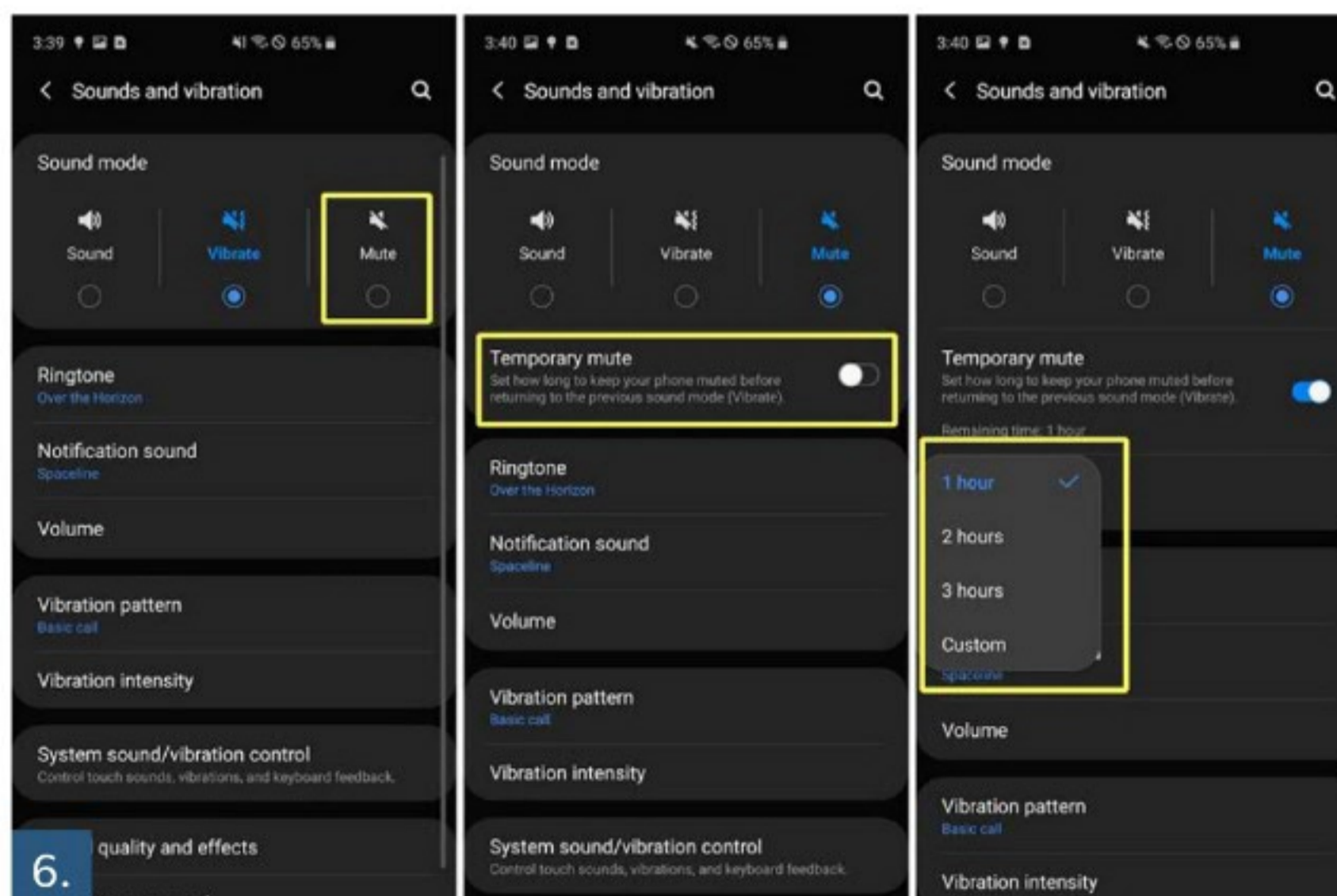
5. STOP ACCIDENTALLY TRIGGERING SAMSUNG PAY

Samsung Pay isn't a new feature, but its shortcut at the bottom of the screen is more of a nuisance on the S20 than ever before. I lost count of how many times I

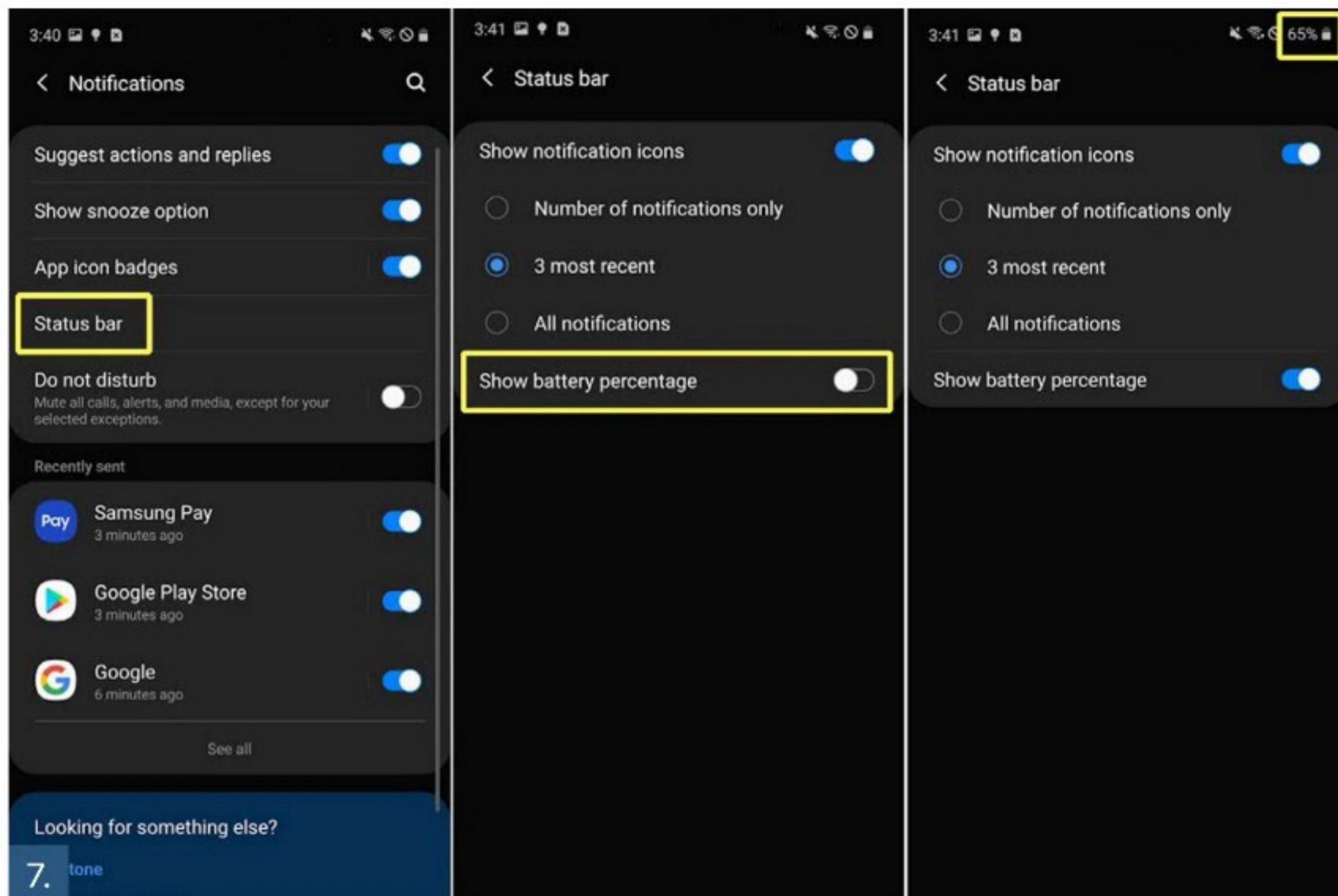
Home Screen option.

6. AUTOMATICALLY UN-MUTE AFTER SILENCING YOUR RINGER

This is a solution to a problem I didn't even



realize I had. We all do it: turn our phone on silent at a movie or meeting and forget to turn the ringer back on when it's over. With One UI 2 on the S20, you set your phone's ringer to turn on automatically after a set period of silence. To find it, head over to Settings, then



Sounds And Vibration. Select the Mute option at the top and the Temporary Mute toggle will appear, letting you choose the duration of your muting.

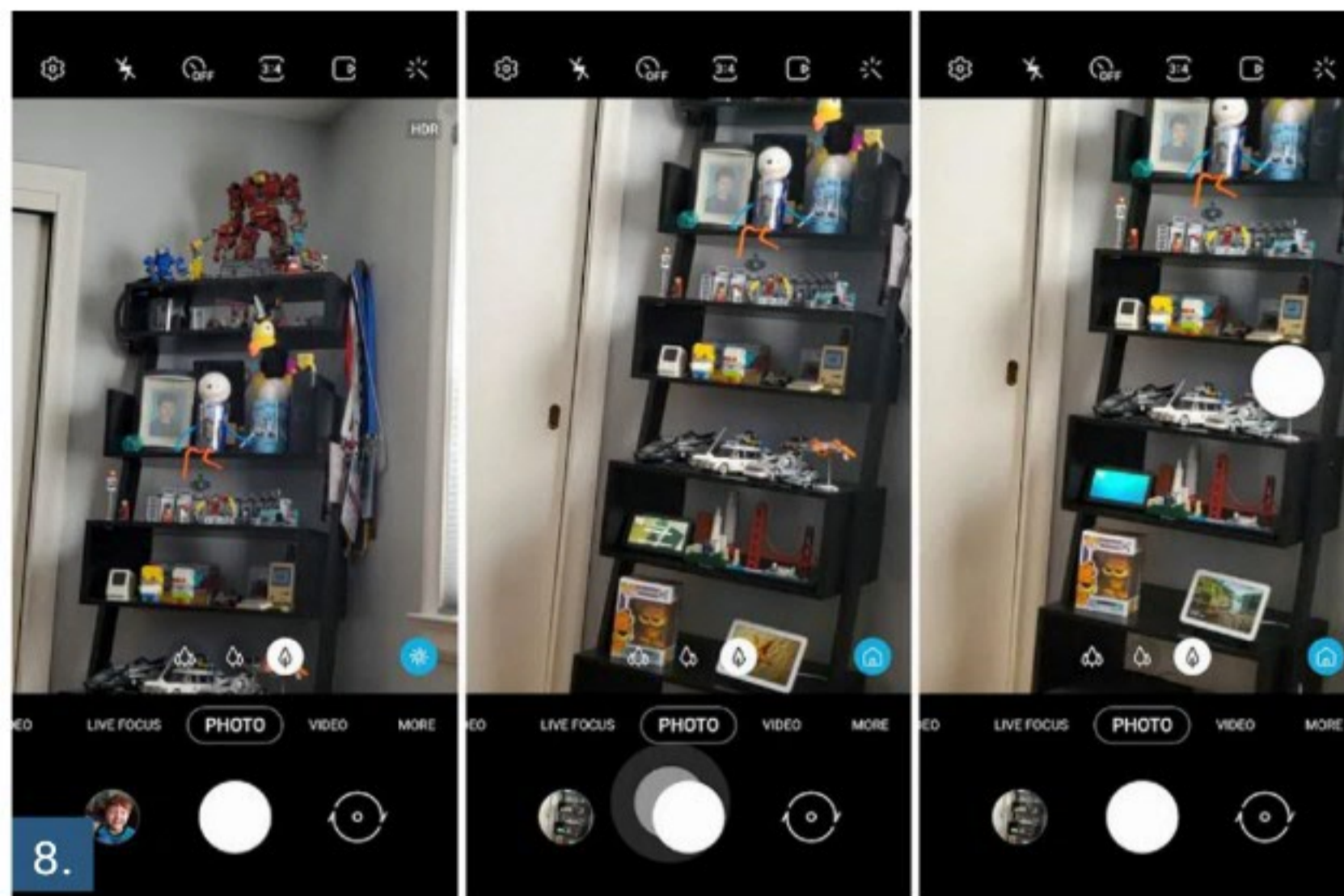
7. BRING BACK THE BATTERY PERCENTAGE

No matter which S20 you buy, you'll get great battery life, but you'll still want to keep an eye on your percentage. However, One UI on the S20 does away with the battery percentage to save space in the status bar. Here's how to get it back: Go to the Notifications tab in Settings and select Status Bar. Inside you'll see a Show Battery

Percentage toggle, which will put the number back in the status bar.

8. REPOSITION THE SHUTTER BUTTON WHEN TAKING A PIC

The S20 Ultra is so big, you're going to need an entirely new grip to use it. That's especially true when you're using the camera, but there's a hidden way to make it a little more finger-friendly: move the shutter button to a new spot. All you need to do is tap and drag on the shutter button when you're in the camera button, and move it wherever you want on the screen. Once you



get in the way of full-screen photos and videos. You can hide it if you'd like. It's not the most elegant solution—all it really does is add a black line across the cam and push the screen down—but it works. You can find the option in the Full Screen Apps tab in the Display settings.

find a place you like, the app will remember it for next time.

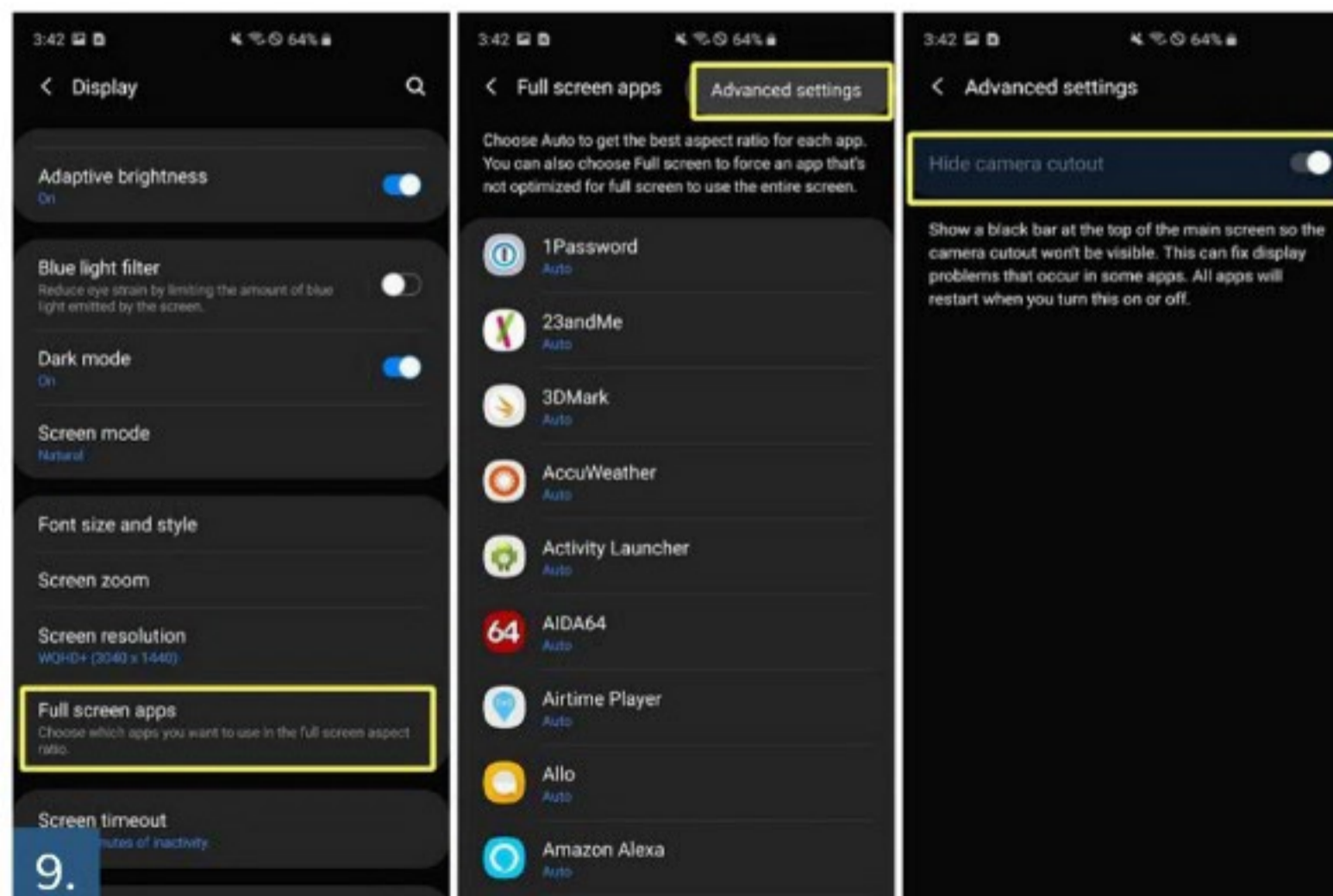
9. BLOCK OUT THE SELFIE CAMERA

The hole-punch camera on the S20 is much improved over the S10, but it's still going to

Tap the menu icon in the top right corner to get to Advanced Settings, and flip on the Hide Camera Cutout toggle.

10. FINE-TUNE YOUR SPACE ZOOM

Whether you're using 100X Space Zoom on the S20 Ultra or zooming to "only" 30X on the S20 or S20+, it can be extremely difficult to control with the standard two-finger pinch, even if you're using a tripod. There's an easier way to do it. If you tap and hold on one of the three camera views, the zoom bar will appear below your fingers, letting you slowly zero in on your subject. 🔌





10 cool things you can do with Google Home devices

There's more to Google Home than just playing music and Googling trivia with voice queries. **BY SARAH JACOBSSON PUREWAL**

Voice-activated assistants like Google Home and Amazon's Alexa have been around for a few years now, but they're still kind of gimmicky—they're not exactly J.A.R.V.I.S.-level AIs.

But Google Home might be more useful than you realize, especially if you're only using it to verbally start your Spotify playlists and occasionally settle a family argument when nobody has their phone handy. There are plenty of ways to use Google Home for

entertainment, information, or as a tool for being productive and learning new skills. If you're going to lace your home with Google devices, you might as well make them work for you.

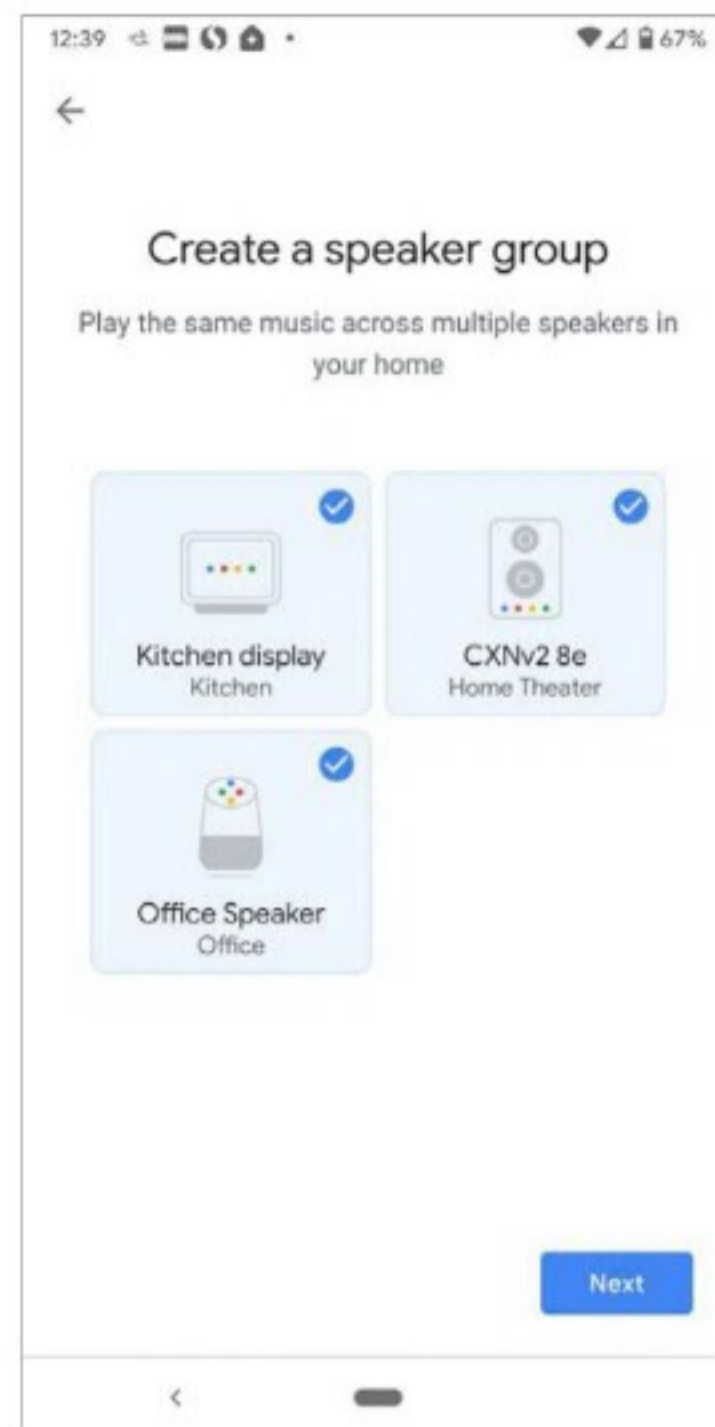
Note: Android users can configure third-party apps in the Google Home app (go.pcworld.com/ghme), but iOS users will need to download the separate Google Assistant app. Most third-party apps no longer need to be "linked" to work, though, so this might not be necessary depending on the app.

1. LINK YOUR SMART SPEAKERS

You don't need to buy a high-end amp and loudspeaker system to fill your home with music. Google Home has an apparently unlimited speaker-linking feature called Speaker Groups.

All you need are two or more compatible devices (Google Home, Google Nest Mini [2nd Gen], Google Home Mini [1st Gen], Google Home Max, Google Nest smart displays, Chromecast, Chromecast Ultra, Chromecast Audio, or TVs or speakers with built-in Chromecast) on the same Wi-Fi network.

To set up a speaker group, open the Google Home app and click on the + sign in the upper left corner. Under the heading Add To Home, tap Create Speaker Group. Select the speakers you want to link together



Google lets you group its smart speakers, smart displays, and Chromecast clients together, so you can play the same music all over your home.

and tap Next, give your speaker group a name, and tap Save.

To play music on your new speaker group, say, "OK, Google, play [song/artist/playlist] on [speaker group]." Alternatively, you can use the wake word "Hey Google," if that feels more natural.

Note: Linking certain devices (Chromecast, Chromecast Audio, Chromecast built-in speakers) in a speaker group might result in a synchronization error in which the music to one speaker is delayed. If you experience this, open the Google Home app, tap the device you want to correct, open its settings menu, and scroll down to Group Delay Correction.

2. BROADCAST MESSAGES

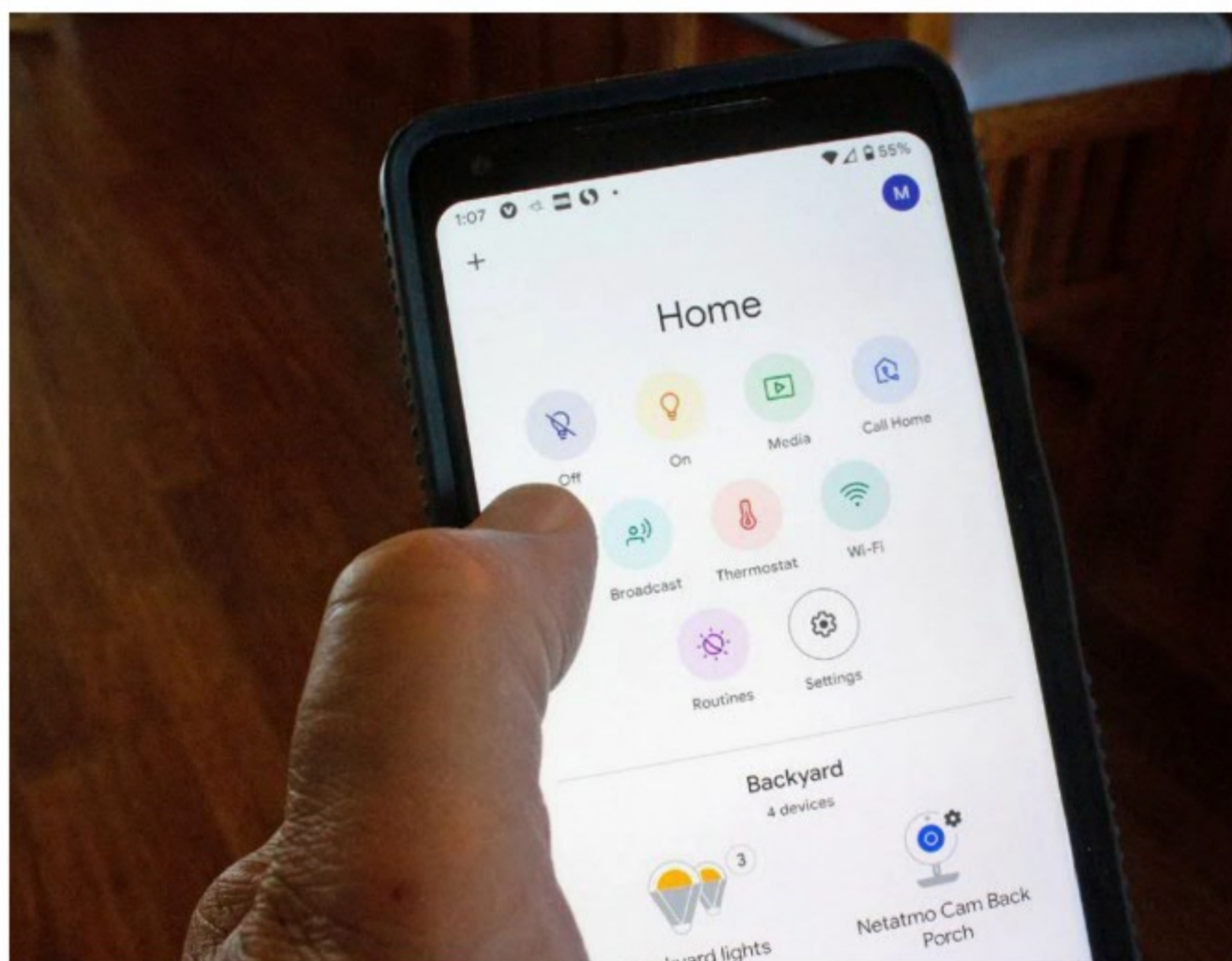
Google Home's Broadcast feature lets you send an audio message to all of the Google Home devices on your network. And if you broadcast directly from Google Assistant, you can send your message to all the Google Home devices you're currently signed into (even if they're on different networks—or in completely different locations).

It's sort of like a household PA system, only slightly more useful because people on the other end can respond to broadcasts (but their response will go only to the device that originated the broadcast). To do this, say "OK, Google: reply [message]."

To broadcast a custom voice message, say, "OK, Google, broadcast [message]." Your message will play on all connected Google Home devices except the one you're broadcasting from. You can also use the commands

"shout," "tell everyone," or "announce" instead of "broadcast."

Google also has a handful of preset broadcasts that will play a fun sound effect (such as a rooster crowing, or a dinner bell) alongside a preset message. Preset broadcasts will play on all connected Google Home devices including the one you're broadcasting from. Presets include waking up and going to bed ("OK, Google, wake up everyone," "OK, Google, time for bed"), announcing meals ("OK, Google, breakfast is ready," "OK, Google, it's lunch time," "OK, Google, dinner is served"), leaving/arriving home ("OK, Google, time



Google Home's Broadcast feature lets you send verbal messages to any or all of the Google Home smart speakers or smart displays in your house.

to leave," "OK, Google, I'm home"), and announcing entertainment ("OK, Google, the movie is about to start," "OK, Google, the show is about to start").

3. SET UP ROUTINES

Google Home's Routines are designed to help streamline your life by triggering multiple actions with a single command (or at a certain time).

To manage and set up Routines, open the Google Home app, tap the Routines icon, and tap Manage Routines. Google Home has six preset routines called Good Morning, Bedtime, Leaving Home, I'm Home, Commuting To Work, and Commuting Home. The presets are pretty

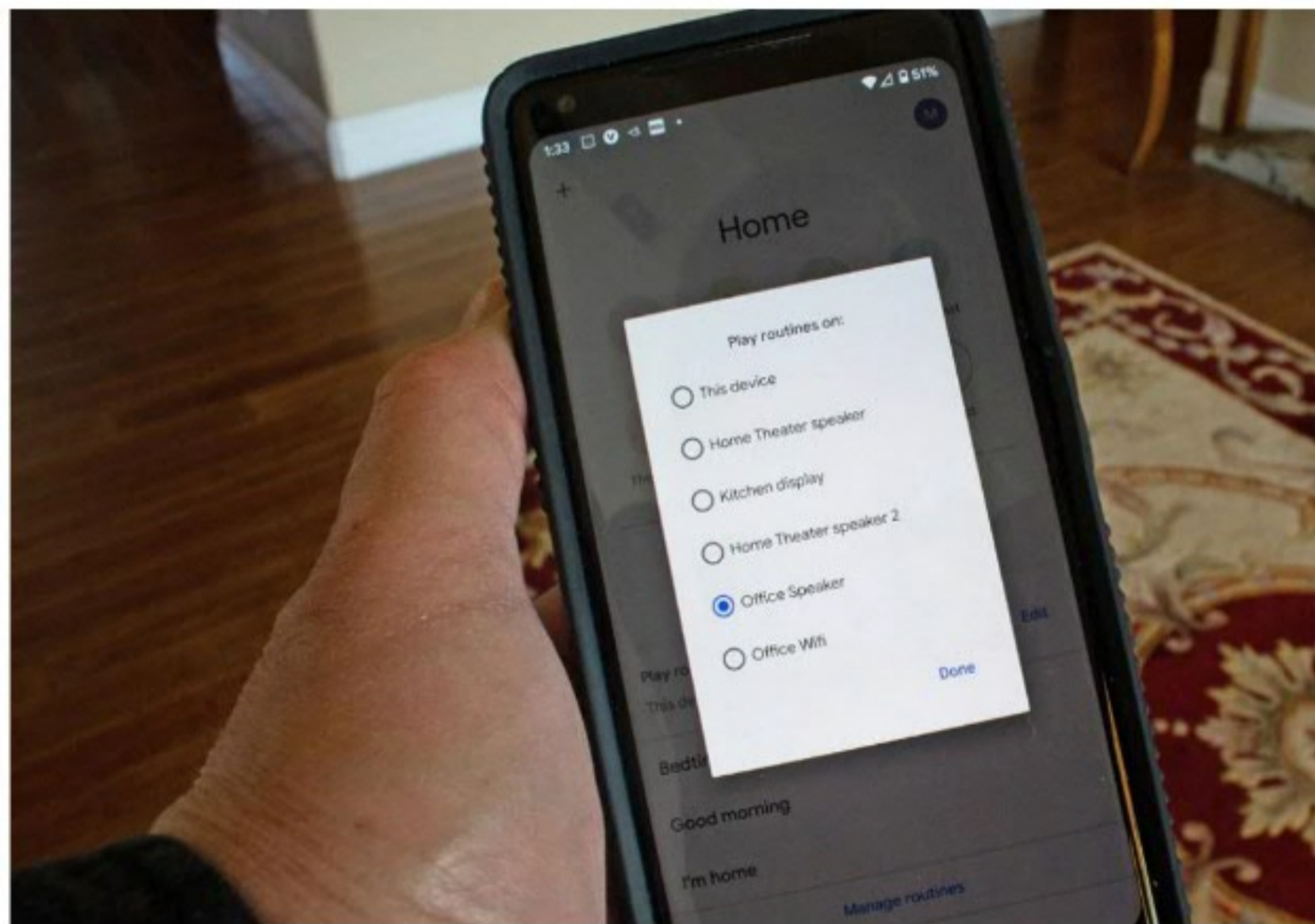
straightforward: Trigger the Bedtime routine, and Google Home will do things like put your phone on silent, ask what time to set an alarm for, and turn off your lights (if you have connected lights). The presets are just suggestions—you can fully customize them with different commands, actions, and media.

You can also set up your own custom routines to do just about anything. To set up a new routine, tap the plus symbol in the Manage Routines menu and add the command(s) to trigger the routine, the action(s) to be performed, and the media to be played. It's also possible to set up routines that are triggered by a specific time/day—e.g., every weekday at 7 a.m.—

rather than a verbal command.

4. RELAX

Google Home has its own library of soothing ambient tracks at the ready when you need some background sound to help you sleep, meditate, or just relax in general. If you're not picky about the type of sound you want to hear, say, "OK,



You'll need to assign routines to one of your Google Home smart devices. This feature would be much more useful if you could assign a routine to the device in the room you think you'll be in when you need it to run.

Google, help me relax," or "OK, Google, play ambient noise" for a random pick. You can also ask for specific sounds by name: Relaxing sounds, nature sounds, water sounds, running water sounds, babbling brook sounds, oscillating fan sounds, fireplace sounds, forest sounds, country night sounds, ocean sounds, rain sounds, river sounds, thunderstorm sounds, and white noise.

Google Home also features a sleep timer, which you can set by duration (e.g., two hours) or by time (e.g., 1 a.m.). To set a sleep timer using Google Home's ambient tracks, say, "OK, Google, play [sound] for [duration]," or "OK, Google, stop playing [sound] in [duration]." You can also say, "OK, Google, play [sound] until [time]," or "OK, Google, stop playing [sound] at [time]."

5. LISTEN TO A STORY

You probably shouldn't use Google Home to replace real-life storytime, but it can work in a pinch if you need to entertain your kids (or yourself). Just say, "OK, Google, tell me a story," and Google Home will play a short, random children's story from its library of stories (don't worry, all the stories are family friendly). The stories come from third-party apps and are fully voiced and narrated, so you don't need to worry—you're not going to be subjected to the Google Assistant voice robotically stuttering through a tale.

You can narrow the story down by

type—for example, "OK, Google, tell me a princess story," or "OK, Google, tell me a story about dinosaurs," or "OK, Google, tell me a bedtime story." You can also ask for a specific story—for example, "OK, Google, tell me the story of Snow White," or "OK, Google, tell me the Hansel and Gretel story."

If you're looking for something a little less involved than a story, you can also ask Google Home to read a poem or tell a joke.

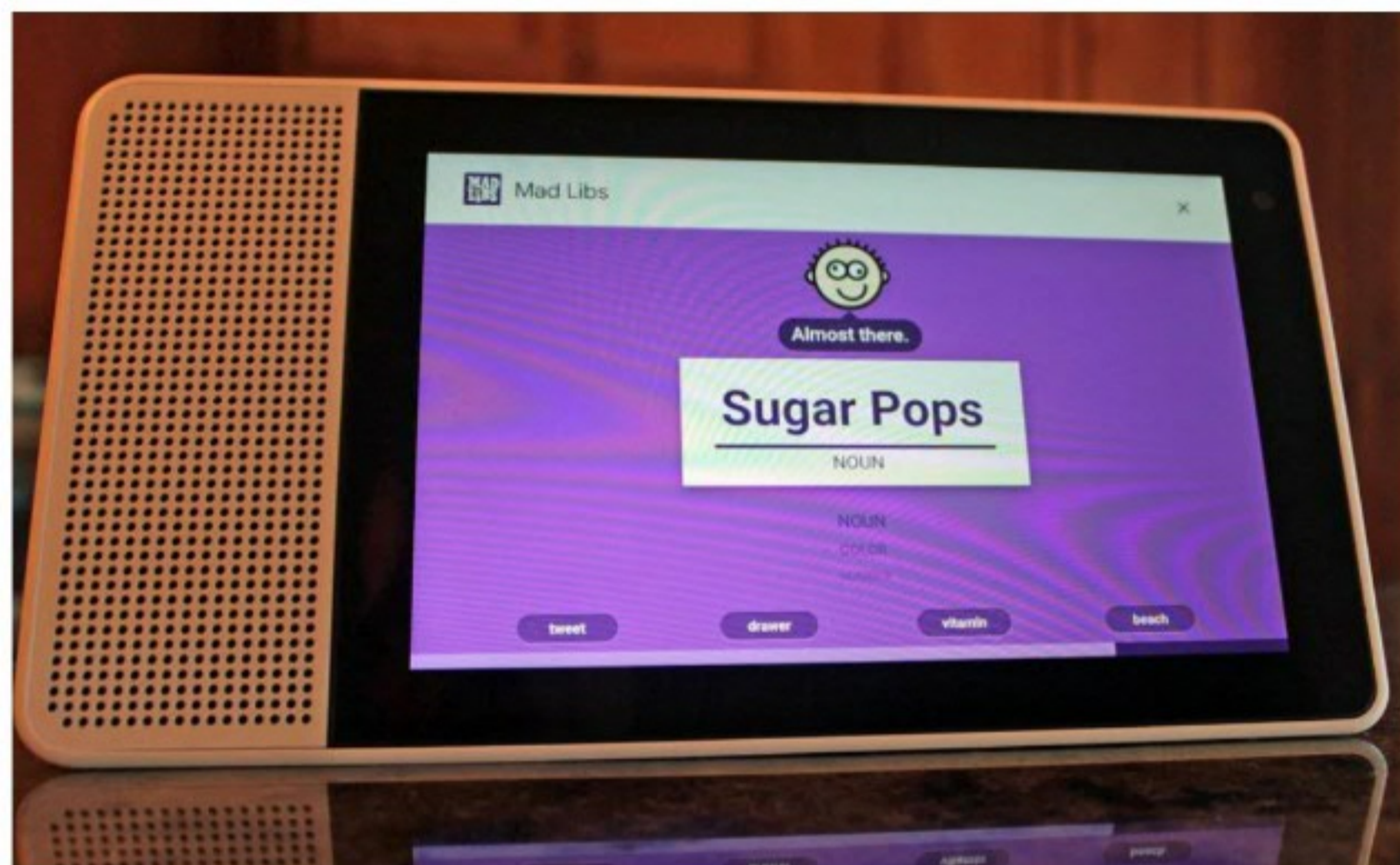
6. PLAY GAMES

Interactive audio games are one of the many ways Google Home can keep you and your friends entertained. Google Home integrates with hundreds of third-party games—everything from trivia to hangman to choose-your-own-adventure games—many of which can be played on your own or with a group. Google Home can even help you with your options, just say, "OK, Google, what games can you play?" or "OK, Google, what trivia games can you play?"

Here are some games we recommend trying:

"OK, Google, play Song Quiz" or "OK, Google, play SongPop." In these two musical guessing games, you try to guess the song title and artist from a short clip.

"OK, Google, play [trivia game]." A handful of trivia game options: Are you feeling lucky? Try Star Wars Trivia Challenge, Marvel Movie Quiz, Animal Trivia, Space Trivia, Tricky Mind Trivia, or TriviaCrack.



Some of the games you can play on Google Home-compatible devices, such as Mad Libs, have a visual element that makes them even more fun to play on Google smart displays.

“OK, Google, play Mad Libs.” Google will ask you for words and will use them to fill in the blanks to create a mad lib.

“OK, Google, play Space Bungalow.” This is an audio-based choose-your-own-adventure game in space (well, in a space bungalow).

“OK, Google, play Truth or Dare.” Let Google come up with truth-or-dare questions for you.

7. LEARN A NEW LANGUAGE

Google Home doesn't have a native feature that will teach you a new language, but it's a good supplement for language learning.

That's because Google Home taps into Google Translate, so you can use it to translate words or phrases, or have it act as a real-time

translator. To find the translation of a word or phrase, say, “OK, Google, what's [word/phrase] in [language]?” or “OK, Google, translate [word/phrase] to [language].” To use Google as a translator, say, “OK, Google, be my translator,” and Google will ask which language you want to translate to.

If you're feeling ambitious, you can also change Google Home's language to see if it understands you. To change the language, open the Google Home app and go to the settings menu. Scroll down to Google Assistant Services and tap More Settings. Under Assistant, tap Languages, and choose a new language.

Google Home also integrates with some third-party language learning apps that can help you practice phrases and review words. These include Busuu (Spanish), Learn French, Learn Japanese, Learn Arabic, Learn German, and Speak Chinese.

8. STAY HEALTHY

It's not quite Peloton, but Google Home can make a decent at-home workout partner. You

can use it to play music, find workout playlists, and set timers, as well as use it as a stopwatch. It also works with a handful of apps that can guide you through a quick high-intensity workout or a guided meditation session. Here are some apps we recommend:

“OK, Google, talk to Fitness Buddy.” This app generates workout ideas based on what type of workout you’re looking for (e.g., a leg workout).

“OK, Google, talk to 5 Minute Plank.” Do you like planking? Do you like planking for five minutes? This app walks you through a five-minute plank workout that you can do anywhere.

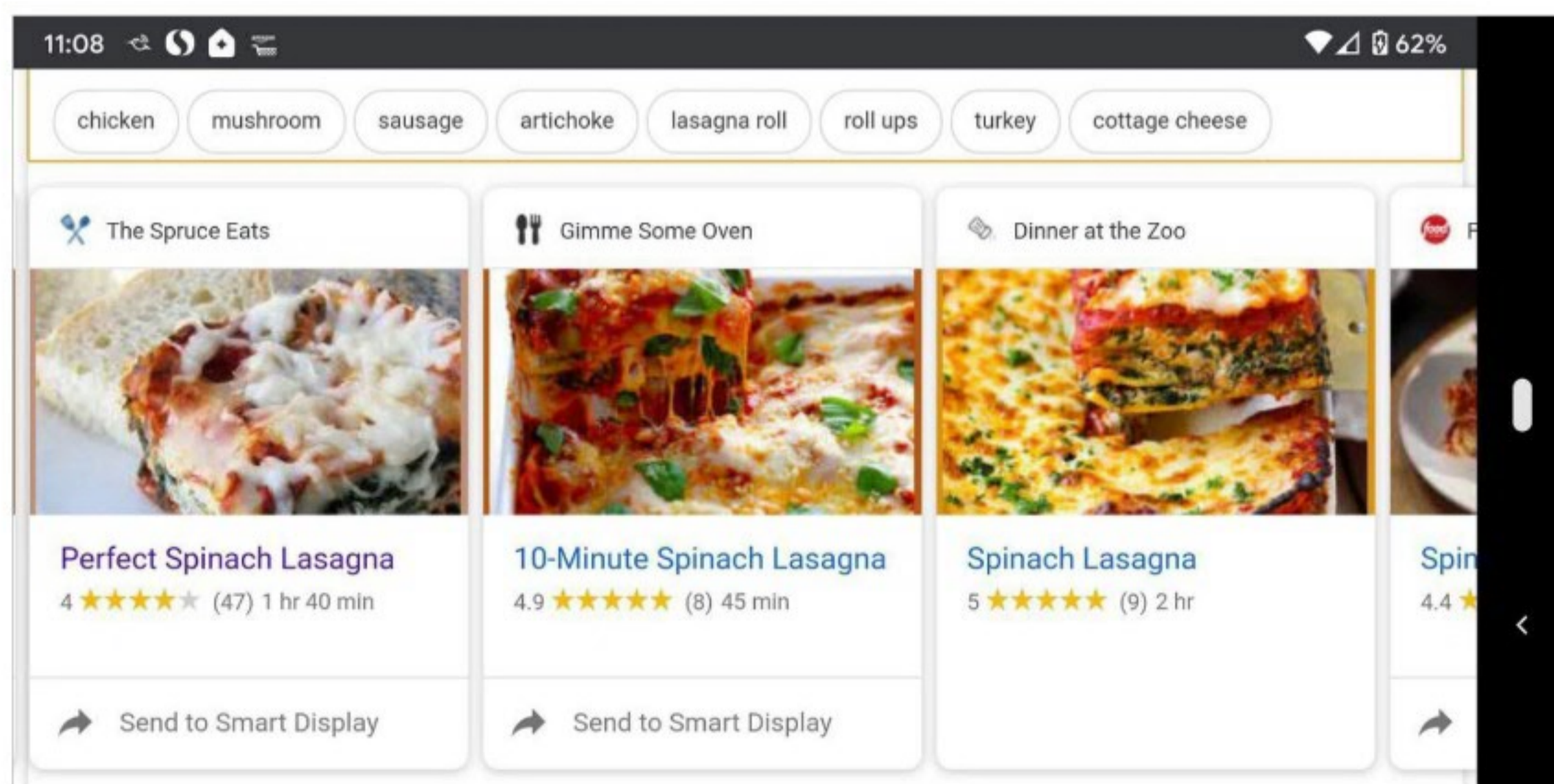
“OK, Google, talk to Quick Workout.” Quick Workout guides you through a quick, home-based bodyweight workout.

“OK, Google, talk to Headspace,” or “OK, Google, talk to Calm.” Headspace and Calm are subscription-based guided meditation apps that each offer a handful of free sessions.

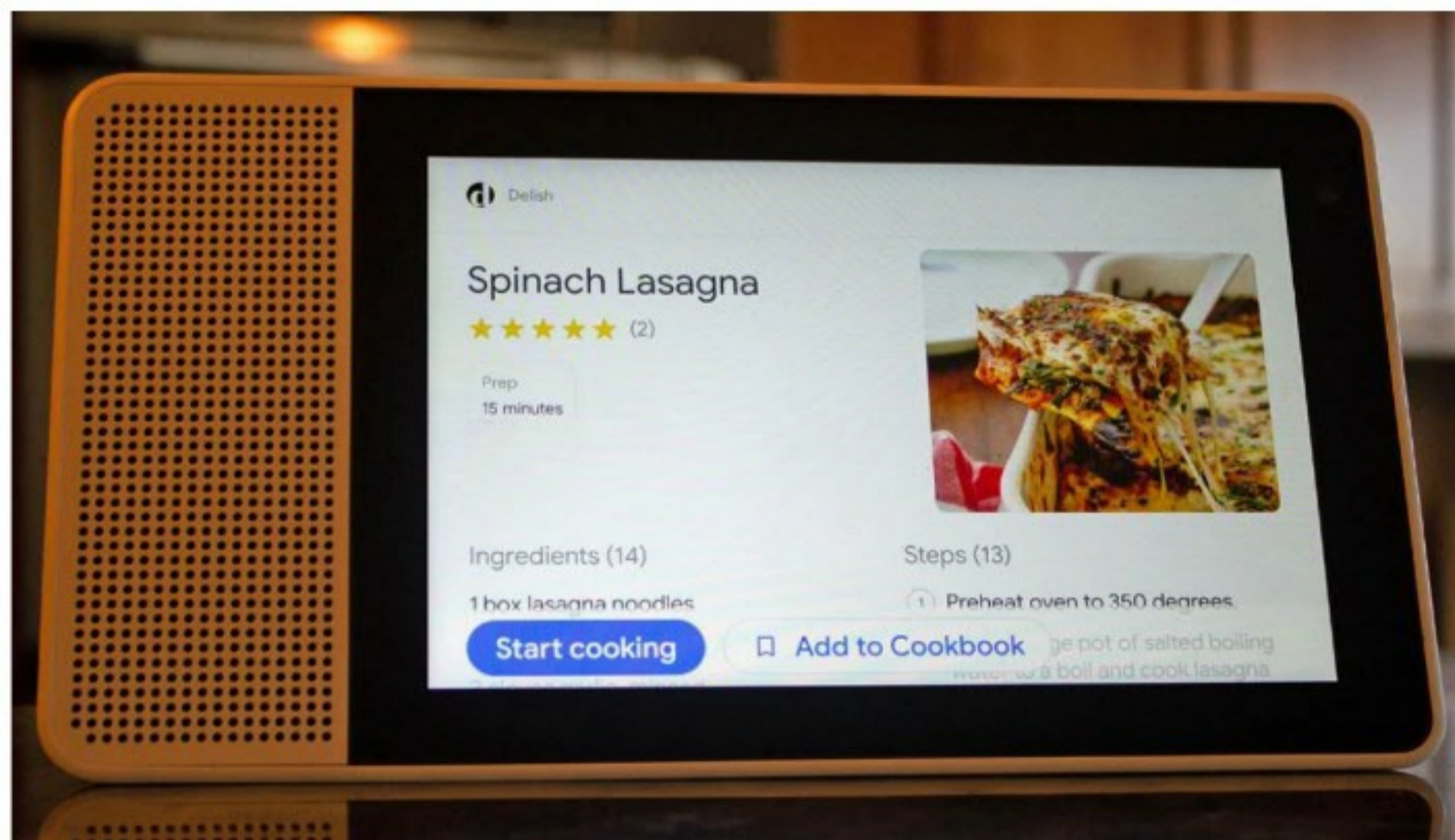
9. BE A MASTER CHEF

Google Home can be useful in any room of your house, but it’s especially useful in the kitchen. Here are some of the ways you can use Google Home to help you cook:

“OK, Google, find a recipe for [dish].” Google will search websites such as [AllRecipes.com](https://www.allrecipes.com) to find a suitable recipe for whatever dish you want. You can also find a recipe on your smartphone or tablet and send it to Google Home (just tap the Send To Smart Speaker shortcut that appears next



Search for recipes on your smartphone or tablet, and you can send any you like to your Google Home smart speaker.



When you find a recipe you want to try, you can send it from your smartphone or tablet to a Google Smart Display, such as the Lenovo model shown here.

to your search result).

If you have a Google smart display, such as a Google Nest Hub Max (go.pcworld.com/hmax) or Lenovo Smart Display (go.pcworld.com/lsmid), and the recipe has a video attached, you can send it to that device, instead.

Next, say, "OK, Google, start recipe," and Google Home will read the recipe to you step-by-step (or play the video on your smart display). You can ask Google to proceed to the next step ("OK, Google, next step"), repeat a step ("OK, Google, repeat step"), or read a different step ("OK, Google, what's step [number]").

"OK, Google, set timer for [time]." Google can set timers, check timers ("OK, Google, check timer"), and set named timers ("OK, Google, set timer called [name] for [time]").

"OK, Google, how many teaspoons are in a tablespoon?" Google Home can perform unit conversions, find calorie and nutrition information, and recommend substitutions (e.g., "OK, Google, what can I use instead of butter?") while you're cooking.

"OK, Google, how do I cream sugar and butter?" Google Home can help you with any cooking terms or directions you don't understand.

"OK, Google, add [item] to my grocery list." If you don't already have a grocery list that's distinct from your shopping list, Google Assistant will ask if you want to create one. Reply in the affirmative, and Google Assistant will create your list and add the item you asked it to add. When you arrive at the store, pull out your smartphone and say "OK, Google, show me my grocery list," and it will appear on your display.

10. GO FURTHER WITH IFTTT

Google Home can do quite a bit, and lots of functionality has been added since the service debuted. But it still has plenty of limitations, especially when it comes to smart tech that isn't compatible with the platform. Instead of revamping your entire smart home to work with Google, you might first want to try the original web-based automator: IFTTT.

IFTTT, which stands for "If This, Then That," is a free automation service that connects various web services, apps, and devices using conditional statements. Basically, IFTTT takes an action originated on one service and uses it to trigger an action on another service. IFTTT is compatible with far more apps, devices, and services than Google Home is, and it's highly customizable, which means you can use IFTTT to force Google Home to trigger all sorts of tasks.

To get started with IFTTT, you'll need to sign up for an account (or sign in) and connect the Google Assistant service along with any other services you'd like to use (social media, phones, other smart home devices, etc). Once you have all your services connected, you can create your own IFTTT applets or download applets that other users have built to perform tasks. Here are some of the most useful IFTTT applets for Google Home users:


Add a to-do in iPhone's Reminders app

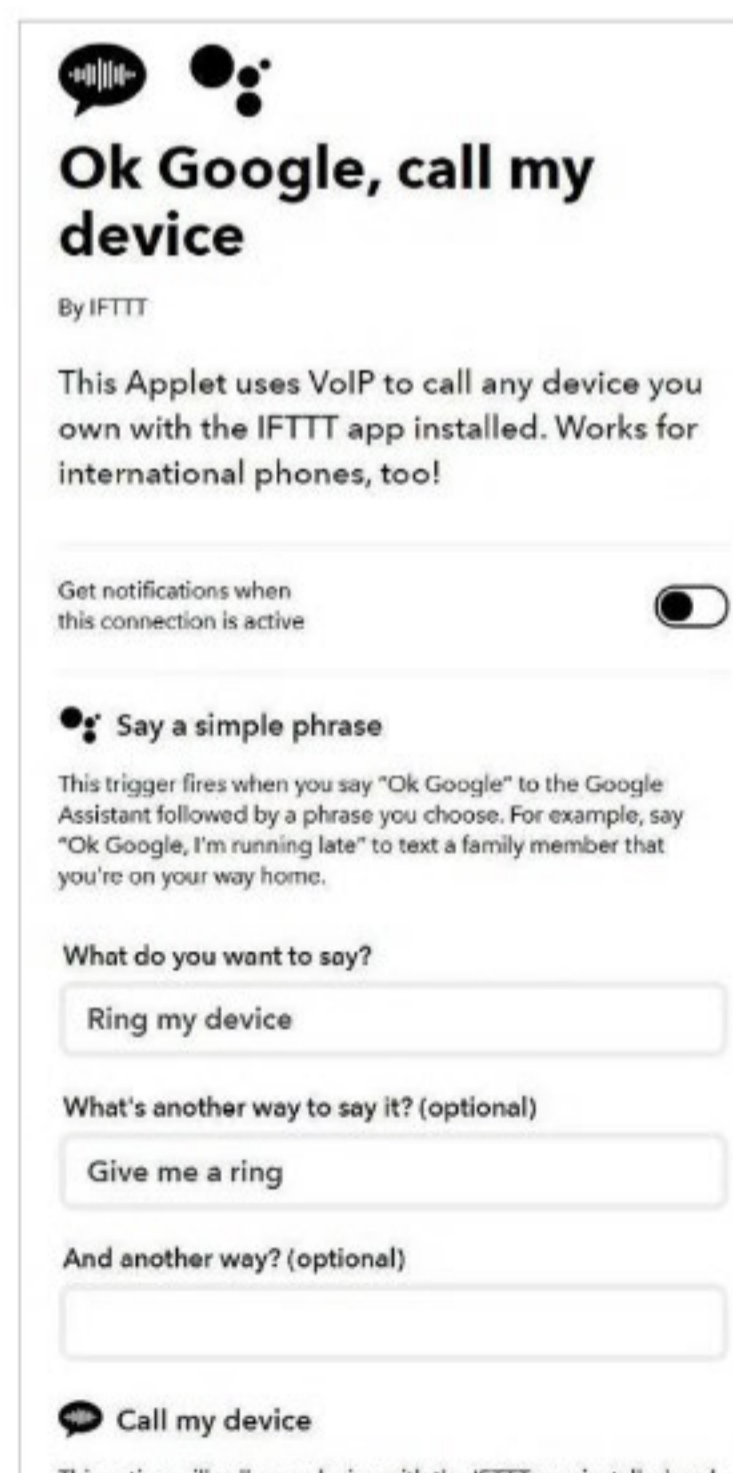
with Google Home: "OK, Google, add a reminder to my iPhone [reminder]" (go.pcworld.com/adrm).

Send a text message with Google Home: "OK, Google, message [name]" (go.pcworld.com/gmss).

Add a song to a designated Spotify playlist with Google Home: "OK, Google, add [song name] by [artist name]" (go.pcworld.com/adsp).

Tweet with Google Home "OK, Google, tweet [message]" (go.pcworld.com/atwt).

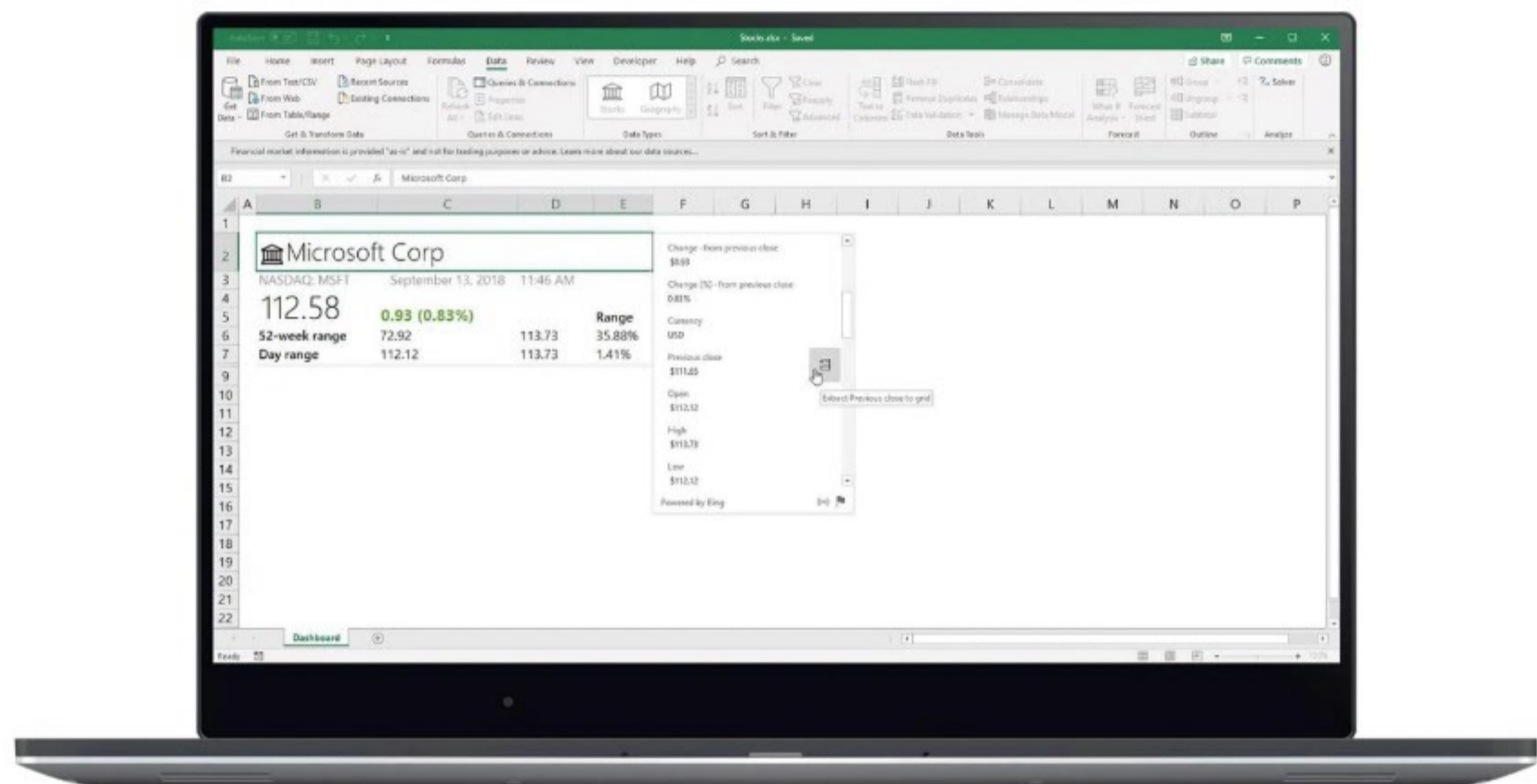
Add an event to your iOS calendar with Google Home: "OK, Google, add to my iOS calendar [event title], [day and time]" (go.pcworld.com/iocl). 



Google Assistant and IFTTT are a match made in heaven. Lost your phone in your house? Ask your Google Home smart speaker or smart display to ring it for you!

Excel formulas: The most popular functions and tools

Make sure these date and time functions, math tricks, and data manipulation tools are all at your disposal. **BY JD SARTAIN**



Excel has over 475 formulas in its Functions Library, from simple mathematics to very complex statistical, logical, and engineering tasks such as IF statements (go.pcworld.com/ifst, one of our perennial favorite stories); AND, OR, NOT functions; and COUNT, AVERAGE, and MIN/MAX.

The basic functions covered below are among the most popular formulas in Excel—the ones everyone should know. To help you learn, we've also provided a

spreadsheet with all the formula examples we cover here (go.pcworld.com/xlform).

1. TODAY/NOW

There are 24 Date and Time functions listed on the drop-down menu under Formulas > Date & Time: 11 Date formats, 10 Time formats, and as many user-defined custom formats you can create. The TODAY function reveals the current month, day, and year; while the NOW function reveals the current month, day, year, and time of day. This is a handy function if you're one of those

individuals who always forgets to date your work.

1. Enter the following formula in cell A1: **=TODAY()** and press **Enter**.

2. Next, type over that function in A1 with **=NOW()**.

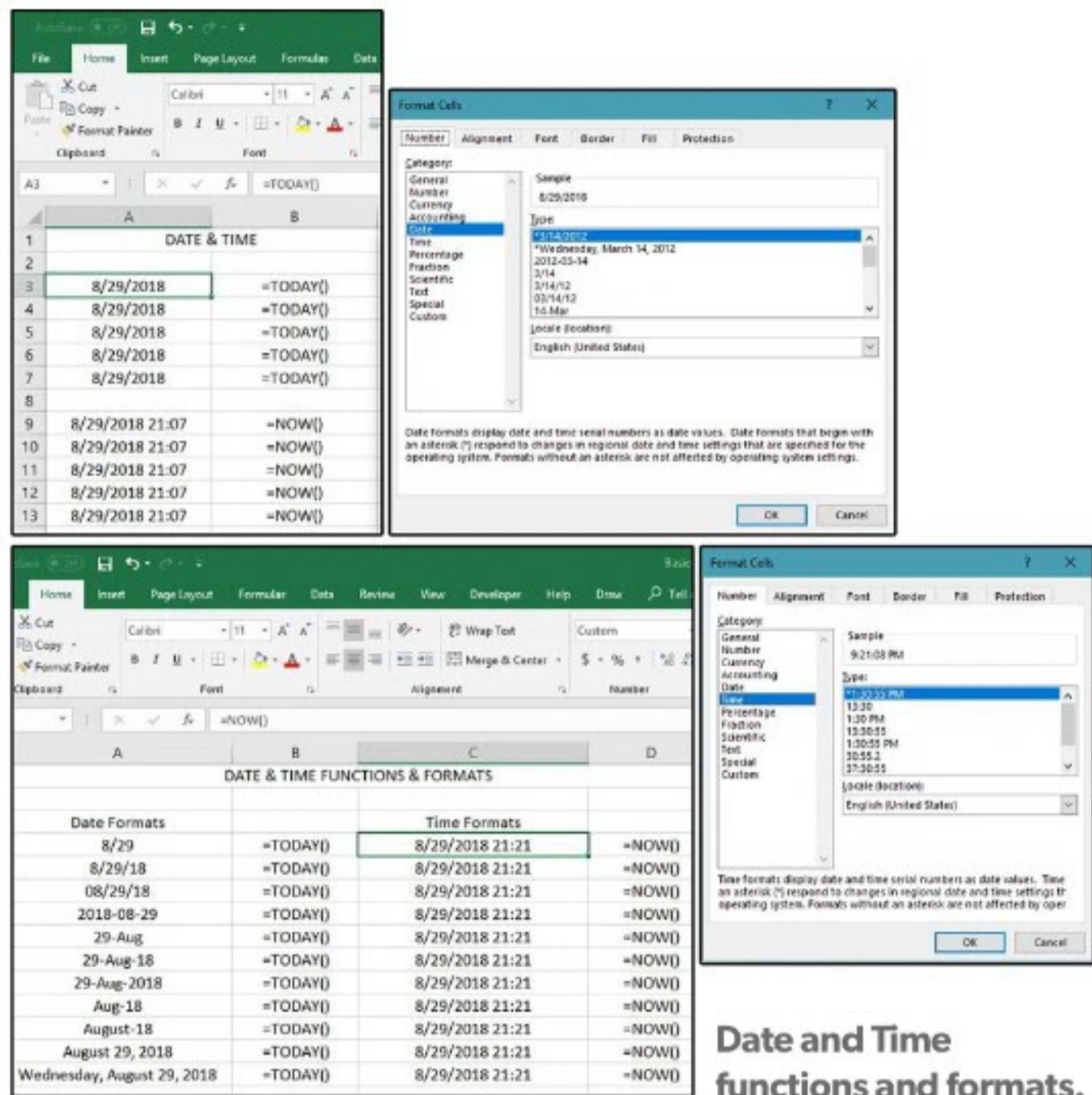
IMPORTANT NOTE: Why type over? In order for these two formulas to work properly, they must be entered in the Home cell, that is, A1, otherwise, they won't update automatically when the spreadsheet recalculates. Press **Shift-F9** to calculate/recalculate the active spreadsheet only, or press **F9** for the entire workbook.

After you enter one of these functions in A1, you can then reformat the Date and Time or use the system default. The default format for the TODAY function is 8/29/18, and the default for NOW is 8/29/18 21:57. If these don't work for you, change them.

3. Position your cursor on the Date or Time you want changed and choose Home > Format > Format Cells.

4. In the Format Cells dialog window, choose Date (or Time) from the Category panel under the Number tab.

5. Scroll through the list of Date/Time formats in the Type dialog pane and select the format that best fits your project.



Date and Time functions and formats.

2. SUM FUNCTIONS

Probably the most frequently used function in Excel (or any other spreadsheet program), **=SUM** does just that: It sums a column, row, or range of numbers—but it doesn't just sum. It also subtracts, multiplies, divides, and uses any of the comparison operators to return a result of 1 (true) or 0 (false).

You can also get the same results just using the plus (+) sign in place of the function **SUM**. For example, both of these formulas produce the same answer: **=SUM(I7*9)** and **=+(I7*9)**. In the spreadsheet graphic, notice that cells E3 through E8 use the **SUM** function, while cells E9 through E14 use the plus (+) sign and the

results are the same.

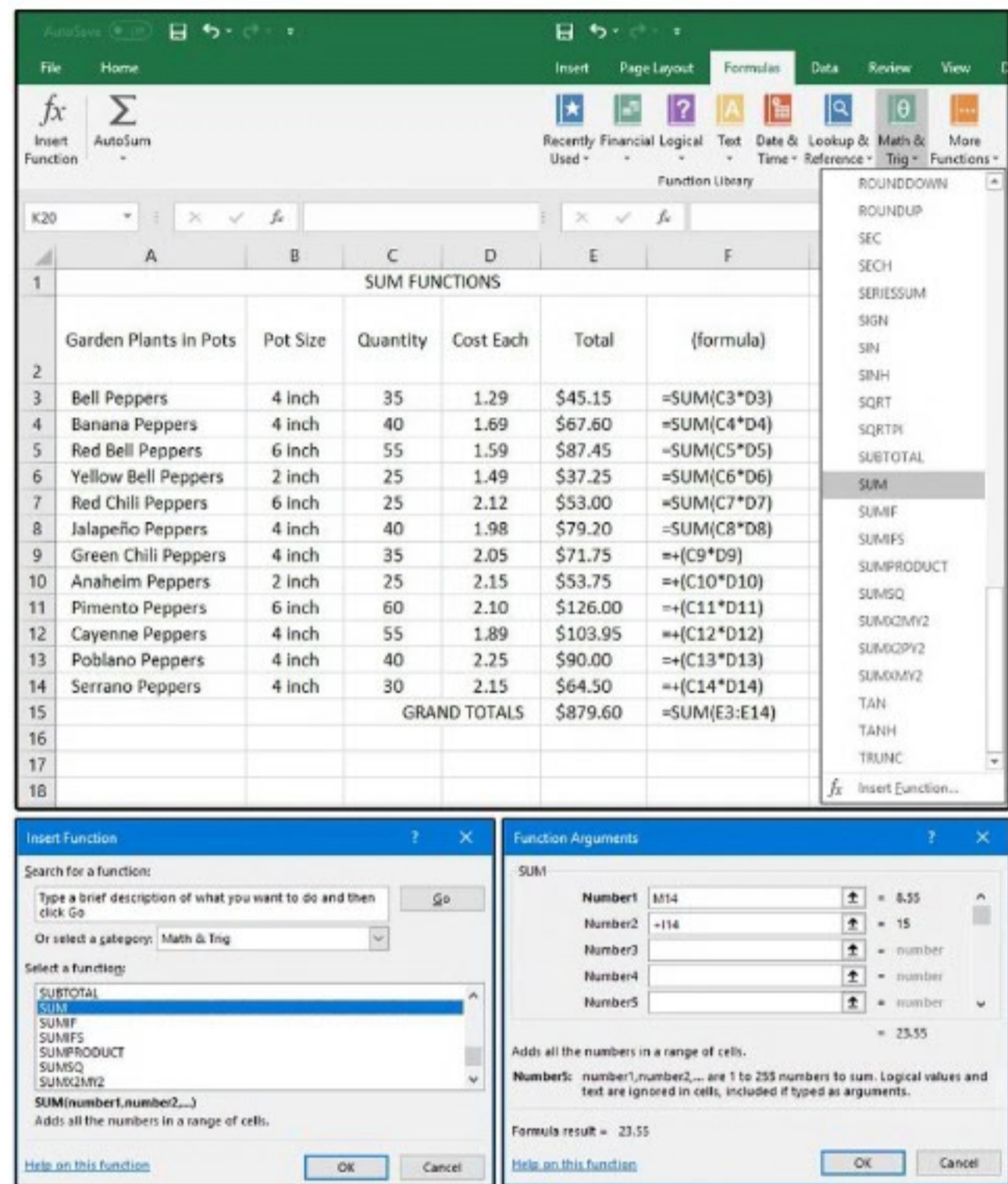
You can enter the SUM function (or + sign) manually or select it from the Ribbon menu under Formulas > Math & Trig (button), then choose from the drop-down list; or choose (from the Ribbon menu) Formulas > Insert Function, then scroll down the list and select it from there.

If you just want to add a single column of numbers, position your cursor in the cell at the bottom of that column, click the AutoSum button > SUM, and press Enter. Excel frames the column of numbers in green borders and displays the formula in the current cell.

The problem comes when the range of numbers you need to calculate gets complicated with multiple calculation operators over multiple cells. For example: =SUM(H1+I1*I1-M1*J1). Remember your high school math? If the numbers inside the formula are not grouped properly, the answer will be wrong. Notice the screenshot below (figure 2).

Enter the following column headers in H2 through P2 (use Alt+ Enter to stack headers in a single cell): Daily Earnings, Plus Bonuses, Times Days Worked, Gross Pay, (formula), Minus Meals at \$9.00 per day, Total Monthly Earnings, Formula, and Comment.

NOTE: The formula columns are FYI only



Sum functions using multiple calculation operators.

and provide no intrinsic value to the spreadsheet. They just “display” the formula for your benefit (so you can see the syntax of each formula used).

For this exercise, you can enter the same values in H3:11, I3:11, and J3:11, with or without the blank rows in between (again, added for easier viewing). Complete as follows: \$86.00, \$20.00, 22.0 workdays, and the rest are formulas. Note that as we build each formula, we are combining the steps, eventually, into a single formula.

We start out with three separate formulas. The first is to add the Daily

earnings, plus Bonuses, multiplied by the number of days worked in a month, which equals Gross Pay: =SUM(H3+I3*J3) in cell K3. Notice that the answer is \$526.00. That just doesn't look right (see table below).

Use your calculator to check the formulas to ensure they're correct BEFORE you copy them to the rest of the cells in the column.

The formula in K3 is wrong. It requires grouping the numbers according to the order of calculation using commas or parentheses.

Note the corrected formula in cell K4: =SUM(H4+I4)*J4. Check your numbers again (with your calculator) and note that this formula is correct. The correct answer is \$2,332.00.

4. The second formula (in M4) is =SUM(J4*9), which multiplies the workdays (22) times \$9.00 to get the cost of meals per day. The correct answer is \$198.00.

6. The third formula (in N4) calculates the monthly earnings minus the meals: =SUM(K4-M4); answer is \$2,134.00.

7. In the next group (H6:N8), the formulas in M6:M8 remain the same: =SUM(J7*9), etc.—again that's the number of workdays times the cost of meals. But the formulas in column K are eliminated and then combined with the

formulas in column M: =SUM(H7+I7)*J7-M7. Note that the syntax (the structure or layout of the formula) is correct in cells N7 and N8, but incorrect in N6.

8. The next group (H10:H11) combines the formulas in column M with the formulas in column N: =SUM(H11+I11)*J11-(M11*J11)—note that the formula in N10 is incorrect. By combining these formulas into one, you can eliminate columns K and L.

9. Also, instead of "hardcoding" the price of the meals (as shown in M3:M4 and M6:M8), you can now change the price of the meals in column M (M10:M11) when inflation dictates an increase instead of changing the formula.

3. RAND FUNCTION

The RAND function is really simple and traditionally used for statistical analysis, cryptography, gaming, gambling, and probability theory, among dozens of other

	H	I	J	K	L	M	N	O	P
1									
2	Daily Earnings	plus Bonuses	Times Days Worked	Gross Pay	(formula)	Minus Meals at \$9.00/Day	Total Monthly Earnings	(formula)	
3	\$86.00	\$20.00	22.0	\$526.00	=SUM(H3+I3*J3)	\$198.00	\$328.00	=SUM(K3-M3)	WRONG
4	\$86.00	\$20.00	22.0	\$2,332.00	=SUM(H4+I4)*J4	\$198.00	\$2,134.00	=SUM(K4-M4)	CORRECT
5									
6	\$86.00	\$20.00	22.0			\$198.00	-18656.00	=SUM(H6+I6)*J6-M6	WRONG
7	\$86.00	\$20.00	22.0			\$198.00	2134.00	=SUM(H7+I7)*J7-M7	CORRECT
8	\$86.00	\$20.00	22.0			\$198.00	2134.00	=SUM(H8+I8)*J8-M8	CORRECT
9									
10	\$86.00	\$20.00	22.0			\$9.00	2125.00	=SUM(H10+I10)*J10-(M10*J10)-M10	WRONG
11	\$86.00	\$20.00	22.0			\$9.00	2134.00	=SUM(H11+I11)*J11-(M11*J11)	CORRECT
12									
13	\$89.00	\$15.00	20.5			\$175.28	1956.73	=SUM(H13+I13)*J13-(M13)	CORRECT
14	\$89.00	\$15.00	20.5			\$8.55	1956.73	=SUM(H14+I14)*J14-(M14*J14)	CORRECT
15									
16	\$89.00	\$15.00	20.5			\$8.55	1956.73	=SUM(H16+I16)*J16-(M16*J16)	CORRECT

Complex SUM functions using multiple arguments.

things. In Excel, the RAND function generates a random number between 0 and 1. Note; however, that every time you enter new data and press the Enter key, the list of random numbers you just created changes. If you need to maintain your random numbers lists, you must format the cells as values.

1. Enter the function **=RAND()** in columns A3 through A14. Select that column and press **Ctrl+C** (for copy) or click the Copy button under the Home tab and choose Copy from the drop-down menu. Move your cursor to cell B3 and select Home > Paste > Paste Special. Click the Values button from the Paste Special dialog window, then click OK.

2. Now the list contains values instead of functions, so it will not change. Notice (in the formula bar) that the random numbers have 15 digits after the decimal (Excel defaults to 9), which you can change, if necessary (as displayed in cell F3). Just click the Increase Decimal button in the Number group under the Home tab.

3. If you prefer to work with whole numbers, enter this formula in cell F3: **=INT(RAND()*999)** and you get a 3-digit random number. Copy the formula down through F12, then add another 9 to the string to add another digit to your random number—e.g., four nines equal four digits, five nines equal five digits. Again, you must copy the list and Paste As Values to maintain a static list.

4. COUNT FUNCTIONS

Use the COUNT function to count the number of numeric values in a range of cells; for example: C4:C15 contains the quantity of garden tools Mr. McGregor needs to order for his shop. Note that the answer is 10 (out of 12), because the COUNT function does not include blank cells. However, if you enter a zero, a numeric code, or a date, Excel counts it as an “occupied” cell and includes it in its answer.

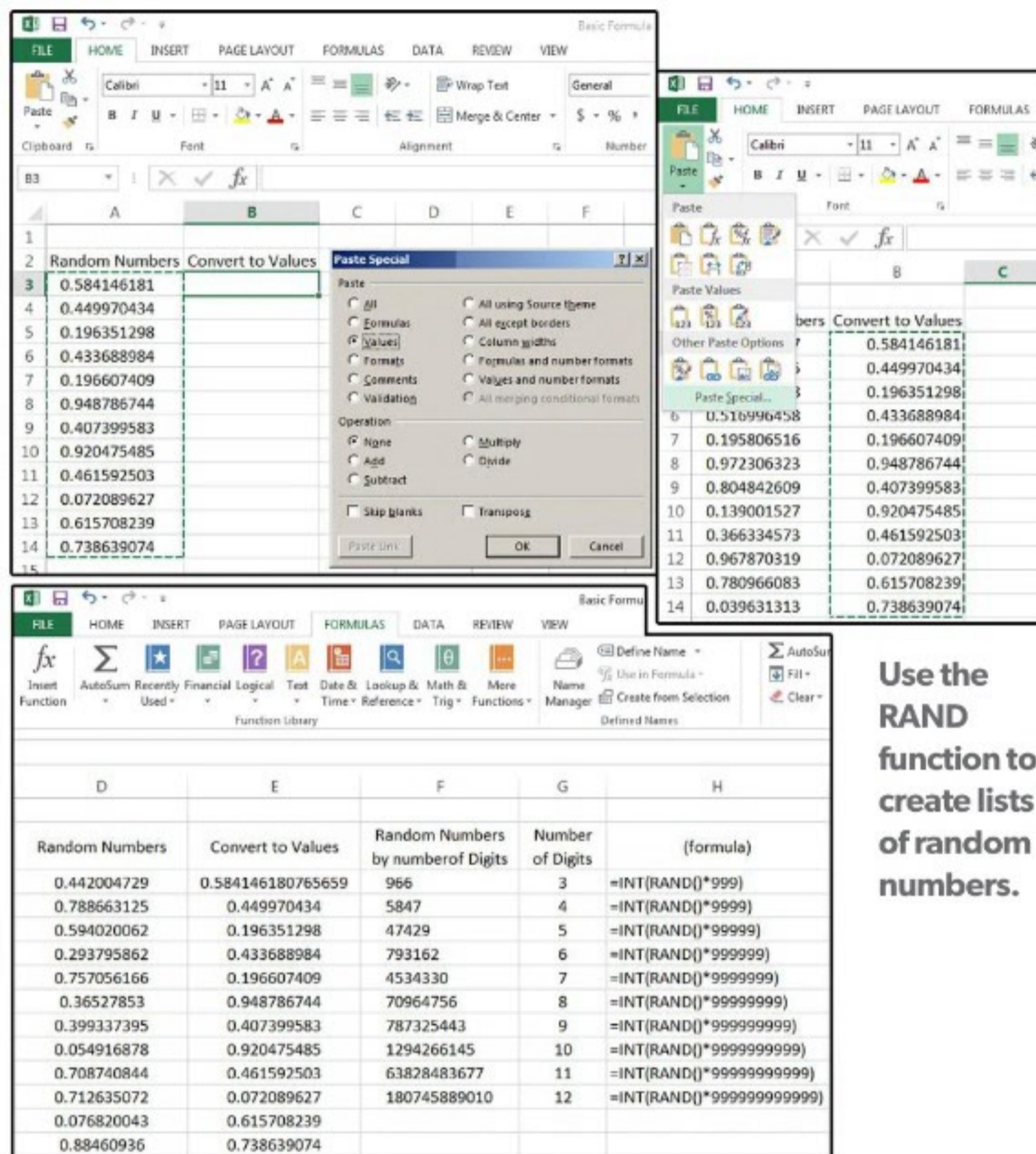
Enter 10 numbers into column C (Quantity). Replace one number with a space (or a tap on the spacebar), then replace another number with a semicolon, and then enter a date into cell C7.

Enter this formula at the bottom of the number list (C16): **=COUNT(C4:C15)**. The answer is 10 (out of 12) because Excel counted all the numbers and the date, but ignored the blank cell (containing the space) and the punctuation in cell C8.

Use the COUNTA function if you want to include numeric values, logical or error values, text, a space (from the spacebar), punctuation, symbols, or any other character on your keyboard.

1. Enter 12 dollar amounts into column D (Price). Replace one cell with a question mark, another cell with a symbol, and another cell with some text.

2. Enter this formula in D16: **=COUNTA(C4:C15)**. The answer is 12 (out of 12) because Excel included all the “non-



1. Enter some numbers in column A. Enter the AVERAGE function at the bottom of the list:

=AVERAGE (A4:A13) and note the answer (in our case) is 53. You can verify your answer with the SUM function; that is:

=SUM(A4:A13/10) = 53.

2. Next enter some more numbers in column C but, this time, add some text to one cell,

punctuation to another, and a space to another. Enter the same formula:

=AVERAGE (A4:A15), and note the answer is 78. To verify, enter the SUM formula omitting the cells

Use the RAND function to create lists of random numbers.

numeric" values and characters.

3. Notice that row 18 (C and D) displays the actual formulas that are in C and D 16.

5. AVERAGE FUNCTION

Most everyone knows that an average is determined by adding all the values in a list, then dividing by the number of values listed; e.g., $4+5+3=12/3=4$, which is the average. You can use the SUM function and add the division all in one formula, or you can just use the AVERAGE function. The syntax is: **=AVERAGE(range)**.

that contain non-numeric characters:

Cells that contain text, logical values, punctuation, or empty cells are disregarded; but cells with the zeros (as a number, but not as text) are included. A text zero would have an apostrophe in front of the zero, which you cannot see in the cell, but is visible in the Formula Bar.

IMPORTANT NOTE: If you're importing huge databases from a mainframe or an outside, external source, sometimes the numbers export as text. How can you know if a number is really text? Generally, text is

COUNT FUNCTION			
	Products	Quantity	Price
1			
2			
3			
4	1 Garden Hoe	60	16.98
5	2 Round Digging Shovel	55	23.44
6	3 Spade		?
7	4 Flat Shovel	62	26.10
8	5 Trenching Shovel	45	😊
9	6 Post Hole Digger	40	22.12
10	7 Pick Axe	2/5/2015	19.02
11	8 Pitch Fork	;	26.99
12	9 Pruning Shears	62	not available
13	10 Leaf Rake	58	25.28
14	11 Garden Rake	56	20.42
15	12 Snow Shovel	35	22.99
16		10	12
17			
18		=COUNT(C4:C15)	=COUNTA(D4:D15)

COUNT & COUNTA count the number of cells that contain something.

left-justified and numbers are right-justified but, because everyone formats their spreadsheets for aesthetics now, that method is unreliable. Another option is to scroll quickly through a long list of imported numbers and watch the Formula Bar. If you see apostrophes before any of the numbers, those entries are text. Last, look for the green triangle in the top left corner of the cell. Unless the previous owner of the spreadsheet instructed Excel to ignore this

error, then the contents of the cell are text.

If the values are text, you must convert them to numbers immediately. To do this, move down to the first number in the list that's actually text. Highlight the range of text that's impersonating numbers. Right-click the yellow warning sign that's left of the first text cell in the range. Click Convert to Number from the pop-up list, and it's done.

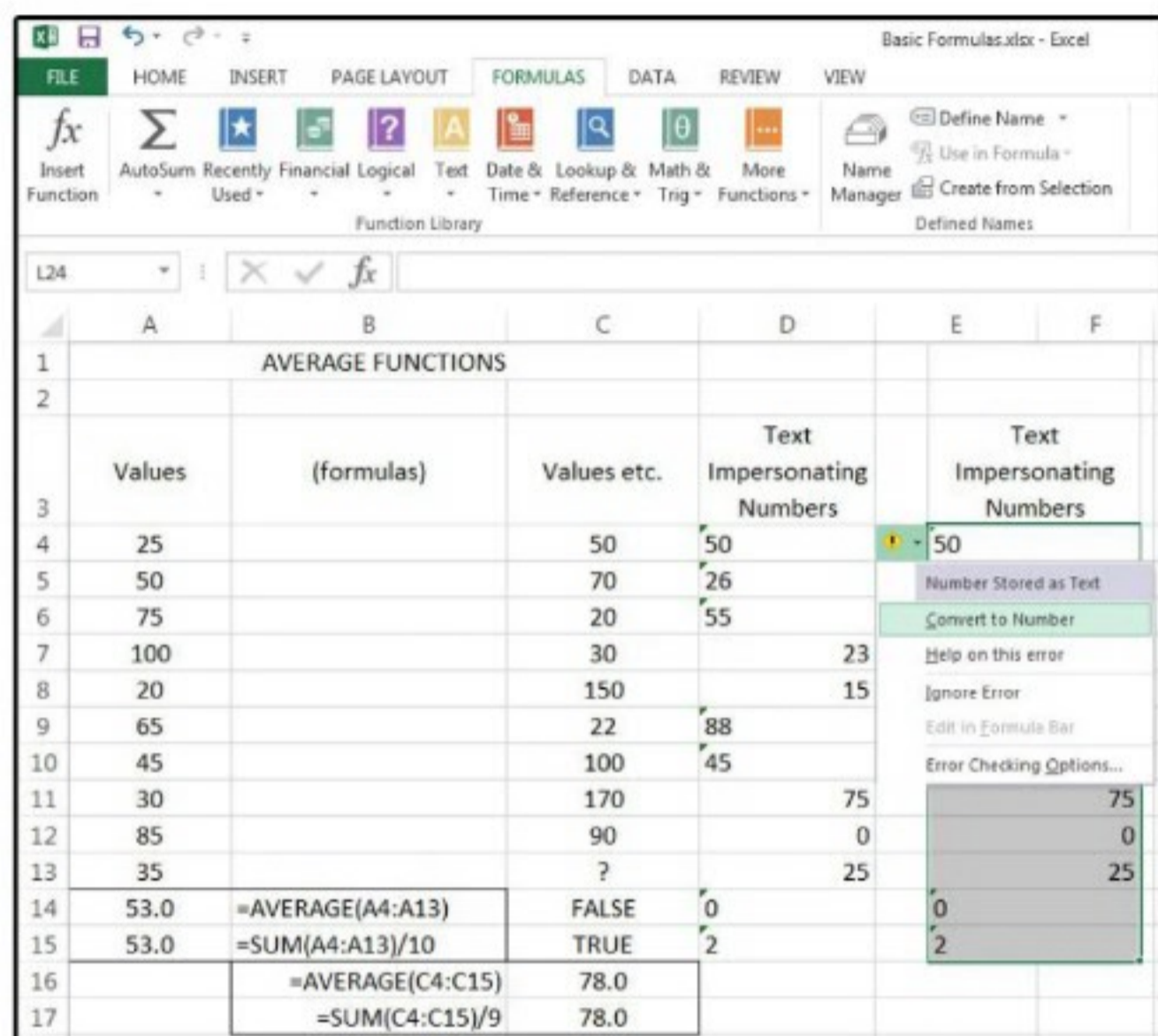
6. MIN/MAX FUNCTIONS

Use the MIN function to find the smallest number in a range of values, and the MAX function to find the

highest. The syntax for these functions are: =MIN(range); =MAX(range) where range equals the list of numbers you're calculating.

Common uses of this function are; for example, find the highest/lowest grade in a classroom; the highest/lowest sales dollars in a store; the highest/lowest batting averages of your favorite baseball team; and so on.

Some would ask, why not just sort the data? You could, but every time the numbers



The AVERAGE function.

changed, you'd have to re-sort. And, if you're sorting multiple columns/fields with a lot of records/rows, the sort option could get cumbersome.

The MIN/MAX functions remain the same regardless of the changes in the data, even if you add more rows (as long as you add the rows using the Insert > Row feature within the existing range—that is, above the cell that contains the formula).

Enter some numbers in column A4:A11, then enter this formula in A13:

=MIN(A4:A11) and this formula in A14:

=MAX(A4:A11).

NOTE: The MIN/MAX functions disregard empty cells, TRUE/FALSE answers, text, text impersonating numbers, symbols, and punctuation.

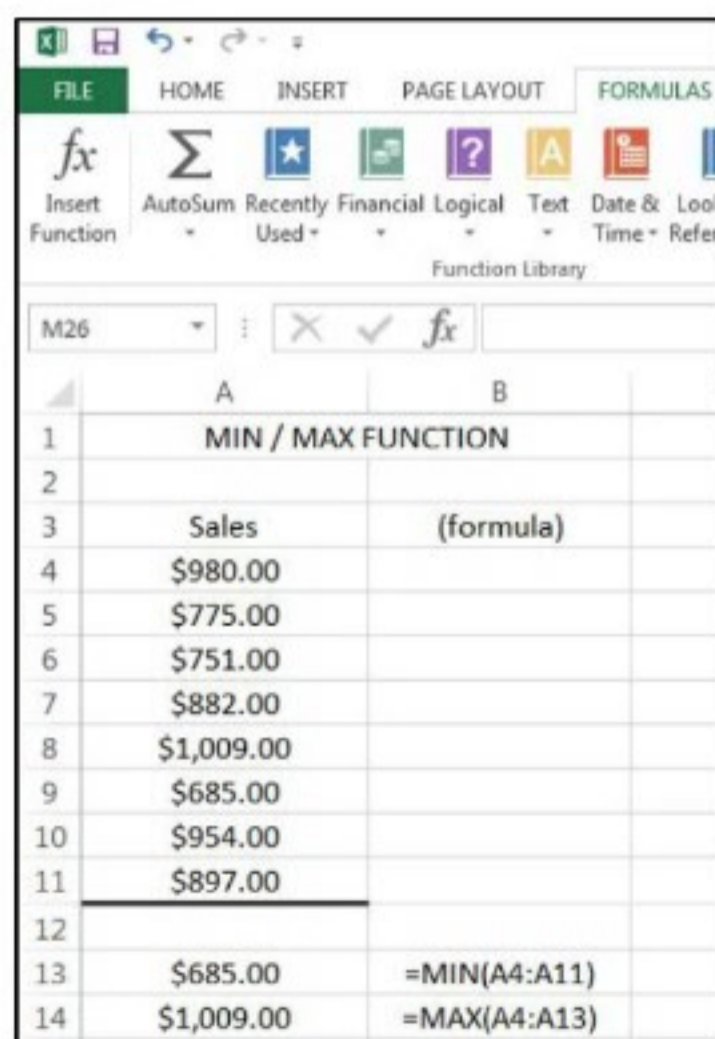
7. CONCAT/CONCATENATE

The functions CONCAT and CONCATENATE do the same thing: They both combine multiple cells, ranges, or strings of data into one cell. The most common use of this function is to combine first and last name into one cell or join the city, state, and ZIP code into one cell.

NOTE: CONCAT replaced CONCATENATE in Excel 2016, but both functions are still available. Note that CONCAT appears only under Formulas > Text And Formulas > Insert Function >

Category > Text, but both CONCAT and CONCATENATE appear under Formulas > Insert Function > Category > All.

Enter some first names in column A and last names in column B. Enter the following



The MIN & MAX function.

formula in column C:

=CONCATENATE(A4," ",B4) or **=CONCAT(B4," ",C4)**, then copy the formula down. What are the double quotes for? See Note below #2.

2. Enter a few cities (or ski resorts) in column F, states in column G, and ZIP codes in column H. Enter the following formula in column I: **=CONCATENATE(F4," ",G4," ",H4)**.

NOTE: If you want a space between the first and last name, you must enter that space inside quotation marks in your formula. The same thing is true for punctuation, such as a comma between city and state. In the following formula the “,” (quote comma quote—in red) tells Excel to insert a comma between the data in F15 (city) and the data in G15 (state). The “ ” (quote space quote—in purple) adds a space after the comma between F15 (city) and G15 (state) and another space between G15 (state) and H15 (zip code).

=CONCATENATE(F15, ",", " ", G15, " ", H15).

8. TRIM

This function removes extra (or padded) spaces that infect your data as a result of user error, downloading data from an external source such as the Internet, or importing data from another computer system. And you don't have to “tell Excel” where the spaces are located in the string

of text in each cell; it recognizes the extra spaces and removes them. Note, however, that it will not remove a space in the middle of a word. The syntax is simple: **=TRIM(cell address)**.

1. Enter some data in column A. Add some spaces before, after, and in the middle of multiple words, then enter the following formula in cell A4: **=TRIM(A4)**.

2. Copy the formula down. It's that easy!

NOTE: There is one case where this

First Name	Last Name	Combined	(formula)
Meryl	Streep	Meryl Streep	=CONCATENATE(A4,"",B4)
Harrison	Ford	Harrison Ford	=CONCATENATE(A5,"",B5)
Mos	Def	Mos Def	=CONCATENATE(A6,"",B6)
Bill	Maher	Bill Maher	=CONCATENATE(A7,"",B7)
Gerard	Butler	Gerard Butler	=CONCATENATE(A8,"",B8)
Sandra	Bullock	Sandra Bullock	=CONCATENATE(A9,"",B9)
Zooney	Deschanel	Zooney Deschanel	=CONCAT(B10,"",C10)
Martin	Freeman	Martin Freeman	=CONCAT(B11,"",C11)
Cate	Blanchard	Cate Blanchard	=CONCAT(B12,"",C12)
Benedict	Cumberbatch	Benedict Cumberbatch	=CONCAT(B13,"",C13)
Idris	Elba	Idris Elba	=CONCAT(B14,"",C14)
Jamie	Foxx	Jamie Foxx	=CONCAT(B15,"",C15)

City / Ski Resort	State	Zip	Combined	(formula)
Park City	UT	84414	Park City, UT 84414	=CONCATENATE(F4,"",G4,"",H4)
Stowe	VT	02215	Stowe, VT 02215	=CONCATENATE(F5,"",G5,"",H5)
Sun Valley	ID	83353	Sun Valley, ID 83353	=CONCATENATE(F6,"",G6,"",H6)
Taos	NM	87571	Taos, NM 87571	=CONCATENATE(F7,"",G7,"",H7)
Aspen	CO	81611	Aspen, CO 81611	=CONCATENATE(F8,"",G8,"",H8)
Waterville Valley	NH	03215	Waterville Valley, NH 03215	=CONCATENATE(F9,"",G9,"",H9)
Northstar	CA	96161	Northstar, CA 96161	=CONCATENATE(F10,"",G10,"",H10)
Mt. Rose Ski Tahoe	NV	89511	Mt. Rose Ski Tahoe, NV 89511	=CONCATENATE(F11,"",G11,"",H11)
Big Sky Resort	MT	59716	Big Sky Resort, MT 59716	=CONCATENATE(F12,"",G12,"",H12)
Jackson Hole	WY	83025	Jackson Hole, WY 83025	=CONCATENATE(F13,"",G13,"",H13)
Steamboat Springs	CO	80487	Steamboat Springs, CO 80487	=CONCATENATE(F14,"",G14,"",H14)
Mt Hood	OR	97041	Mt Hood, OR 97041	=CONCATENATE(F15,"",G15,"",H15)

Use CONCAT & CONCATENATE to combine data from multiple cells into one cell.

function does not work, and that's with a non-breaking space character used in webpages. The decimal value is 160, and the HTML code is . You can remove this character using a combination of TRIM, CLEAN, and SUBSTITUTE.

9. UPPER/LOWER/PROPER

Another easy group, these functions convert text in a cell or range of cells to uppercase, lowercase, or proper case. Proper case is first letter in caps and remaining letters in lowercase. The syntax is simple: function, cell address.

1. Enter some mixed-case data in column A; e.g., cAlifornia, nEW yORK, spanlSH. Enter the following formula in column B, **=UPPER(A4)**; in column C, **=LOWER(A4)**; and column D, **=PROPER(A4)**.

2. Notice that Excel corrects all the misplaced case errors and converts the data correctly. Copy the formulas down, and that's it for this simple one.

NOTE: In Word, you can use Shift-F3 to cycle through uppercase, lowercase, and proper case, but this shortcut key is not available in Excel. Note that the Excel function =PROPER is called Sentence case in Word.

10. REPT

When Lotus 1-2-3 was the only game in town, you could enter a backslash followed by any character and Lotus would repeat that

The screenshot shows an Excel spreadsheet with the following data:

Dog Breed	# of Extra Spaces	Extra Spaces Removed	(formula)
Samoyeds	1	Samoyeds	=TRIM(A4)
Siberian Husky	3	Siberian Husky	=TRIM(A5)
Collies	1	Collies	=TRIM(A6)
Golden Retriever	2	Golden Retriever	=TRIM(A7)
German Shepherd	0	German Shepherd	=TRIM(A8)
Alaskan Malamute	3	Alaskan Malamute	=TRIM(A9)
Beagle	3	Beagle	=TRIM(A10)
Australian Shepherd	4	Australian Shepherd	=TRIM(A11)
Springer Spaniel	3	Springer Spaniel	=TRIM(A12)
Cocker Spaniel	2	Cocker Spaniel	=TRIM(A13)

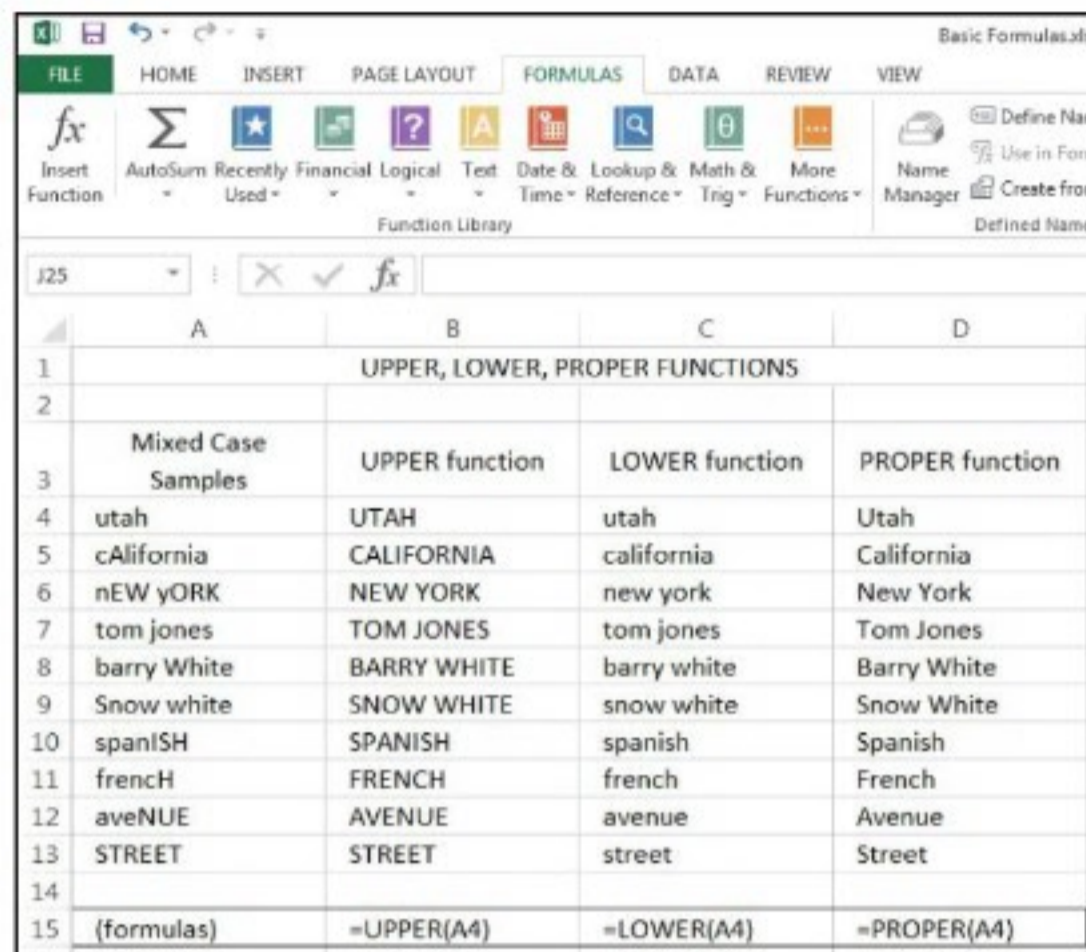
Use TRIM to remove extra or padded spaces from your data.

character throughout a cell. If the cell width grew larger or smaller, so did the character. In Excel, this feature is handled by the function REPT. It's not quite as efficient because you must add the character to the formula, then specify how many times you want that character repeated. This means if the cell width is increased, the repeated character is not, and if the cell width is decreased, the repeated character bleeds over into the adjacent cell.

The syntax for this function: **=REPT ("*", 5)**; **=REPT ("-", 10)**, **=REPT ("+", 12)**. You can repeat any character on the keyboard plus symbols.

11. IF STATEMENT

The IF function (also more commonly called IF statements) work like this: IF, then, else.



	A	B	C	D
1	UPPER, LOWER, PROPER FUNCTIONS			
2				
3	Mixed Case Samples	UPPER function	LOWER function	PROPER function
4	utah	UTAH	utah	Utah
5	cAlifornia	CALIFORNIA	california	California
6	nEW yORK	NEW YORK	new york	New York
7	tom jones	TOM JONES	tom jones	Tom Jones
8	barry White	BARRY WHITE	barry white	Barry White
9	Snow white	SNOW WHITE	snow white	Snow White
10	spanISH	SPANISH	spanish	Spanish
11	frenCH	FRENCH	french	French
12	aveNUE	AVENUE	avenue	Avenue
13	STREET	STREET	street	Street
14				
15	(formulas)	=UPPER(A4)	=LOWER(A4)	=PROPER(A4)

Use UPPER & LOWER & PROPER case to alter case of characters.

Basically, that means if a condition is true, then do one thing, else/otherwise do something else. For example, if the puppy is a Labrador, then buy a blue collar, otherwise/else, buy a red collar.

The syntax (the way the commands are organized in the formula) of the IF statement is: =IF(logic_test, value_if true, value_if_false). IF statements are used in all programming languages and, although the syntax may vary slightly, this function provides the same results.

1. Enter the following column headers: Cookie Boxes Sold; 3rd Prize =More than 500 Sold, Less than 1000; 2nd Prize =More than 1000 Sold, Less than 1500; 1st Prize =More than 1500 Sold, Less than 2000; Grand Prize =More than 2000 Sold

2. Enter some numbers into column A4:A13. Mix it up so you get data in all of the

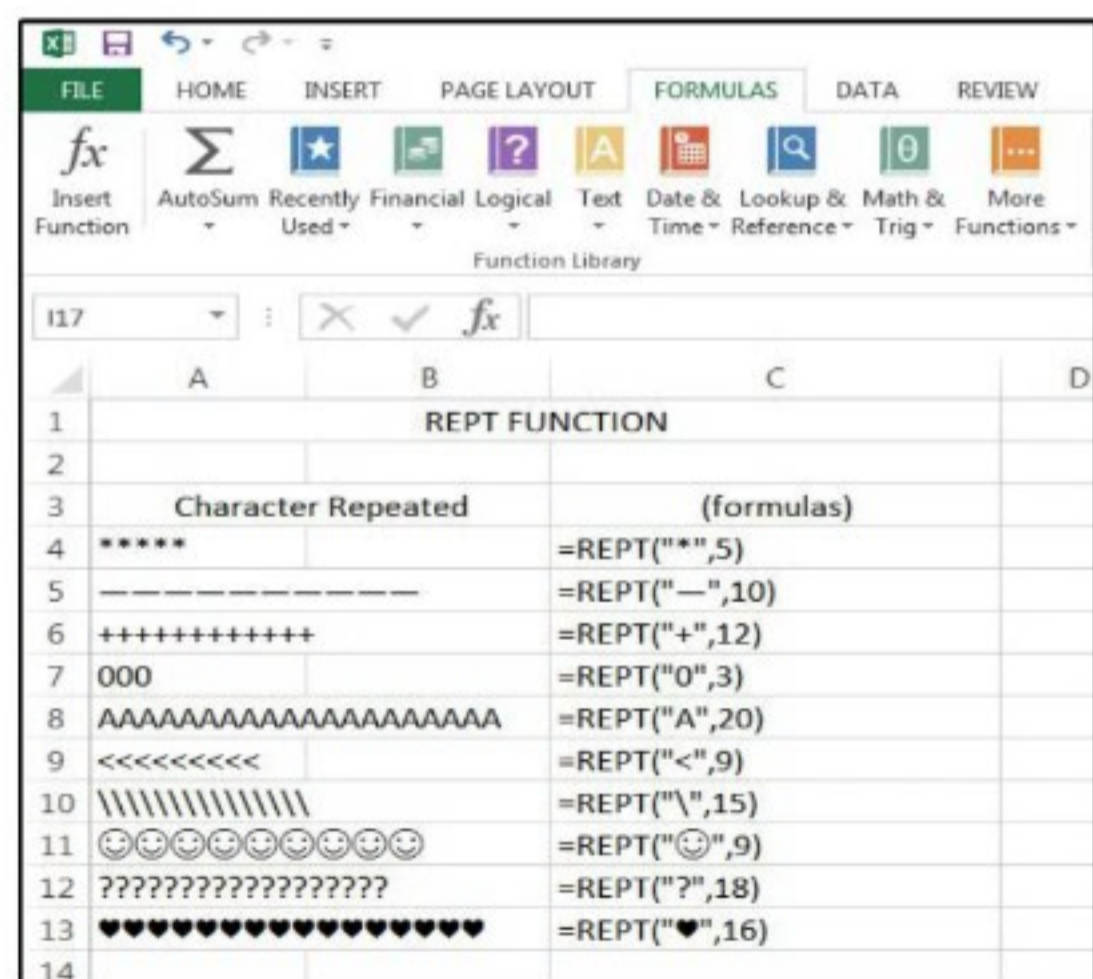
Sold columns.

3. Enter this formula in B4:
=IF(\$A4>500, \$A4, 0).

NOTE: There is a \$ sign before the column letter 'A' in the above formula. To enter it, place your cursor on the first 'A' in the formula, then use the function key F4 to cycle through the Absolute and Relative References. Stop when the \$ sign precedes the 'A' (for each A in the formula). This tells Excel NOT to change the column letter, but only change the row numbers when this formula is copied. If you put a dollar sign before both the column letter and the row number, neither would change.

4. Copy the formula in B4 to C4, D4, and E4, then edit as follows: in C4,

=IF(\$A4>1000, \$A4, 0); in D4,
=IF(\$A4>1500, \$A4, 0); and E4,
=IF(\$A4>2000, \$A4, 0). Then copy



	A	B	C	D
1	REPT FUNCTION			
2				
3	Character Repeated		(formulas)	
4	*****		=REPT("*",5)	
5	-----		=REPT("-",10)	
6	+++++		=REPT("+",12)	
7	000		=REPT("0",3)	
8	AAAAAAAAAAAAAAAAAAAA		=REPT("A",20)	
9	<<<<<<<<<<<<<<<<<		=REPT("<",9)	
10	\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\		=REPT("\\",15)	
11	☺☺☺☺☺☺☺☺☺☺☺☺☺☺		=REPT("☺",9)	
12	????????????????????		=REPT("?",18)	
13	♥♥♥♥♥♥♥♥♥♥♥♥♥♥♥♥♥♥		=REPT("♥",16)	
14				

Use the REPT function to repeat any character on the keyboard, as well as symbols.

down.

5. The formula works, but you have to review each column to see who won the prizes, because each column shows ALL the values greater than the amount in the formula. That's ok for a small spreadsheet, but not for anything larger than a single screen.

6. We need a Nested IF statement for this one. Repeat numbers 1, 2, and 3 above beginning on row 20; but instead of the formula in 3 above, enter this formula in B20: **=IF(AND(\$A20>500,\$A20<1000),\$A20,0)**.

7. Repeat number 4 above, but edit the formulas like this: in C20, **=IF(AND(\$A20>1000,\$A20<1500),\$A20,0)**; D20 = **=IF(AND(\$A20>1500,\$A20<2000),\$A20,0)**; and in E20, **=IF(\$A20>2000,\$A20,0)**. Yes, this last one is different because there is no "less than" amount. Then copy down. Now you can look at each column and determine immediately who the winner is for that category.

12. AND/OR

AND and OR are common functions in the programmers' environment, also referred to as Boolean operators (along with NOT). AND means that all conditions in the query must be true; OR means that at least one condition must be true.

For example, looking for an applicant

	A	B	C	D	E
1	SIMPLE IF FUNCTION				
2					
3	Cookie Boxes Sold	3rd Prize - More than 500 Sold Less than 1000	2nd Prize - More than 1000 Sold Less than 1500	1st Prize - More than 1500 Sold Less than 2000	Grand Prize - More than 2000 Sold
4	525	525	0	0	0
5	498	0	0	0	0
6	1475	1475	1475	0	0
7	1720	1720	1720	1720	0
8	790	790	0	0	0
9	114	0	0	0	0
10	2050	2050	2050	2050	2050
11	740	740	0	0	0
12	1600	1600	1600	1600	0
13	2085	2085	2085	2085	2085
14					
15	(formulas)	=IF(\$A4>500,\$A4,0)	=IF(\$A4>1000,\$A4,0)	=IF(\$A4>1500,\$A4,0)	=IF(\$A4>2000,\$A4,0)

	A	B	C	D	E
17	NESTED IF FUNCTION WITH AND FUNCTION				
18					
19	Cookie Boxes Sold	3rd Prize - More than 500 Sold Less than 1000	2nd Prize - More than 1000 Sold Less than 1500	1st Prize - More than 1500 Sold Less than 2000	Grand Prize - More than 2000 Sold
20	525	525	0	0	0
21	498	0	0	0	0
22	1475	0	1475	0	0
23	1720	0	0	1720	0
24	790	790	0	0	0
25	114	0	0	0	0
26	2050	0	0	0	2050
27	740	740	0	0	0
28	1600	0	0	1600	0
29	2085	0	0	0	2085
30					
31	(formulas B&D)	=IF(AND(\$A20>500,\$A20<1000),\$A20,0)		=IF(AND(\$A20>1500,\$A20<2000),\$A20,0)	
32					
33	(formulas C&E)		=IF(AND(\$A20>1000,\$A20<1500),\$A20,0)		=IF(\$A20>2000,\$A20,0)

Basic IF statements and nested IF statements.

with MS Word AND MS Excel experience means the applicant must have both skills to qualify for the job. This condition would provide a TRUE result. Looking for an applicant with MS Word OR Excel means the applicant must have one OR the other, but not necessarily both. Also a TRUE result. Having neither skills would, obviously, provide a FALSE result.

1. Copy the numbers from the

spreadsheet in item 13, or download the full workbook at go.pcworld.com/xlfrm.

2. Enter the following AND formula in cell D4: **=AND(\$B4>=501,\$C4<=500)**. Again, note the \$ signs. Then copy down to cell D13.

3. Enter this formula in cell F4: **=OR(\$B4>=501,\$C4<=500)**, then copy down. Notice the results in the rows with borders; that is, 5, 8, and 13. The AND results are all FALSE because both conditions were false (or not true); while the OR results were all TRUE because one of the conditions was true, while the other was false. If this seems confusing, study the numbers in columns B and C. Then read the formulas that calculate for the AND function, then the OR function, and it will make more sense.

13. NOT

Having explained above how the AND and OR functions (also called Boolean operators) work, the third Boolean operator in that mix is the NOT function. Ever search through a really long list of data and

wish you could remove all the entries that do NOT apply? For example, I want to see everything available about alternative energy EXCEPT (or NOT) nuclear.

In Excel, it's an easy task. Create a list of 25 companies that provide various alternative energy sources and what those resources are (columns A, B, C; begin on row 4). Enter the following formula in cell C4: **=NOT(B4="Nuclear")**. Then copy the formula from C4 down to C5 through C28.

If the response is TRUE, the energy source is NOT nuclear. If the response is FALSE, the energy source IS nuclear. Yes, it's reverse logic and you may not immediately see a need for this function but, if you're an avid Excel user, you will discover many reasons to use this formula in the future.

TIP: Remember that Boolean logic applies throughout all database programs, including your favorite search

	A	B	C	D	E	F	G
1	AND OR FUNCTIONS						
2							
3		Bonuses		AND function	(AND formulas)	OR function	(OR formulas)
4	Gordon	525	200	TRUE	=AND(\$B4>=501,\$C4<=500)	TRUE	=OR(\$B4>=501,\$C4<=500)
5	Maya	498	316	FALSE	=AND(\$B5>=501,\$C5<=500)	TRUE	=OR(\$B5>=501,\$C5<=500)
6	David	690	410	TRUE	=AND(\$B6>=501,\$C6<=500)	TRUE	=OR(\$B6>=501,\$C6<=500)
7	Fran	501	500	TRUE	=AND(\$B7>=501,\$C7<=500)	TRUE	=OR(\$B7>=501,\$C7<=500)
8	Louis	844	616	FALSE	=AND(\$B8>=501,\$C8<=500)	TRUE	=OR(\$B8>=501,\$C8<=500)
9	Beth	410	595	FALSE	=AND(\$B9>=501,\$C9<=500)	FALSE	=OR(\$B9>=501,\$C9<=500)
10	Pete	780	309	TRUE	=AND(\$B10>=501,\$C10<=500)	TRUE	=OR(\$B10>=501,\$C10<=500)
11	Rosie	500	510	FALSE	=AND(\$B11>=501,\$C11<=500)	FALSE	=OR(\$B11>=501,\$C11<=500)
12	Wilson	388	675	FALSE	=AND(\$B12>=501,\$C12<=500)	FALSE	=OR(\$B12>=501,\$C12<=500)
13	Ellen	475	439	FALSE	=AND(\$B13>=501,\$C13<=500)	TRUE	=OR(\$B13>=501,\$C13<=500)

AND plus OR functions.

engines. The Boolean operators AND and OR must be in all-caps to function as an operator. In Google, the Boolean NOT operator is the minus sign; for example, to list all alternative energy sources EXCEPT nuclear, type this in the search field box: **list all alternative energy sources -nuclear.**

14. RIGHT & TEXT-TO-COLUMNS

Imagine that your boss just sent you a file with 100,000 names and addresses compiled from several data dumps off multiple different database systems, such as Oracle RDBMS, SAP Sybase ASE, Informix, MongoDB, Redis, and Couchbase. The file is in a CSV (comma separated values) delimited format, so you can open it in Excel, but the delimiters are all over the place—some are commas, some are spaces, some are tabs, and so on. Your job is to reformat the run-on data into five fields: Name, Address1, Address2, City, and State.

A. First, separate the city, state, and ZIP codes into different columns. Select column C (City, State, ZIP), then choose Data > Text To Columns. Ensure the Delimited button is checked, then click Next. On the next screen, ensure that the Comma box is checked, then click Next. Browse through the list to ensure the separation is correct, then click Finish. Excel divides the one

The screenshot shows an Excel spreadsheet with the following data:

	A	B	C
1	Alternative Energy Sources		
2			
3	Company	Energy	Not Nuclear
4	Vestas Industries	Wind Turbines	TRUE
5	Hydro-Québec	Hydroelectric	TRUE
6	Rezatec	Biomass	TRUE
7	Berkshire Hathaway.	Geo Thermal	TRUE
8	Duke Energy	Hydroelectric	TRUE
9	GE Wind Energy	Windmills	TRUE
10	Horizon Solar Power	Solar	TRUE
11	Dresden Generating Station	Nuclear	FALSE
12	Azura Station	Wave Energy	TRUE
13	Chesapeake Energy	Natural Gas	TRUE
14	Sapphire Energy	Bio Fuels	TRUE
15	La Rance Tidal Power Plant	Tidal Energy	TRUE
16	Goldwind	Windmills	TRUE
17	Swansea Bay Tidal Lagoon	Tidal Energy	TRUE
18	Comanche Peak Nuclear Power	Nuclear	FALSE
19	Mutriku Breakwater Wave Plant	Wave Energy	TRUE
20	NextEra Energy Resources	Wind Turbines	TRUE
21	Dominion Energy	Hydroelectric	TRUE
22	LanzaTech	Biomass	TRUE
23	Millstone Nuclear Power Station	Nuclear	FALSE
24	Ballard Power Systems	Hydrogen Gas	TRUE
25	SDE Sea Waves Power Plant	Wave Energy	TRUE
26	MeyGen Tidal Energy Project	Tidal Energy	TRUE
27	McGuire Nuclear Station	Nuclear	FALSE
28	Pili Biotechnology	Biomass	TRUE
29			

Using the NOT Boolean operator.

column into two.

B. Now we need to separate the ZIP codes from the state names. For this task, the Text To Columns option would not be accurate, because the only delimiter available is a space. Because some of the states have multiple names such as Prince Edward Island, the Text To Columns function would spread the data across too many columns.

C. The solution is to use the =RIGHT function. Because some of the ZIP codes

have five digits and some have six, enter the following command in cell E2: **=RIGHT(D2,6)**, then copy from E2 down to E3 through E16. Done. Column E now contains ZIP codes only. However, column D still has both states and ZIP codes.

15 & 16. LEFT & LEN

Use this function to separate the states from the ZIP codes. Enter the following formula in cell F2:

=LEFT(D2,LEN(D2)-6), then copy down from F2 to F3 through F16.

Basically this formula says go to cell D2, count 6 places from the left and remove those characters, leaving the remaining characters in cell D2 (regardless of how many). As long as one piece of information inside a cell is unique, you can use that information to add, delete, or replace other data inside that cell.

To move or manipulate the data in columns E or F (which contain formulas), highlight the column and choose Copy, move your cursor to another column, and

choose Paste Special > Values, then click OK.

17. PMT

Need a new car and want to stick to a budget? Use this handy function to determine how much your payments would be on that new car you just took for a test drive. The process is simple: Enter

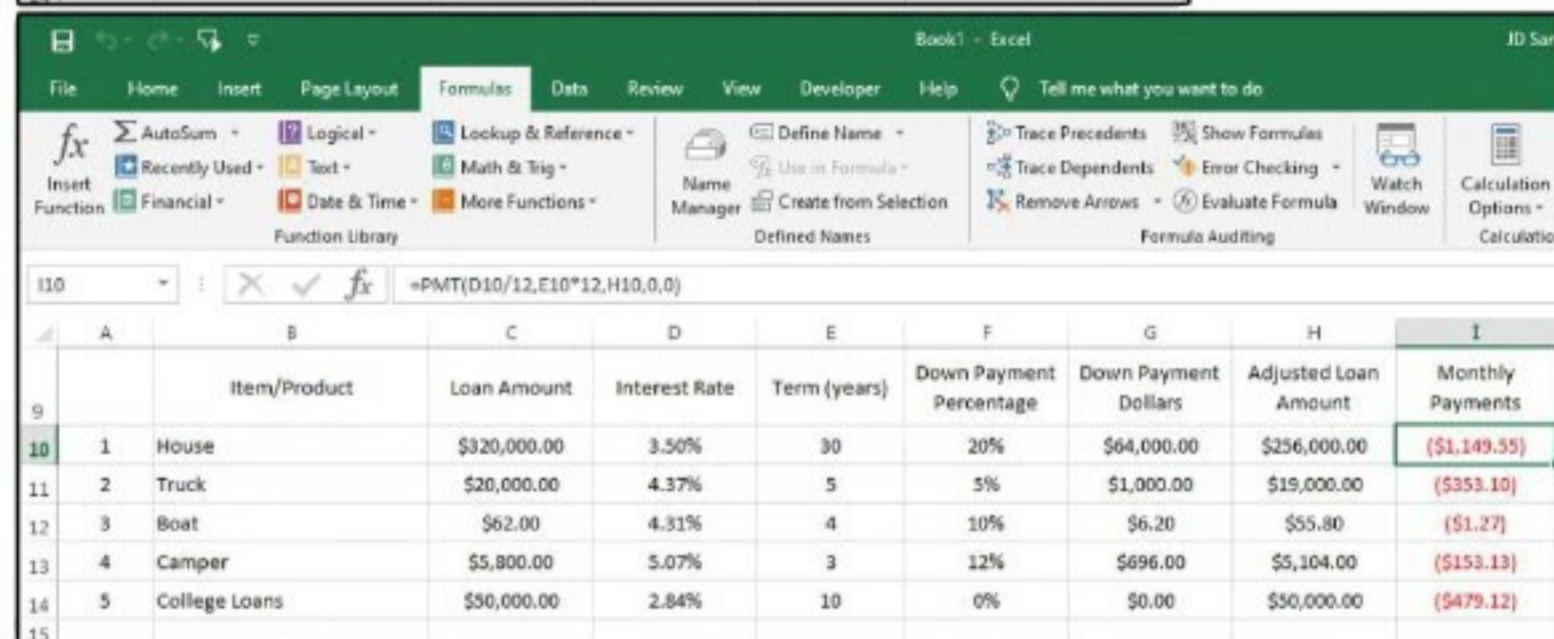
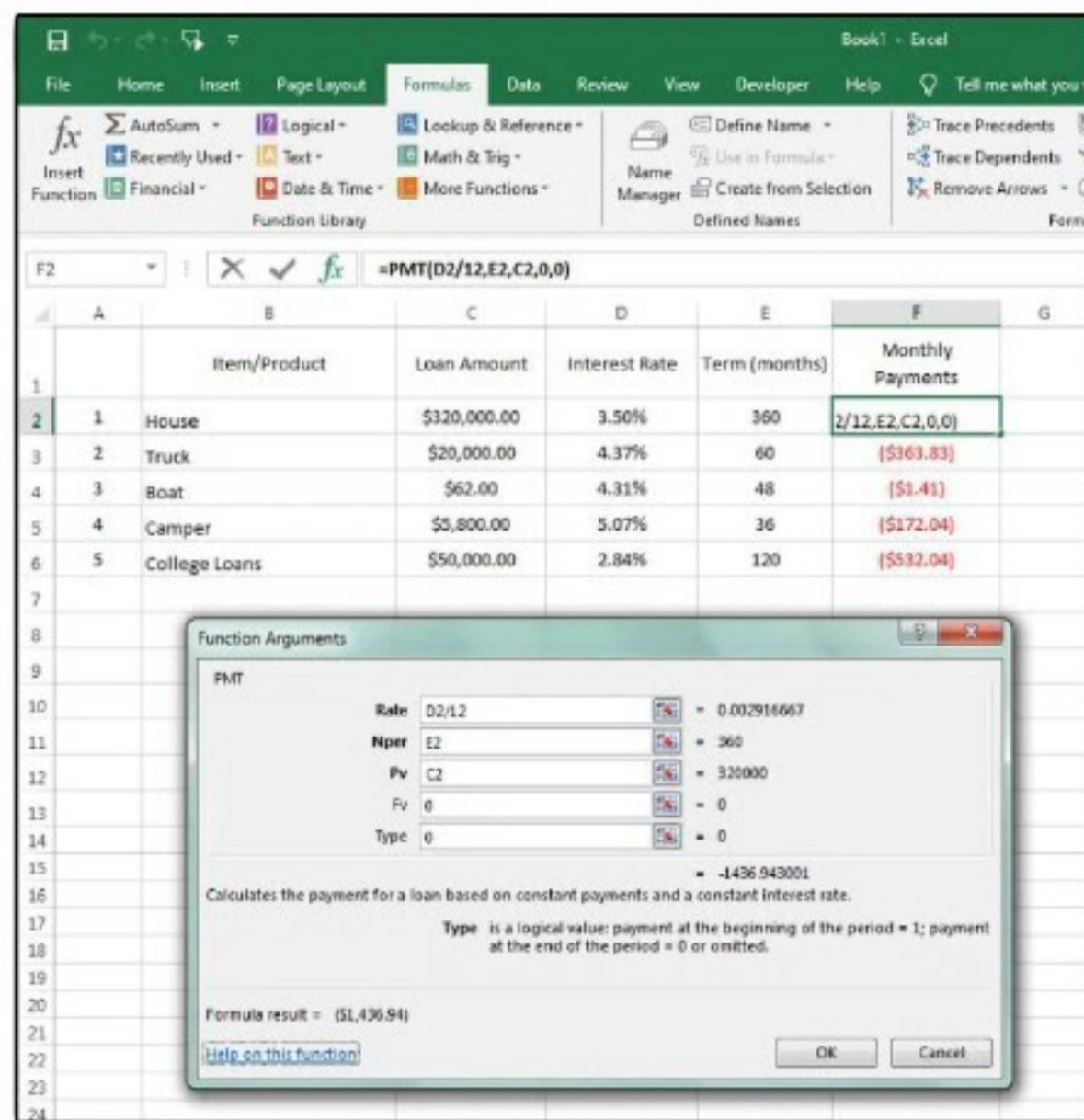
The screenshot shows an Excel spreadsheet with the following data:

	B	C	D	E
	Address	City, State, Zip		
2	54 Rural Route	Tampa	FL 33602	33602
3	37525 Beanstalk Blvd	Fantasy Island	USA 12345	12345
4	13 Bagshot Row	Hobbiton	Shire 54321	54321
5	4 Privet Drive	Little Whinging	Surrey 533704	533704
6	141 Hampstead Garden	Northwest London	England 529085	529085
7	17 Cherry Tree Lane	London	England 529085	529085
8	1000 Kings Landing	Westeros	Crownlands 98765	98765
9	717 Jordan College	Oxford	England 529085	529085
10	Route 17 Moisture Farm Way	Desert Planet	Tatooine 56789	56789
11	147 S Mill Creek Dr	Moab	UT 84532	84532
12	A2X47 Casten Caves	Planet	Kamino 24689	24689
13	1 Green Gables	Avonlea	Prince Edward Island C1A1A1	C1A1A1
14	399 Lexington Rd, Orchard House	Concord	MA 01742	01742
15	4755 Jonesborough Tara	Calyton County	GA 30237	30237
16	221 B Baker Street	London	England 529085	529085

The screenshot shows an Excel spreadsheet with the following data:

	A	B	C	D	E	F
	Name	Address	City, State, Zip			
2	Edward Scissorhands	54 Rural Route	Tampa	FL 33602	33602	FL
3	Jack Spriggins	37525 Beanstalk Blvd	Fantasy Island	USA 12345	12345	USA
4	Bilbo Baggins	13 Bagshot Row	Hobbiton	Shire 54321	54321	Shire
5	Harry Potter	4 Privet Drive	Little Whinging	Surrey 533704	533704	Surrey
6	Hermione Granger	141 Hampstead Garden	Northwest London	England 529085	529085	England
7	Mary Poppins	17 Cherry Tree Lane	London	England 529085	529085	England
8	Daenerys Targaryen	1000 Kings Landing	Westeros	Crownlands 98765	98765	Crownlands
9	Lyra Belacqua	717 Jordan College	Oxford	England 529085	529085	England
10	Luke Skywalker	Route 17 Moisture Farm Way	Desert Planet	Tatooine 56789	56789	Tatooine
11	Indiana Jones	147 S Mill Creek Dr	Moab	UT 84532	84532	UT
12	Boba Fett	A2X47 Casten Caves	Planet	Kamino 24689	24689	Kamino
13	Anne Shirley	1 Green Gables	Avonlea	Prince Edward Island C1A1A1	C1A1A1	Prince Edward Island
14	Jo March	399 Lexington Rd, Orchard House	Concord	MA 01742	01742	MA
15	Scarlett O'Hara	4755 Jonesborough Tara	Calyton County	GA 30237	30237	GA
16	Sherlock Holmes	221 B Baker Street	London	England 529085	529085	England

Using the RIGHT, LEFT, and LEN functions.



Use the PMT function to calculate your auto payments for that new car.

the function followed by the interest rate divided by 12 (for 12 months), the Term (or number of monthly payments), followed by the Loan Amount.

Enter this formula in cell F2: **=PMT (D2/12 , E2 , C2 , 0 , 0)**, then copy from F2 down to F3 through F6.

To calculate a down payment, enter the down payment percentage in column F; enter the formula in column G;

enter the adjusted loan amount formula in column H; and the new monthly payment formula in column I. Also, change the Term (in months) to Term (in years) in column E—for example, instead of entering 360 months for a House Loan, enter 30 years.

Enter the following formula in cell G10: **=SUM (C10 * F10)**. Enter this formula in cell H10: **=SUM (C10 - G10)**. And enter this formula in cell I10: **=PMT (D10/12 , E10 * 12 , H10 , 0 , 0)**.

Note that the Interest Rate is still divided by 12, and that the Term (in years) is multiplied by 12.

Handy tip: Have you ever wondered why some currency formats center the dollar amount and the dollar sign (\$1500.00), while others push the numbers

aligned to the right and push the dollar sign aligned to the left (\$ 1500.00)? To center the number and the dollar sign, highlight the cell, and choose Home Tab > Number Group > Number Format > Currency. To align the dollar sign left and the numbers right, highlight the cell, then click the \$ symbol in the Number group.

We hope that knowing how to use these formulas will help you better use Excel. 📌



If you're having graphics card problems, try a clean driver install

Many graphics card problems can be fixed by performing a clean install of your GPU drivers. **BY BRAD CHACOS**

If you're suffering from software bugs or other problems with your graphics card, one of the first things to try is performing a clean installation of your drivers. That point was driven home for PC gamers recently when AMD, in a post (go.pcworld.com/whql) announcing WHQL certification for its bug-squashing new Radeon Software Adrenalin 2020 Edition 20.2.2 driver (go.pcworld.com/r202), told gamers to factory-reset the software if they encounter further issues.

It's a great reminder. Performing a clean install won't fix GPU issues all the time, but it'll sure fix them a lot of the time.

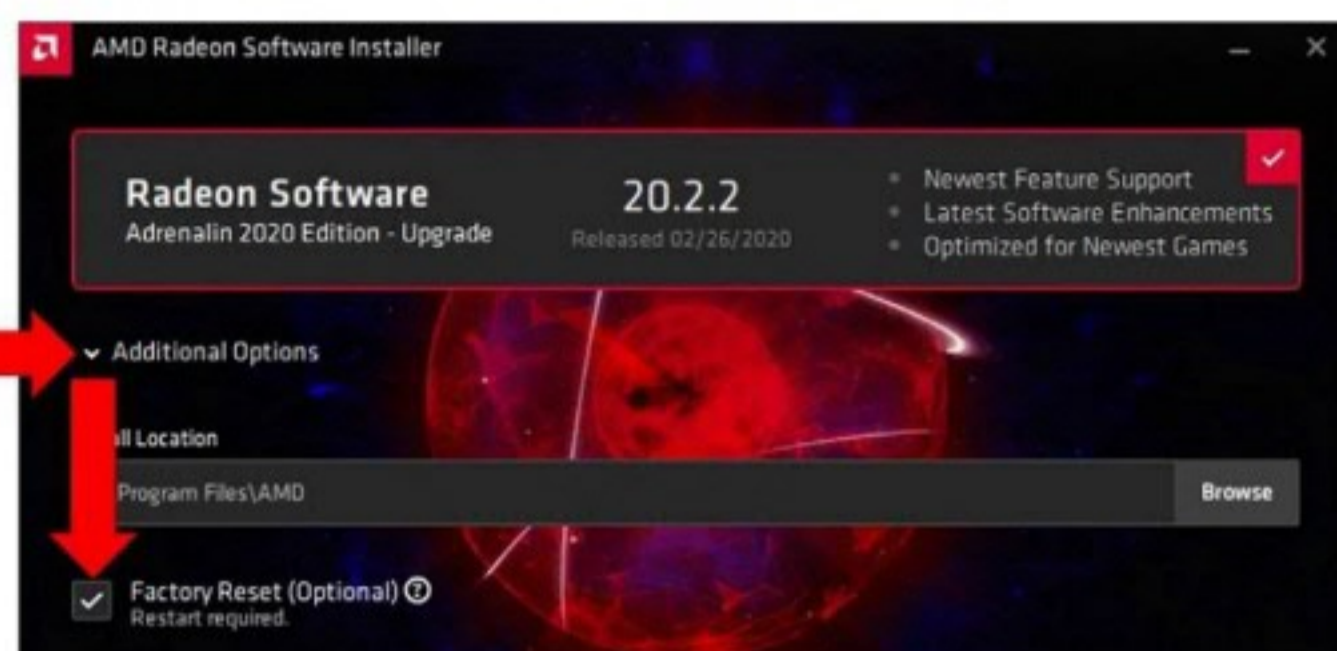
Modern graphics card drivers are complicated beasts, sinking hooks deep into your computer. Considering that both AMD and Nvidia's drivers weigh in at roughly half a gigabyte, they're some of the more complex software on your PC. They build atop your existing installation, and that's generally a good thing! It keeps your existing settings intact. But

express-installing drivers can cause issues sometimes. Performing a clean install starts over from scratch, potentially eradicating conflicts that can manifest as bugs or performance issues. I even do it every now and again on my personal rig, just for general system health.

“Often, many problems can be resolved with a clean installation of our driver,” AMD’s Warren Eng said in the company’s post. “In order to perform a clean installation, you must select the ‘Factory Reset’ option at the beginning of the installation process. Once this is selected, old instances of the driver will be removed, and the uninstaller will restart your system before the new driver installation begins.” Easy-peasy.

If you have a GeForce graphics card, resetting the drivers takes a slightly different (but still simple) process. Start the installation process, click Custom install, and make sure to check the Perform A Clean Installation box. From there, complete the task normally.

As Nvidia’s checkbox warns, performing a clean driver install blasts away your previous version of the software, which means that all settings will be returned to their default. The same goes for AMD’s clean installation process, which it dubs “Factory reset.” That could be a headache if you heavily customize your graphics card’s software, but worthwhile if you’re suffering from software issues. If

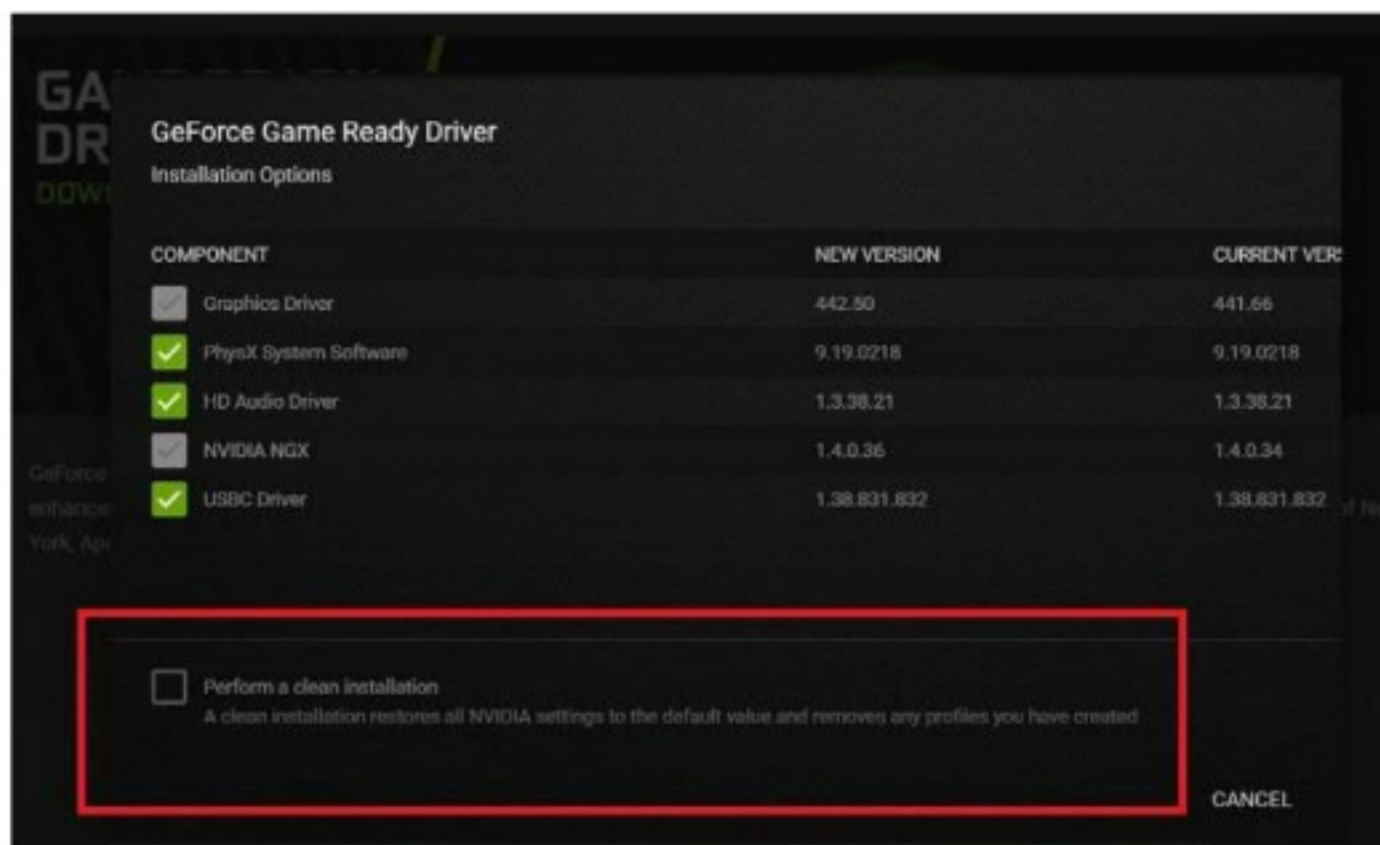


How to factory-reset (clean install) Radeon graphics drivers.

you’ve tinkered extensively, you might want to jot down your altered settings before initiating the process, so you can get everything back the way you want it more easily afterward.

Performing a clean install has solved problems we’ve seen more times than not, especially for Radeon graphics cards. But sometimes, even that isn’t enough. Seriously: Graphics drivers sink their hooks deep, and sometimes the default clean installation options misses things. If you’re still having troubles after performing a clean installation using Radeon Software or GeForce Experience, give the superb Display Driver Uninstaller software (go.pcworld.com/dsdr)—simply called DDU by enthusiasts—a whirl.

“Display Driver Uninstaller is a driver removal utility that can help you completely uninstall AMD/Nvidia graphics card drivers and packages from your system, without leaving leftovers behind (including registry keys, folders and files, driver store),” the description reads. The free, long-established program is a must-use tool in our own



HOW TO GO BACK TO OLD DRIVERS

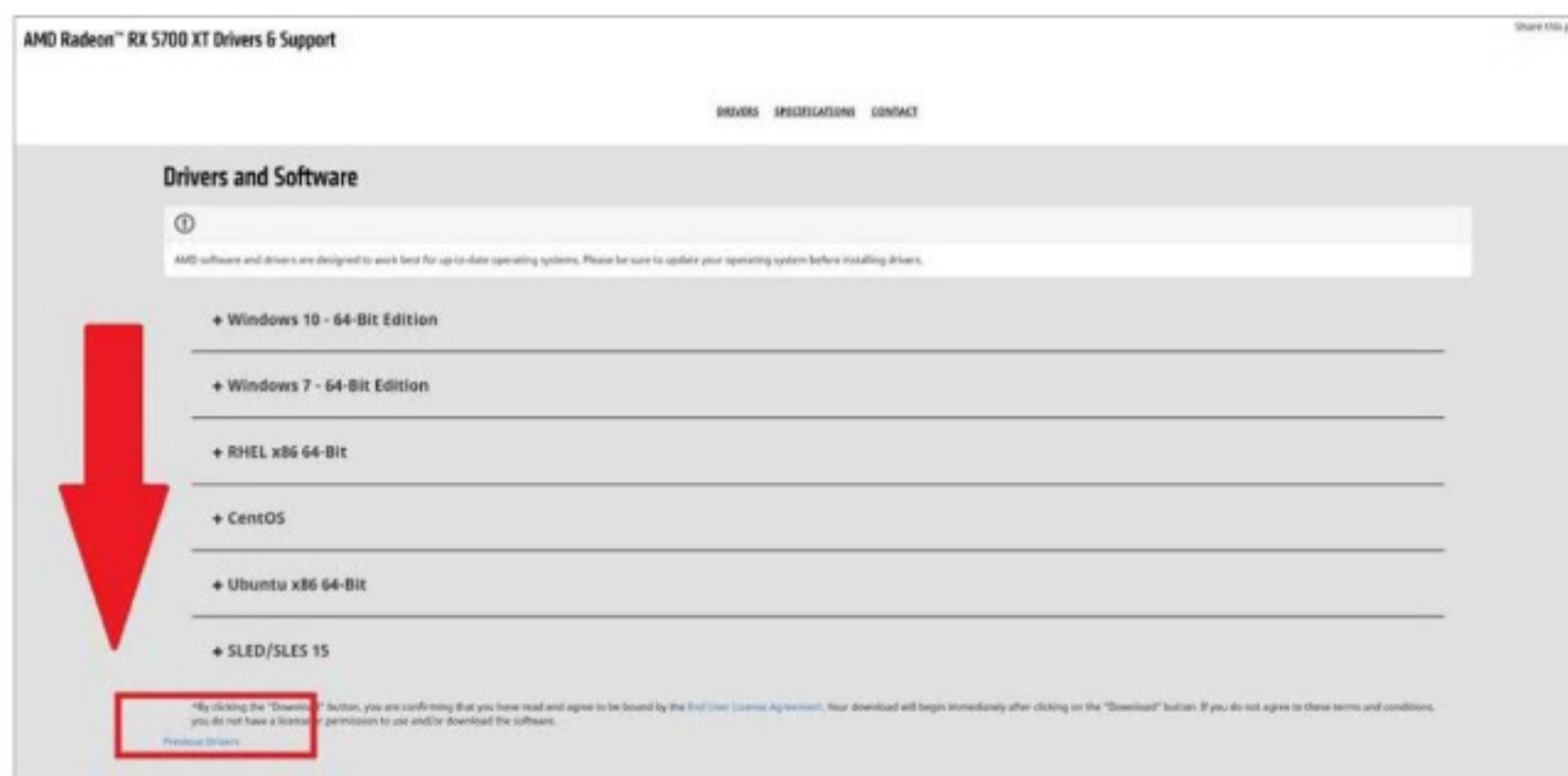
If you're still running into troubles, well, you're out of luck. Check your driver's release notes to see if you're encountering a known issue. If not, you can hop into forums to try and find help, or you can uninstall the problematic software and reinstall a previous

graphics card testing process. DDU's saved our bacon dozens of times when we've encountered driver bugs.

Display Driver Uninstaller performs invasive surgery, so the creators warn that you'll want to create a system restore point before you begin—there's a button to do so right in the software. For best results, you'll also want to run it in Safe Mode. When DDU's done working its magic, try installing your graphics card drivers yet again.

driver version that you know worked. You can find Nvidia's driver archives here (go.pcworld.com/nrch).

AMD doesn't maintain a central archive, but if you head to its driver page (go.pcworld.com/drpg) and search for your graphics card, you'll get a list of the latest available drivers. Scroll past those, and at the very bottom of the new releases, you'll see a tiny blue Previous Drivers link, as shown below. Click that to summon past versions.



Where to find older drivers for your Radeon graphics card.

Good luck. If you'd rather splurge on new hardware than fiddle with software problems, be sure to check out our guide to the best graphics cards for PC gaming (go.pcworld.com/gmcr). 

Discover the unsearchable



Discover the forest

Find a trail near you at
[DiscoverTheForest.org](https://www.DiscoverTheForest.org)



Tech Spotlight

A video showcase of the latest trends



Watch the video at
go.pcworld.com/ghm

Google Nest Hub Max vs. Amazon Echo Show

→ The Google Nest Home Max is a great smart display, with a gorgeous screen, a built-in Nest security

camera, and Chromecast support. But it's hard to beat Echo when it comes to the size of its ecosystem and broad smart home support.