

PC MAGAZINE

HOW TO BUILD A **KICK-ASS** GAMING PC FOR **\$1,000**

+ AMD Ryzen
Threadripper
2950X Reviewed

COVER STORY

BUILD A KICK-ASS GAMING PC FOR \$1,000



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Lensbaby Sol 45

8Bitdo DIY Mod Kit for SNES Classic Controller



Lensbaby Sol 45

HARDWARE

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Crucial MX500



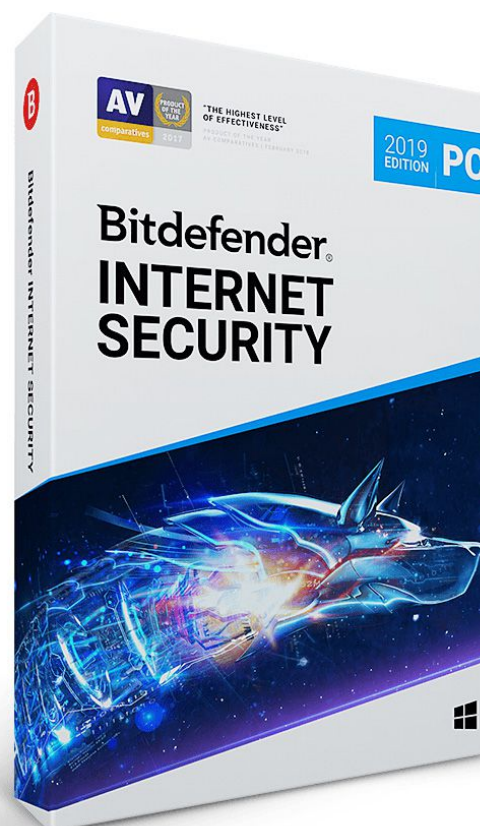
AMD Ryzen Threadripper 2950X

SOFTWARE & APPS

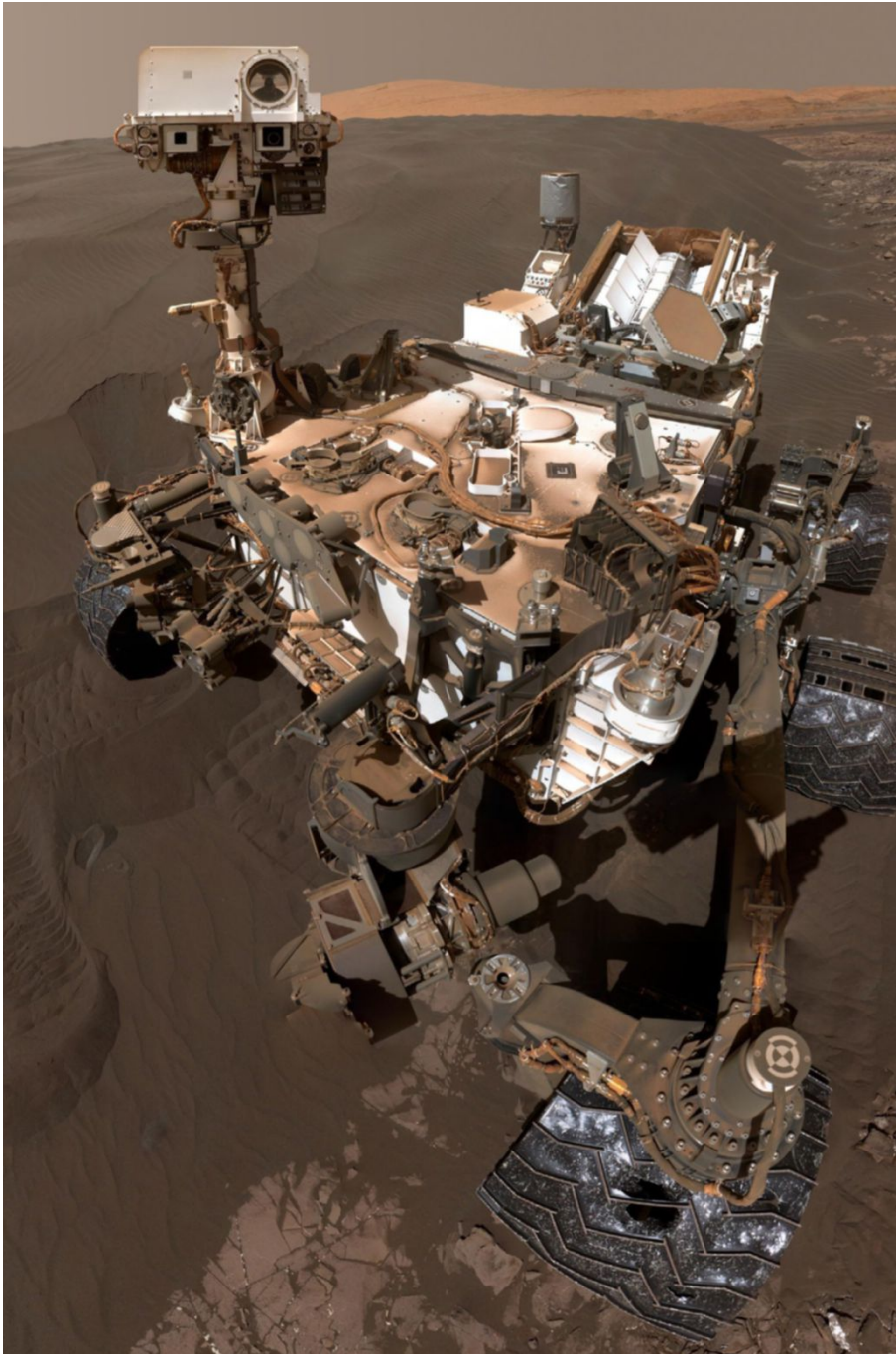
Bitdefender Internet Security

Dashlane

Bitdefender
Internet Security



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DOUG NEWCOMB

The High Cost of Parking

“

If people really wanted privacy, they would not be on Facebook or social media in general.

”

JOHN C. DVORAK

Last Word

TIPS & HOW TOS



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Play all of your old favorites

6 BAD HABITS THAT ARE DESTROYING YOUR PC

Give your PC a longer life



Calling All DIYers

Here at PCMag, we dedicate a large percentage of our time and resources to (surprise) reviewing PCs: the ones that companies build and sell. But now and again, we love to get our hands on some killer components and put together our own machines, just the way we want them.

Hardware Analyst Matt Buzzi and Executive Editor John Burek are perhaps the most skilled among us at this kind of project. The pair has live-streamed computer builds of various kinds numerous times. For our September issue, we challenged them to build a gaming PC without spending more than \$1,000.

In our cover story, you can follow the process they went through in deciding on just the right parts for this machine and doing the build itself (yes, it was also live-streamed—you can view the video in our archives on PCMag's Facebook page), as well as how this kickass budget gaming PC actually turned out. Spoiler alert: It's very colorful.

If you're inspired to try a DIY computer project yourself, check out PCMag.com for component reviews and various tips and how-to stories. And if you're already an experienced builder, we'd love to hear about your projects: What have you created? Which are your go-to cases, chips, and other parts? And what kinds of challenges have you encountered and (hopefully) triumphed over?

@cmangis

Speaking of do-it-yourself, September is the month that Maker Faire comes to New York City (9/22 and 9/23). To anyone who loves building computers (or really, building just about anything): This is your tribe. You'll find nearly everything you can imagine that's DIY-related, from the deeply functional to the insanely creative.

If you're in the NYC area, don't miss it! And if not, there are regional Maker Faires all over the country (and the world). Check at makerfaire.com/map to find the closest one to you.

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Too-Soon Tech

John C. Dvorak's August column, "3 Big Tech Ideas That Need to Be Shelved (for Now)," pointed the finger at the driverless car and the cashless society, as well as voting over the internet.

Driverless cars don't have to be perfect. They just have to be much more reliable than humans, which they will definitely be.

—*beachmike*

Wrong.... A lot of aspects of "new technology" often have to be better than the technologies they replace. And that's before you even start looking at the economics. For example, if the automobile were invented today, you'd never get approval to have vehicles drive around with 10-20 gallons of highly combustible fuel in them that causes them to burst into flames upon collision....Driverless cars don't just have product safety and regulation hurdles. They have legal framework hurdles. The same changes in liability laws that have made manufacturers in other industries more and more liable even when their products are misused need to be dealt with, including issues with owners modifying their cars.

—*Vigilabo_Vigilum*

"Can they be made hacker-proof?" This reminds me of a Douglas Adams quote: "A common mistake that people make when trying to design something completely foolproof is to underestimate the ingenuity of complete fools."

—*reamon*

Driverless vehicles simply can never comprehend the unknown, the unplanned, and the random occurrences that could be avoided by an actual driver behind the wheel. They cannot anticipate trouble like human operators can. Driverless vehicles can only be reactive, not proactive ... Mark my words, we will call them “dumb cars” once these get out on the road. Or four-wheeled killers. To think of the billions of dollars being wasted on this sham of a technology, when we could be improving gas mileage or vehicle safety.

—*Rudy*TM

Some restaurants and stores are already refusing to take cash. I checked, and there is no federal law requiring them to accept cash. I use cash a lot and will not patronize any place that refuses to take cash.

—*lbalsam*

The day we are forced to only use electronic money is the day the totalitarian state has come into complete power in this country. If they decide to hurt you, they'll just switch your cards off. Your grocery store card, your gas cards, all of your cards will be switched off. So when you need to buy food to eat or you need gas to go to work, they will stop you ... and if you try to flee, they will track you down and you will be powerless to stop them from hurting you or the ones you love. Sleep well.

—*Ivan van Ogre*

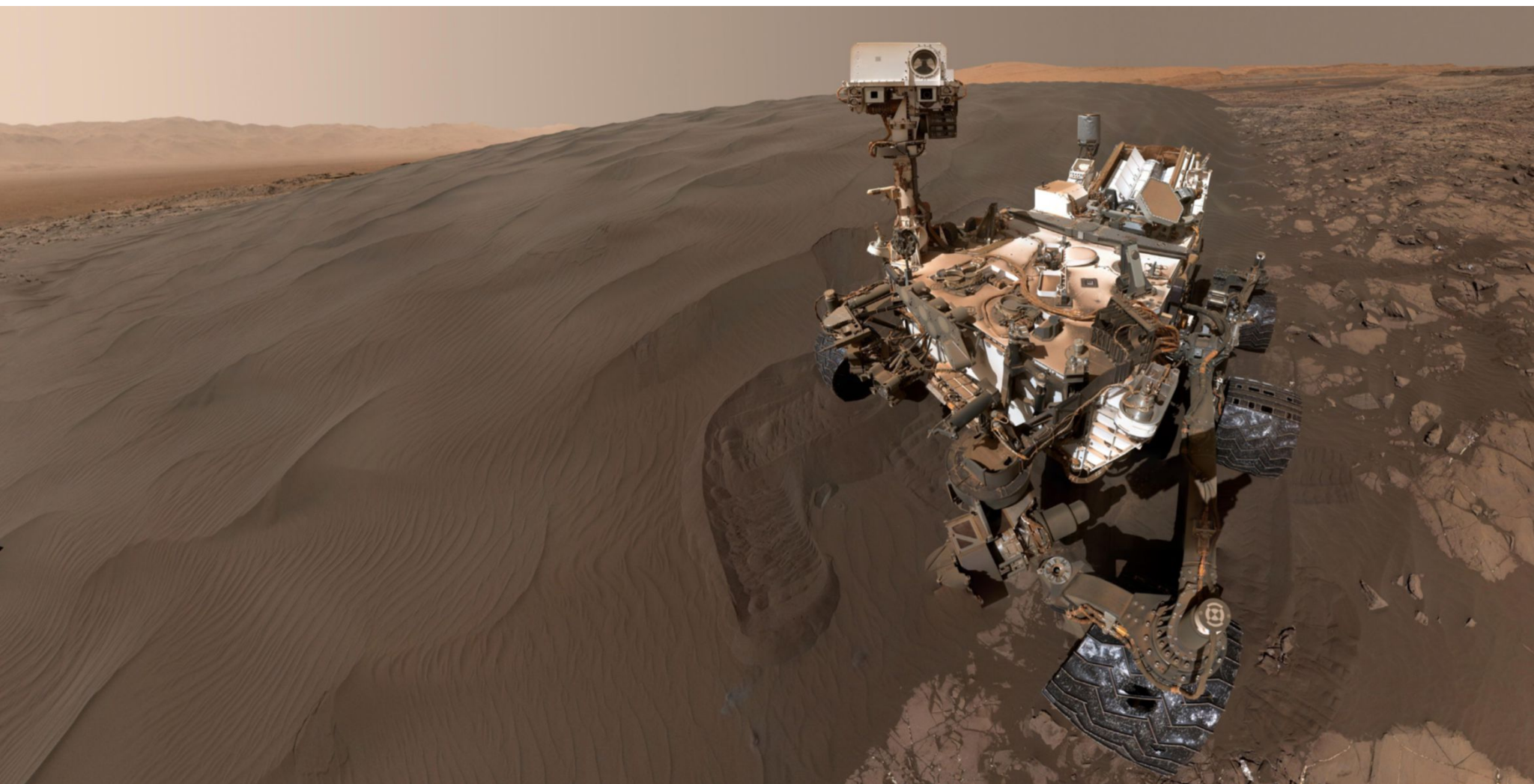
Ask us a question!

Have a question about a story in *PC Magazine*, one of the products we cover, or how to better use a tech product you own? Email us at letters@pcmag.com and we'll respond to your question here. Questions may be edited slightly for content and clarity.



Curiosity Rover in 7th Year on Mars, Still Going Strong

BY RYAN WHITWAM



It was a crazy idea on the face of it—sending a \$2.5 billion robot to another planet with a complex rocket-sled contraption to get it safely to the surface. It worked, though, and Curiosity began its exploration of the red planet six years ago. As the rover begins its seventh year on Mars, let's look at how it got there and where it's going.

Curiosity is simply the payload of a mission known as the Mars Science Laboratory (MSL), which had been in the planning phase since 2004. This spacecraft contained the rover and its landing apparatus, which was responsible for the most accurate landing Martian landing of any known object. MSL launched from Earth on November 26, 2011, and the landing took place on August 6, 2012.

Most of the discoveries we've made about Mars since then are thanks to Curiosity. Early on in the mission, NASA reported that Curiosity had gathered compelling evidence of an ancient stream bed — a place where water flowed on the currently dry planet. It would go on to gather even more evidence of an ancient, watery Mars. This caused scientists to reassess their ideas about the planet's evolution.

Curiosity also discovered important substances on Mars that indicate it could have supported life in the past. After drilling into rocks in the Gale Crater, the rover reported the presence of water, carbon dioxide, oxygen, sulfur dioxide, and hydrogen sulfide. That was all before Curiosity reached its true target on Mars—Mount Sharp. It started climbing the slopes in 2014, discovering high levels of organic molecules: more evidence for past life on the planet.

Later in the mission, Curiosity delivered evidence that water does still occasionally flow on the surface of Mars, and it found more evidence of an ancient lake in Gale Crater. The rover's wheels have taken a beating over the years, but it's still trudging up Mount Sharp. More recently, Curiosity delivered even more data on the possibility of life in ancient Martian lakes and confirmation of complex organic molecules.

As Curiosity has continued climbing, it has set a record for the longest distance driven on another planet. The rover has been so successful that NASA is using Curiosity as a base for the upcoming Mars 2020 rover. NASA planned for Curiosity to conduct a two-year study of the planet at least, but the rover has worked so well that its mission has been extended indefinitely. As long as Curiosity can do science, it'll get done.



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Magic Leap's Mixed-Reality Headset Is Finally on Sale

BY ROB MARVIN



After years of secret development and billions of dollars, you can finally buy a Magic Leap mixed-reality headset. The Magic Leap One Creator Edition, which the company calls a “spatial computing” device, has officially shipped in the US for \$2,295.

The system comes with three pieces: a headset, called Lightwear; a small, wearable computer called the Lightpack with an integrated CPU and GPU to render the headset’s graphics; and a handheld controller that looks similar to that of an HTC Vive or other VR headset controller.

For the past seven years, Magic Leap has built up endless hype and increasing skepticism along with more than \$2.3 billion in funding from the likes of Alibaba, Andreessen Horowitz, Google, Warner Bros., and the Kingdom of Saudi Arabia. The secretive startup has also struck content partnerships with Disney and the NBA.

The mixed-reality experience itself is similar to that of the Microsoft HoloLens or the 3D AR/VR experiences you can build with tools such as Amazon Sumerian. The headset's computer vision and spatial audio technology powers mixed-reality gaming, the ability to fill the real world with persistent, lifelike digital objects, and soundfield audio.

Two cables extend from the back of the Lightwear headset and feed down into the circular, belt-mounted Lightpack hardware unit. The wireless controller offers force control and haptic feedback with six degrees of freedom, smooth movement, and intuitive gesture response.

“
Magic Leap has built up endless hype and increasing skepticism along with more than \$2.3 billion in funding.
”



Android Pie Promises Smarter, Simplified Interface

BY MICHAEL KAN



Google Pie has arrived. The company has rolled out the Android 9.0 update to its Pixel smartphones. Other handsets from Sony, OnePlus, and Essential will begin receiving the update by the end of this fall, Google announced.

Android Pie (simply called “P” until this rollout) includes a whole host of new AI-powered features that are designed to make your phone smarter and to simplify the experience of using it. Perhaps the most visible change is a tweak to Android’s three navigation buttons on the bottom of the interface: Google has replaced them with a pill-shaped on-screen home button and a diminutive back button.

To see a preview of the apps you're using, all you need to do is swipe up from the home button. You'll be presented with a carousel view of every app. To get to the phone's app drawer, you swipe up twice from the home button.

Also among the upgrades is a new "Adaptive Battery" system, which promises to help your phone save battery life by better restricting idle apps that run in the background. The phone will also attempt to predict what apps you like to run by displaying shortcuts to them at certain times of day.

"Say it's Tuesday morning, and you're preparing for your commute: You'll be suggested actions like navigating to work on Google Maps or resuming an audiobook with Google Play Books," the company said. "And when you put in headphones after work, you may see options to call your mom or start your favorite Spotify playlist."

Another important addition is the Digital Wellbeing system, which introduces a dashboard that'll tell you how much time you're spending on your phone. The same system includes a few tools to help keep your device use down, such as setting time limits on your favorite apps and a Wind Down mode that'll fade your phone's screen into grayscale right before bedtime.

Not all the new features in Android Pie will be live immediately. The Digital Wellbeing system, for instance, will officially launch on Pixel phones this fall.



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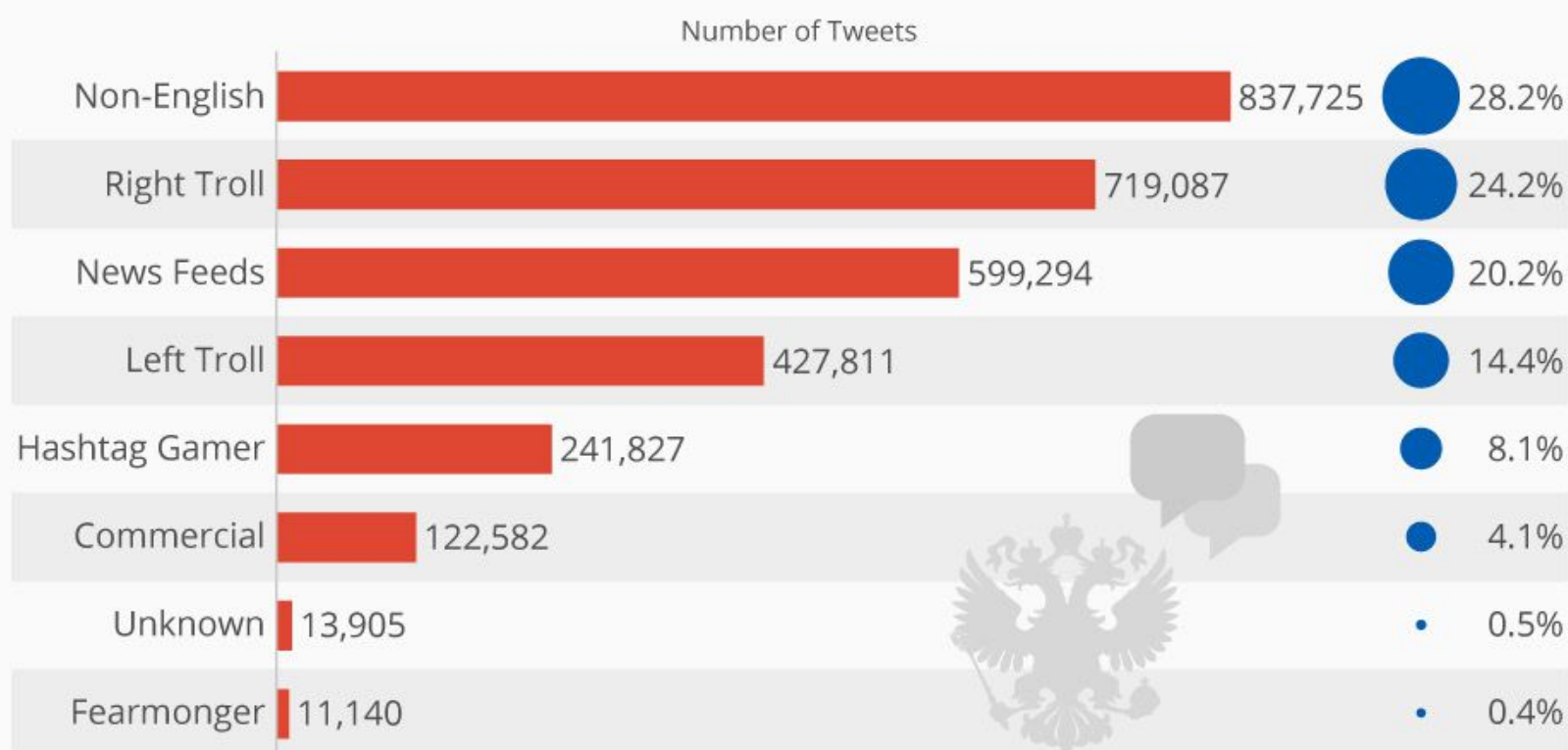


What Russian Trolls Are Tweeting About

BY ROB MARVIN

Russia's Twitter Trolls

Russian troll tweets associated with Internet Research Agency, by category*



* The Internet Research Agency is based in St. Petersburg and is engaged in online influence operations on behalf of Russian interests

Based on 2,973,371 tweets from 2,848 Twitter handles from February 2012 to May 2018

Sources: FiveThirtyEight, Darren Linvill and Patrick Warren



@StatistaCharts

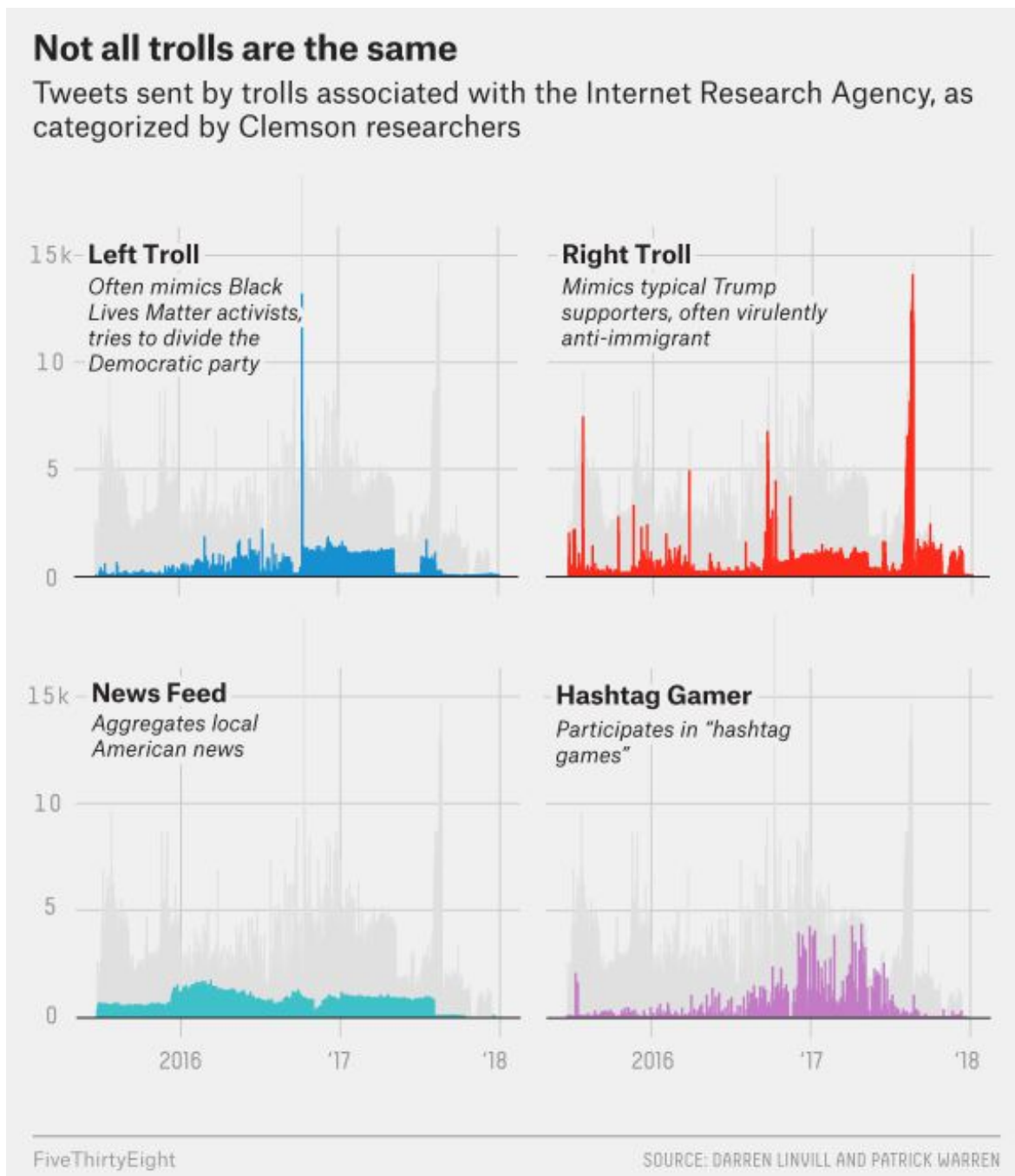
statista

The 12 Russians indicted earlier this year for meddling in the 2016 US presidential election had day jobs at the Internet Research Agency (IRA), a St. Petersburg-based company and Russia's most infamous troll factory.

Two Clemson University researchers, Darren Linvill and Patrick Warren, used social media tracking software to collect 2,973,371 tweets from 2,848 Twitter handles traced back to the IRA. The result, published and analyzed by data-driven journalism outlet FiveThirtyEight, is the most comprehensive view we've seen to date of Russian trolls' social media activity.

The researchers' breakdown identified some interesting trends by sorting the troll accounts into different categories based on their tweets. While the most popular category was simply non-English tweets at 28.2 percent, right behind it were right-wing troll accounts, which made up 24.2 percent of the almost 3 million tweets analyzed.

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Linville and Warren broke down the troll tweets into five primary categories: Left Troll, Right Troll, News Feed, Hashtag Gamer, and Fearmonger. Linville said Right Trolls, accounting for 617 handles and 663,740 tweets, act like “bread-and-butter MAGA Americans, only all they do is talk about politics all day long,” pushing out tweets with anti-immigration rhetoric, for example.

Left Trolls accounted for 14 percent of the data with 230 handles and 405,549 tweets. These accounts were more apt to use hashtags such as #MuslimBan or #BlackLivesMatter, tweeting about topics such as gender, religious, and sexual identity in a manner that researchers surmise was meant to divide the Democratic party.

The other three categories had decidedly different aims. News Feed trolls were the third largest category at 20.2 percent (54 handles and 567,846 tweets); according to the researchers, their aim was to serve as local news aggregators with handles such as @OnlineMemphis and @TodayPittsburgh, linking to legitimate news sources but sometimes tweeting with a pro-Russia slant.

Hashtag Gamer trolls had nothing to do with video games. Coming in at a smaller percentage of tweets at 8.1 percent (110 handles and 216,895 tweets), the category refers to the hashtag games played often on Twitter. For example, the researchers said accounts often played innocuous games like #ThingsILearnedFromCartoons, interspersed with more political hashtags such as #OffendEveryoneIn4Words and #ItsSoWhiteOutside.

Linville and Warren didn't focus as heavily on the commercial category (business marketing tweets), and another small percentage of the data went uncategorized. Finally, there's the Fearmongering category at a minuscule 0.4 percent (122 handles and 10,161 tweets), which spread news of fake crises, like claiming salmonella-contaminated turkeys produced by Koch Foods were being sold at Walmart during the 2015 Thanksgiving holiday.

Russian election meddling is showing no signs of slowing down. Microsoft has already stymied several hacking attempts on 2018 midterm election candidates, and Trump administration officials have issued a stern warning about Russia's plan for the 2018 midterm elections.

Inside the Bag of Geek's Editor-in-Chief

BY SHEILAH VILLARI



Going to a comic convention can be stressful, even when you're attending just as a fan. Do I have my badge? Does my outfit look all right? Am I sure I know where I'm going? Now imagine working while you're there, as I do regularly for Geek, PCMag's sister site. Interviews, panels, meetings, and photographs add a whole other layer of anxiety.

I'm extremely fortunate to be surrounded by a crew that keeps Geek and me fully operational when I'm on the road. As Lucas Lee says, "I'm nothing without my stunt team." And here are my absolute travel essentials for con survival.



CAPTAIN AMERICA CANVAS BACKPACK

Having everything I need fit into one bag is a top priority. I like to switch it up depending on how long I'll be traveling for a convention. For the second half of this con season, I've got my Captain America bag. It's comfortable and sturdy, plus I get to rep one of my favorite comic boys while on the show floor. It's also deceptively large, so I can fit even my laptop inside.

<https://www.thinkgeek.com/product/jrso>



MARSHALL MID ANC BLUETOOTH HEADPHONE

I never travel without music, podcasts, or audiobooks. I am also not picky about travel and have been all over the country in planes, trains, and automobiles. A good pair of noise-canceling headphones is a must. Marshall's Mid ANC are my current faves. They're Bluetooth equipped, and I usually get about two days of solid sounds before I need to power up again. And when you turn the active noise canceling on, the exterior noise around you is sucked out of the room. It's really cool. I highly recommend these for all travelers.

<https://www.pcmag.com/review/359888/marshall-mid-anc>



SAMSUNG GEAR SPORT

Conventions are crazy, and I try to pack as much as possible into each one. This means I usually have no time for anything outside of my commitments. I sometimes even forget to eat. Having a good wearable has absolutely kept me on track. I've used the Samsung Gear Sport this past year and couldn't be more in love. Since I can't hit the gym on the road, this watch has been a great way to keep me on top of my goals. Super easy to use and user friendly with my iPhone.

<https://www.pcmag.com/review/356964/samsung-gear-sport>

VERIZON JETPACK MIFI 6620L

Having your own Wi-Fi is so crucial. Larger cons are packed with people, so often your phone won't get much of a signal. But being able to communicate quickly is my only option. I'm very lucky that I get to take the Verizon Jetpack 4G hotspot with me. I've used this not only in convention centers but also in airports, trains, and even on the bus to Awesome Con to finish Saturday edits. I'd be totally lost without this powerful little device.

<https://www.pcmag.com/article2/0,2817,2474046,00.asp>



MOPHIE POWERSTATION PLUS MINI

Get an external battery! It's the only way to survive a full day at a con. I use my phone for everything: I record interviews and panels, take a million pictures, and constantly post on my social channels. I can't have my phone die, so backup is essential. You don't have to go super high-end, like my Mophie Powerstation Plus Mini. But I do recommend Mophie as a brand. I get about 4 charges out of it, and its slender size is perfect, since space is vital.



<https://www.pcmag.com/review/353115/mophie-hold-force-powerstation-plus-mini-for-iphone-7>



LENOVO THINKPAD 13

I never thought I could like a laptop as much as I like my Lenovo ThinkPad. We're basically best friends now, and I'm never without it. No, really—I always have it with me. I edited a Spider-Man article under the Washington Monument once on this laptop. It's compact, light, and quick, and it has great battery life. The total package for a writer and editor on the go.

<https://www.pcmag.com/review/353140/lenovo-thinkpad-13-2017>



APPLE IPAD MINI 2

I'm very much a person who uses travel time to get caught up on my pull list (for non-comic people, that's what you read each week at a comic shop), but bringing 10 single issues with me is not practical. So I use my iPad mini 2. It's almost only used for Comixology and Netflix. Because on long trips, that's all you really need.

<https://www.pcmag.com/article2/0,2817,2427096,00.asp>



AQUIO IBTB2BB DOUBLE-WALL STEEL INSULATED HYDRATION BOTTLE

A cool thing about being a member of the press/guest/speaker at conventions means that you aren't subject to the same rules as standard attendees—you get to bring a lot of your own things. A really good water bottle is key for staying both earth- and health-conscious. I really like this Aquio bottle, because it comes with a Bluetooth speaker. I usually leave the speaker in my hotel room, but it comes in handy later when I'm listening back to interviews or just playing music while I write.

<https://www.pcmag.com/news/361993/aquio-water-bottle-sports-a-built-in-bluetooth-speaker>

STAR TREK TNG SKANT UNIFORM

Cosplay is one of the unique, fascinating, and wonderful experiences of conventions. I've met so many brilliant people through this community. I also fully support wanting to dress up but still being somewhat professional. Casual cosplay is how I go these days (although I did interview Ricky Whittle while I was dressed as Jughead). This beautiful—and snug—*Star Trek* Command-style “skant” is one of my easy go-to cosplays. It's classic, comfy, and very recognizable. That's all you want when you're going to be in it for hours.

<https://www.thinkgeek.com/product/knlt>



TRIO CABLE OF MULTI-USE

I'm not always well organized, especially when I travel: Trying to keep track of so many things is a nightmare. This trio cable has been a lifesaver; it's everything I need in one cord.

<https://www.thinkgeek.com/product/hukn>



MARVEL KAWAII WALLET

I got stranded in Seattle for 11 hours after Emerald City Comic Con, but thankfully, I had my Winter Soldier pillow from Lydia Anslow with me. I've never been to a show without him; he's often the only way I can be comfortable and sleep in whatever transportation I've decided on. And my current essential is a wallet that everything fits into: phone, IDs, badge, money, and most important, all the creators' business cards.

<http://www.lydiaanslow.com>,
<https://www.thinkgeek.com/product/jlhm>

Has Slack Really Won the Office Chat War? Hell, No!

Big news in the office chat arena: Atlassian threw in the towel. After scoring big with HipChat and then trying to score even bigger with the more modern Stride, Atlassian couldn't meet its internally projected numbers with either product, so it sold them both to what even I, a recovering Microsoftee since 2012, realize is (currently, at least) the best-known name in office chat: Slack.

While the exact financial terms of the deal remain undisclosed, both companies seem to be getting what they want. But while that's great for Slack, it still can't call itself the winner of the office chat wars. It can't even call itself the clear leader.

LOOKING AT THE DEAL

When you look at the deal's plusses, you'd think everyone should be smiling. Atlassian gets to dump two products the company said weren't living up to expectations while simultaneously enjoying an 18 percent jump in its share price. The benefit to Slack is two-pronged, once the deal takes full effect in February 2019: First, it gets to do away with a key competitor; and second, its overall customer number gets an easy boost as long as it manages to retain them once its migration of HipChat and Stride accounts actually starts to happen.



Oliver Rist is executive editor at PCMag in charge of business technology and IT coverage. He writes opinions, features, and reviews with a focus on the emerging trends.

But does that mean Slack's won the office chat war? Not even close.

@OliverPRist

"We use Slack extensively," said Ashvin Naik, CEO of SalesPal.io, itself a collaboration-oriented company developing conversational intelligence analysis tools. "But the main reason we're using it now is because it's free. If we were paying for it, I'd want more value along the lines of what [Microsoft] SharePoint offers."

He went on to say that in his mind, the chat arena is evolving so fast it's impossible to predict who'll be leading even 24 months from now, citing his high school-age son looking over his shoulder one day and commenting that his Slack interface "looks like a lame version of Discord."

What that shows, aside from a need for PCMag to review Discord from a business perspective, is that the office chat and online collaboration arena is still a development hotbed and therefore considered dewy tech darlings by VCs—witness Slack's own \$250 million financing round only last year. That means no matter what Slack does today, a well-funded new unicorn could show up at any time. Remember also that while Atlassian was certainly a key competitor for Slack, it was hardly the only one. And the remaining list still carries a lot of muscle—notably Google, Microsoft, and just this past week, Facebook.

WORKPLACE GARNERS VALUE

That's right: It seems Facebook finally took a long look at its Workplace by Facebook codebase and decided to add some actual value outside of automatically building your org chart.

So it bought Redkix, an office chat startup that was building some innovative organizational features on top of the typical chat interface. It was also well on its way toward taking sizeable nibbles out of Slack's market share with initial investments from several angels as well as Wicklow Capital and Salesforce Ventures. If Facebook manages to keep the innovation momentum flowing instead of simply disappearing the Redkix code, Slack could see a powerful new competitor emerge, likely by the middle of next year. And not just a powerful one but also a hungry one, given Facebook's epic share-price faceplant in July.

That kind of description paints Redkix as a small fish in a large pond, but it's now part of a behemoth; and Slack isn't that far out of swaddling clothes itself. The aforementioned \$250 million the company raised last year from SoftBank Corp. brings its outside investment total to just over \$840 million. Combined with its publicized growth and revenue numbers, that has analysts valuing Slack at around \$5.1 billion. But let's look at those numbers a little more closely.

According to Slack, it's currently generating \$200 million of annually recurring revenue with over 8 million overall users, roughly 3 million of whom are actually paying for the service as of May 2018. Its own growth numbers are adding roughly 1 million users to that paid number every year. Which, to be fair, is very fast. Even at that speed, though, it'll be a while before it gets out of its \$840 million investor hole, let alone grows into its \$5.1 billion valuation, and yet even longer before it's bringing in the buckets of pure profit that giants like Google and Microsoft are raking in.



If Facebook manages to keep the innovation momentum flowing, Slack could see a powerful new competitor.



So let's look at the giants a little more closely. Microsoft Office, which includes its dedicated Slack-killer Microsoft Teams, is already at 135 million users, and most can be classified as paid. Google claims 4 million users for Google G Suite, which includes access to Google Hangouts Chat, or whatever they're calling it this week, and it puts in a fraction of the marketing effort of either Slack or Microsoft. The upshot? Based purely on numbers, Slack can't even call itself the current leader in office chat, much less the overall winner.

THE LITTLE GUYS

And lest we forget, behemoths aside, that still leaves a number of well-positioned second-tier players, including Zoho Cliq, Cisco Webex Teams, and RingCentral Glip—all known names, each with an established customer base and vying for its piece of the office messaging pie. Right behind them are newer players, perhaps more mature than Redkix but still definitely able to employ the startup moniker: companies such as Discord, Twist, and Ryver, among others.

All in all, Slack's made a solid move purchasing Hipchat and Stride. But it's a move that'll serve mainly to firm up Slack's hold as one of the best-known names in office chat. That's great, but it's not in itself a leadership metric. Who the actual leader is in that industry is up for grabs on an almost monthly basis. And as for an overall winner? We're a long way from settling on that.



Based purely on numbers, Slack can't even call itself the current leader in office chat, much less the overall winner.



Why Teaching AI to Play Games Is Important

OpenAI, the artificial intelligence research lab founded by Sam Altman and Elon Musk, recently declared that it would be sending a team to Vancouver in August to participate in a professional tournament of the famous online battle game Dota 2. But unlike other teams that will be competing for the multi-million-dollar prize, OpenAI's team will involve no humans—at least, not directly.

Called OpenAI 5, the team consists of five artificial neural networks that have been burning through the huge computing power of Google's cloud and practicing the game over and over, millions of times. OpenAI 5 has already bested semi-pros at Dota 2 and will be testing its mettle against the top 1 percent of players come August. *[Editors' note: This column was written in July.]*

At first glance, spending expensive computing resources and scarce AI talent to teach AI to play games might seem irresponsible. OpenAI houses some of the world's top AI scientists, who, according to The New York Times, earn seven-figure salaries. After all, can't they work on more important problems, such as developing AI that can fight cancer or make self-driving cars safer?



Ben Dickson is a software engineer who writes about disruptive tech trends, including artificial intelligence, VR and AR, the IoT, and blockchain. Ben also runs the blog Tech Talks.

Absurd as it may seem to some, games have proven to be an important part of AI research. From chess to Dota 2, every game AI has conquered has helped us break new ground in computer science and other fields.

GAMES HELP TRACE AI'S PROGRESS

Since the inception of the idea of artificial intelligence in the 1950s, games have been an efficient way to measure the capacity of AI. They're especially convenient in testing the capacity of new AI techniques, because you can quantify the performance of AI with numeric scores and win-lose outcomes and compare it against humans or other AI.

The first game that researchers tried to master through AI was chess, which in early days was considered the ultimate test of advances in the field. In 1996, IBM's Deep Blue was the first computer to defeat a world champion (Garry Kasparov) in chess. The AI behind Deep Blue used a brute-force method that analyzed millions of sequences before making a move.

While the method enabled Deep Blue to master chess, it was nowhere near effective enough to tackle more complicated board games. By today's standards, it's considered crude. When Deep Blue defeated Kasparov, a scientist remarked that it would take another hundred years before AI could conquer the ancient Chinese game of Go, which has more possible moves than the number of atoms in the universe.

But in 2016, researchers at Google-owned AI company DeepMind created AlphaGo, a Go-

playing AI that beat Lee Sedol, the world champion, 4 to 1 in a five-game competition. AlphaGo replaced the brute-force method of Deep Blue with deep learning, an AI technique that works in a much more similar way to how the human brain works. Instead of examining every possible combination, AlphaGo examined the way humans played Go, then tried to figure out and replicate successful gameplay patterns.

The researchers of DeepMind later created AlphaGo Zero, an improved version of AlphaGo that used reinforcement learning, a method that required zero human input. AlphaGo Zero was taught the basic rules of Go and learned the game by playing against itself countless times. And AlphaGo Zero beat its predecessor 100 to zero.

Board games have limitations, though. First, they are turn-based, which means the AI isn't under the strain to make decisions in an environment that changes constantly. Second, the AI has access to all the information in the environment (in this case the board) and doesn't have to make guesses or take risks based on unknown factors.

Considering this, an AI called Libratus made the next breakthrough in artificial intelligence research by beating the best players at Texas Hold 'Em poker. Developed by researchers at Carnegie Mellon, Libratus showed that AI can compete with humans in situations where it has access to partial information. Libratus used AI techniques to learn poker and improve its gameplay as it examined the tactics of its human opponents.

Real-time video games are the next frontier for AI, and OpenAI isn't the only organization



AlphaGo examined the way humans played Go, then tried to figure out and replicate successful gameplay patterns.



involved in the field. Facebook has tested teaching AI to play the real-time strategy game StarCraft, and DeepMind has developed an AI that can play the first-person shooter game Quake III. Each game presents its own set of challenges, but the common denominator is that all of them present the AI with environments where they have to make decisions in real time and with incomplete information. Moreover, they give AI an arena where it can test its might against a team of opponents and learn teamwork itself.

For now, no one has developed AI that can beat professional players. But the very fact that AI is competing with humans at such complex games shows how far we've come in the field.

GAMES HELP DEVELOP AI IN OTHER FIELDS

While scientists have used games as testbeds for developing AI techniques, their achievements have not remained limited to games.

In 2011, IBM introduced a supercomputer that was capable of natural language generation and processing (NLG/NLP) and was named after the company's former CEO, Thomas J. Watson. The computer played the famous TV-show quiz game *Jeopardy* against two of the world's best players and won. Watson later became the basis for a huge line of AI services by IBM in different domains including healthcare, cybersecurity, and weather forecasting.

DeepMind is employing its experience from developing AlphaGo to use AI in other fields



Games give AI an arena where it can test its might against a team of opponents and learn teamwork itself.



where reinforcement learning can help. The company launched a project with National Grid UK to use the AlphaGo's smarts to improve the efficiency of the British power grid. Google, DeepMind's parent company, is also employing the technique to slash the electricity costs of its huge data centers by automating the consumption control of its different hardware. Google is also using reinforcement learning to train robots that will one day handle objects in factories.

Libratus, the poker-playing AI, might help develop the kind of algorithms that can help in various situations such as political negotiations and auctions, where the AI has to take risks and make short-term sacrifices for long-term gains.

I, for one, am looking forward to seeing how OpenAI Five will perform in August's Dota 2 competition. While I'm not particularly interested in whether the neural networks and its developers take home the \$15 million prize, I'm keen to see what new windows its accomplishments will open.



Google is also using reinforcement learning to train robots that will one day handle objects in factories.



The High Cost of Parking

High on the list of pet peeves for drivers in crowded urban areas is the endless search for parking. But once robo-taxis hit the road in large numbers—and they’re already being deployed by Waymo in Phoenix—and passengers can be dropped at the doorstep of their destinations, searching for parking could become a thing of the past.

Repurposing parking spaces could open vast areas of prime real estate for other uses—including mixed-use housing, office parks, and more urban green spaces. It could also save residents of large cities and even small towns lots of money, according to a new study by Eric Scharnhorst of the Research Institute for Housing America, the think tank for the Mortgage Bankers of America.

The study analyzed parking in five US municipalities—New York, Philadelphia, Seattle, Des Moines, and Jackson, Wyoming—using data from parking authorities, city departments of transportation, property tax assessment offices, the US Census, satellite images and Google Maps. In what the study calls “the first complete parking inventories” in the five locations, it assessed the total number of parking spaces in each city—whether on the street, in lots, or structures—and calculated the overall estimated replacement costs of parking infrastructure to come up with the cost per household given local land prices.



Car tech expert Doug Newcomb has written for *Popular Mechanics*, *Road & Track*, and other publications, and is the author of *Car Audio for Dummies*.

It concluded that parking can cost residents up \$200,000 per household.

@dougnewcomb

The study found that there are more than 2 million parking spaces in Philadelphia, 1.85 million in New York, 1.6 million each in Seattle and Des Moines, and just over 100,000 in Jackson, which has a population of only 10,000. The rural resort town, known for great skiing and as the gateway to Grand Teton and Yellowstone National Park, has more than 50 parking spaces per acre—25 times its residential density of just two households per acre—and 27 parking spaces for each of household.

By contrast, with a population of just over 200,000, Des Moines has nearly 30 parking spaces per acre, or roughly 20 times its residential density (1.5 households per acre). At 1.5 million people, Philadelphia has 25 parking spaces per acre, almost four times the city's household density of 6.8 per acre.

With its population of 8.5 million, New York is the only city in the study that has fewer parking spaces per acre than households—10—which works out to slightly more than half a parking space (0.6) for each household. But while anyone who has ever tried to park in New York knows how difficult it can be to find an open spot, the city also has the highest share of transit commuters in the US.

Perhaps the most eye-opening part of the study is the monetary cost of all those parking spaces, which was arrived at by “calculating the median price of a square foot of land ... and making some

conservative assumptions about the construction costs of surface and structured parking,” Scharnhorst says. While parking cost each household over \$75,000 in Des Moines, more than \$100,000 in Seattle, roughly \$30,000 in Philly, and just \$6,570 in New York, it costs each household in Jackson almost \$200,000.

Of course, self-driving cars will arrive first in major metropolitan areas, where human-driven taxis and ride-sharing vehicles are already deployed in large numbers and there’s an established market—and more jockeying for available parking spaces. But while it’s estimated that current self-driving cars cost about \$250,000 each, perhaps Jackson, Wyoming, may want to consider wooing the company’s robo-taxis to the resort town and converting scarce and valuable real estate now used for parking to other purposes. And save money in the long run.

doug_newcomb@pcmag.com

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At 1.5 million people, Philadelphia has 25 parking spaces per acre, almost four times the city’s household density of 6.8 per acre.
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Lenovo Smart Display (10-inch): Great for Google-centric Households



Google Assistant has caught up to Amazon Alexa in just about every way but one: hardware. Whereas Amazon has offered the screen-equipped Echo Show and Echo Spot for some time, the Lenovo Smart Display is the first smart speaker to pair hands-free Google Assistant voice control with a touch-screen display. We tested the 10-inch model, and while it isn't as powerful as the Google Home Max on the audio front, it helps further narrow the gap between Alexa and Google Assistant and makes an attractive addition to any Google-centric household.

**Lenovo
Smart Display
(10-Inch)**

\$249.99



TWO SIZES, SIMILAR DESIGNS

The Lenovo Smart Display comes in 8- and 10-inch screen-size versions at \$199.99 and \$249.99, respectively. The larger model features 1,920-by-1,200 resolution and a bamboo back panel, and the smaller Smart Display has a 1,280-by-800 resolution and a soft-touch gray back panel. The two-inch active speaker driver on the 10-inch model is slightly larger than the 1.75-inch driver on the 8-inch version, but both use the same 10 watts of power and twin passive tweeters. At 6.8 by 12.4 by 5.3 inches, the 10-inch Smart Display is much larger than the Echo Show, but its rounded corners and white speaker grill make it look a lot friendlier.

A pyramid-shaped stand extends from the left and bottom sides of the back of the Smart Display, holding the screen very steady at a slight tilt to make it easier to see from above (such as when you're standing over a counter or nightstand). The triangular panels of the stand let the Smart Display sit in landscape or portrait orientation, but the portrait orientation is currently used only for video calls made with Google Duo. The back panel of the Smart Display gently curves into the pyramid of the base, disrupted only by a connector for the included power adapter in the lower-right corner (when in landscape orientation).

Two pinhole microphones flank a volume rocker and a microphone mute switch on the right side of the top edge of the Smart Display. Around the corner, a small sliding switch moves a physical privacy screen over the 5MP camera located to the upper right of the screen. Two more pinhole microphones sit below the switch. On the bottom of the Smart Display, a small rubber door covers a USB-C port for service; it has no consumer use.

Lenovo Smart Display (10-Inch)

PROS Bright, crisp screen. Attractive design. Google Assistant is powerful and useful. Google Cast adds media flexibility. Supports YouTube.

CONS Relatively weak bass and low overall audio power. Voice and video chat only through Google Duo.

ANDROID THINGS

Both versions of the Lenovo Smart Display use a 1.8GHz Qualcomm Snapdragon 624 CPU to drive Android Things, Google's Android-based embedded device operating system. The Snapdragon 624 is a solid mid-range processor, but its power isn't nearly as relevant on an embedded device such as the Smart Display as it would be on a smartphone or tablet.

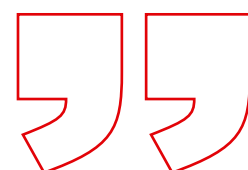
Ultimately, this isn't a device for apps or games; it's built entirely around Google Assistant and accessing Google's first-party and a handful of third-party services with ease. Even if Android Things supported installing apps, you wouldn't get very far with it; the Smart Display features only 2GB of RAM and 4GB of flash storage for its operating system.

THE VISUAL GOOGLE ASSISTANT

The Smart Display is built around Google Assistant, using voice commands and the touch screen to function like a Google-powered Echo Show. The microphones listen for the wake phrase "Hey Google," which makes the Smart Display listen to any request you say immediately after. You can ask Google Assistant for weather reports, sports scores, news, unit conversion, trivia, and other general information, which your chosen Google Assistant voice will read to you.



Both versions of the Lenovo Smart Display use a 1.8GHz Qualcomm Snapdragon 624 CPU to drive Android Things.



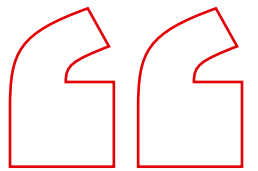
The large screen adds a useful visual dimension to the answers, showing maps when you ask for directions, ingredient and step lists when you ask for a recipe, and video reports when you ask for the latest news. If you use Google's various services, such as Gmail and Google Calendar, the Smart Display can show your upcoming appointments. Unfortunately, enterprise G Suite services don't work with Google Assistant, so you can't check your work messages or schedule if your employer runs its own G Suite system.

The Smart Display has some entertainment and media consumption options, but they're generally very Google-centric. You can ask Google Assistant to play music from Google Music, YouTube Music, Spotify, Pandora, or Deezer; watch videos on YouTube (something you can't do on Amazon's devices); and read audiobooks purchased through the Google Play store. That's about the limit of what you can ask Google Assistant to do with your voice, but the inclusion of Google Cast on the Smart Display opens up other options with your smartphone or tablet.

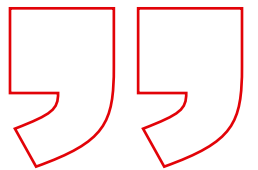
As a Google Cast device, the Smart Display is like a TV with a Chromecast connected to it; you can stream any video or music from a Google Cast-compatible app such as Hulu or Netflix. You just need to use the relevant app to cast it instead of asking Google Assistant to bring up the content.

Whatever visual information you request from Google Assistant or video you stream through Google Cast shows up crisp and bright on the 10-inch screen. The 1,920-by-1,200 resolution of the 10-inch Smart Display means a very sharp picture that can be comfortably seen from a modest distance. Colors look vivid, and the LCD can get quite bright for indoor viewing. When it's not actively being used, the Smart Display's Ambient Mode can show curated photos from Google, your own Google Photos, or a clock face.





You can do more varied tasks with Alexa than with Google Assistant, and it supports more smart home devices.



Both Alexa and Google Assistant are powerful, functional voice assistants. You can do more varied tasks with Alexa than with Google Assistant, and it supports more smart home devices, but the gap is quickly closing (and the major names are covered by both voice assistants). On the other hand, you have to be a bit more careful in how you phrase requests to Alexa than to Google Assistant, which is much more forgiving in understanding natural language.

SMART HOME AND VIDEO CHAT

The Smart Display's touch enhances your level of control over compatible smart home gadgets. You can ask Google Assistant to turn your smart lights on or off, adjust smart thermostats, and even bring up live feeds of home security cameras. Certain devices—the Nest Thermostat, for example—feature adjustable touch-screen controls that pop up on the Smart Display, letting you tweak settings with a touch in addition to your voice.

Like the Echo Show, the Lenovo Smart Display can make video calls. Also like the Echo Show, the video calls are limited to a single platform-specific service. For the Echo Show, you can make calls only through Amazon's Drop In messaging feature. For the Lenovo Smart Display, you're restricted to making calls through Google's Duo service.

Duo is similar to Google's no-longer-supported Hangouts, but it's simpler and more directly based on person-to-person communication rather than group chat. You can't use Hangouts with the Smart Display or any third-party voice or video chat platforms, such as Skype, but since Google Duo is readily available and comes preinstalled on most new Android phones, it's much more likely to be used than Amazon's Drop In.

A MODEST, CRISP SPEAKER

Lenovo promotes the Smart Display as a voice-assistant-equipped display rather than a speaker, but its 10-watt driver and Google Cast support invite us to look at it as an audio device as well. The Smart Display isn't quite as powerful as the Echo Show in terms of sheer audio output, but it sounds much more crisp and clean, handling higher frequencies with a finesse the Show lacks.

Don't expect strong bass out of the Smart Display. It struggles with our bass test track, The Knife's "Silent Shout," distorting at high volume levels when the kick drum hits stress the driver. The heartbeat-like drums from Massive Attack's "Teardrop" fare a bit better, but still show hints of crackling at maximum volume. The vocals on the Massive Attack track come through clearly with plenty of treble edge, though that edge also overemphasizes the rain-like vinyl crackle that should stay in the background.

The Real McKenzie's "Chip" sounds exciting and dense on the Smart Display, with the squeal of bagpipes and the gravelly brogue of the vocals coming through clearly. The drums don't get quite as much prominence as they do on speakers that can handle more bass, but the mix manages to sound fairly balanced despite the lack of low-end.



The 10-inch Lenovo Smart Display is a good-looking, decent-sounding tabletop smart speaker that lets you use Google Assistant hands-free.

Like the Echo Show, the Smart Display can't compare with similarly priced Bluetooth speakers (or the pricey Google Home Max). There's no shortage of speakers in the \$150-to-\$200 range that can produce far more bass rumble with even better balance across the frequency spectrum at volume levels that eclipse the Smart Display. But of course, they're simply speakers, lacking the display you get here. You can still get voice-assistant support with some of them, such as the JBL Link 10 and Sonos One.

CONCLUSIONS

The Lenovo Smart Display's large, bright touch screen displays information on request, and its modest speaker driver can put out some appreciable audio for the device's size and scope. Like Alexa and the Echo Show, Google Assistant's media playback capabilities are limited mostly to first-party services on the Smart Display, but the addition of Google Cast makes it much more flexible as a bed or bedside entertainment device. If you can't ask Google Assistant to bring up whatever you want to watch or listen to, you can just stream it from your phone to the Smart Display.

The 10-inch model we tested is very appealing at \$250, with more flexibility and a friendlier aesthetic than the Echo Show. Either Smart Display is well suited for a counter, shelf, nightstand, or anywhere else you would put a clock radio. If you don't want to spend at least \$200 on a voice-assistant device with a display and a modest speaker, the smaller, ball-shaped Echo Spot is available for just \$130 and is the ideal size for a crowded nightstand, but its puny 2.5-inch screen isn't nearly as good for reading or watching video.

WILL GREENWALD

The Smart Display can't compare with similarly priced Bluetooth speakers (or the pricey Google Home Max).



Lensbaby Sol 45: Affordable Art Lens



There's a new budget-friendly art lens from Lensbaby. The Sol 45 slides in between the entry-level Spark and the premium Composer Pro II in both price and features. The Sol 45 delivers the classic Lensbaby look—a sharp central area surrounded by blur—and is compatible with a multitude of full-frame and APS-C camera systems. Add in a pair of Bokeh Blades, which add texture to background blur when you're focusing close, and you've got a really fun lens at half the price of the Composer Pro II. The Sol 45 isn't quite as versatile, but it's a good fit for those who don't need the flexibility that the Composer's optic swap system provides. Like its premium sibling, the Sol 45 is an Editors' Choice.

Lensbaby
Sol 45

\$199.95



SLIM, SOLID CONSTRUCTION

The size of the Sol 45 depends on which camera system you use. For an SLR, it's a near-pancake lens, measuring 1.5 by 2.9 inches (HD) and adding just 5.3 ounces to your camera. The mirrorless version is a bit bulkier, at 2.5 by 2.9 inches and 9.6 ounces, as it requires the same difference between the glass and sensor as the SLR model does.

Both versions support 46mm front filters, although you won't be able to adjust the Bokeh Blades when you use a filter. Still, if you plan on using the Sol 45 for video, adding neutral density to maintain proper shutter angles under bright light is a necessity.



Lensbaby sells the Sol 45 for Canon, Nikon, Pentax, and Sony SLRs, as well as for Fujifilm and Sony mirrorless cameras. There's no Samsung version—the NX system has been dead for a long time, but this is the first Lensbaby release in recent memory not to support it. Micro Four Thirds shooters can certainly adapt an SLR version with ease, but you're better off waiting for the Sol 22 (\$199.95), which is designed specifically for the M43 sensor size. It's not shipping yet but will lag behind the Sol 45 by only about a month.

Lensbaby

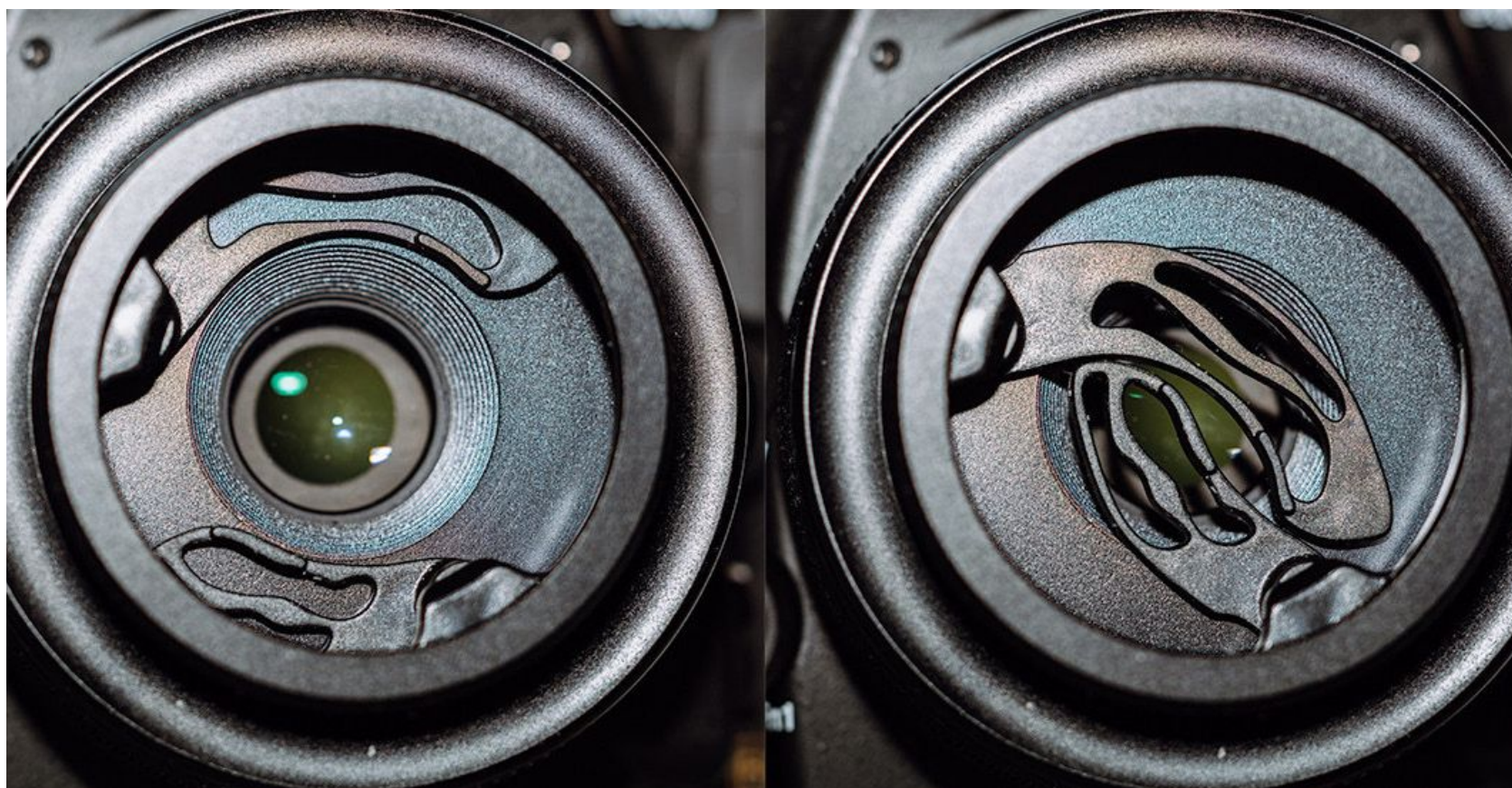
Sol 45

PROS Sweet-spot Lensbaby effect. Tilt adjusts sharp area of photo. Bokeh Blades add texture to backgrounds. Compact, lightweight design. Compatible with multiple camera systems.

CONS Focus ring is a little narrow. Bokeh Blades effect reduced when capturing distant subjects.

The Sol 45 is finished in matte-black and has an all-metal barrel. It's a pure manual focus optic. The focus ring is knurled, so you can find it by feel, and it sits at the front of the lens, jutting out from the wider base by a quarter-inch or so when set to infinity focus—it extends out from the barrel as you focus closer. The short extension makes it a bit uncomfortable to grip and turn; it doesn't prevent you from focusing, but it's not quite as comfortable to adjust focus as it should be.

As with the Composer Pro II and the Spark, you can tilt the Sol 45 to adjust the plane of focus. The mechanism used to do so is quite nice to use: Twist the base clockwise to unlock it, and then you can tilt it in any direction. Tilting the lens changes the position of the sharp area of focus in your image. You can also center and lock the tilt adjustment by twisting the lens counterclockwise.



And then there are the Bokeh Blades, shown above. New to the Sol series, these are two plastic arms that sit inside the lens; they can be swung toward the edges so they don't affect your images or moved in over the glass to add some interesting texture to photos. One blade is larger than the other, so you can use them independently to change the look of your shot or put both over the front element for a more pronounced effect. The blades can be rotated to change the orientation of the texture they produce.

BOKEH BLADES ADD TEXTURE

The Sol 45 goes back to Lensbaby's roots, echoing the look of early models and its current Sweet 35, Sweet 50, and Sweet 80 optics, all of which are compatible with the Composer Pro II and capture images with a small central area of sharpness that quickly gives way to blur.

But unlike with the Composer, you can't change out the Sol 45's optical group—it's a fixed 45mm f/3.5 design. There's no adjustable aperture, either. You lose a bit in versatility, but you also save some money and get a smaller lens. The Composer Pro II ranges in price from \$300 to \$400, depending on which Lensbaby optic you opt to purchase with it.

Aside from the effects of the Bokeh Blades, the Sol 45 is very similar to the Sweet 50 in look. The focal length is very slightly wider, and the aperture is a bit narrower, at f/3.5 versus f/2.5. So what do the Blades bring to the table?

The answer is texture in the blurred area of your images—in some cases. Use them when you're focusing on a distant subject, and you aren't likely to see anything different in your shot. But when you're working close, the effect is very pronounced. Take a look at the comparison below—the image on the left was shot without the blades engaged, while the one on the right uses both to change the look of the background.





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But for an extra \$100, the Sol 45 is an excellent choice for photographers who think the Spark is a bit too basic.

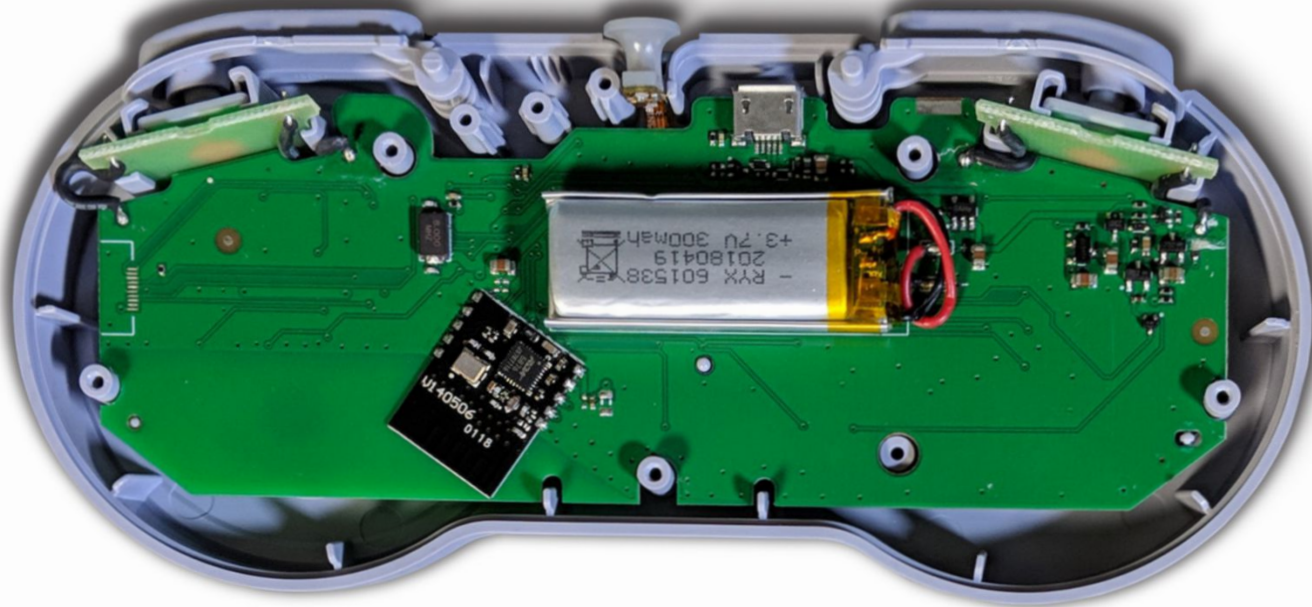
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AN AFFORDABLE SWEET SPOT LENS

The Sol 45 isn't the most entry-level Lensbaby lens—that honor goes to the \$90 Spark. But for an extra \$100 and change, the Sol 45 is an excellent choice for photographers who think the Spark is a bit too basic. The Sol 45 is smaller and allows you to set the amount of tilt, while you need to physically hold the Spark in place while making an image.

We're awarding the Sol 45 our Editors' Choice for special effects and art lenses. For \$200, it allows you to make photos with the signature Lensbaby look, a useful effect for isolating your subject from the rest of the world. The Composer Pro II is still our pick for photographers with a bigger budget—but it costs \$300 and up, and its price goes higher when you purchase additional optics. You don't get that option with the Sol 45, but photographers who don't want to go whole hog into the world of Lensbaby will appreciate it.

JIM FISHER



8Bitdo DIY Mod Kit for SNES Classic Controller

Game controllers have come a long way since the 8-bit era, but there's still something satisfying about the classic gamepads of the early '90s. The rectangle of the NES and the dog bone of the SNES controllers are simple, functional, and incredibly sturdy. Of course, they're also wired controllers that require an adapter to use with any modern system. You can use the NES Classic and SNES Classic Editions and their old-school controllers with more modern connectors, but they're still wired. You can also use a classic-style wireless controller like the 8Bitdo SN30. The company has another solution, though, and it lets you breathe new life into your old, unused gamepads.

**8Bitdo
DIY Mod Kit
for SNES Classic
Controller**

\$\$19.99



The 8Bitdo DIY Mod Kit line is a collection of kits for modifying your original or Classic Edition controllers. They're inexpensive and easy to use, and they can turn your 8- or 16-bit gamepad into a Bluetooth controller like the SN30. 8Bitdo offers Mod Kits for both the original and Classic Editions of the NES and SNES controllers, along with a kit for the three-button Sega Mega Drive/Genesis controller. We tried out the Mod Kit for the SNES Classic Edition gamepad.

EVERYTHING BUT THE CONTROLLER

Each 8Bitdo mod kit comes with a new printed circuit board (PCB), which serves as the brain of the gamepad. This holds all the circuitry of the controller; everything outside of it is just a plastic shell. The buttons of the controller aren't even mechanically actuated buttons, like you would find in a mouse or on a keyboard; they're just plastic shapes with conductive foam that closes different circuits on the PCB, sending a signal through the board to your gaming device that the button was pressed.

8Bitdo DIY Mod Kit for SNES Classic Controller

PROS Easy to install.
Functional. Multiple
systems supported.

CONS Limited
controls compared
with modern
gamepads.
Proprietary charging
cable unless you open
up the gamepad every
time you want to
charge it.



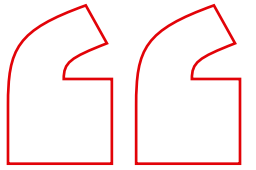
A rechargeable battery is included, built into each PCB. Each kit also comes with a short USB-to-micro USB cable and a Philips-head screwdriver sized for the controller you're modding. You get everything you need to mod a controller except the controller itself.

INSTALLATION

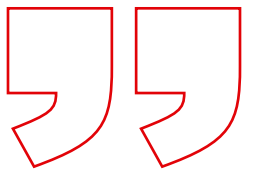
The modding process is simple. You don't need to solder anything or even plug any wires into sockets. Just open up the controller by removing the five screws on the back with the included screwdriver, take out the PCB and connected cable, and insert the mod kit's PCB.

Each board is pre-drilled with holes that match the posts on the inside of the controller shells. When aligned correctly and facing the right direction, they'll fit in securely (the side of the board with the dark pads should be facing the button side of the controller shell). The SNES mod kit boards have two smaller boards attached to the main piece by wires. These slide into the slots under the shoulder buttons. After the main board and (if applicable) shoulder button boards are in place, the last step is to fit the attached indicator LED into the hole the controller cable previously extended. When that's done, screw the back half of the controller shell into the front half, and you have a modded gamepad.

The internal battery needs to be recharged with the included USB cable, which terminates in a very narrow barrel connector that plugs into a port on the indicator LED mounted into the gamepad's cable hole. A micro USB port sits on the PCB itself and can also directly charge the gamepad, but you need to open it up again to access it. Because the Mod Kit's package is a simple cardboard box that you can easily close and stash, you should keep it around to hold the charging cable and instruction card; you don't want to lose either of them.



**The 8Bitdo DIY
Mod Kit line is
a collection of
kits for
modifying
your original
or Classic
Edition
controllers.**



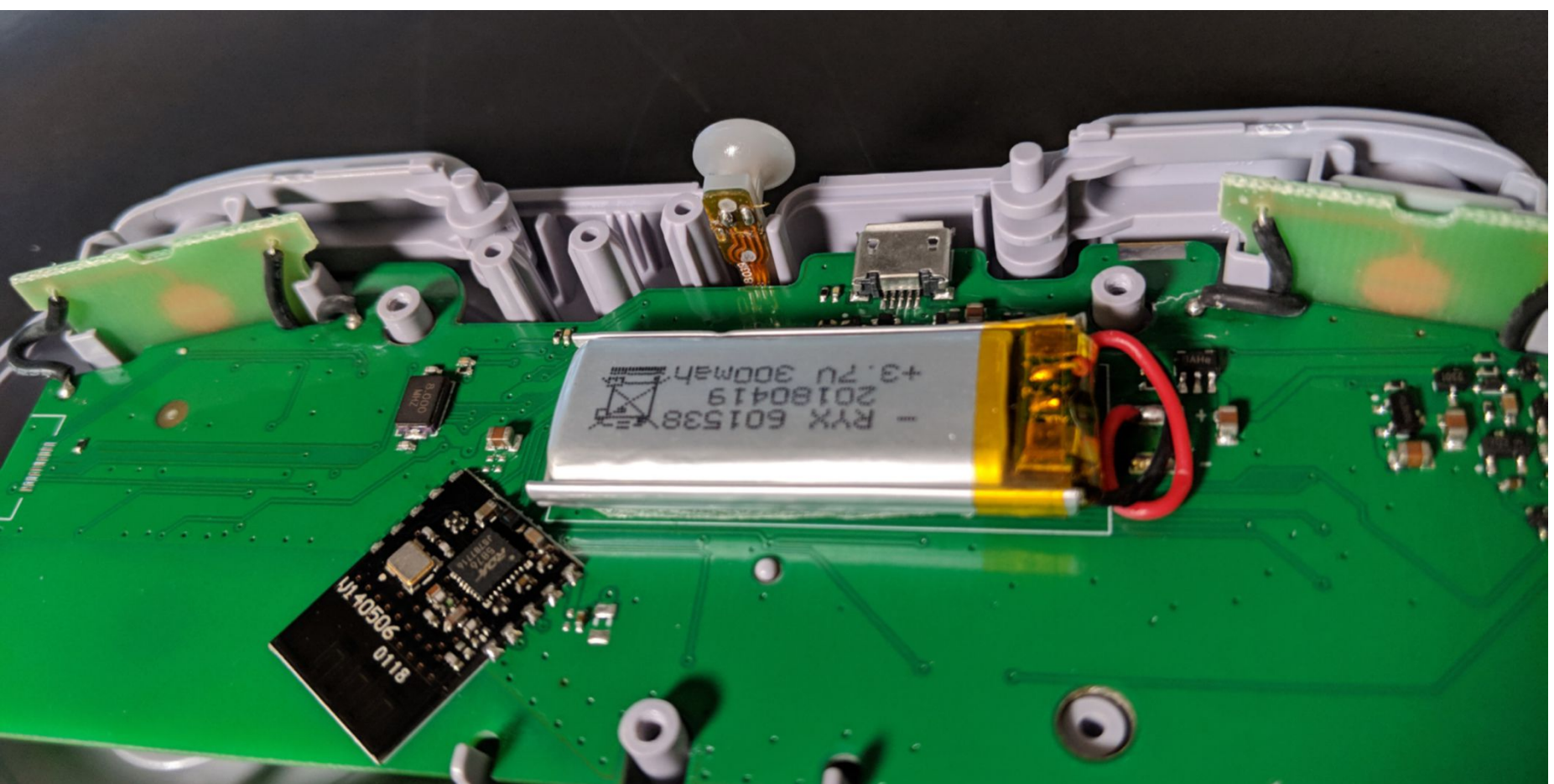
WORKS WITH PCS AND SWITCHES

Like 8Bitdo's own pre-built wireless gamepads, the modded controller can work with PCs, Macs, Android devices, the Nintendo Switch, and classic game systems with 8Bitdo's Bluetooth receivers. Holding the A, B, Y, and X buttons when pressing the Start button to power on the modded gamepad puts it into Mac, Android, Switch, or PC mode, making it function as the correct type of input device for whatever you want to use it with.

I tested the modded SNES controller with both a PC and a Nintendo Switch, following the startup and pairing instructions to put the gamepad into the correct mode. It paired with both devices perfectly and had no issue connecting.

I played Ducktales from The Disney Afternoon Collection on the PC, and it worked very well. Putting the gamepad into PC mode by holding X and pressing Start makes it function as an XInput device that appears to modern Windows computers as an Xbox 360 or Xbox One controller. I navigated the menus and started to attack skeleton ducks with my cane in Transylvania without any issues, and the SNES direction pad and buttons made the action feel responsive and comfortable.

I also played the Mega Man X Legacy Collection on the Switch with the modded gamepad. It paired through the Switch's controller menu easily, and functioned exactly as it was supposed to. Playing Mega Man X games wirelessly with a modded SNES Classic controller felt just like playing the first Mega Man X on a SNES Classic with the unmodded, wired controller.



For both systems, you're limited with the available buttons on the modded controller. This means no analog sticks and no secondary triggers by default. You can manually map the direction pad to function as the left or right analog stick by holding the Select button and one of the directions, but you're still limited to only one type of directional input (direction pad, left stick, or right stick) at once. When connected to a Switch, holding the down control and Select button at the same time triggers the Home button, which is very helpful for using the controller with that system.

For both classic Capcom collections, it means you can't bring up the system menus or activate special features, such as rewinding the action. It's still a pure gameplay experience for the individual games, but get ready to use your keyboard or Joy-Cons if you need anything beyond the direction pad, face buttons, and two triggers.

EASY UPDATES FOR OLD CONTROLLERS

8Bitdo's DIY Mod Kits let you turn your old (or newer Classic Edition) gamepads into Bluetooth controllers that can work with almost any computer, phone, tablet, or Nintendo Switch. They're simple \$20 kits that are easy to install and use, and they help you cling to your beloved old gamepads long after you've lost the cables that let you use their original consoles. Because the kits are so simple, you won't learn much about the inner workings of the gamepads beyond what the PCBs look like, but you'll still get a good look at the surprisingly elegant guts of your controller before sealing it up with a new Bluetooth board.

For those who don't have any old controllers to modify or want a more modern control scheme, 8Bitdo's premade wireless gamepads are just as functional. The minimalist NES and SNES-inspired controllers such as the SN30 are available for just \$10 more than the mod kits, and fully equipped dual-analog, quad-trigger controllers such as the SN30 Pro can be found for \$50. If you don't need wireless at all, Retro-Bit offers a variety of classic gamepads with USB connectors for use with modern systems.

WILL GREENWALD



AMD Ryzen Threadripper 2950X: Even Better Now



You might think that AMD bestowed the name “Threadripper” on its flagship CPU to evoke massive thread counts and the ability to burn through pretty much any intensive computing task. (You’d be right.) You could also laugh off the name as marketing hyperbole dreamed up in a Madison Avenue boardroom. (Maybe.) But either way, there’s no denying that the first Threadripper chips were among the most powerful consumer CPUs on the market when they debuted, and the second-generation chips are even more powerful.

**AMD Ryzen
Threadripper
2950X**

\$899.00



How much more? The flagship first-gen Ryzen Threadripper 1950X has 16 cores and 32 computing threads, but AMD is now selling a 32-core, 64-thread Threadripper 2990WX (\$1,799), part of a new two-chip Threadripper WX line, with a 24-core version (the \$1,299 2970WX) to follow in the fall. These two new CPUs are overkill for most PC-building enthusiasts both in terms of raw compute power and price, so we're focusing on the Threadripper 2950X for our initial second-generation Threadripper review.

This new chip is the direct replacement for the 1950X. It's got the same number of cores and threads but a slightly increased base clock speed of 3.5GHz (with the ability to boost to up to 4.4GHz) and a lower cache latency, among other minor improvements. Even better, it retails for \$899, \$100 less than the debut prices of the 1950X and its closest Intel alternative, the Core i9-7900X. (A \$649 12-core complement, the Threadripper 2920X, will follow in October, along with the 24-core chip.)

AMD Ryzen Threadripper 2950X

PROS Excellent multi-threaded performance. 64 PCI Express lanes. Expanding ecosystem of components. Easy-to-use Ryzen Master software utility.

CONS Variable performance on 1080p gaming. Complex installation process.



So if you're building a tricked-out video-editing workstation or yearn for a gaming-and-streaming rig, the Threadripper 2950X is an excellent choice for a CPU. Like the 1950X before it, it earns our Editors' Choice award. It's far from the only excellent choice in the high-end desktop (HEDT) market these days, though, since the first-gen Threadripper chips can now be had at significant discounts, and Intel will almost certainly release refreshed Core X-Series Core i7 and i9 CPUs in the next few months. But let's dig into why the Threadripper remains a whopper of a bargain for extreme power seekers.

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THREADRIPPER'S EXPANDING ECOSYSTEM

Discounts and product refreshes are mainstays of consumer technology, so if you wait around for the next one, you could end up never buying a single component. That would be a shame in this case, because one of the Threadripper 2950X's most notable ancillary improvements is an expanded ecosystem of complementary components. Since it supports the same X399 chipset as the 1950X, it's compatible with any X399 motherboard, even those that were designed before it was introduced.



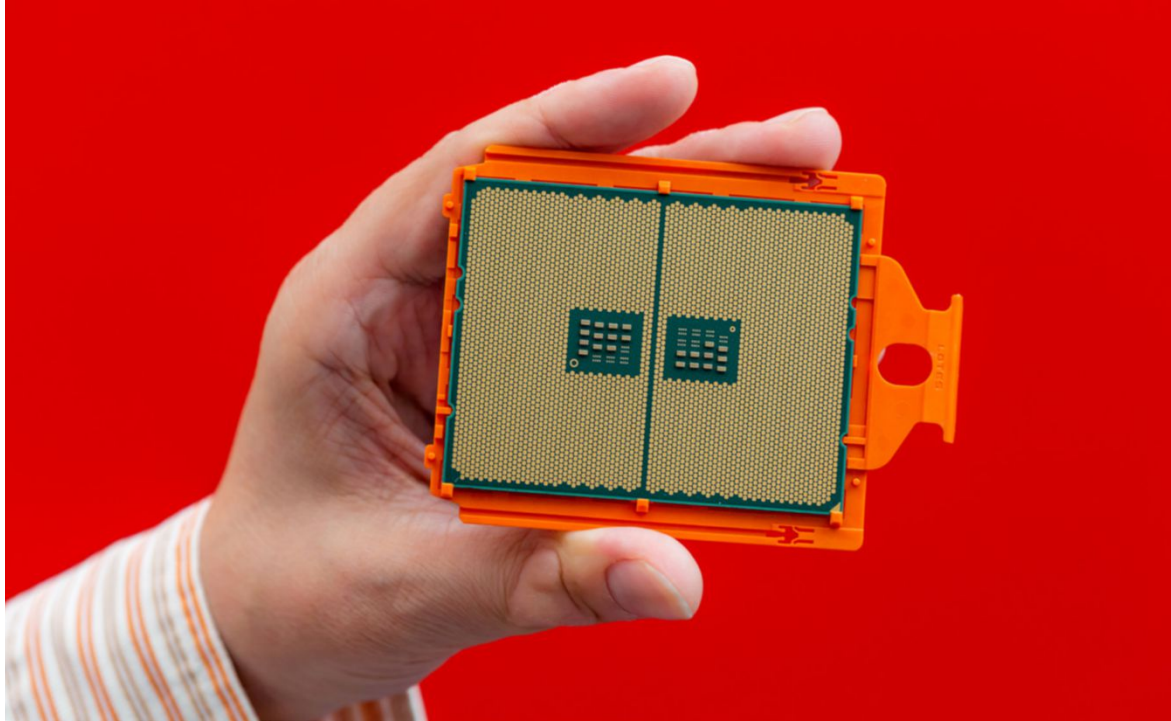
In fact, we tested it with the same Asus ROG X399 Zenith Extreme motherboard and Thermaltake Floe Riing RGB 360 liquid cooler that we used to test its predecessor. An older X399 board, such as the Asus model we used, may require a BIOS update to be compatible with the Threadripper 2950X. Luckily, all X399 boards support USB flashback, which means you can update the BIOS from a file installed on a USB stick instead of having to boot up with a different CPU first.

More than 30 coolers are now officially compatible with Threadripper chips, a few of which are air cooling solutions designed specifically with the Threadripper in mind. One of these is the new Cooler Master Wraith Ripper, which can deal with the heat from any chip in the second generation, including the monster 32-core 2990WX.

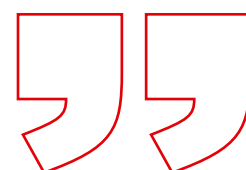
The absence of adequate liquid cooling solutions is one of the few reasons why you might not have wanted to buy a Threadripper 1950X. The chip is huge, essentially comprising two ordinary Ryzen chips fused together, which means that it is bigger than most of the liquid cooling heat sinks on the market last year. The 2950X isn't any smaller, and it has the same 180-watt thermal design power (TDP, a measure of required heat dissipation), but new solutions like the Wraith Ripper should do a better job of covering a larger portion of the CPU's heat spreader.

Not only are there more and better Threadripper cooling solutions, but the chips are also better equipped to adapt their heat output to the maximum that the cooler can handle. This is thanks to an update to AMD's Precision Boost feature. The original version of Precision Boost lowers the CPU clock speeds to a steady, safe level when it detects a complex multi-threaded task, such as 3D rendering, even when the cooler and the power supply would allow higher speeds. An updated version available on the 2950X, called Precision Boost 2, is far more granular.

It continuously adjusts the clock speed in increments as small as 25MHz to allow the CPU to run at the highest possible frequency based on the capabilities of the power supply and cooler. These adjustments happen as frequently as 1,000 times per second. The result, according to AMD, is that clock speed will decrease at a slower rate as the CPU heats up under a heavy workload.



**Threadripper
CPUs now
support DDR4
memory clock
speeds of
2,933MHz, up
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in the first
generation.**



SUPPORT FOR FASTER MEMORY

Threadripper CPUs now officially support DDR4 memory clock speeds of 2,933MHz, up from 2,667MHz in the first generation. Theoretically, this should help with memory-dependent processing tasks, although, of course, you can configure the memory manually to run at lesser speeds when you're experiencing compatibility issues or experiment with even higher settings at your own risk.

The connection between the processor and memory modules is also important in determining how well your Threadripper-powered PC will handle memory-intensive tasks. Each of the Threadripper 2950X's two dies is directly connected to two memory channels and by default also has access to the memory channels connected to the other die—thanks to Infinity Fabric, AMD's marketing name for the technology that allows different parts of the chip to talk with one another.

Infinity Fabric results in an extraordinarily innovative and scalable CPU design, but it also introduces latency as it passes requests within the chip. If you're running applications for which memory latency has a large impact on performance, you can force each die to use only its directly connected memory by enabling the "Local" memory option in AMD's Ryzen Master software utility.

LIFE IN THE 64 FAST LANES

Many of the best things about Threadripper chips aren't changing with the 2950X. Aside from support for basic technologies that every cutting-edge CPU should have, such as USB 3.1 Gen 2 and PCI Express NVMe for lightning-quick storage, the 2950X is capable of handling 64 PCI Express lanes. You will probably never use all 64 lanes, but if you plan to install two GPUs and two PCIe SSDs, you'll occupy 40 lanes and have plenty of leftovers for future add-ins.

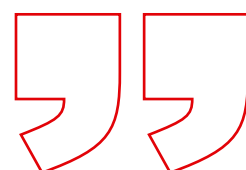
This arrangement would be tighter or, in some cases, impossible on an Intel Core X-series chip and the current X299 platform. The lane count can vary with these chips depending on which one you install. For example, the Core i9-7900X supports 44 lanes, while the Core i7-7820X supports 28. (The short-lived "Kaby Lake-X" chips that also work on this platform support only 16.)

Like every Ryzen CPU, the Threadripper 2950X is overclockable, and AMD's Ryzen Master software utility makes it easy to adjust clock speeds directly from Windows instead of using the BIOS. Second-generation Threadripper chips have an updated Extended Frequency Range (XFR) tool, dubbed XFR2, that auto-adjusts the speed of every processor core to extend the amount of time the CPU is overclocked before it gets too hot. With the 1950X, XFR would operate across only a subset of the cores.

AMD cautions that overclocking, whether done manually or using tools in Ryzen Master, voids the warranty. Assuming you don't overclock, you'll enjoy the three-year warranty that AMD includes with boxed versions of the Threadripper 2950X. (We'll get into our experience overclocking the Threadripper 2950X later.)



If you plan to install two GPUs and two PCIe SSDs, you'll occupy 40 lanes and have plenty of leftovers for future add-ins.



The Ryzen Master software also lets you toggle between Creator and Game modes. The former is the default and used under most circumstances, and Game mode is a special state that disables half the cores and changes the memory state to accelerate performance in certain games.

One of the Threadripper 2950X's few glaring omissions, at least for video editors and photographers, is the X399 platform's lack of Thunderbolt 3 support. Thunderbolt 3 offers blazingly fast data-transfer speeds of up to 40GBps, and it's quickly becoming the interface of choice for professional and prosumer external hard drives and RAID arrays. The lack of Thunderbolt 3 support isn't entirely AMD's fault, since Intel developed the technology and charges royalties to use it (the royalties may end this year). In addition, the motherboard must support Thunderbolt 3, and no current X399 motherboards on the market do.

BUILDING A THREADRIPPER PC

Installing a Threadripper CPU is a unique process because of its large size (remember, it's essentially two regular Ryzen chips fused together). Instead of just dropping the CPU into its slot and attaching the screws and heat sink, you first have to slide the Threadripper into a folding bracket and then fasten down that bracket to the motherboard using a torque screwdriver that AMD provides in the Threadripper box. PC-building enthusiasts will appreciate the novel steps, but if you just want to build as quickly as possible, don't count on it; you'll need to slow down and proceed carefully, as the bracket mechanism and the 4,000-plus in-socket pins are delicate.



In addition to the Threadripper 2950X and Asus X399 Zenith Extreme, our testbed includes the following components:

- **Processor:** AMD Ryzen Threadripper 2950X
- **Mainboard:** Asus X399 Zenith Extreme
- **Memory:** G.Skill Flare X DDR-3200 (two 16GB kits)
- **Boot drive:** Samsung SSD 970 EVO (500GB/M.2)
- **Hard drive:** Seagate 4TB Desktop HDD ST4000DM000
- **Chassis:** Mean:IT 5pm
- **Power supply:** Thermaltake Toughpower Grand 1200W
- **CPU cooler:** Thermaltake Floe Riing RGB 360
- **Video card:** Nvidia GeForce GTX 1080 Founders Edition

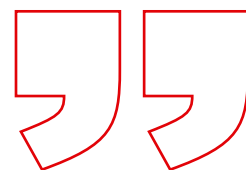
This is an identical testbed to the one we used for the 1950X with the exception of faster memory. The 1950X testbed used G.Skill TridentZ RGB memory, while the 2950X testbed uses G.Skill Flare X memory pegged at 2,933MHz using the XMP profile in the BIOS. An Nvidia GeForce GTX 1080 Founders Edition video card handles display output for our CPU-specific tests, and a 500GB Samsung SSD 970 EVO is our boot drive. It all goes into a Mean:It tempered-glass 5PM case, and a Thermaltake Toughpower Grand 1200 power supply powers everything.

PERFORMANCE TESTING

On the Intel side, its 10-core Intel Core i9-7900X is going to be the Threadripper's chief competition, though for our formal comparisons we also dropped in the eight-core Core i7-7820X (a Core X-Series chip, too) as the step down from the Core i9-7900X. And, of course, we dropped in the top-end Core i9-7980XE Extreme Edition (Intel's flagship 18-core part, still at \$1,999 at this writing) for a look at the top end of the Intel line and, in fact, the entire HEDT market.



If you just want to build as quickly as possible, don't count on it; you'll need to slow down and proceed carefully.



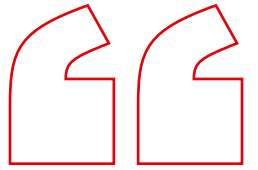
Looking back to the previous AMD generation, we're also charting in the Threadripper 1950X (the forebear to the 2950X) and the Threadripper 1920X, AMD's step-down 12-core model. And we're also looping in the two top-end chips in Intel's and AMD's "mainstream" lines. The Core i7-8700K is the current head honcho for Team Blue on its mainstream socket (if you discount the limited-edition Core i7-8086K, which we're in the process of reviewing), and the AMD Ryzen 7 2700X is the top dog in the new second-generation Ryzen line. The Core i7 is a six-core/12-thread chip, while the Ryzen 7 features eight cores and 16 threads.

On thread-hungry tests and tasks, the Ryzen 7 2700X and Core i7-8700K won't stand a chance against the 16-core/32-thread Threadripper 2950X; this was the case with the previous generations of each of these chips versus the Threadripper 1950X. The 10-core Core i9-7900X, should be in the same league as the Threadripper parts (for the most part) given its pricing, and we expect the 18-core Core i9-7980XE Extreme Edition to be the alpha dog in tasks that gobble up cores and threads.

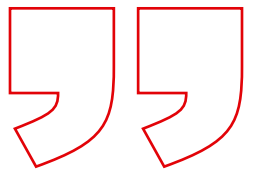
That said, the Core i9-7980XE has a suggested price of \$1,999, more than twice that of the top Threadripper chip, and it hasn't budged much from that rarified price spot since its debut in 2017. That's a lot of extra moolah to pay for a few extra cores. Let's see if it's worth it.

CINEBENCH R15

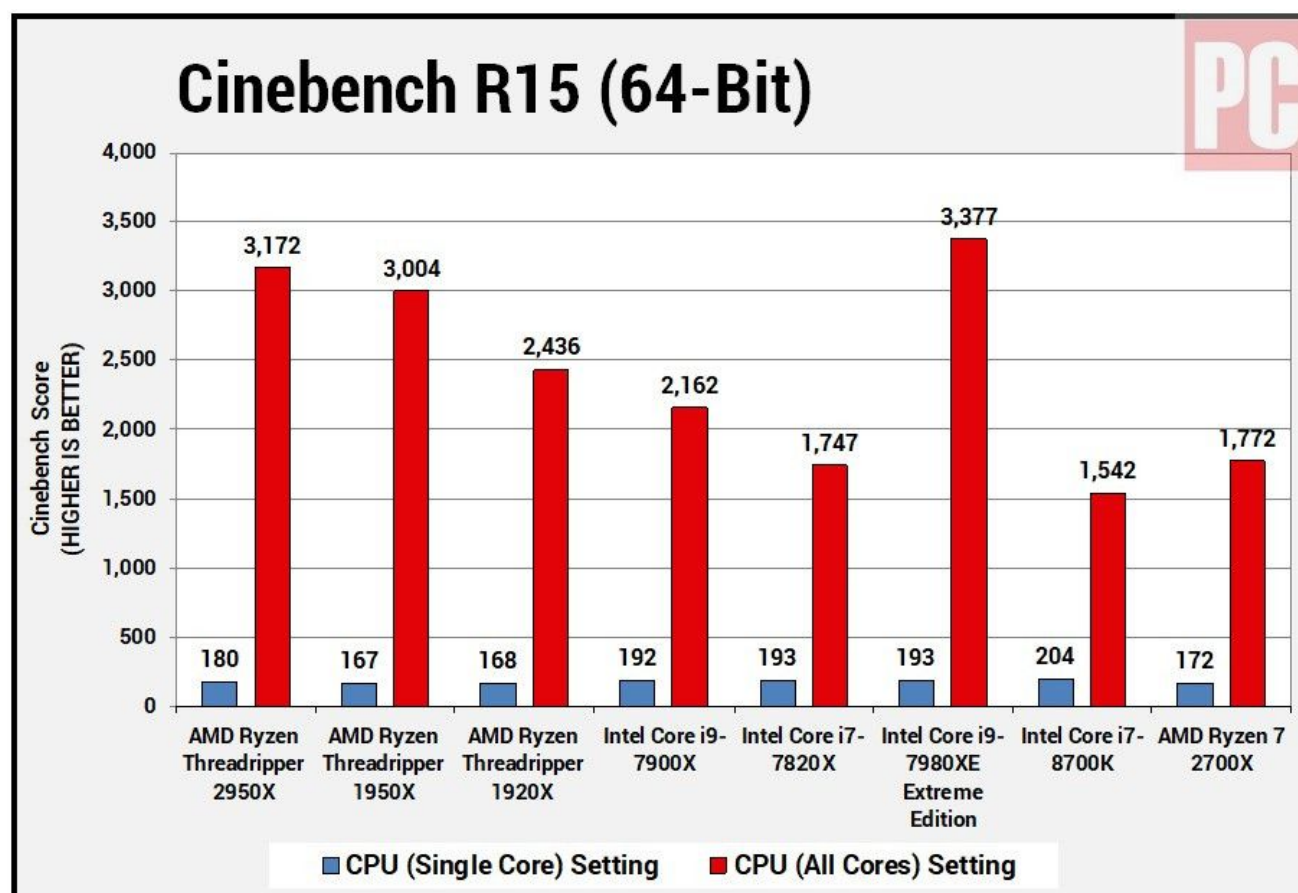
First up in our testing regimen: Maxon's CPU-crunching Cinebench R15 test. Cinebench is a fully threaded test that's one of the best at-a-glance measures of a task making use of all available processor cores and threads. In practice, many applications, even pro applications, can't leverage all threads as well as Cinebench can, but this horsepower trial shows the top potential of the chip, using the CPU rather than the GPU to render a complex image.



On thread-hungry tests and tasks, the Ryzen 7 2700X and Core i7-8700K won't stand a chance against the Threadripper.



Along with the usual test that makes use of all available cores, we've mapped in the single-core results here, to get a sense of how AMD's new chip fares with single-threaded workloads.

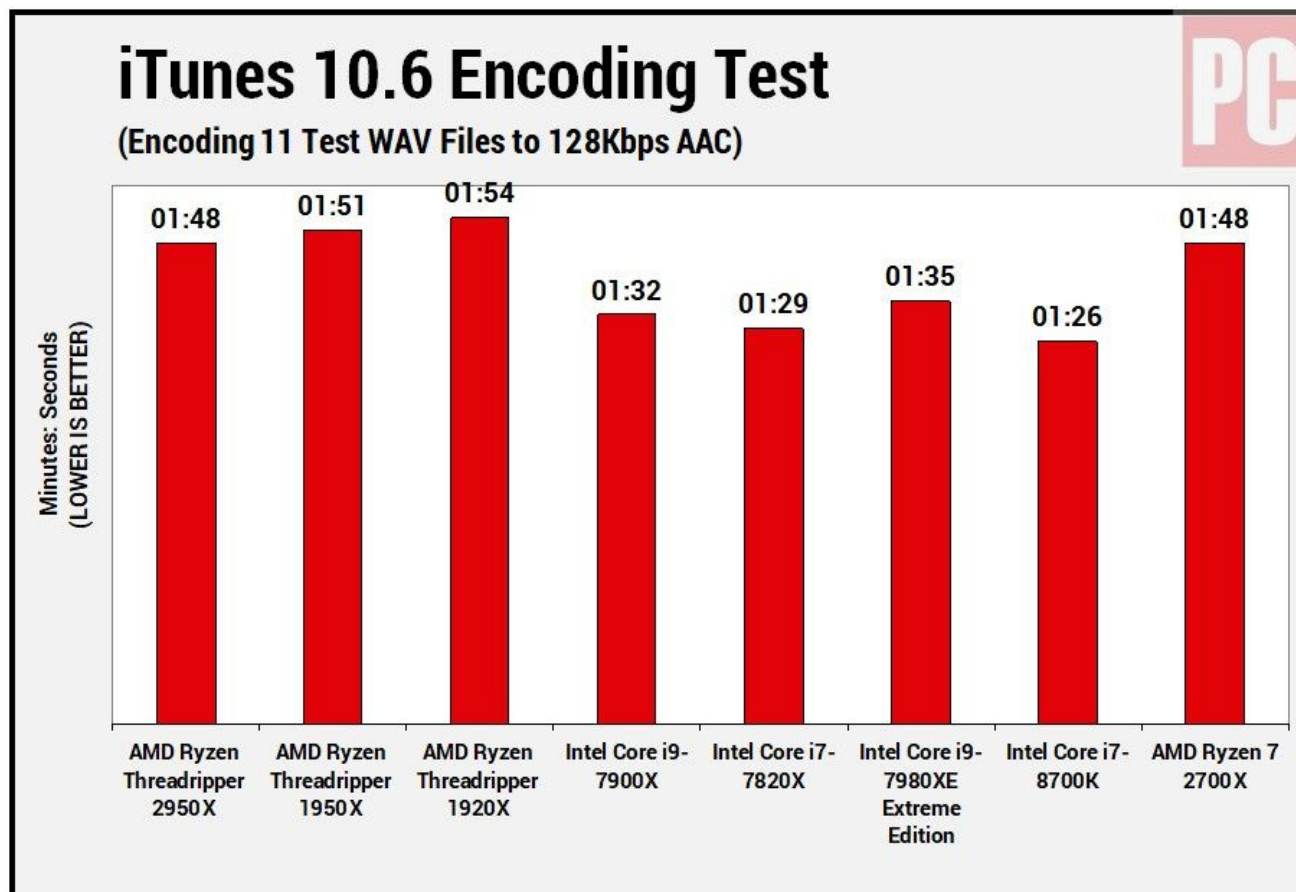


The Threadripper 2950X's first showing is an impressive one, and about what we'd expect from a generational step-up. That's an approximately 6-percent uptick from the Threadripper 1950X to the 2950X in the All Cores trial, with the 2950X encroaching ever closer to the 18-core/36-thread Intel Core i9-7980XE. It also tops its closest-in-price Core X-Series competitor, the 10-core/20-thread Core i9-7900X, by a healthy 30 percent on the multithreaded trial.

The Single Core setting tells a different tale. The Threadripper 2950X shows a decided uptick from the 1950X and 1920X, with the Intel chips still in the lead. That said, with the 2950X, the Intel lead has been halved. It was about 15 percent last year, and now it's down to about 8 percent.

ITUNES 10.6 CONVERSION TEST

We then switched over to our venerable iTunes Conversion Test, using version 10.6 of iTunes. This test taxes only a single CPU core, as much legacy software still does. We're hoping that no one will be doing much conversion action on software this old on a CPU this cutting-edge, but it's an interesting exercise.

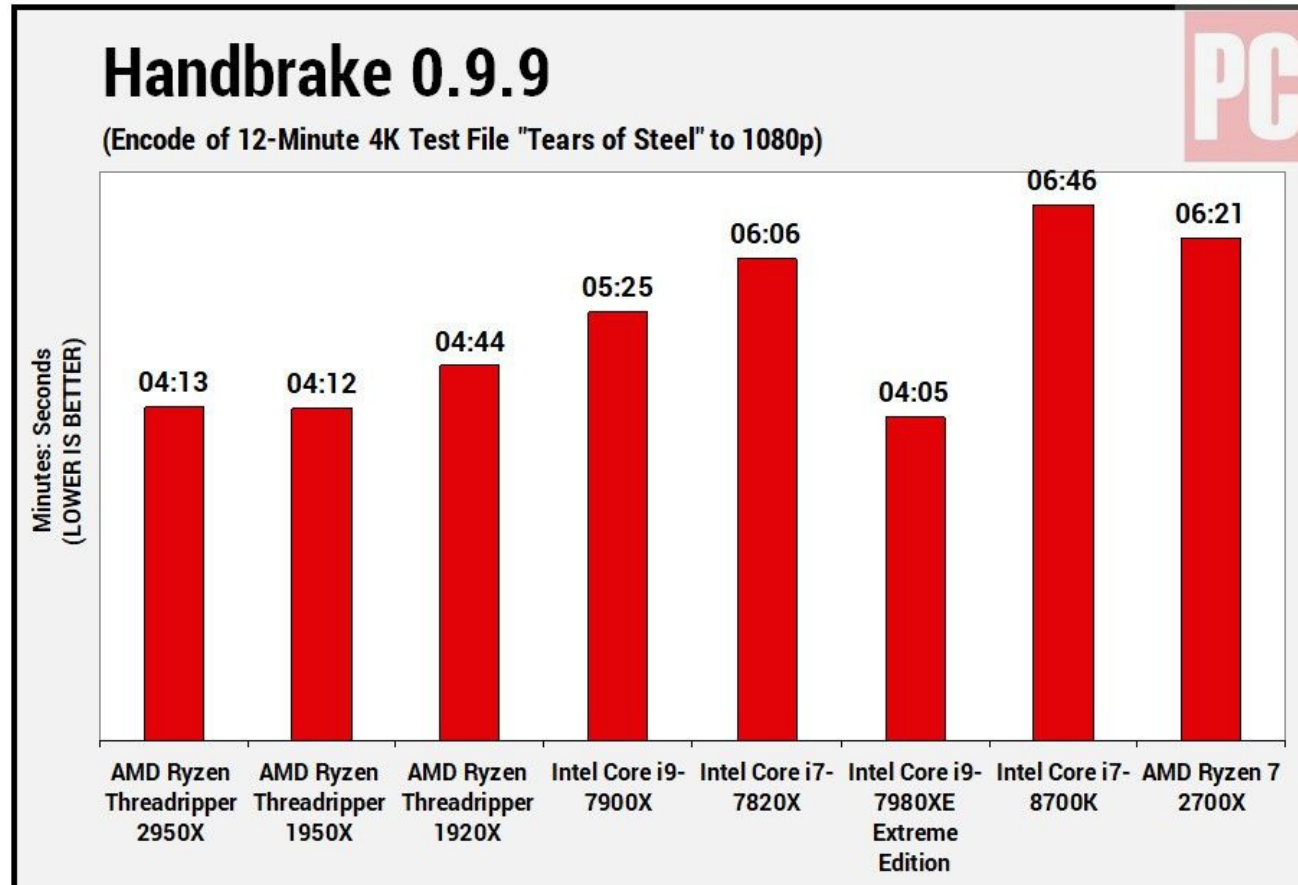


You can see a reflection of the single-core Cinebench test here in the iTunes benchmark. Because audio transcoding with this version of the application taxes only a single core, we suspected as much. The difference here between the 2950X and the Intels is around 20 percent.

We'd still like to see the Threadrippers do better here, but we think their showing is more than good enough given the likely usage profile of this chip. The newer Intel parts are appreciably faster, but most relevant software that a Threadripper buyer might consider should be able to make good use of multiple cores. And if single-core tasks are primarily what you do, Threadripper and Core X are not what you ought to be looking at; check out a much cheaper Intel Core i7-8700K.

HANDBRAKE 0.9.9

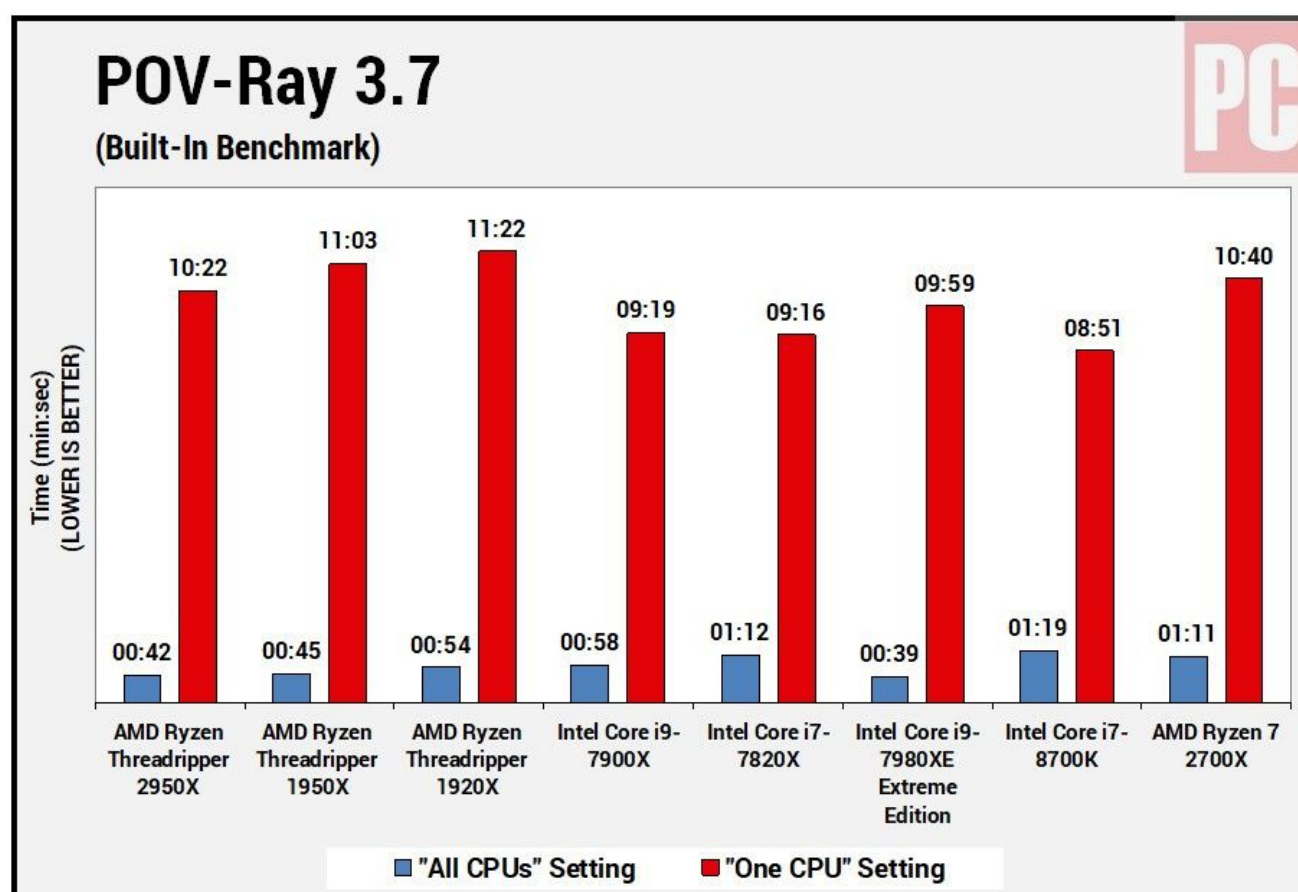
This is a time-consuming test of video-crunching capabilities. Handbrake, a commonly used utility for converting videos from one format to another, benefits from having lots of cores and threads at your disposal. In this test, we use a nice, big hunk of near-4K video to see how the chips perform with a sustained task of this kind, as the CPU has plenty of time during the render to heat up and, potentially, throttle. We tasked the CPUs to convert a 12-minute-and-14-second .MOV file encoded in H.264 (the showcase short film Tears of Steel, at a resolution of 3,840 by 1,714) into a 1080p MPEG-4 video...



Only the 18-core Core i9-7980XE could catch the new Threadripper or its parent—and not by a whole lot. To get a better sense of how impressive that is, Intel’s top-end predecessor to the Core i9-7980XE, the Intel Core i7-6950X Extreme Edition, took about 6.5 minutes to complete this test, and just a couple of years ago that was riding high as a \$1,799 CPU whose price—like that of the Core i9-7980XE—didn’t budge much for its active life on the market.

POV-RAY 3.7

Next up, using the “All CPUs” setting, we ran the POV-Ray benchmark, which challenges all available cores to render a complex photorealistic image using ray tracing. After that, again to get a sense of how the chips handle single-core performance, we ran the same benchmark using the “One CPU” setting.

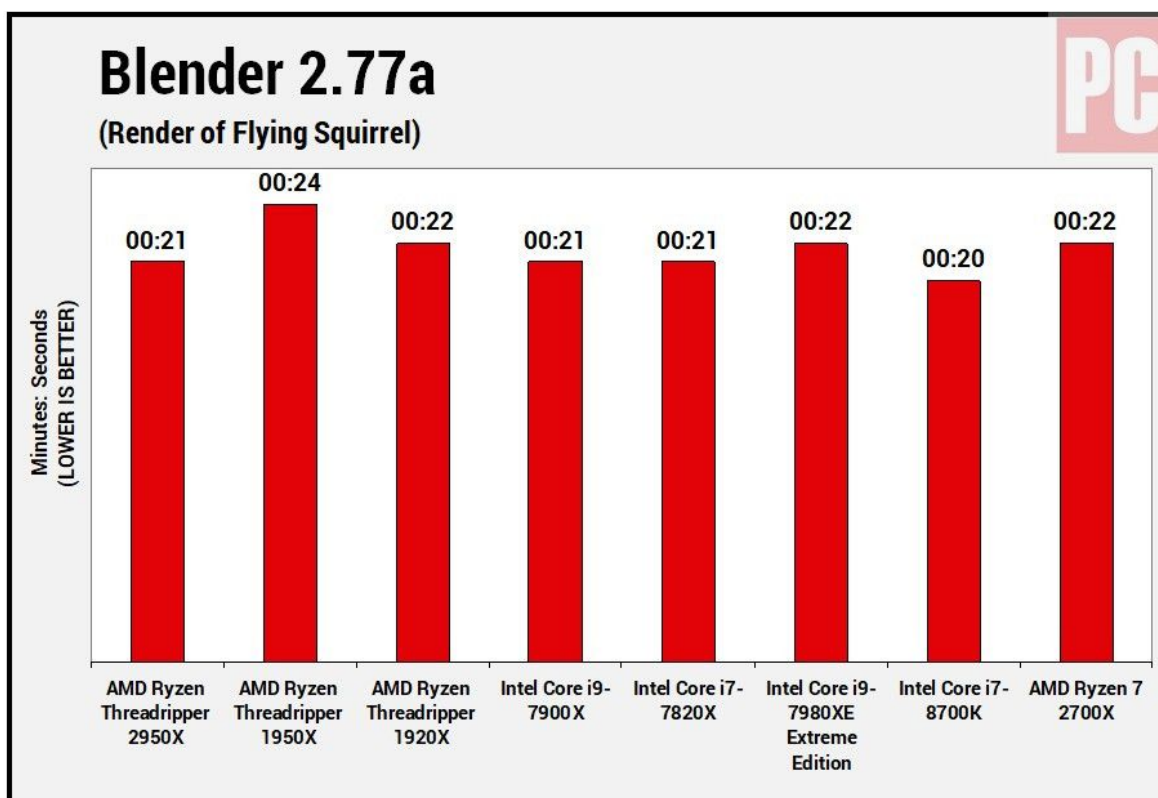


We saw a mirror here, more or less, of what we saw with Cinebench. The Intel chips in this test set were better at the One CPU setting, but the Threadripper parts new and old pulled ahead of everything else, barring the mighty Core i9-7980XE, on the All CPUs test. The Core i9-7900X was competitive, but it couldn't best the extra cores and threads that AMD offers at similar or lower prices.

BLENDER 2.77A

Blender is an open-source 3D content-creation program that can be used to design and create visual effects, animation, and 3D models for use in video games or 3D printing. We open a standard test file (it's of a flying squirrel) and time how long the test processor takes to finish the render.

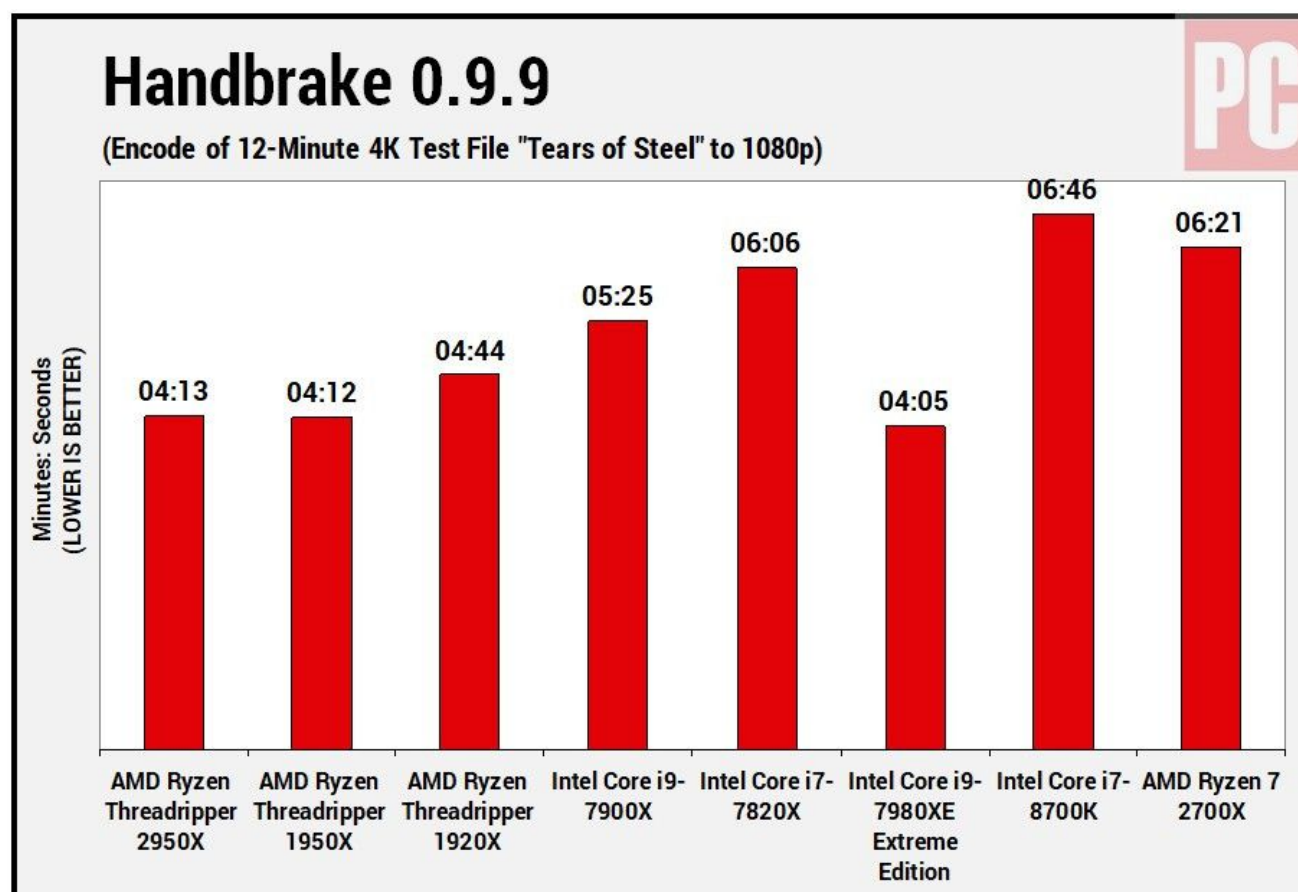
“The Core i9-7900X couldn't best the extra cores and threads that AMD offers at similar or lower prices.”



The results here were all quite close, but the Threadripper 2950X held its own against a slew of pricier Intel silicon. It seems Blender prefers a balance of cores and raw clock, rather than simply maximum cores and threads, as indicated by the competitive showings of the Ryzen 7 2700X and Core i7-8700K.

7-ZIP 16.04 BENCHMARK

Last, we fired up the popular 7-Zip file-compression software and ran its built-in compression and decompression benchmark, which is another useful test of a CPU's multi-core abilities. Operations of this kind are very CPU-intensive, and the 7-Zip program is fully threaded.

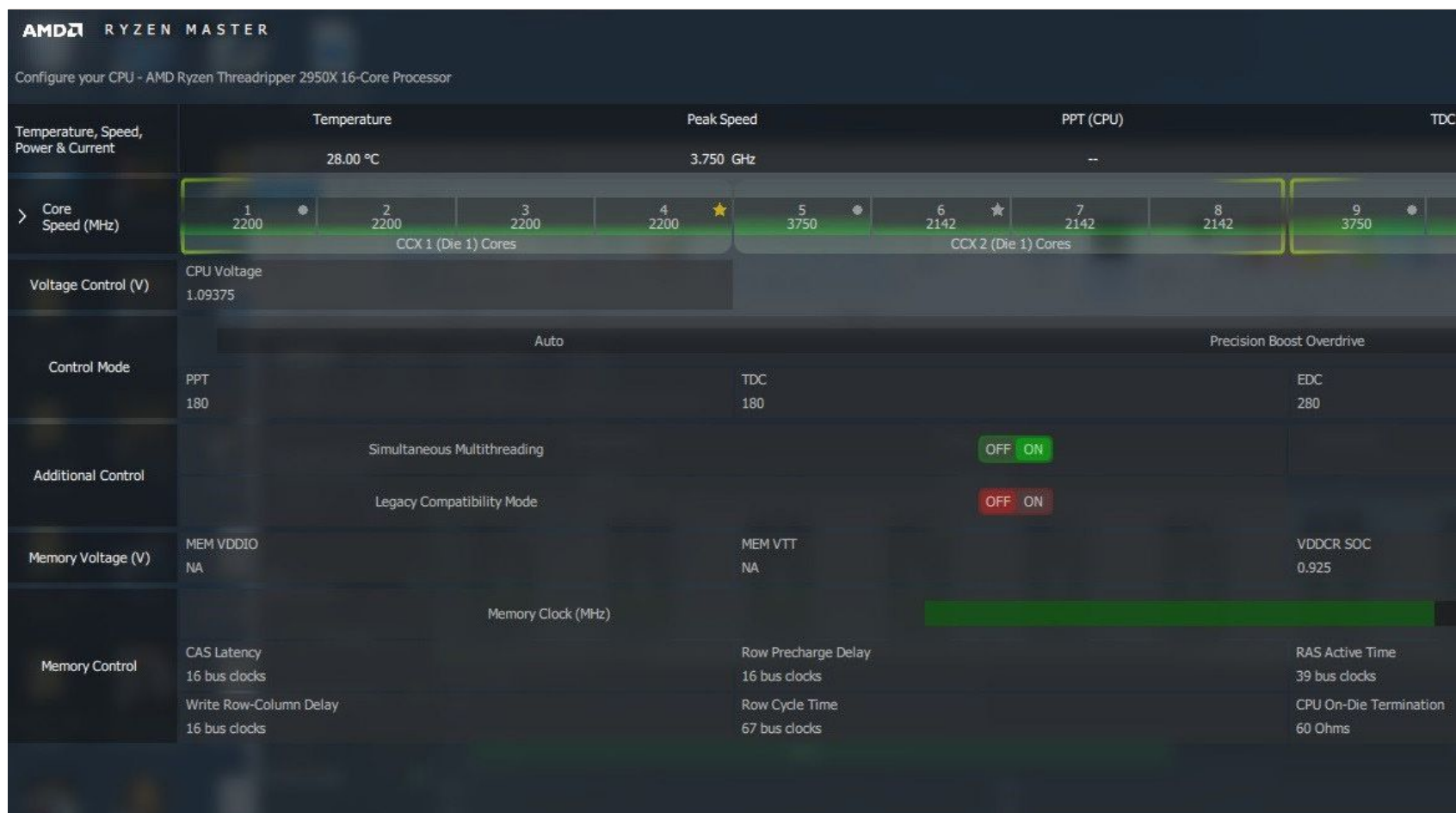


On this last test, the Threadripper chips dominated, with the Threadripper 2950X in particular pummeling almost all takers, with the exception being the much pricier Core i9-7980XE.

OVERCLOCKING

AMD provides a downloadable app, Ryzen Master, for system monitoring and overclocking, as well as the ability to toggle between Creator and Game Modes. You can use Ryzen Master to tweak clocks and voltages from within Windows versus the usual BIOS-level approach.

With the Threadripper 1950X, we were able to get the chip stable at 3.9GHz with various tweaks and by bumping up the voltage a fair amount (1.125V to 1.325V). We first decided to let Ryzen Master do the work, engaging Precision Boost Overdrive to see if the more granular controls over power management and other similar settings would make a difference. We had some modest successes in our Cinebench trials, but ultimately it didn't matter as much as the full manual mode, tweaking the voltage and core clock across all cores step by step.



In our manual trials, we knocked the voltage to 1.3V and tweaked up in 25MHz increments from the base clock of 3,500MHz. (The software allows for 25MHz up-steps.) We found the best balance at all cores set to 3,950MHz; at that setting, the system ran stably, and we shaved 11 seconds off our Handbrake render time for a gain of about 4.5 percent. Cinebench shot up to a score of 3,333, an improvement of just shy of 5 percent. On our sample, going much beyond either locked the system up or didn't produce better scores than at our 3,950MHz setting.

So clearly, there is some overhead to exploit. That said, we still can't recommend overly aggressive overclocking of the 2950X. Again, overclocking does void your warranty. So if you care about the longevity of your \$899 processor, stay at or stick close to stock speeds unless you're an overclocking vet with a solid cooler.

GAMING PERFORMANCE

One point of contention with the original Threadrippers was gaming performance at relatively "low" resolutions with high-end video cards: in other words, in situations where the CPU itself and memory latency comes into play. Testing from many outlets indicated that at 1080p, for example, the maximum frame rates in many games showed some suppression versus the same games, settings, and video card in use on recent high-end Intel silicon.

With 2017's Threadripper 1950X chip, AMD stated in its reviewer's guide that "the AMD Ryzen Threadripper processor was not designed for or intended to run games at the 1,920x1,080 resolution." The company argued at the time that when you're spending this much on a processor and platform, you should probably be pushing more pixels on a higher-resolution monitor. We're not arguing with the logic of that, but the fact is that 1080p is a popular gaming resolution and is also favored by competitive gamers with high-refresh-rate screens. So we ran some anecdotal tests with the GeForce GTX 1080 Founders Edition card in concert with the Threadripper 2950X to see what kind of improvements have been made. (Again, memory was set to 2,933MHz, the newly supported JEDEC profile ceiling for the Threadripper platform.)

As mentioned earlier, Threadripper has both a Creator mode and a Game mode that you can switch between using the Ryzen Master software. Creator mode is enabled by default, and it offers the best performance for tackling tasks that require lots of threads. Game mode disables a number of cores (the amount depends on the chip; in the 2950X's case, it disables eight of the 16) and tweaks the RAM to the Local memory (aka "NUMA") mode to favor gaming.

What's actually happening under the hood is complicated. But AMD says across the 75 or so games it tested with this generation of the chip, Game mode offered a roughly 5 to 10 percent improvement in some titles, with the effect and variability ranging from game to game. Some games prefer more cores; others benefit more from less latency.

Given the mostly under-10-percent difference between the two modes, though, unless you're a frame-rate stickler, you may want to just leave Creator mode enabled, especially since you need to reboot when switching between the two modes. The only issue with that approach is that you might run into a game that won't launch without some cores disabled, which will require enabling Game mode. (That didn't happen among eight titles we launched.)

At 4K (3,840 by 2,160), all of the late-model CPUs were within 2 or 3 frames per second of one another on the six test games we tried, signaling that the CPUs weren't the bottleneck; the limitations were around the video card's ability. So we shifted all of our testing to 1080p.

First, we fired up Rise of the Tomb Raider in DirectX 11 mode at the game's Very High detail preset and ran the built-in benchmark. The Threadripper 2950X turned in an average frame rate of 121 frames per second (fps) in Creator mode. That's within a few frames of what we saw in the past with the various Intel Core X solutions.

We then shifted over to a few games that we had tested using the same GeForce GTX 1080 video card in our Core i7-7700K video-card testbed. Hitman (2016), on the High detail setting, showed a 3- to 4-percent delta between the Ryzen Threadripper 2950X and the Core i7-7700K, tested under both DirectX 11 and DirectX 12. That's good, as the Core i7-7700K (as well as its 8700K successor) tends to outperform both the Threadripper chips and the Intel Core X line for gaming at 1080p. Likewise, Tom Clancy's: The Division, at 99fps (2950X) versus 108fps (7700K) was just an 8 percent deficit.

We then did a systematic run through seven games new and older. Testing solely at 1080p, we tried each at an elevated settings preset in Creator mode (that is, with all cores running and direct memory access mode engaged), Game mode (with half the cores disabled and local memory access mode engaged), and in Creator mode with the local memory access setting engaged (as an experiment, to see if any of the games benefit from this combo approach).

	PRESET	CREATOR MODE	GAME MODE	CREATOR MODE (local memory)
Rise of the Tomb Raider	Very High	121	127	117
Far Cry Primal	Ultra	77	96	51
Sleeping Dogs	High	167	183	174
BioShock Infinite	Ultra+DDOF	179	158	153
Hitman (2016)	High	104	106	96
Tomb Raider (2013)	Ultra	255	251	245
Tom Clancy's The Division	Ultra	100	102	100

“
The Threadripper 2950X turned in an average frame rate of 121 frames per second (fps) in Creator mode.
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The frame-rate penalty at 1080p varies a bunch by game, but it mostly ranges from negligible to modest. The Threadripper 2950X is a slightly better gamer at 1080p than its predecessor, and at least in our handful of test games, Creator versus Game mode mattered only sometimes.

The main takeaway is that if you really want the best possible gaming performance specifically at or around 1080p resolution, above all else, and the core/thread count is a distant second concern, you're in the wrong review. Go for a chip with fewer cores and higher clocks, such as the Core i7-8700K.

Otherwise, this is mostly a non-issue. Both the Threadripper and Core X chips deliver high enough frame rates to satisfy all but the most discerning high-fps game junkie. And the kind of buyer with the money and need for a Threadripper platform ought to have graduated to a 1440p or 4K panel by now. And at 4K resolution, it doesn't matter; the video card's the issue, not the CPU.

THREADRIPPER: STILL A RIPPING-GOOD VALUE

The Ryzen Threadripper 2950X is slightly faster than its 1950X predecessor at the types of computing tasks that lap up all of the processor cores and threads that they can find. This includes ray tracing, 3D rendering, converting and exporting media files, and other highly specialized tasks, the sort you might use an Intel Xeon-powered workstation for at the office. And you could certainly shell out the amount of money you'd spend on a 2950X build out a Xeon workstation instead.

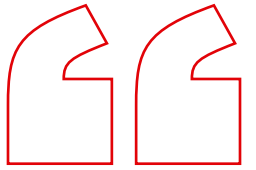
But where's the fun in that? Aside from the satisfaction of assembling your own PC, there's a certain aura to a build with a Threadripper inside of it. The awesome name is certainly part of that aura, but so is the fact that you're getting workstation-level performance at a price that, until recently, wasn't possible in a consumer-grade chip. The 2950X's \$899 retail price classes it as a luxe-level CPU, but it's still \$100 less than both its Threadripper predecessor and its nearest competitor, the Intel Core i9-7900X.

Now that the Threadripper ecosystem has had a year to mature, you can also select among dozens of motherboards, coolers, power supplies, and other components to suit your tastes and budget. This further narrows the gap with Intel's Core X-Series chips and affords significantly more room for creative expression than you'd get from an off-the-shelf system such as the Alienware Area-51 Threadripper Edition.

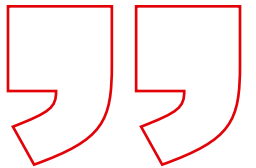
The platform has its downsides, of course. Aside from minor inconveniences, including the lack of Thunderbolt 3 support, the Threadripper 2950X is a smidge behind the Core i9-7900X and other Intel Core X and mainstream-CPU solutions when it comes to 1080p gaming performance, just like its predecessor. The difference isn't immense; it's gotten smaller and varies significantly depending on the game you're playing. But the fact remains that if you want to consistently milk out every last frame that your 144Hz high-refresh monitor and Nvidia GeForce GTX 1080 Ti will display, you're better off with an Intel chip.

Any chip at this price range, AMD or Intel, is suited to a rather small subset of potential PC builders: people who need as much multi-thread, multi-core compute power as possible for the money. (Or folks who have the cash for PC bragging rights but can't see spending twice as much money for incremental gains.) If that's you, this is the best chip of its kind that you can buy.

TOM BRANT, JOHN BUREK



Any chip at this price range, AMD or Intel, is suited to a rather small subset of potential PC builders.





Acer Swift 7 (2018): World's Thinnest Laptop

Acer's Swift 7 ultraportable is back, and at just over a third of an inch thick, it's holding on to its bragging rights as the world's thinnest laptop. This is no humble-brag, either: It's going to be tough for any laptop maker to top this machine on thinness, seeing as the profile is barely thick enough to host any ports. With a spiffy, all-metal design, the Swift 7 is a real stunner, but it's pricey at \$1,699.99. And all that glamour demands concessions, including a low-wattage CPU, a 14-inch 1080p screen, and tight storage capacity. The Huawei MateBook X Pro remains our Editors' Choice ultraportable for its excellent feature set and price. But Acer's ultra-slim machine is a success story if you need to go thin—at all costs.

**Acer
Swift 7
(2018)**

\$1,699.99



THE MOST PORTABLE ULTRAPORTABLE

Putting aside the technicality of the “world’s thinnest” tag for a moment, the Swift 7 is a head-turner, drawing the praise of everyone I showed it off to. Made entirely of sleek black metal, the Swift 7 has that rare “it factor” that inspires product envy. It looks and feels high-quality, from the solid metal to the diamond-cut corners and silver trim.

Much of the appeal, though, comes back to its thinness. The Swift 7 measures just 0.35 inch thick, an almost absurdly slim measurement evident at just a glance. (The footprint is more pedestrian, at 12.91 inches wide by 9.33 inches deep.) The Swift 7 doesn’t just barely scrape into its “I’m thinnest” distinction, either, with several hundredths of an inch shaved off the thinnest competition we’ve tested. The HP Spectre 13, for example, measures 0.41 inch thick, while the Dell XPS 13 comes in at 0.46 inch and the Razer Blade Stealth at 0.54 inch. Sure, you’ll still need calipers to measure that, but the comparisons are not mere squeakers.

The Swift 7 is also fairly light, at 2.6 pounds, though it feels a little dense because of the preponderance of metal and the size. That’s lighter than the Dell XPS 13 and Razer Blade, but the HP Spectre 13 wins the weight war at 2.4 pounds. (Remember that the Swift 7 is a 14-inch laptop, versus the 13-inch screens on the XPS 13 and Spectre 13.) Acer’s laptop owes its svelte profile to its fanless design, which also means it runs in silence. But that design decision mandates its pound of flesh in performance.

Acer Swift 7 (2018)

PROS Thinnest laptop in the land. Attractive all-metal design. Bright, touch-enabled display. 4G LTE support. Good battery life.

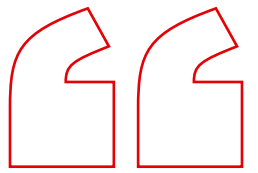
CONS Pricy. Low-wattage Y-series CPU is slower than the competition. Display is only 1080p. 256GB of storage is a little light, given price.



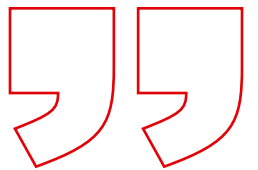
The Swift 7 isn't a convertible laptop, but its 14-inch in-plane switching (IPS) display does support touch input. It bears a full HD (1,920-by-1,080-pixel) native resolution, though with its glossy finish and high brightness, it looked a bit sharper than 1080p to me, at first. That's still an endorsement of its quality, and a Corning Gorilla Glass 2 coating makes it that much more durable.

Part of my initial thinking about the screen resolution was that I expected it to be higher than 1080p for the price. While a screen of this size doesn't need a super-high resolution, the competition generally offers at least one notch more. The Huawei MateBook X Pro boasts a 3,000-by-2,000-pixel native resolution, while the \$1,499 Blade Stealth unit we reviewed offered a QHD+ panel (3,200 by 1,800 pixels). The Swift 7's display may look pretty, but there's no making up for fewer pixels.

The keyboard is pleasantly unaffected by the laptop's thinness, for the most part, managing decent travel and a comfortable typing experience. It's not one of the best notebook keyboards I've laid fingers on, but it's average in feel for a thin-laptop keyboard and completely usable. That is far from a given on a laptop in this class. You simply can't expect more comfort when there's only so much distance that the keys can travel up and down, based on the chassis thickness.



While a screen of this size doesn't need a super-high resolution, the competition generally offers at least one notch more.



The touchpad feels very nice to pan and scroll with, though it lacks dedicated left and right click buttons, and you can't physically depress the touchpad. That means tap-to-select only, and no clicking and holding to drag icons or move a scroll bar as I'm used to, which took some adjusting.

THIN ON CONNECTIVITY

One area where this laptop's extreme thinness gets it into some trouble is with the ports. The Swift 7 offers only two USB Type-C ports, the only kind of general connectors slim enough to fit into a frame like this. Neither port supports Thunderbolt 3, which provides lightning-fast data-transfer speeds. The ports do include DisplayPort video-out support, however, and Acer includes a USB Type-C dongle with connections for HDMI, USB, and Ethernet.

Having to keep track of, carry, and use the dongle is an annoyance, but the Swift 7 is hardly the first laptop to go all USB-C. That said, the Razer Blade Stealth, Dell XPS 13, Huawei MateBook X Pro, and the 13-Inch Apple MacBook Pro all offer at least one USB Type-C port with Thunderbolt 3.

Outside of these physical connections, the Swift 7 supports 802.11ac Wi-Fi, Bluetooth 4.1, and 4G LTE connectivity, the last being uncommon in this class of laptop. The laptop can accept physical nano SIM cards but also has a built-in "eSIM," which you can use to sign up for service plans provided by Ubigi: The US-based plans are a \$4.99-per-day option (limit: 500MB for the day), \$29.99 for 3GB spread across 30 days, or \$99.99 for 12GB across six months. The Swift 7 ships with a profile that gives you 1GB of free data for 30 days.



The ports do include DisplayPort video-out support, and Acer includes a USB Type-C dongle with connections for HDMI, USB, and Ethernet.

I tested the 4G performance in a few locations around our NYC office, browsing the web and running speed tests using Ookla's Speedtest. (Note that Ookla is owned by PCMag's parent company, Ziff Davis.) The laptop scored 8.51Mbps downstream and 3.83Mbps up, roughly the same as smartphone performance in these areas and suitable to work needs on the go, delivering on one of this laptop's selling points.

The onboard storage is swift but limited to a single capacity and a single drive. Only a solid-state drive (SSD), not a chunky hard drive, could fit in such a shaved-down chassis, so the Swift 7 offers a 256GB PCI Express NVMe SSD as its storage solution. Like the screen resolution, that's underwhelming for the price, though it's true that adding more solid-state storage gets expensive. That said, the MateBook X Pro includes 512GB, and the Blade Stealth is configurable from 256GB all the way to 1TB. The XPS 13 unit we reviewed does match the 256GB capacity, and its base model comes with only 128GB.

Acer supports the Swift 7 with a one-year warranty, which is typical of its class.

ALAS, SLIMMED-DOWN SPEED, TOO

Given that the Swift 7's super-slim form is made possible by a fanless design, Acer's designers had to cut the heat output somewhere to make it all work.

Acer opted for the Intel Core i7-7Y75 processor, a dual-core CPU that's one of Intel's lowest-wattage options, in an effort to avoid thermal troubles in a laptop this thin. But there's a lot more about that chip, underlying its Core i7 nomenclature, that you should realize.

Although the Swift 7 performed decently for general usage—such as puttering around the desktop, browsing the web in multiple tabs, and running a couple of programs at a time—the limitations of the CPU became evident in more strenuous tasks. The “Core i7” in the name is misleading, in this instance, as it doesn't live up to the speeds that this tag usually implies. This is one of Intel's Y-series processors, which are exceedingly low-power CPUs with much lower base clock rates than Intel's U-series chips, which are found in many ultraportables. Combine a low 1.3GHz base clock speed and 8GB of memory (DDR3, not DDR4), and the Swift 7 underwhelmed on the productivity and multimedia benchmark tests I ran.

Its PCMark 8 Work Conventional score was so-so, roughly matching my experience in general use, but Cinebench, Handbrake, and Photoshop all posted low or slow scores.

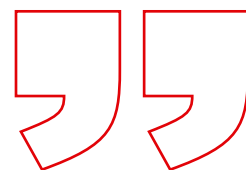
Only a handful of systems we've tested matched that long runtime on the Handbrake test, as the Swift 7 really struggled to encode the short (4-minute) test video file. The other machines here were roughly twice as fast or faster. In a pinch, the Swift 7 can churn through CPU-intensive tasks or media projects, but it's far slower than other pricey ultraportables because of its design constraints. Tasks that hit the CPU hard for long periods show up this laptop's limitations the most, since the passively cooled design cannot sustain high burst clock speeds for long. The Core i7-7Y75 CPU may have a lofty Turbo Boost speed, but it can't maintain it long due to this laptop's thermal limits. Likewise, the Core i7-7Y75's integrated graphics silicon means the Swift 7 is not much of a performer in 3D applications, but that is the case with most laptops in this category...

The MateBook X Pro stands above this particular crowd thanks to its Nvidia GeForce MX150 graphics—a low-end discrete chip, yes, but discrete graphics nonetheless. That provides modest capability for less-demanding 3D programs or games, unlike the Swift 7 and its compatriots, which simply don't have much to offer in that regard.

Battery life, on the other hand, is an area in which the Swift 7 did very well. Despite the chassis not leaving much room for chunky cells, the Swift 7 ran for 12 hours and 52 minutes (12:52) on our video-playback rundown test. That just edges out the MateBook X Pro and Spectre 13, while comfortably beating the Blade Stealth and XPS 13 by hours.



The Swift 7 can churn through CPU-intensive tasks or media projects, but it's far slower than other pricey ultraportables.



In this general crowd, only the 2018 Apple MacBook Pro's 16:26 time or Lenovo Yoga 920's 22-plus hours (neither charted above) makes the Swift 7 look anything less than great. Given the Swift 7's extreme emphasis on being so thin and light, I'd be disappointed if I couldn't tote it for extended periods off the charger. Acer hit the mark on this front.

CAN YOUR LAPTOP BE TOO THIN?

The Swift 7 lives up to its billing as a razor-thin ultraportable. It is long-lasting, travels light, and packs a nice display, all key elements for work or pleasure on the go. It makes some compromises to achieve its class-leading size, though, and I'm not sure they're worth the thinness for many buyers.

Including a low-wattage processor hampers performance, and the value of shaving off a few extra hundredths of an inch doesn't outweigh that concession. The alternatives are already very thin and weigh roughly the same amount, so beyond bragging rights, being the absolute thinnest doesn't gain you much else. (Also, some of the Swift 7's less expensive competitors top it in performance, screen resolution, and storage.)

That said, if maintaining the lowest possible profile is the most important decision point in your purchase, the Acer Swift 7 is a laptop you'll be proud to carry. But the Huawei MateBook X Pro remains our Editors' Choice pick in its class, while the Dell XPS 13 and Razer Blade Stealth are excellent alternatives.

MATTHEW BUZZI

“Despite the chassis not leaving much room for cells, the Swift 7 ran for 12 hours and 52 minutes on our video rundown test.”



Crucial MX500: Great Value For an Upgrade SSD



Not only is an upgrade to a solid state drive (SSD) one of the most effective ways to speed up your aging desktop or laptop, but depending on the capacity and the interface of the drive you select, it can be cheaper than replacing other components. (CPU upgrades often don't make sense without a larger system teardown, and RAM is pricey these days.) That's especially true of the Crucial MX500 (\$110 for 500GB, as tested). Not only is this drive cheaper than prestige Serial ATA (SATA) SSDs such as the Samsung SSD 860 Pro, but its throughput speeds are hardly slower. As a result, it is one of the best-value SATA drives available for upgrading the storage in a mainstream PC, and it earns our Editors' Choice award.

Crucial
MX500

\$110.00



The MX500 is available in both M.2 and 2.5-inch varieties, so one type or the other is installable in pretty much any modern PC. Our 500GB review unit is in the 2.5-inch drive form factor, which means it fits in a standard laptop drive bay (for notebooks that still use full-size drives) or in most any desktop chassis. You can also opt for the much smaller M.2 version, which resembles a stick of gum and attaches directly to the motherboard (assuming the motherboard is recent enough to have an M.2 connector).

No matter which version you choose, performance should mostly be the same, assuming that you're comparing MX500 models of equal capacity. This drive uses the SATA bus, the same as any modern consumer hard drive, instead of PCI Express in concert with the NVMe protocol. Maximum NVMe speeds are roughly six times greater than those that SATA will allow, but the difference isn't readily apparent in everyday computing tasks.

Crucial MX500

PROS Low cost per gigabyte. Excellent performance for a SATA SSD. Available in 2.5-inch or M.2 SATA versions. Capacity options from 250GB to 2TB. Long warranty.

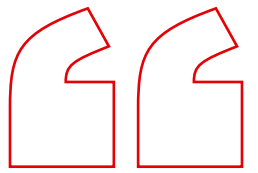
CONS Endurance rating low for usage cases involving heavy data writes.



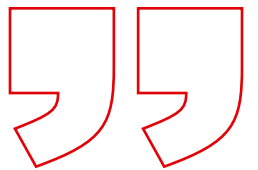
Once you've selected the MX500's form factor, you'll need to decide which capacity you need. Crucial offers the MX500 in a wide range of them, from 250GB up to 2TB. In between is a 1TB model, in addition to the 500GB capacity of our review unit. SSD prices change frequently, but none of the MX500's capacity iterations costs more than 30 cents per gigabyte at this writing, aggressive pricing by mainstream SSD standards. High-performance PCIe NVMe drives tend to circle around 40 cents per gigabyte, and elite-level SATA drives such as the Samsung SSD 860 Pro can push 50 cents per gigabyte. These make the MX500 look downright affordable by comparison.

Affordability does mean compromise, however. For the MX500, that compromise comes in the form of a lesser endurance rating—endurance meaning how long the drive is estimated to last before its memory cells start to degrade. Crucial estimates that the 500GB model can sustain up to 180 terabytes written (TBW) before its cells begin to wear out. In absolute terms, that's a relatively low figure, although it's slightly better than the 160TBW that the 525GB version of the Crucial MX300 (the MX500's predecessor) could sustain. The 512GB version of the Samsung SSD 860 Pro, in contrast, is rated for a whopping 600TBW. In general, the higher capacity the drive, the higher its endurance, so the fact that these ratings are all for drives with roughly the same capacity makes the Samsung SSD's sky-high TBW rating that much more impressive.

The MX500's endurance is cause for concern only if you plan to install it in a web server, copy many gigabytes of data to and from your drive every day, edit videos all day long, or expose it to other similar workloads. Crucial points out that 180TBW is the equivalent of writing 98GB per day for five years, an unlikely scenario for a typical consumer laptop or desktop.



Crucial estimates that the 500GB model can sustain up to 180 terabytes written (TBW) before its cells begin to wear out.



The upshot: For most prospective buyers, the MX500 should perform normally for longer than it takes the rest of the PC's components to become obsolete or for the capacity of the SSD itself to become passe. In fact, the drive comes with a five-year warranty, which is the same plan length that Samsung and Western Digital offer for their premium SSDs.

PUSHING AGAINST SATA'S CEILING

A speedy SSD offers such a significant boost to system performance because its memory cells allow much faster access to stored data than is possible from moving drive heads. The latter must seek specific areas on a conventional spinning hard disk drive (HDD) each time you open an app or scroll through a photo album. The MX500 is among the fastest SATA drives we've tested, which means that it offers a dramatic improvement when you're using it to replace an older HDD.

On the Crystal DiskMark 6.0 sequential data access test, the SSD recorded read speeds of 563MBps and write speeds of 522MBps. Those are nearly the same results that the much more expensive Samsung SSD 860 Pro (564MBps read, 533MBps write) achieved, and they're approaching the theoretical maximum of 600MBps for the current version of the SATA interface.

PC PERFORMANCE TESTS

Product	Tested Capacity	PCMark 8 ▲	Crystal DiskMark 6.0 ▲			
		Storage Test	Sequential Read Q32T1 (MBps)	Sequential Write Q32T1 (MBps)	4K Read Q1T1 (MBps)	4K Write Q1T1 (MBps)
Crucial MX500 SSD	500GB	4,988	563	522	39	101
Samsung SSD 860 PRO	1TB	5,003	564	533	39	111
WD Blue 3D NAND SATA SSD	1TB	4,983	563	534	36	94

▲ High scores are best ▼ Low scores are best

Sequential speeds are what you'll see advertised on the box or Crucial's website, and while they accurately describe the MX500's maximum potential, you won't necessarily experience them consistently during everyday use. That's because everyday tasks like opening and closing apps, switching between them, and booting up the PC all access files non-sequentially, or randomly. We use Crystal DiskMark's 4K file type tests to approximate these random file access requests. The MX500 delivered 39MBps read speeds on this test and 101MBps write speeds, again closely mirroring the results that the SSD 860 Pro recorded (39MBps read, 111MBps write).

For a second opinion of an SSD's everyday performance, we use the PCMark 8 Storage suite, which simulates how the drive can handle a wide variety of requests, including web browsing, editing photos, and playing video games. Most SSDs score within a few dozen points of 5,000 on this proprietary test, and the MX500 did not disappoint, coming in at 4,988.

Finally, the MX500 is also adept at transferring large files between different locations on the drive. On the AS-SSD Copy Benchmark, it transferred an ISO file at 933MBps, a sample program at 444MBps, and a sample game at 874MBps.

“As a budget drive, the Crucial MX500 doesn't come with specialized software to let you fine-tune performance.”

PC PERFORMANCE TESTS

Product	Tested Capacity	AS-SSD ▲						
		Sequential Read (MBps)	Sequential Write (MBps)	4K Read (MBps)	4K Write (MBps)	Copy Benchmark: ISO File (MBps)	Copy Benchmark: Program Folder (MBps)	Copy Benchmark: Game Folder (MBps)
Crucial MX500	500GB	469	475	36	89	933	444	874
Samsung SSD 860 PRO	1TB	514	493	34	92	912	426	839
WD Blue 3D NAND SATA SSD	1TB	483	472	34	103	946	294	821

▲ High scores are best ▼ Low scores are best

These results are very similar to those of both the Samsung SSD 860 Pro and the WD Blue 3D. Note that if you plan to transfer large files or huge folders regularly, be aware of the endurance limitations discussed above.

As a budget drive, the Crucial MX500 doesn't come with specialized software to let you fine-tune performance, perform secure erases, and other similar tasks. But the SSD's firmware is upgradable by downloading the latest version from Crucial's website. The drive also comes bundled with an app from Acronis that lets you clone your existing hard drive, one of the trickiest parts of performing an SSD boot drive upgrade while maintaining your OS installation.

VALUE-MINDED SATA SCREAMER

Because the Crucial MX500 is a top-performing SATA drive with aggressive pricing, it's a strong choice for most everyday-use situations faced by casual upgraders. Speedy competitors such as the Samsung SSD 860 Pro that cost more because of their higher endurance ratings are great drives in their own right, but they cater to more of a niche upgrade concern. Unless you will be subjecting your drive to significant read and write operations that are outside the scope of ordinary PC activities, the MX500 should stay relevant for as long as or longer than your PC's other components. So there's little reason to shell out more for a drive with a higher endurance rating unless your data-writing habits merit that kind of insurance.

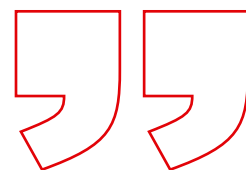
One limitation that the MX500 shares with all SATA drives, however, is the SATA interface's 600MBps throughput limit. If you have a newer high-end motherboard that has a PCI Express-capable M.2 slot, and you're upgrading or building a high-end gaming rig or media-editing workstation, it could be worth spending extra for a PCI Express/NVMe SSD like the WD Black NVMe, which will give you as much as six times the potential throughput that SATA can provide.

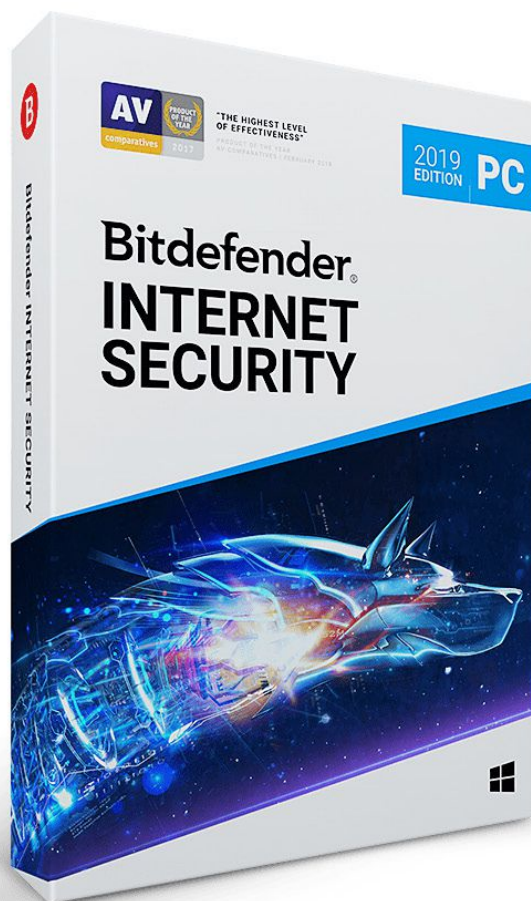
For most other consumer usage cases, though, the MX500's performance will more than suffice. That, plus its comprehensive selection of capacities and form factors and its long warranty, help it snag our Editors' Choice award for budget SSDs.

TOM BRANT



One limitation that the MX500 shares with all SATA drives is the SATA interface's 600MBps throughput limit.





Bitdefender Internet Security: Editors' Choice Security Suite



When you decide you need more protection than a simple antivirus offers, you can always upgrade to a full-blown security suite. Typical suite add-ons include firewall protection, spam filtering, and parental control.

Bitdefender Internet Security adds these and more to the already rich complement of features found in Bitdefender Antivirus Plus. This entry-level suite has so many layers that it rivals the second-tier mega-suites of some of its competitors. Furthermore, its components are, on the whole, excellent. It's an Editors' Choice security suite.

**Bitdefender
Internet Security**

\$47.99



As with Kaspersky, Trend Micro, and ESET, Bitdefender costs just shy of \$80 per year for three licenses (though you can buy a single license for \$59.99). Webroot goes for a good bit less, \$59.99 per year for three licenses; that subscription price would get you one Bitdefender license. McAfee Internet Security appears to cost more, but with McAfee your \$89.99 gets you a year of protection for every device in your household, be it Android, iOS, macOS, or Windows.

SHARED ANTIVIRUS FEATURES

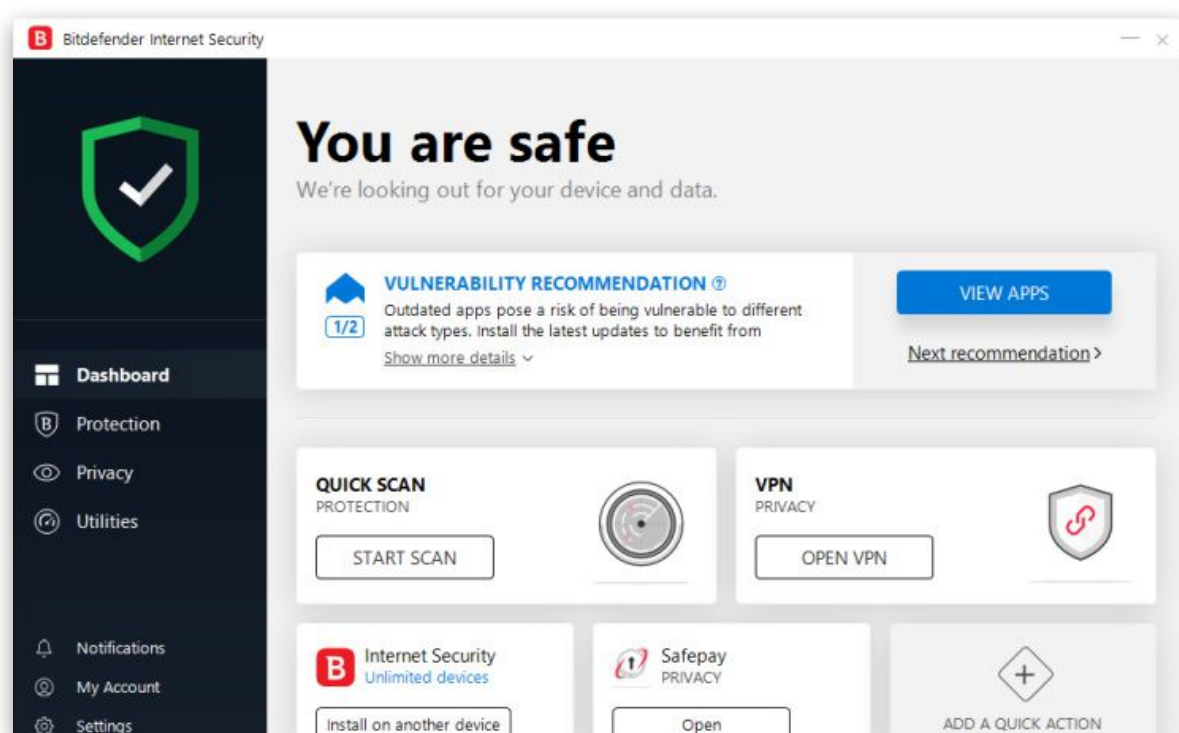
The suite got a full user interface makeover with this latest edition. Autopilot has graduated from just making security decisions in the background to actively offering recommendations for using the program. You can place your five favorite Quick Actions right on the main dashboard or dig into the Protection and Privacy pages for full access to all features. In the suite, the Firewall, Antispam, File Encryption, Webcam Protection, and Parental Control components are all enabled.

Bitdefender's antivirus is overflowing with useful security features, many of them new in this edition. All four of the independent testing labs that I follow include Bitdefender in their regular reports, and all give it excellent marks. AV-Comparatives even named it Product of the Year for 2017. Normalizing and averaging the scores to a 10-point scale, Bitdefender gets 9.8 points, beaten only by Kaspersky with 9.9.

Bitdefender Internet Security

PROS Outstanding scores in independent antivirus lab tests and our web protection tests. Multilayered ransomware protection. Included VPN. Full-featured parental control. File encryption. Webcam security. No performance impact. Many bonus features.

CONS Unlimited VPN access requires separate subscription. With antivirus disabled, ransomware-specific features missed one uncommon sample in testing. Parental control for iOS not fully functional.



In my malware protection test, Bitdefender scored very well, though not at the top. It set a new record in my test using very recent malware-hosting URLs, managing 99 percent protection, a new record. Norton, the previous record-holder, scored 98 percent.

Bitdefender's protection against web-based threats also soared to the top in my phishing protection test. Here, too, it foiled 99 percent of the fraudulent sites, handily outscoring the protection built into Chrome, Firefox, and Internet Explorer. Trend Micro Internet Security and ZoneAlarm came very close, with 98 percent.

A new Network Threat Protection component supplements existing web protection by watching for signs of attempts to exploit system and application vulnerabilities. When challenged with a collection of about 30 exploit attacks generated by the CORE Impact penetration tool, it detected and blocked about 44 percent. The fully patched test system was not in any actual danger from these attacks. Symantec Norton Security Premium owns this test, with 100 percent detection.

Every antivirus should protect against ransomware, just as with any other type of malware, but a slip-up that lets a zero-day ransomware attack succeed can have a huge impact. Bitdefender shores up its basic antivirus with many layers of ransomware-related protection. Safe Files stops any unauthorized program from making changes to your sensitive files. Advanced Threat Defense identifies malware, including ransomware, by its behavior. The new Ransomware Remediation tool backs up your important files at the first hint of ransomware activity, restoring them when the threat is past. In testing with the regular antivirus component disabled, Bitdefender foiled all the file-encrypting ransomware samples, though it missed one uncommon full-disk-encrypting attack (which would have been caught by the main antivirus component).

OTHER SHARED FEATURES

Bitdefender's antivirus includes a ton of features that many companies would reserve for a full security suite. Bitdefender Wallet is a complete, if basic, password manager. It captures and replays your passwords, syncs across devices, generates strong passwords, and even fills web forms with your personal data.

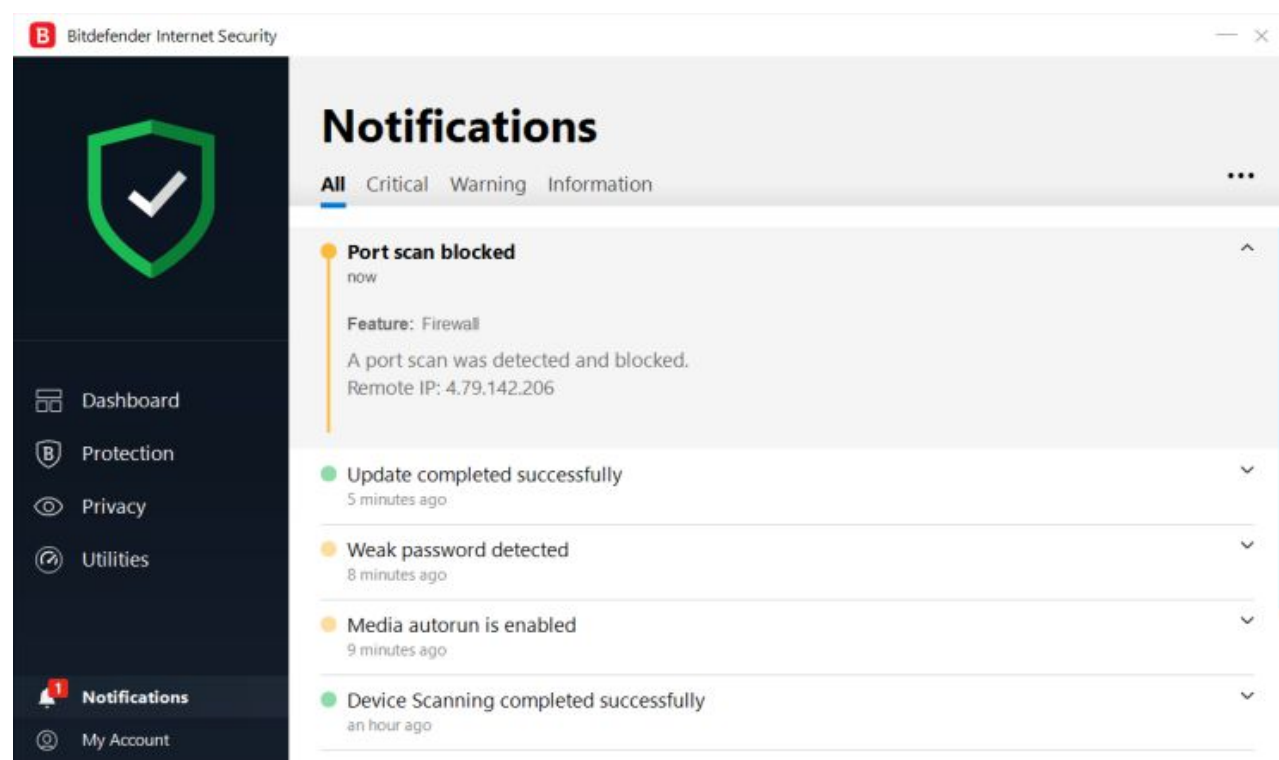
When you visit a bank website or other financial site, Bitdefender offers to open the site in Safepay. Safepay is a separate desktop, isolated from other processes, that includes a hardened browser. Wallet works with Safepay, and you can enable Flash if you must, but it accepts no other add-ons.

New with this edition, Bitdefender Antivirus includes a full-scale VPN. It's based on AnchorFree Hotspot Shield and uses that company's infrastructure, but with additional privacy layers. Out of the box, it gives you 200MB of bandwidth per device per day, using a program-selected server. To lift the bandwidth cap and gain access to all servers, you need a separate subscription, which lists for \$49.99 per year.

The list of advanced features just goes on and on. A Vulnerability scanner identifies missing security patches for Windows and popular programs, as well as weak Windows account passwords. You can use the File Shredder to permanently delete sensitive files so that not even a forensic technician can recover them. If pernicious malware resists Bitdefender, you can cut the legs out from under it by rebooting in Rescue Mode. In this Linux-based operating system, Windows malware can't run and so can't defend itself.

UNOBTRUSIVE FIREWALL

Bitdefender's firewall correctly blocked the web-based port scan tests I hit it with. It put all the system's ports in stealth mode, and reported when it detected and blocked a port scan. To be fair, when you have a home network, the devices connected to it already enjoy the protection of network address translation (NAT). Their IP addresses are local to the network, not visible from the internet and not subject to port scan attacks. My test system needs a special configuration to avoid protection by NAT.



My contacts at the company tell me the latest edition of Bitdefender Internet Security offers a few small enhancements for the firewall. Specifically, it allows rule exceptions for local network addresses, to allow connection to printers and other computers on the network.

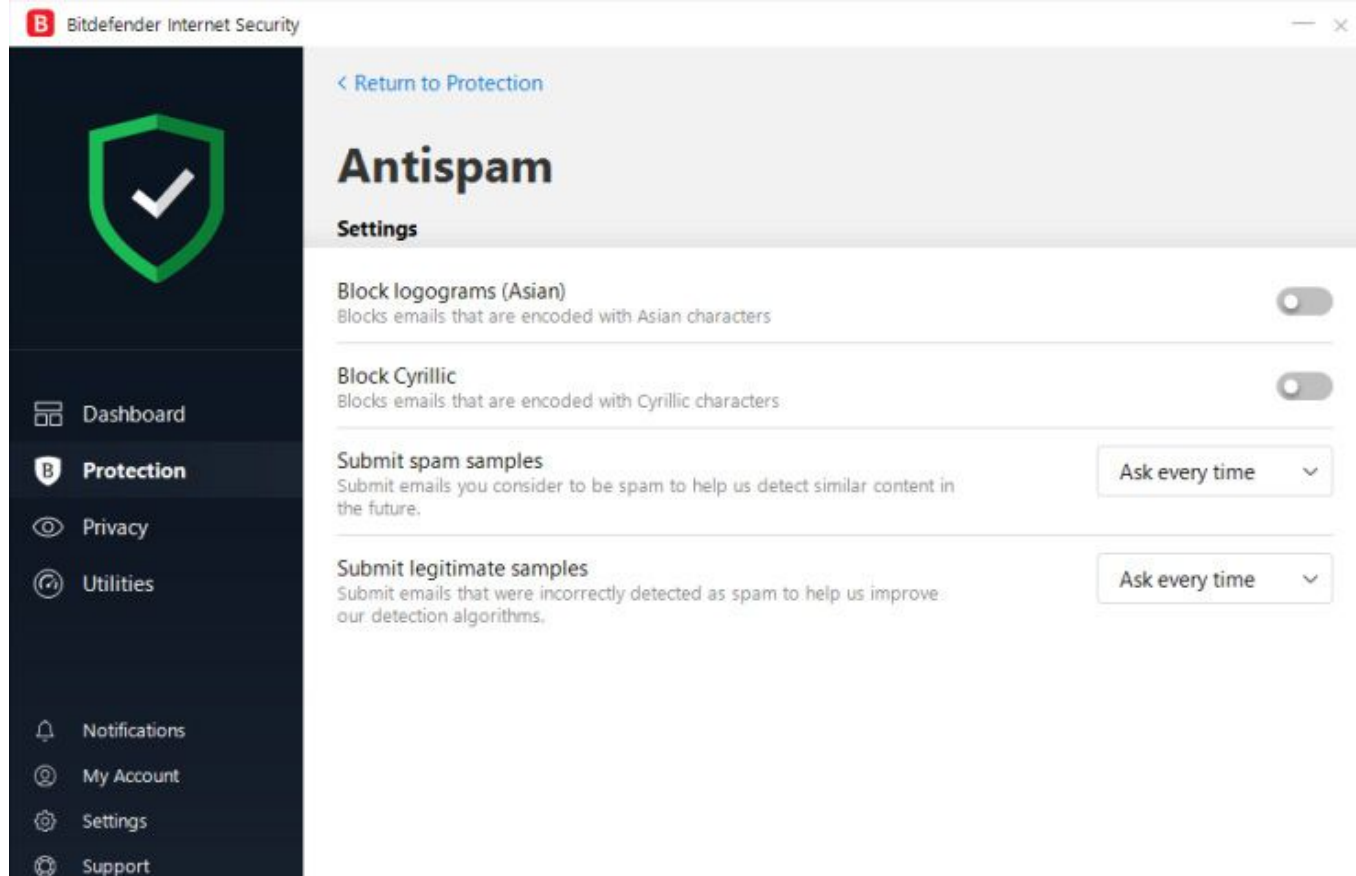
The flip side of firewall protection involves controlling how programs on your system make use of your internet and network connections. In Autopilot mode, Bitdefender's firewall configures access permissions for known programs and monitors unknown programs for any signs of network chicanery. Norton works in much the same way, and the levels-of-trust system in Kaspersky Internet Security is similar.

For those who want notification every time an unknown program attempts access, Bitdefender used to offer Paranoid Mode. That option still appears, but the name has been softened to Alert Mode. How would you react to being asked whether `rtpog.exe` should be allowed an outbound connection to 34.197.42.244 using port 8088? Most users should leave Alert Mode alone.

Protection against network-based attacks that try to exploit security vulnerabilities on your system is a feature often associated with a firewall component. With Bitdefender, that Network Threat Protection now shows up right in the antivirus. It fended off 44 percent of the exploit attacks I generated; note, though, that none of them could have harmed the fully patched test system. Still, Norton's 100 percent protection is noticeably better.

Firewall protection isn't worth much if a brand-new malware program can reach in and turn it off. I found no way for a program to simply flip a switch in the Registry to turn off protection (no big surprise, though; that's an old trick that hardly ever works anymore). I found that I could kill off some less central components, including the parental control updater and system tray interface. But the core components resisted attack and revived the ones that I managed to kill off.

Loading up a view of Windows services, I found five running Bitdefender services. I couldn't stop them; the Stop link didn't even appear. And my other trick, setting the startup status to Disabled, just resulted in a disdainful "Access denied." Bitdefender remains thoroughly hardened against direct attack.



SPAM FILTER

Spam filtering becomes less and less significant as more people get mail through web-based services such as Gmail or Yahoo, which filter it out. But if you use another provider, perhaps a local ISP that doesn't filter spam, you need a local spam filter to protect your inbox. As long as your account uses the basic POP3 and SMTP protocols, Bitdefender can help.

The spam filter integrates with Microsoft Outlook and Mozilla Thunderbird, adding a toolbar that lets you mark spam messages that got past the filter or valid messages that it filtered in error. You can also click to put a sender on the Friends list or Spammers list. Those using a different email client must create an email rule to divert marked spam messages into their own folder and manage the Friends and Spammers lists from Bitdefender's spam filter settings.

When you use the toolbar to mark a missed spam message, Bitdefender asks for permission to send that message in for analysis in the cloud, thereby improving the filter. I suggest tweaking the settings so it always sends missed spam messages for analysis. Bitdefender also asks for permission to send valid messages that were mismarked as spam, but that seems like a bad idea. Do you really want to send Bitdefender your personal email for analysis?

ZoneAlarm's spam filter features many pages of configuration choices. With Bitdefender, there are next to no settings. You might consider setting it to block emails using Cyrillic or Asian character sets, assuming you never get legitimate mail using those character sets.

PARENTAL CONTROL

Previously, Bitdefender offered a feature called Parental Advisor. The current edition renames this component to Parental Control, adding a few features that weren't previously available.

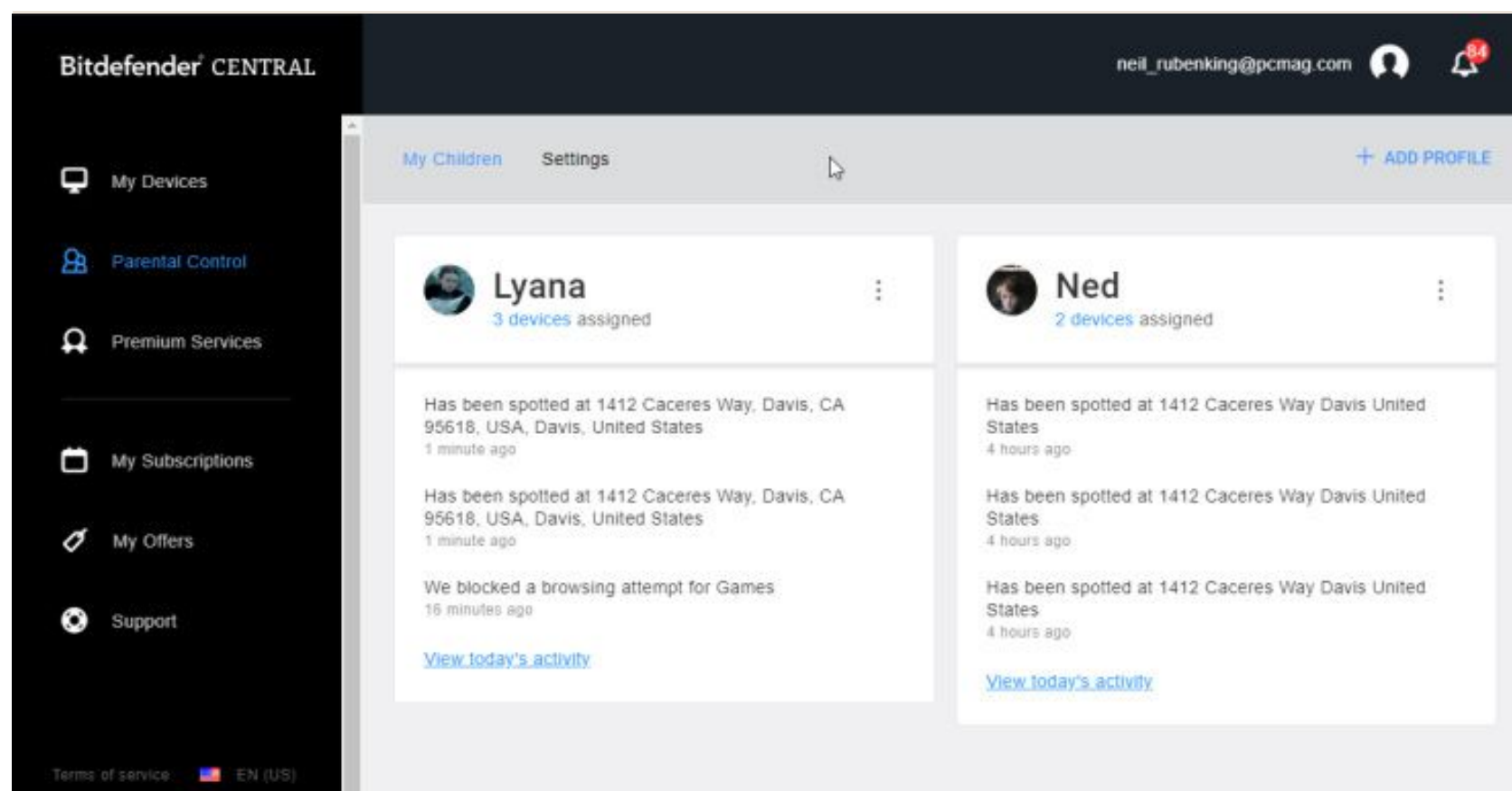
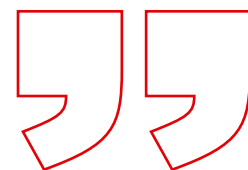
As with most modern parental-control software, you manage profiles for each child (no limit on how many) from the online console. And it works on Windows, macOS, Android, and iOS devices. You don't get full control on iOS, but where the previous edition offered only location tracking, the product now lets parents control the availability of specific apps.

To start with Parental Control, you log into Bitdefender Central and create a profile for your child. The profile includes name, birthdate, and an optional photo. Next, you identify the child's devices. It's important to do this before working on settings, because some of the settings rely on information gathered from those devices.

On Windows device with Bitdefender installed, it's a snap. Select Devices from the child's profile, choose the active device, select a user profile, and click Save. On a device without a Bitdefender installation, the system walks you through getting the main suite in place.



The previous edition offered only location tracking; the product now lets parents control the availability of specific apps.



Installed on a macOS device, Bitdefender controls the whole device, not just one user account. From the device itself, log into Bitdefender Central, select the child's profile, choose devices from the three-dot menu, and click Add Device. The system leads you through installing a trial of Bitdefender Antivirus for Mac. It's a bit odd, but when the trial expires, your parental control protection remains active for as long as your Bitdefender Internet Security subscription does. When you associate the device with the profile, Bitdefender installs additional security. I had trouble at this point, because I didn't respond in time to a prompt telling me to allow Bitdefender in security settings. This resulted in an installation that looked OK but did not actually work.

To install on Android, you download the parental component from the app store and log in to your account to associate it with a child profile. During installation, you must give it several high-end permissions: Accessibility, Device Administrator, and Usage Access. Take care during this process, as it needs these (as well as more mundane permissions) to function correctly.

Installation on an iOS device is similar: Download the app, associate it with a profile, and give it all requested permissions. After installation, the app offers instruction on how to install Bitdefender's MDM profile for full functionality. Note that anyone who has the passcode for the device can remove this profile.

SETTING LIMITS FOR YOUR KIDS

Back in the online console, click a child profile and click Websites. Bitdefender can block access to sites in 42 categories, some clearly inappropriate, some more innocuous. Based on the birthdate you entered for the child, it sets an initial selection of categories for blocking. For my imaginary ten-year-old, the blocked categories included Pornography but not Mature Content or Web Proxy; I turned on blocking for those two.

On the Activity page for each child, you get an overview of what's going on. It shows recent location check-ins, apps used on each device, most-visited websites, blocked website categories, and time spent on each device.

Click Screen Time to set limits on the child's use of devices. This page has a big Pause button at top; according to the floating help tip, it blocks use of the child's Windows, macOS, and Android devices when active. My contacts at the company said it also severely limits available apps on iOS devices, leaving the child free to call parents but not much more.

Screen-time limits aren't enabled by default. When you turn on just this feature, it limits device usage during Bedtime (by default, 9 p.m. to 9 a.m.) every day of the week. You can tweak those times or add additional restrictions. There's also an option to impose a daily limit. Bitdefender calculates the limit based on Windows and Android use but, according to the instructions, puts Windows, Android, and iOS devices on pause when time's up. There's no mention of macOS.

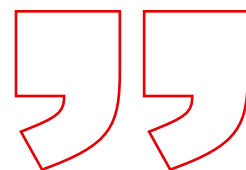
At its simplest, Child Location lets you locate your child's mobile devices on a map. The mobile parental-control app also lets the child actively check in on arriving at a location. You can define Safe and Restricted areas: You name the area, click the center on a map, and set a radius from 100m to 200m. For Safe areas, you can request that the child check in on arrival. When the child enters a Restricted area, parents get a notification.

When you open the Applications page, you see a list of the child's devices, along with the applications Bitdefender detected on the selected device and the amount of time spent on those applications. You can also choose to block specific apps. This feature is a bit different for iOS devices, as Bitdefender can't gather usage information. In addition, blocking on iOS applies to built-in apps such as Safari, Camera, and Facetime individually, but to block any third-party app, you must block all of them.

The Phone Contacts page works only on mobile devices. You can review the child's contact list and block access by any unwanted contact. There's also an option to block calls from private numbers that don't reveal their caller IDs. On Android, you can choose to monitor text messages by replacing the default app for SMS.



You can define Safe and Restricted areas: Name the area, click the center on a map, and set a radius from 100m to 200m.



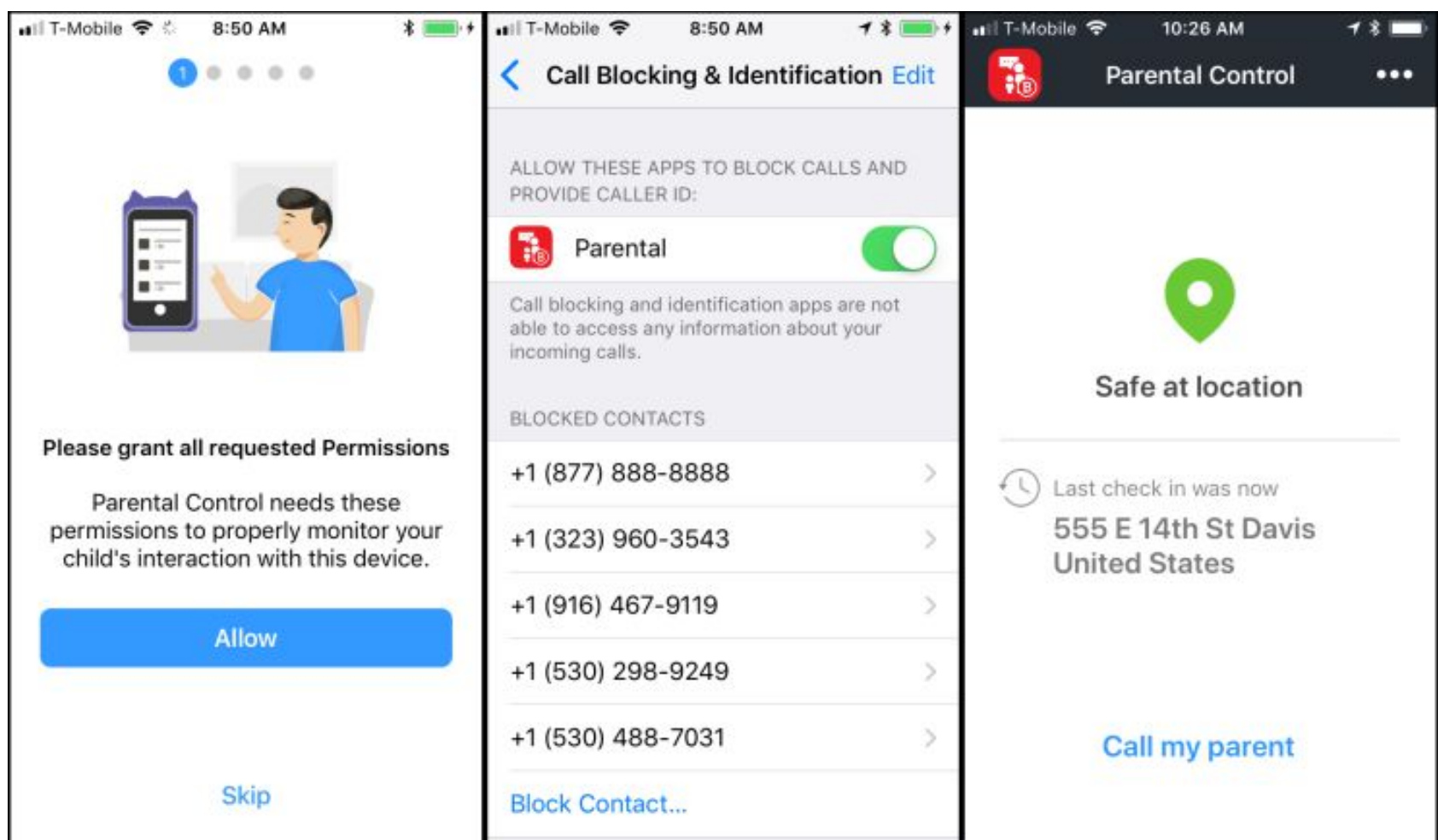
PARENTAL CONTROL IN ACTION

I had a lot of trouble with the initial setup. I had to reinstall the macOS version twice to catch the request for security access. It didn't seem to work initially on the Android device. But eventually I got it working.

To test the content filter, I tried opening a variety of inappropriate websites. On the Windows test system, it worked fine, blocking all the test sites and replacing the page with a very simple notification. Because I turned on Web Proxy blocking, it prevented access to HTTPS-protected anonymizers, too; don't forget to enable that category. Previously I found find that I could do an end-run around the content filter by using a non-standard browser and a secure anonymizing proxy. This time, the proxy loaded, but Bitdefender still blocked naughty sites accessed via secure proxy. That's impressive.

Content filtering replaced blocked sites with a notification page on the Android device as well, in my testing. On the Mac, it works a bit differently: The browser simply displayed an error message with a slide-in notification from Bitdefender saying it blocked the site.

Location tracking worked just fine in my tests. I took Android and iOS devices to another location, and Bitdefender immediately located them on the map. I couldn't test the control of Phone Contacts because my mobile testbeds aren't provisioned for calling, but I assume it works.



The time restriction setting proved effective. Working on testing before 9 a.m., I found that it blocked my access to apps on Windows, macOS, and Android. When I lifted the restriction, I thought at first that it didn't work, because my browsers still reported themselves unable to contact Google. As it turns out, blocking search engines is one of the defaults; I changed it.

The Pause setting also worked fine in Windows, macOS, and Android. It didn't "block the child's . . . devices" the way the help tip says it should, but it did block use of apps.

Pause had no effect on the iOS device I used for testing. I gave it an hour, in case it needed time to notice the setting change, with no result. I also tried disabling specific apps from the console, also with no result. My Bitdefender contacts confirmed a problem with the MDM servers, one they say should be corrected soon.

While I couldn't make the Pause button or app control work on my iOS testbed, the previous edition didn't include that feature at all, so there's no real loss. Bitdefender's parental control system remains among the best supplied as part of a security suite, with content filtering, time scheduling, all-device Pause feature, geofencing, and more. Norton and Kaspersky are among the few that outdo Bitdefender, feature-wise. Check Point ZoneAlarm Extreme Security licenses the well-known Net Nanny. All too many suites include parental control that's limited, porous, or both.

EASY FILE ENCRYPTION

Do you have documents on your computer that you wouldn't want anyone else to see? Yeah, you do! A data-stealing Trojan that somehow got past Bitdefender's defenses could slurp up those files and transmit them to its master. Should you step away from the computer without locking the desktop, a nosy cousin or coworker could view your secrets with impunity. To keep out the snoops, protect your sensitive data using encryption.

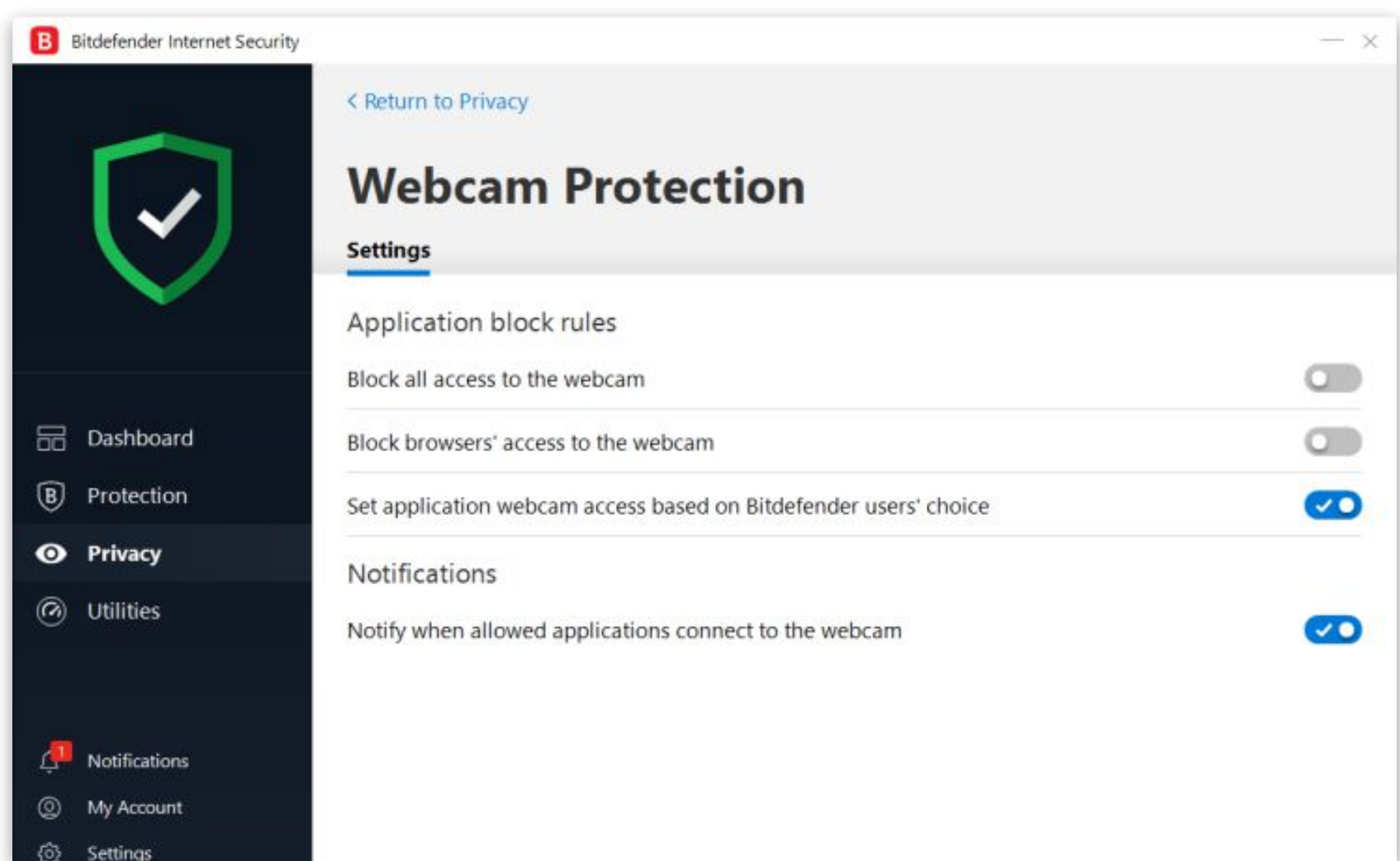
As with ESET Internet Security, AVG, and others, Bitdefender's encryption system works by creating encrypted storage volumes. These volumes, called vaults, look like any other disk drive once opened with a password. You can freely move files into and out of the vault, create new files, edit files—anything you could do in a physical drive. Once you lock the vault, however, its contents become completely inaccessible.

You can create as many vaults as you think you'll need. For each vault, you define a name, accept or change the location for the file representing the vault, and set the vault's size (at least 100MB). You can assign the vault a specific drive letter or just let Bitdefender pick a letter, starting at Z: and working down. Don't lose the password. Without it, your files become so secret that not even you can access them.

The File Shredder component becomes more useful in this suite than in the antivirus. Hiding your secret files in encrypted storage is pointless if you leave the unsecured originals out in the open. And deleting those files, even if you bypass the Recycle Bin, still allows the possibility of forensic recovery. For maximum security, you should copy sensitive files into a vault and then shred the originals.

WEBCAM PROTECTION

The idea that some internet creeper could connect to your webcam and spy on you is enough to give anyone the shivers. In a nod to the need for spyware protection, Bitdefender now includes a webcam protection component. Like the similar feature in Kaspersky, it limits webcam access to trusted programs—either programs such as Skype that are already on its list or ones that you've approved. When a new program attempts webcam access, you choose whether to allow it. And new in this edition, Webcam Protection can manage Windows Store apps.



Bitdefender's Mac antivirus doesn't offer this feature, which makes sense—neither does the Windows antivirus. Webcam protection exists in Kaspersky Internet Security for Mac, but it's a simple on-off switch without the system of trusted applications found in the Windows product.

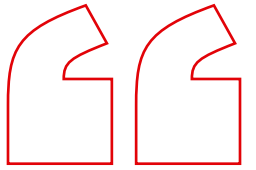
NO PERFORMANCE HIT

When a security product causes a noticeable system slowdown, users are just going to turn it off. Thus, poor performance equals poor security. The companies that make these products know this, and they work hard to minimize any system impact. Bitdefender aced all three of my performance tests.

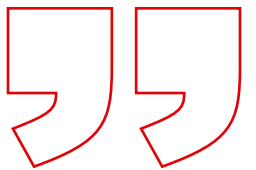
Loading up a big security suite at Windows startup could leave you waiting around to use the computer. To measure boot time, I run a script that checks CPU usage every second, calling the system ready when it tracks 10 seconds with CPU usage under five percent. Subtracting the start of the boot process (reported by Windows) yields a measure of boot time.

I run multiple tests on a clean, physical computer, then install the suite and run another set of tests. Comparing the two averages yields a measure of impact on the boot process. Bitdefender had no impact I could measure.

My file move and copy test attempts to measure a security suite's effect on day-to-day file manipulation activities. A script times how long it takes to move and copy a large collection of varied files between drives. As before, comparing the average time with and without the suite yields an impact measure. Another script measures the time required to repeatedly zip and unzip that same file collection.



The idea that some internet creeper could connect to your webcam and spy on you is enough to give anyone the shivers.



Surprisingly, these two tests both ran measurably faster after I installed the suite. I ran the test a second time to confirm. I quizzed my Bitdefender contacts about this apparent anomaly. They replied that the product includes a caching mechanism that does indeed speed up common file activities, and pointed out an independent lab award for performance.

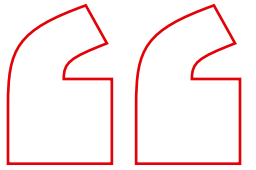
Bitdefender joins Norton, adaware, and Webroot SecureAnywhere Internet Security Plus in the elite crew of security suites that didn't slow any of my performance tests.

A SWEET SUITE

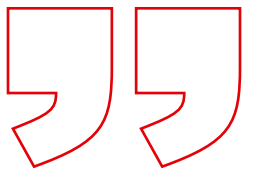
Just as Bitdefender Antivirus Plus has features that typically show up only in a suite, Bitdefender Internet Security goes beyond the feature set usually found in an entry-level suite. It has the expected firewall and spam filter and an unusually thorough parental control system. In addition, it offers webcam protection and a file encryption system, which are less common.

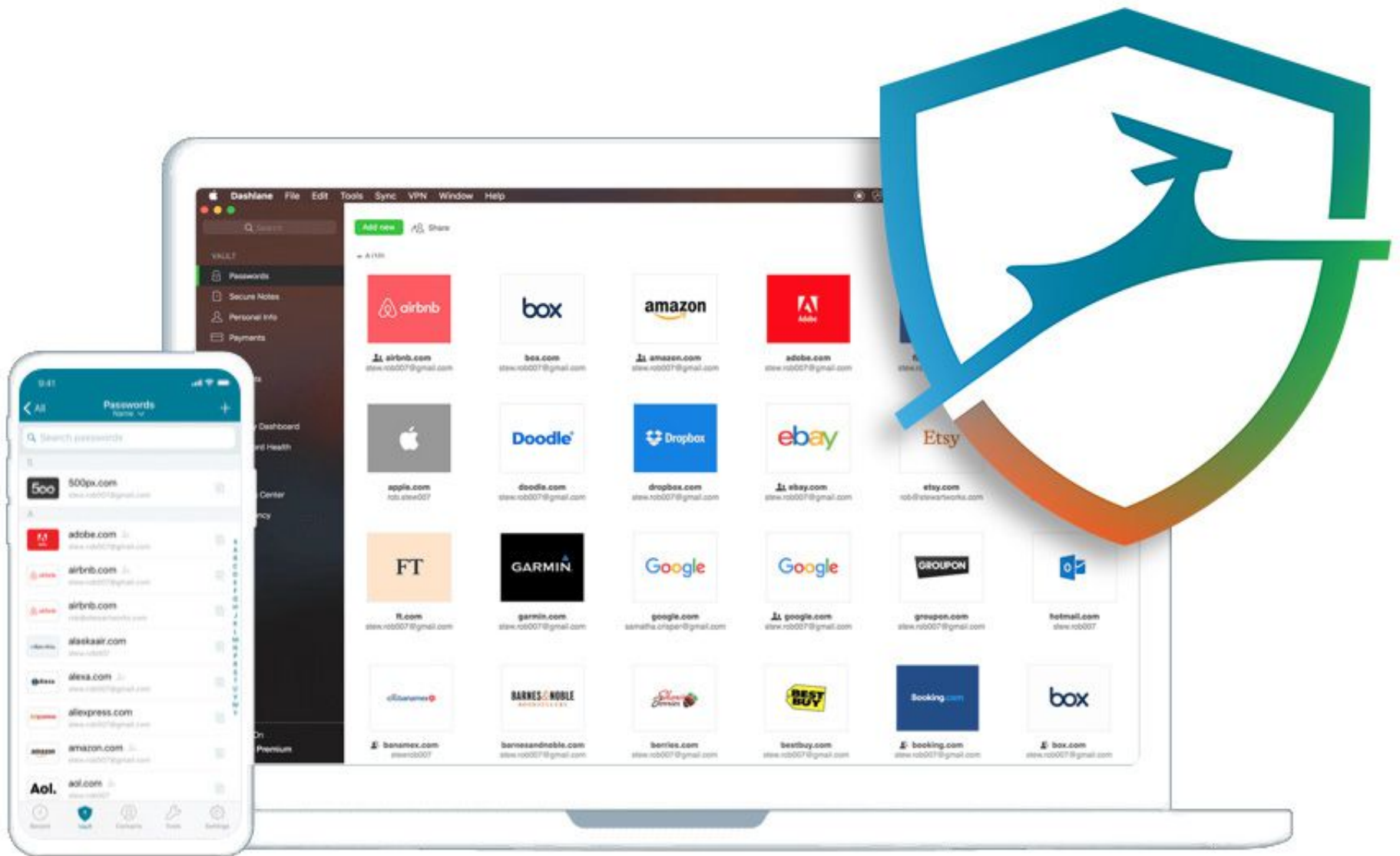
Kaspersky Internet Security also gets fantastic ratings from the antivirus labs and goes beyond security suite basics. Bitdefender Internet Security and Kaspersky Internet Security share our Editors' Choice award for security suites.

NEIL J. RUBENKING



When a security product causes a system slowdown, users are just going to turn it off. Poor performance equals poor security.





Dashlane Makes Smart Password Management a Breeze



Passwords are all about identity—you prove your identity to a site by logging in with the correct password. Conversely, anybody who guesses your password can pretend to be you.

Using a strong, unique password for every site minimizes the possibility of password theft, but nobody can remember all those passwords, not without the help of a password manager. Dashlane performs all the basic and advanced tasks of a password manager, and it does so with flair.

Dashlane

\$59.88 a year



Version 6, reviewed here, adds several new features aimed at protecting your identity, not just your passwords. Its Dark Web scan checks whether your email addresses appeared in any data breaches, the new VPN protects your identity and other data as you communicate on the web, you get 1GB of secure storage for your most sensitive files, and the Identity Dashboard puts all identity-related data at your fingertips.

Dashlane is free to use, with one condition: You can use it on only a single device, with no ability to sync with your smartphone, tablet, and so forth. That's a strong limitation—enough that I don't review Dashlane as a free product. Starting with Version 6, the free edition also imposes a 50-password limit on new users; this limit doesn't apply to continuing users. On the plus side, there's also a new emergency backup for users of the free edition. By comparison, the free LastPass puts no limits on the number of passwords or on syncing across devices. LogMeOnce Password Management Suite Premium is free without any similar limitation.

Up from \$39.99 per year, Dashlane Premium now costs \$4.99 per month, billed as \$59.88 annually. Just looking at password management alone, that's on the high side. Keeper and Sticky Password Premium both cost \$29.99 per year, and LogMeOnce's premium edition costs \$39.99. Of password managers I've reviewed, only Intuitive Password costs more, at \$60 per year.

But when you factor in the usual cost of VPN protection, Dashlane begins to look like a deal. It uses a licensed version of Hotspot Shield, which costs \$12.99 per month, discounted to \$71.88 yearly. You can use Hotspot Shield on five devices, while Dashlane puts no limit on the number of devices.

Dashlane

PROS Syncs across all your Windows, macOS, Android, and iOS devices. Offers all essential and advanced password management features. Includes VPN protection. Scans Dark Web for compromised accounts. Captures online shopping receipts.

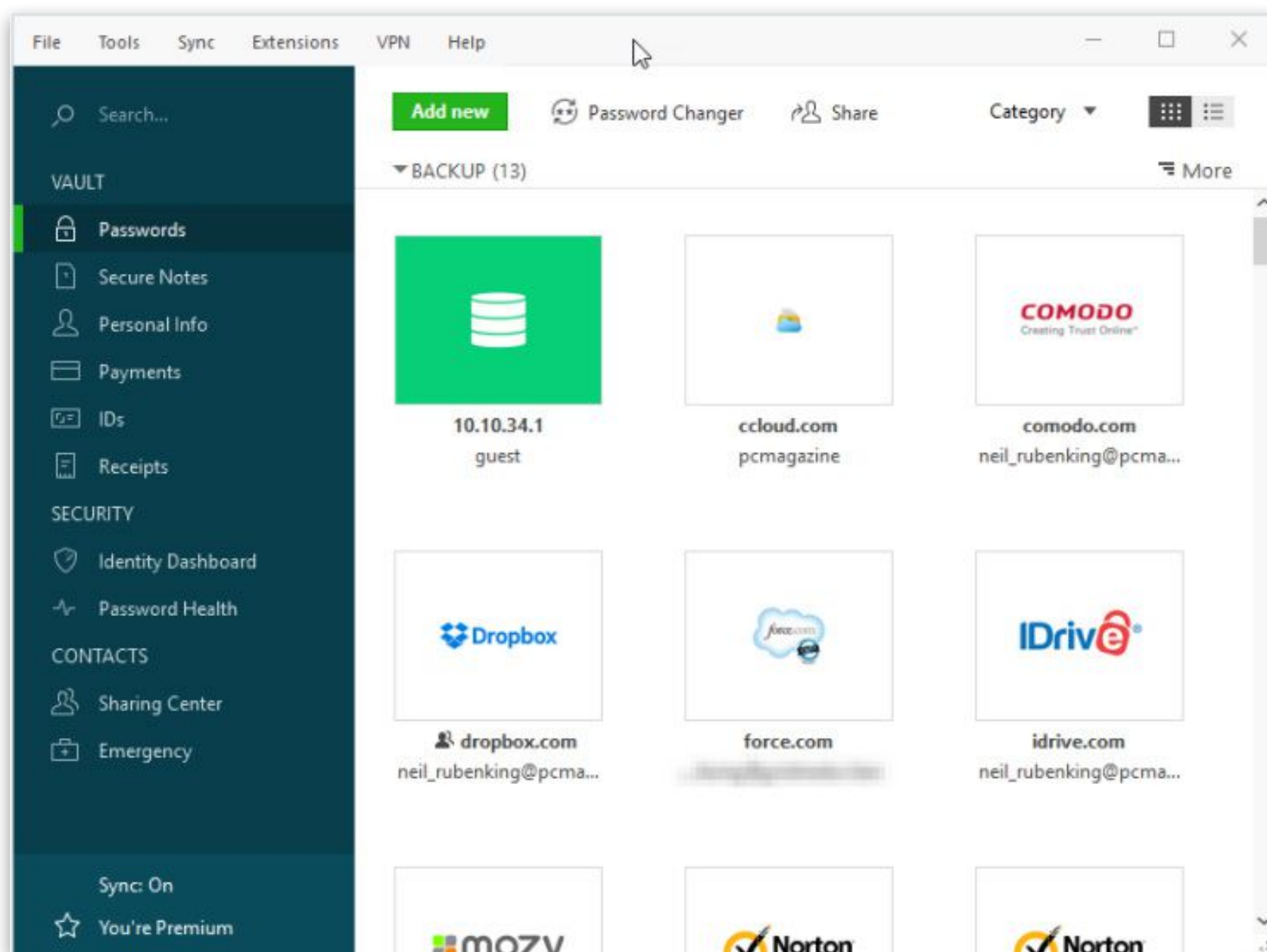
CONS Expensive, especially if you already have a VPN. Can't choose VPN server country. No special handling for nonstandard logins. Limited support for Internet Explorer.

There's also a new Premium Plus plan for \$9.99 per month, \$119.88 annually. The Plus features are all about identity. At the Plus level, Dashlane monitors your credit score and alerts you when anything unusual happens. If you become a victim of identity theft, it offers “restorative support” as well as up to \$1 million in identity theft insurance. This review covers the Premium plan, not Premium Plus.

BASIC PASSWORD MANAGEMENT FEATURES

The small menu that you pull down from the Dashlane browser toolbar button is sufficient for most activities. The app captures credentials as you log in and replays them when you revisit sites, as expected. To edit existing entries or access advanced features, you need to open the full application. New in this edition, you can attach files to your Secure Notes, for up to 1GB of secure cross-device storage.

A basic Keeper Password Manager & Digital Vault subscription lets you store just five such attachments, but for \$9.99 per month extra, you can store unlimited items, up to 10GB. Keeper's five-user family pack costs about the same as a one-user Dashlane subscription, and it comes with storage included, making it quite a good deal.



Dashlane puts its user-interface elements right where you need them. If you're signing up for a new website, the password generator shows up just under the password entry box. If you have more than one set of credentials saved for a site, it pops up a menu that lets you choose.

You may occasionally run across a site whose login screen is weird enough that Dashlane doesn't recognize it. LastPass Premium, RoboForm, and Keeper handle this problem by letting you manually ask to save all data fields. But Dashlane doesn't include this rarely needed manual-capture feature.

Just after installation, Dashlane offers to import passwords stored (insecurely) in Chrome, Firefox, and Internet Explorer; you can also import those passwords by choosing from the application's menu. Jumping ship from another product? You can import data exported by LastPass, RoboForm, and several other competitors. LastPass is even more welcoming, with the ability to import from several dozen competitors.

If you've got a ton of saved passwords, you may find it handy to view them by category. Switch to category view, collapse all categories, and open just the one you want for easy access.

The simplest way to access your passwords is to type in the search box. As you type, a list of found items narrows to show just the items that match. You can launch a site directly from the list of found items or open a full menu of actions for an item. This menu lets you edit the saved info, see password history, share the item (more about sharing later), and more.

It's a snap to launch the full dashboard from the browser extension. A left-rail menu offers access to features in three groups, which have changed a bit since the previous version. In the Vault group, you can view and manage your saved passwords, check your security score, and add or view secure notes. The Vault group now also includes personal data for filling forms and separately stores credit cards and IDs. The Security group includes the new Identity Dashboard and the Password Health report. Finally, under Contacts, you can manage secure password sharing and emergency access to your account. I'll explain these features in detail later.

Conveniently, you can use the browser extension in standalone mode. That means you can use Dashlane on any platform that includes a supported browser. So, for example, you could use it on a Chromebook or a Linux box. The extension, available for Chrome, Edge, Firefox, Opera, and Safari, lets you view and edit passwords, secure notes, and credit card details. For advanced features such as setting up sharing and emergency access, you still need to use the app.

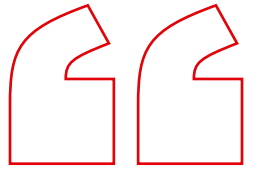
There's no standalone Dashlane extension for Internet Explorer. The simple IE extension handles in-browser tasks like capturing and replaying passwords and offers the password generator as needed. But for all other activities, including finding and launching saved logins, you must use the Windows app.

There's one more way to access your Dashlane data; just log into your account online from any browser. Without a browser extension, you can't capture or replay your passwords. You can, however, edit your saved items, launch websites, and copy/paste login credentials.

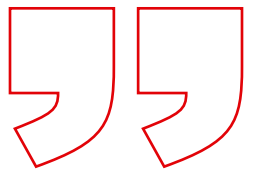
PROTECT YOUR PASSWORDS

As always, it's important to use a strong master password. Dashlane requires at least eight characters, including at least one digit, one lowercase letter, and one uppercase letter. But don't just go for the minimum. I would strongly advise at least 12 characters, using all character sets.

For added security, enable two-factor authentication. You can choose whether Dashlane will require the second factor on every login or just when you (or someone else!) attempts to log in from a new device.



**Dashlane
requires at least
eight
characters,
including one
digit, one
lowercase letter,
and one
uppercase letter.**



Dashlane specifically supports Google Authenticator and work-alikes such as the free Duo Mobile and Twilio Authy. Just snap the QR code displayed by Dashlane with your authenticator app to make the connection. You can also set Dashlane to authenticate using your fingerprint on Android and iOS devices, and it even supports facial authentication on the iPhone X.

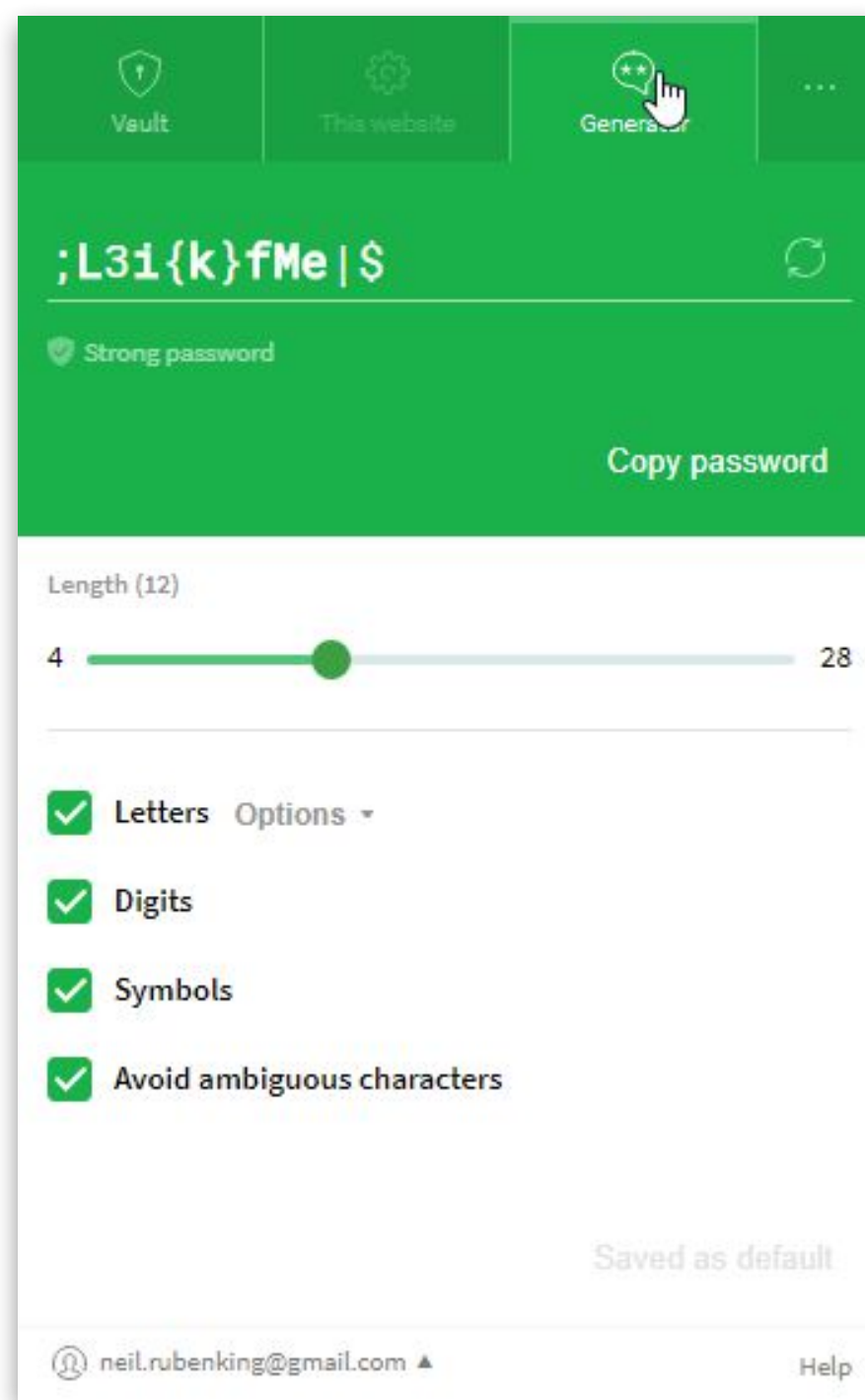
Once you've set up smartphone-based two-factor authentication, you can register one or more U2F (universal 2nd factor) security keys. With that simple step accomplished, log in using your master password and then insert the U2F key or, if using the Nano form-factor, just touch the U2F key that stays in one of your device's USB slots. By requiring your presence for login, U2F foils remote attacks based solely on the master password. Smartphone-based authentication now serves just as backup, in case you lose all your U2F keys.

The free LastPass supports smartphone-based authentication, like Dashlane, and even includes the low-tech option to authenticate using a printed wallet-sized grid. LastPass Premium adds authentication by YubiKey, fingerprint reader, or a specially configured USB drive but doesn't yet support U2F.

Sticky Password and RoboForm support fingerprint authentication. True Key's core functionality centers on multifactor authentication. Factors include possession of a trusted device, fingerprint authentication, and facial recognition. In fact, with sufficient authentication factors, True Key lets you reset your master password, something few others do.

PASSWORD GENERATOR

Any time you click in a password field to create a new account or change an old password, Dashlane pops up an offer to generate a secure password for you. This offer appears right below the password field, so it's easy to click. But you don't get an opportunity to configure the password manager at this point.



For more control over how the password manager works, click the browser toolbar button, then click the password generator button. Here you can set the generated password length and choose from four character sets, digits, uppercase letters, lowercase letters, and symbols.

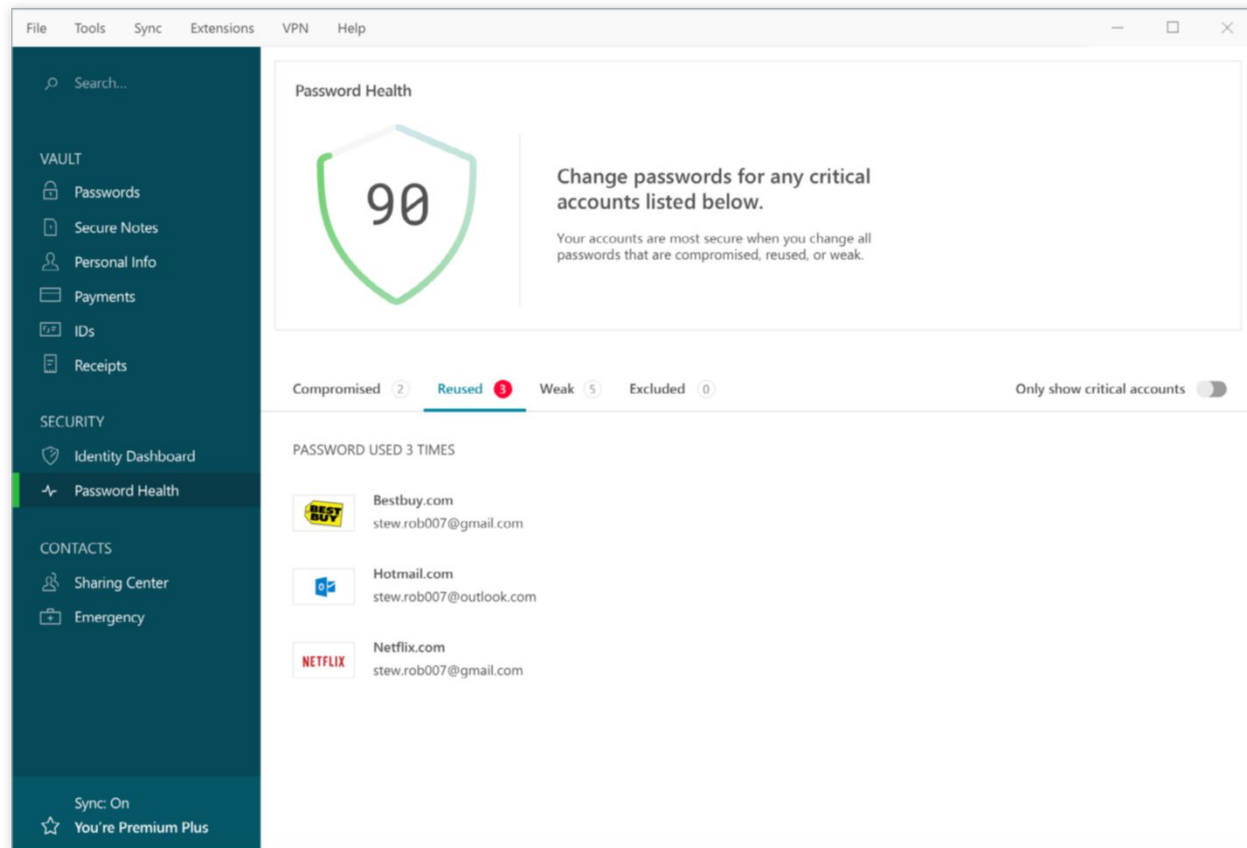
Dashlane defaults to a 12-character password using all character sets. That's decidedly better than Ascendo DataVault, which defaults to eight characters, all of them letters. Even so, I suggest you raise Dashlane's password length to 16 characters. After all, you don't have to remember the generated passwords. Note that 16 characters using all character sets is the default for True Key. Out of the box, RememBear Premium generates 18-character passwords, while Password Boss Premium and 1Password default to 20 characters, and Myki to an impressive 30 characters.

HOW STRONG ARE YOUR PASSWORDS?

Getting all your passwords into Dashlane is a great first step, but you can't stop there. You need to clean up your passwords, fixing any that are weak and replacing any that you've used on multiple sites. Don't worry; Dashlane makes this process extremely simple. Click the Password Health item on Dashlane's left-rail menu for a quick percentage rating of your security level, much like what you get with the Security Challenge in LastPass.

Below the percentage health score, Dashlane offers lists of Compromised, Reused, and Weak passwords. There's also a list of passwords you've excluded from the health rating, perhaps because passwords policies on the site involved require a weak password.

Previously, Dashlane offered a list of all your passwords with a safety percentage as well as a color-coded description: Very Unsafe, Unsafe, Not So Safe, Safe, and Super Safe. You could point to any item for details on how it got that rating. For example, a perfectly complex password may be on the unsafe list because you've used it on several different sites. In the current edition, the Weak passwords page lists only those deemed Extremely Unsafe or Very Unsafe. My Dashlane contact confirmed that Password Health won't give you a list of Unsafe or Not So Safe passwords. I definitely prefer the old way.



Fixing the weak and reused passwords can be a tough slog, but don't let that stop you. Pick the worst five or six and click the Replace now button for each. That will log you in to the site. From there, go to the change password dialog and let Dashlane create and save a new, strong password for you.

CHANGING YOUR PASSWORDS

You may notice that the button next to some weak passwords has the title Auto-replace now, rather than just Replace now. Clicking that button invokes Dashlane's automatic Password Changer. For the full, automated experience, though, you're better off invoking Password Changer from the Tools menu.

Tech experts at Dashlane have analyzed hundreds of popular sites to devise scripts that automate the password change process. That lets Dashlane perform a hands-free password update for any supported site, and Dashlane supports over 500 popular sites.

The security percentages and color-coding that I miss in the Password Health report make an appearance in the Password Changer window. You can check off any or all supported sites and click one button to have Dashlane change them all. You'll see a progress indicator by each item, advancing as Dashlane logs into the site, navigates to the password-change screen, and updates the password. LastPass's similar feature supports about 80 sites, but it needs to launch a browser tab for each site and warns you strongly to leave those tabs alone.

I'm a huge fan of automatic password updates. Since Dashlane remembers all your passwords, there's no real reason for you to be involved at all. There are a few exceptions, though. Some passwords you can't avoid typing yourself, like the Microsoft ID that you use to log in to modern Windows versions. And some sites have password-format requirements that Dashlane's automatic password generator can't meet. For most sites, however, it's fantastic.

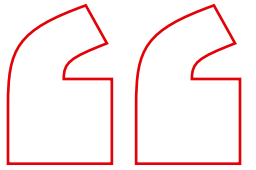
SHARE YOUR PASSWORDS SECURELY

When a buddy asks for your password to some website “so I can check something,” you know the answer. Just say no! But sometimes you really need to share credentials with a colleague or partner. Dashlane makes secure sharing easy.

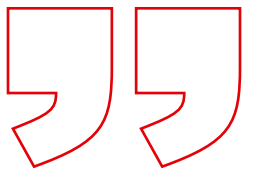
Just point to the item, click the menu icon, and select Share item. Enter the email address of the recipient, and specify how much access you're offering. If you choose to limit access, the recipient can log in using the shared item but can't view, edit, or share it. A recipient with full rights to the shared item can view, edit, and share it, or revoke access by others who share it—even you! You can enter a personal message before sending the request.

As with the similar feature in LastPass, the recipient will both receive an email and get a notification in Dashlane's Sharing Center. A recipient who doesn't yet use Dashlane will need to set up a free account, of course.

Once the recipient accepts, the item's status in your own Sharing Center will change from Pending to Full Rights or Limited Rights, depending on your choice. You can click an icon to switch between full and limited or click another to revoke the share.



When a buddy asks for your password to some website “so I can check something,” you know the answer. Just say no!



EMERGENCY CONTACTS

What happens if a self-driving bus runs over you tomorrow? Will your heirs tear their hair out trying to figure out how to access your accounts? Dashlane's emergency contact feature ensures that you can pass along your digital legacy after your demise, and it doesn't even require probate.

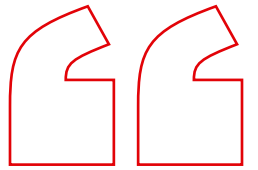
Setting up an emergency contact to inherit your passwords is as simple as sharing one password, with one important difference: You can set a waiting period for full access. If your heir tries to get your credentials while you're still aboveground, you can respond to the notification email to deny access. And then you should look for a more trustworthy heir.

LastPass includes a similar feature, but Dashlane takes it a step further. In addition to defining an heir for your entire stash of passwords, you can also grant someone access to a subset of those passwords. For example, you could make your boss the recipient of only your work-specific passwords. Zoho Vault separates personal and business password entries and allows an administrator to take control of the business collection.

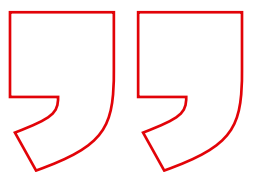
ADVANCED FORM FILLING

Once a product can fill username and password fields, it's only a small step to filling other fields on web forms. Like many password managers, Dashlane can also help you with filling personal data in web forms. But Dashlane takes the concept farther than many competitors do.

RoboForm Everywhere is the most flexible in this area—not surprising, given that it started life as a form-filler. It lets you record a wide variety of personal data, names, email addresses, bank accounts, and more. It also supports multiple entries for every field. With LastPass, you can define any number of full personal profiles or credit-card-only profiles.



Dashlane's emergency contact feature ensures that you can pass along your digital legacy after your demise.



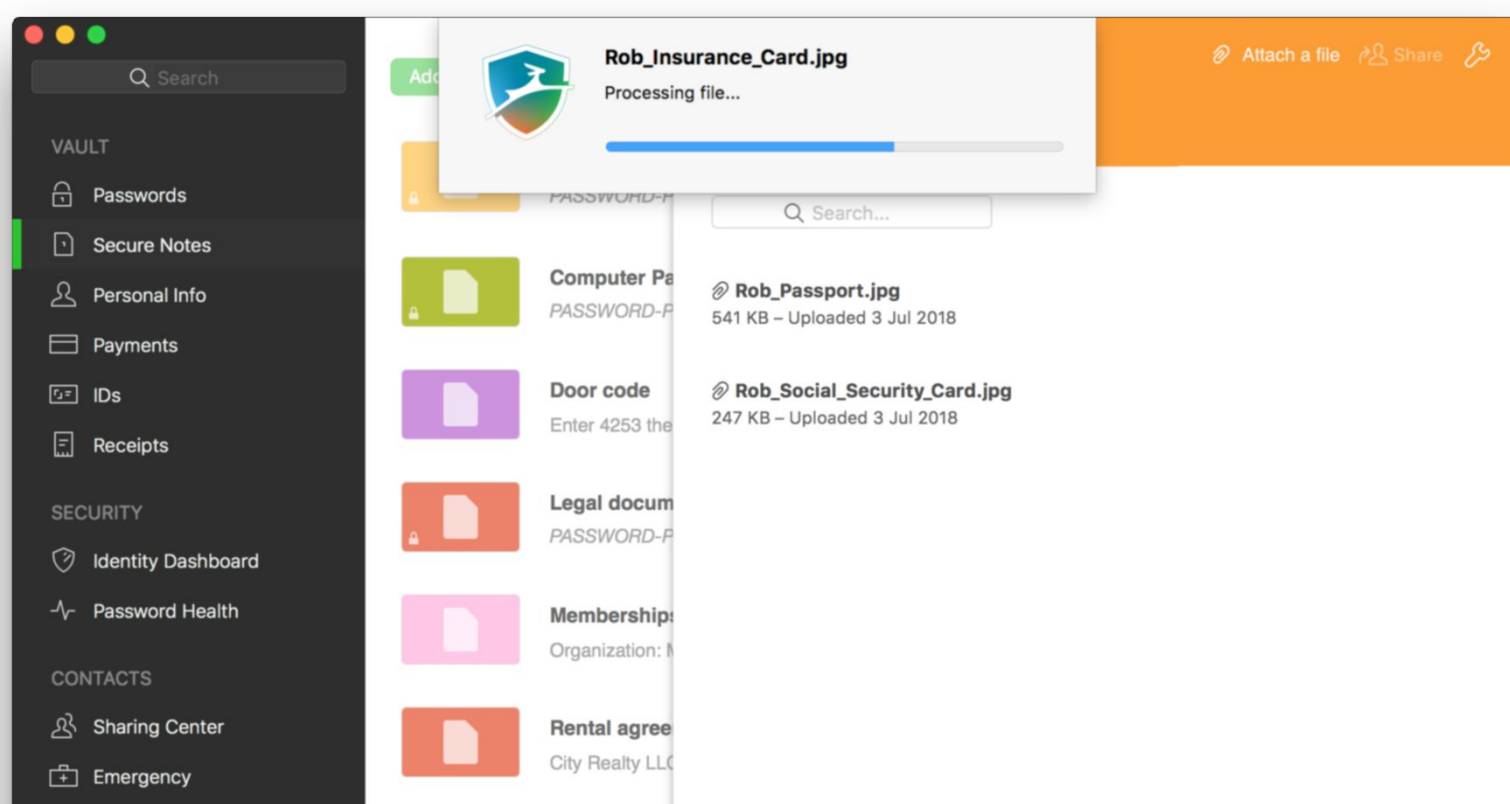
Dashlane divides personal info into name, email, phone, (snail-mail) address, company, and website. You can add any number of each type. When Dashlane detects a Web form, it puts a tiny impala icon in each entry field. You click in any field and select the desired entry from the popup menu. At that point, Dashlane fills all the fields using the selected entry, but you can change any of those with another click. For example, you might fill the phone number first, then click in one of the address fields to select a different address.

Dashlane handles payment information separately and beautifully. In the main Dashlane interface, you enter as many credit cards, bank accounts, or PayPal accounts as you need. For each credit card, you specify the color and the issuing bank. When you click the credit card field on a Web form, you'll see images of your cards, each with the proper color and bank logo. It's especially good for those with a visual orientation.

Dashlane handles passports, driver's licenses, and other IDs in a similar fashion. Your passport displays using the color and style of the country you selected, and your driver's license looks like an actual license, with the state clearly displayed.

RECEIPT CAPTURE

On shopping sites, Dashlane's help with web forms doesn't end when you've filled in all your personal data. Dashlane offers to capture its own receipt for the transaction, with the full amount and, when possible, a list of purchased items. It even snaps a screenshot or two, in case you have trouble with the merchant and need to show some added proof. In the event Dashlane doesn't capture the item name, you can edit that before saving.

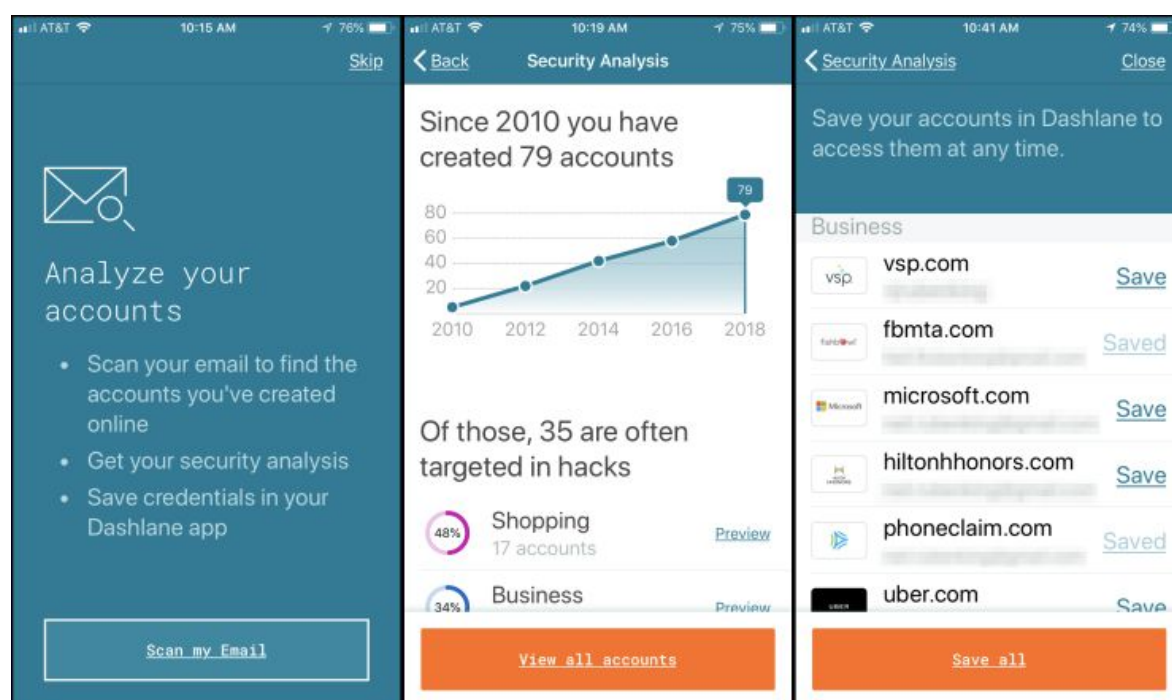


From the main Dashlane interface, you can view your list of receipts, dig in for details, and view the associated screenshots for each. It's a handy record of your online shopping, and I haven't seen it in any other product.

INBOX SCAN

Dashlane's Inbox Scan feature slipstreamed into version 5, well after my earlier review. With your permission, this scan rifles through your inbox seeking email messages that its pattern-matching algorithm suggests involve creation of an online account. It took a little while to go through eight years of my email, but when it finished, it reported finding 79 accounts. The summary display offered a breakdown of accounts in often-hacked categories such as shopping and social media.

The summary display offered a breakdown of accounts in often-hacked categories such as shopping and social media.



This is a nice touch for mobile-only users. Dashlane running on Windows can siphon up passwords stored in browsers, but both Android and iOS make that practice impossible.

You can tap to see the accounts in each category or tap for a complete list. And you can tap any item to save it in Dashlane or tap a button to save all the accounts.

There's still some work to do. Those new items have the website and the username. But Dashlane can't magically deduce the password. You must fill it in yourself. Fortunately, the added items show up at the top of the Recents list.

DASHLANE FOR ANDROID AND IOS

Except for its macOS-specific interface changes, Dashlane on the Mac is identical to the Windows edition. Dashlane's Android app and iOS app are also very similar, with a few differences. For example, the mobile editions don't capture receipts for your purchases, but they do offer Inbox Scan.

On iOS devices, Dashlane can manage app passwords only for apps that support iOS Share Sheets. This feature has been around for a while, and it's gaining traction. More than 180 apps support it, including some big names such as eBay, Flipboard, Tumblr, Twitter, and Uber. As noted, iPhone X users can log into Dashlane using facial recognition. On an iPad, you can drag and drop credentials into the appropriate fields.

On a mobile device, Dashlane itself can take the place of Google Authenticator or equivalent for websites that use two-factor authentication. Open the website's entry in Dashlane, find the Security Code line, and tap Generate with Dashlane. Scan the site's two-factor QR code to complete setup. That's it—you'll now find a current security code in the entry, updated every 30 seconds. As the name suggests, Myki Password Manager & Authenticator also serves as both a password manager and a Google Authenticator replacement. Myki stores your passwords locally on your smartphone, with no cloud storage at all.

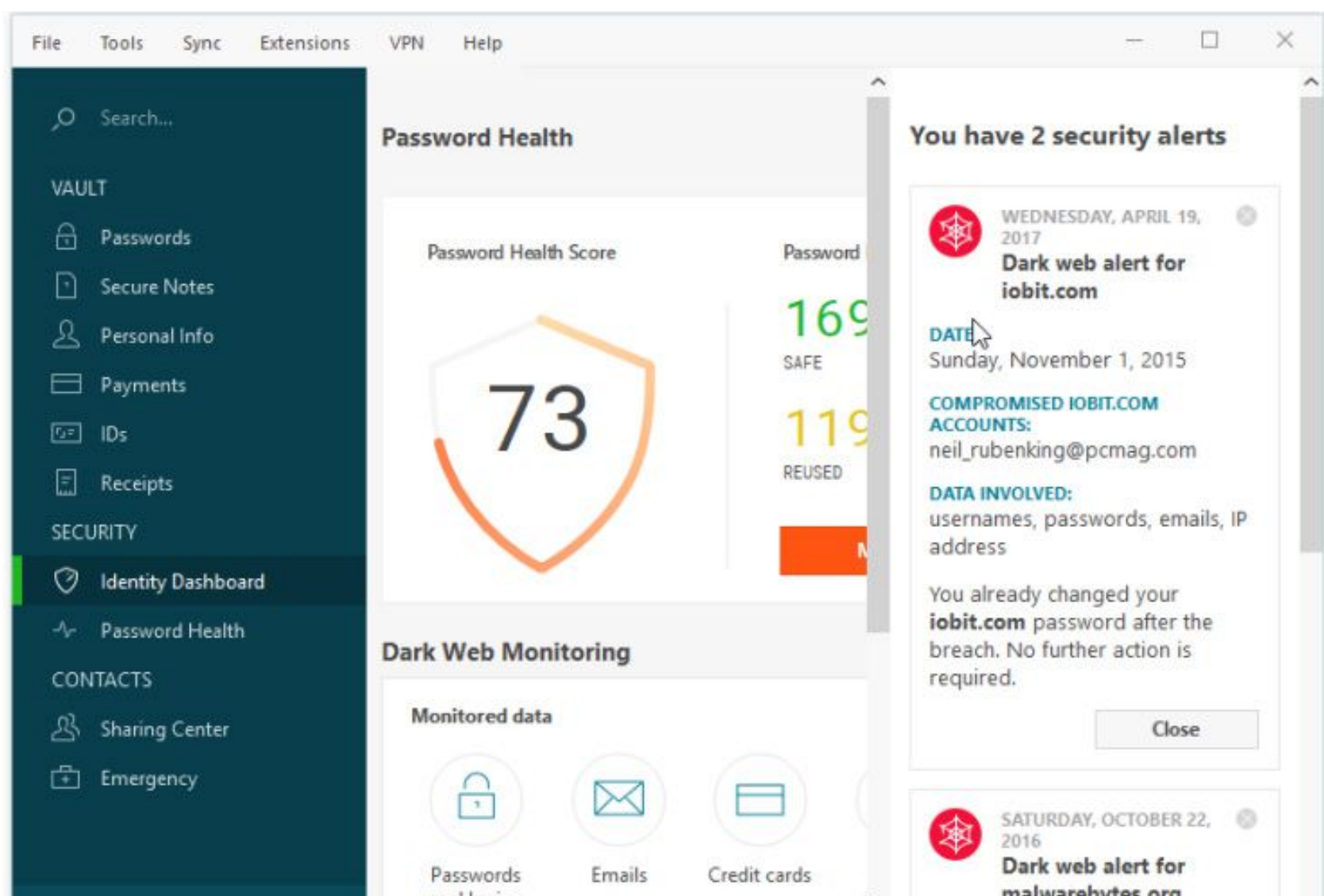


The Android edition also supports auto-login for apps. Once you give it Accessibility permission, it can log in to any app, with no special app extension required. Both mobile editions include their own browser, which can automatically fill passwords and web forms. And you can configure both to fill passwords in the default browser.

DARK WEB SCAN

Hackers who breach a website's security often exchange their ill-gotten login credentials on the Dark Web. Even if no one has used the stolen credentials, you'd still want to know about the theft and change the account password. New in this edition, Dashlane uses Dark Web data licensed from SpyCloud to check your email addresses. According to the FAQ, Dashlane never sends your personal information to SpyCloud.

When you open the Identity Dashboard and add an email address for scanning, Dashlane sends a verification email. Once you click to confirm your ownership of the account, it quickly scans the available data. You get a list of found problems in a web page and detailed alerts in Dashlane itself. On my own accounts, Dashlane found several alerts, but by cross-referencing them with password history, it correctly pointed out that I changed my passwords for those sites after the breach. Alerts go away when you fix the endangered password or when you click to discard them.



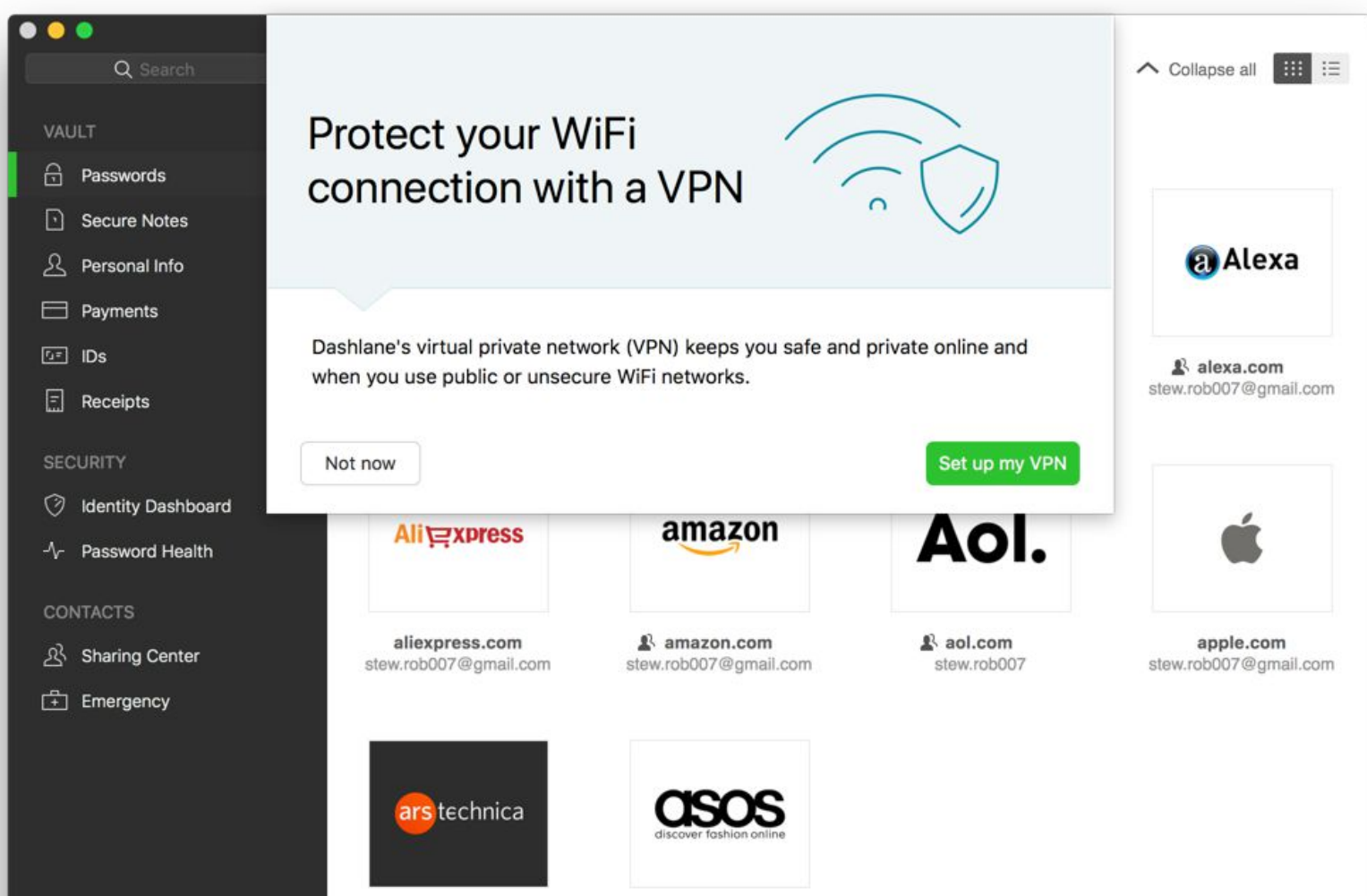
You can add all your email addresses, and you probably should. Dashlane continues to check registered email addresses as it obtains new Dark Web data. This is definitely a useful security enhancement.

Note that if you purchased Dashlane Premium Plus, with its credit monitoring and identity theft insurance, your monitored data shows up in the Identity Dashboard as well. The version I used for testing didn't include the Plus features, but I can see that Dashlane tracks passwords, emails, credit cards, phone numbers, and addresses.

SIMPLIFIED VPN

A password manager helps you use strong, unique passwords for all your sites, and automates the login process. But when you're logging into an unsecured Wi-Fi hotspot, your data could be exposed, especially if you're connecting to a site that doesn't use HTTPS. This latest edition of Dashlane extends its protection beyond the boundaries of your devices by offering a VPN (virtual private network).

To enable VPN protection, you simply click the VPN menu item and choose Setup. Once the quick setup process finishes, select Connect or Disconnect from that same menu. That's the extent of it. There's no option to choose the VPN server; it automatically selects one that's nearby. My Dashlane contact did say, "We're actively evaluating the usage and feedback and could potentially deploy a country selection option in the future."

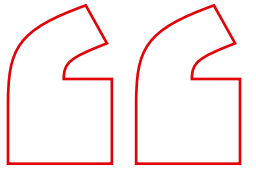


Dashlane licenses its VPN technology from AnchorFree, as do both Bitdefender and Kaspersky. Every product from Bitdefender Antivirus Plus on up includes VPN, as does every Kaspersky product. With Bitdefender and Kaspersky, though, you can use only 200MB of bandwidth per device per day. As with Dashlane, the VPN chooses which server you'll work through. For unlimited bandwidth and a choice of servers, you have to pay an extra \$49.99 per year to Bitdefender or \$4.99 per month to Kaspersky.

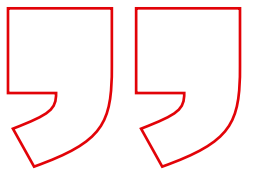
Dashlane, by contrast, gives unlimited VPN bandwidth to all Premium and Premium Plus users. If you're using the free edition or a Premium trial, sorry: No VPN for you. And you can use the VPN on every device where you've installed Dashlane, without limit. In other words, subscribing to Dashlane gets you not only a VPN for your PC but also an iPhone VPN and an Android VPN—for as many devices as you have. Hotspot Shield itself limits users to five devices.

This is a super-simplified VPN. As noted, you can't choose your server. You also can't configure the VPN protocol used. It doesn't reconnect automatically after a lost connection. There's no Kill Switch to cut internet access when VPN protection stops. You can't even see its connection status except by clicking the VPN menu item. A transient notification popup appears briefly when the connection drops, but you don't get an always-available status indicator.

In the past, we've downgraded AnchorFree Hotspot Shield Elite for some questionable privacy policies; those seem to be fixed. In any case, like Bitdefender and Kaspersky, Dashlane doesn't share any personal data with AnchorFree and keeps as little as possible for itself. Per my company contact: "Dashlane provides no identifiable information about our users to AnchorFree."



**Subscribing
to Dashlane
gets you not
only a VPN for
your PC but
also an
iPhone VPN
and an
Android VPN.**



Using a VPN protects your data in transit, which is valuable. People also use VPNs to spoof their location, for reasons ranging from watching UK-only BBC content to communicating safely while reporting on repressive regimes. With Dashlane, you get data protection but no location spoofing. And as noted, you have no chance to tweak its configuration. I'm not sure that a user who knows enough to want VPN protection will be satisfied with these limitations.

BIGGER, BUT PRICIER

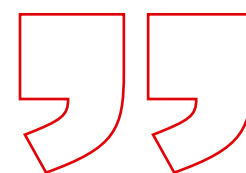
Dashlane provides every standard and advanced password management feature, in a stylish, easy-to-use package. It also offers unique features such as capturing receipts and scanning your Inbox for accounts you might not remember creating. The new VPN support, Dark Web scan, and secure cloud storage definitely enhance security, but I'm afraid some users will balk at the corresponding new price. Of those that see the price as a bargain compared with purchasing VPN protection separately, some already have a VPN, and some may want more VPN control than Dashlane offers.

This is still an excellent password manager, and an Editors' Choice. Keeper Password Manager & Digital Vault is our other Editors' Choice, with a slick interface and a focus on security. You won't go wrong with either, but for about the same price as Dashlane, you can get Keeper's five-user Family Plan along with 10GB of encrypted storage for your sensitive files.

NEIL J. RUBENKING



Dashlane provides every standard and advanced password management feature, in a stylish, easy-to-use package.



FEATURES

HOW TO BUILD A — **KICK-ASS** GAMING PC FOR **\$1,000**

BY MATTHEW BUZZI

As a hardware analyst at PCMag, I've had numerous opportunities to build PCs live on camera. John Burek, our hardware executive editor, and I have been itching to do another, but we wanted to add a twist or limitation that would make our do-it-yourself build useful for readers, entertaining to follow, and nice to look at. We landed on putting together a gaming desktop with a \$1,000 price cap. There's some wiggle room thanks to sales, rebates, and ever-changing component pricing, but we chose the parts by their current cost.

A gaming PC requires a pricey graphics card more than anything else, and once you factor that into the budget, you butt up against the price ceiling pretty quickly. But \$1,000 is a realistic and helpful price point for the average person looking for a game-ready PC, so we were determined to put together the best mix of value and performance.

PICKING THE PARTS

If, like us, you decide to put together a build that stays under a set but reasonable price point, you're simply going to have to make trade-offs. Deciding which parts to add and which to steer away from is a matter of determining what exactly your machine will be used for, which aspects you value most, and the deals you can get at the time.

A DIY builder has to choose seven core components when putting together a PC—a case, a motherboard, a power supply, a CPU, a GPU (or two), RAM, and storage. And many options exist for each of those. Considering cost, function, personal manufacturer preferences, and aesthetics, you have a lot of decisions to make. With our \$1,000 cap, we had to figure out which of these were most important to the concept of an HD gaming machine, and which we could compromise on.

I should note that since we planned to film and photograph the system, the parts are a bit flashier and more RGB-laden than I (or you) might normally select. Below is a rundown of the components we ended up with and our thought process on why we went with them. I won't go through all the alternatives, because there are an endless number, but this should give insight into our decision-making.

Case: Lian Li Alpha 550W (\$127.63). In many ways, the case you choose sets the tone for the whole build. It's obviously the most visual piece of the puzzle, so its aesthetic determines most of the theme and color scheme. Because of the need for some camera-friendly flash, we went with the Lian Li Alpha 550W SECC ATX Mid Tower case. It was a big factor in deciding to go with a black-and-white theme for the rest of the parts—a clean, modern style.

This case's big glass side windows will highlight the components, and it includes eye-catching fan lighting on the front, adding fun and saving me from the task of setting up my own case lighting during a live build. It also looked relatively easy to build in, and who doesn't want that? At \$127, this is certainly pricier than necessary; if you're cutting it close, you can easily shave money off with a less expensive case.

Processor: Intel Core i5-8400 (\$179). Your processor can be a bottleneck for gaming, but as long as you hit a certain performance minimum, which many modern CPUs do, other components are more likely to hold you back. Recent processors are more efficient than ever, with a much more capable baseline than the average CPUs of the past. For this build, we went with a new eighth-generation ("Coffee Lake") Intel Core i5-8400 CPU, which is more than powerful enough for gaming.



Some high-end enthusiasts may insist on an i7, but you truly don't need one for gaming, as it doesn't stress the hyperthreading function that makes i7 models so appealing for other CPU-intensive tasks. Even a Core i3 would suffice, but since it's the heart of the system for gaming and also for everyday tasks, I figured I'd be grateful for the extra juice. Note that this isn't a "K" series processor either, meaning it can't be overclocked, which is unnecessary most of the time for gaming. It also lets me save money on other components, such as the next one.

Motherboard: MSI B360-A PRO LGA 1151 (300 Series) (\$79). Having decided what CPU we were going with, we knew the motherboard type we were looking for. You don't have to spend a lot here—fitting the correct socket type for your processor is the chief concern—but nicer boards come with some nicer features. We went with the MSI B360-A Pro board (LGA 1151 socket), which supports eighth-generation Intel chips like the i5-8400.

The first line of eighth-generation-compatible boards (Z370) cost over \$100; these less expensive B360 models are relatively new. This model comes with a solid port selection and plated heatsinks that don't get in the way of installation, and it fits the black-and-white color scheme. The two main concessions for the B360 boards' lower prices are that you can't overclock CPUs installed in them and that they support only one video card. That syncs up perfectly with the plan for this particular build, so I was happy to save the money. It's relatively straightforward but effective, and at \$79 with a \$10 rebate, this motherboard definitely doesn't break the bank.



Graphics Card: Nvidia GeForce GTX 1070 Founders Edition (\$399). This was a tricky one. We originally budgeted for an Nvidia GeForce GTX 1060—a modest but effective HD gaming card. Most of the time with that card, you get 60fps in HD with settings at or near maximum, but it's not a powerhouse. The GTX 1060 Founders Edition retails for \$299, so from the start we were picking the rest of the components with a GTX 1060 at that price in mind. As the process went on, though, we were tempted by the more powerful GTX 1070. Something about going through all of the trouble to build a gaming-specific machine only to use a GTX 1060 just felt underwhelming.

And so, after a lot of rationalizing and budgeting, we ended up with a Founders Edition GTX 1070. Its \$399 price means some concessions to storage and memory had to be made, but we felt it was worth making them. A graphics card is the main factor in the performance ceiling of a gaming machine, and going with a solid but not great option didn't sit right. This card also allows you to play at a higher resolution with better frame rates when you have, say, a 1440p monitor. On the flip side, you might understandably feel a GTX 1060 is plenty for this type of rig—and that choice gives you \$100 to put toward other components.

As a side note, we were hesitant to go with either of these cards as rumors said Nvidia's next-generation cards might be coming this fall. Sure enough, just before we put this issue to bed, Nvidia announced the first wave of its new Turing cards, coming in September and October. They will be far pricier than the \$399 GTX 1070 we chose; the cheapest will be \$499 versions of the GeForce RTX 2070. So we remain confident in our choice of the GTX 1070 for this build, especially if its price falls in response to the new cards.



Memory: GeIL Super Luce RGB Sync 8GB (2 x 4GB) 288-Pin DDR4 SDRAM DDR4 2400 (\$79). For another entry in the “made to be seen” column for this build, we went for two 4GB sticks of GeIL Super Luce RGB Sync DDR4 memory. For years, RAM has been a relatively low-cost part of the build, but RAM prices have spiked lately and have yet to come back down. That said, \$79 for 8GB is a pretty good deal, and the RGB strips add yet more pizzazz to proceedings.

Eight gigabytes is perfectly adequate for gaming, though—like a Core i7 processor as opposed to an i5—some builders will insist on 16GB. There are benefits to adding more RAM; it certainly won’t hurt and can speed both general and in-game load times. So if you find a good deal and have room in the budget, throw in an extra 8GB. Since we devoted extra funds to the graphics card in this build, 8GB it is.

Storage: Crucial MX500 SSD (\$109). As with the RAM, we made a concession on the storage to afford the GTX 1070. The quality of the storage is actually high—we purchased a speedy 500GB Crucial MX500 SSD. There’s no accompanying larger hard drive, however, so 500GB will have to do for all your games and files. Yes, that will fill up relatively quickly given the large install sizes of modern games, so you’ll have to keep only your favorites or current titles installed at any given time. If you often butt up against the capacity, though, you can always add more storage. And if this amount simply won’t work for you, you could go with a 128GB SSD for your operating system and a few key applications with a larger, less expensive hard drive for the rest.

Power Supply: Corsair VS650 (\$49.99). With everything else selected, we were able to get a sense of how much power we’d need to run the system. The GPU and CPU are the main power drains, and given the components we selected, the 650W Corsair VS Series VS650 is strong enough for the job. 450 to 500 watts is enough for a GTX 1070 and the relevant components, so the VS650 even leaves some headroom to be safe. It’s not one of the fancier options—it’s non-modular, without the higher-end gold or platinum certification—but in a build that doesn’t require excessive power and is trying to stay under a price limit, it should be a fine fit.

All told, for the prices at the time we purchased these items, the build cost \$1,022.62, \$992 after rebates. Costs will, of course, fluctuate with sales and availability, but we were able to just about hit our target. If these components become too pricey in the future, you'll no doubt be able to find similarly priced alternatives to put together a comparable machine. We feel good about these parts on the whole: Our build may be a little short on storage, and some builders might prefer 16GB of memory, but this should add up to a very competent HD gaming machine.

BUILDING FOR AN AUDIENCE

The parts may be on the standard side, but doing this build live on camera for an audience is a unique factor—not something the average person will experience. It's fun, but it comes with certain complications and pressures. With people watching, you feel the need to be as entertaining as you are efficient. If you make a mistake, not only do you know people will probably be critical, but you're aware it will take more precious viewing time to fix. We aim for a live build that's both informative and easy to watch, so it's a delicate balance, and it'll have more rough edges than something that can be stopped, reshot, and edited.



For the camera-shy, that probably sounds stressful—you'd rather enjoy your build in peace, going at your own pace, with nobody judging. Being in front of the camera does add weight to every moment and choice. Most important is that my cobuilder and I account for everything we needed in terms of component acquisition, parts compatibility, and preparation. Doing the build as a pair gives you someone to bounce ideas off of, provides another set of eyes to make sure everything is accounted for before the build, lets you fill air time with your discussion, and adds another set of hands to make things run more smoothly on camera.

Running into an insurmountable obstacle in the middle of a live video because of a missing, incompatible, or broken component is the ultimate nightmare (thankfully, that hasn't happened to us yet!). But it's fun to take live questions, talk to viewers, and make our build as watchable as possible while we work on it at a reasonable pace. In my experience, it's been an entertaining challenge—as long as we don't make any glaring errors! If we do, though, we can count on our viewers to let us know immediately.

THE BUILD

After we decided on, ordered, and finally received all the parts, the time came for the actual build. Since this isn't a step-by-step guide on how to build a PC, I'll just detail our experience with these particular parts and our assembly. (The video of this build is available on PCMag's Facebook page for those who want watch how it all went down and maybe try it themselves.)

As opposed to some builds we've done in the past, no one unusual component in this system added a twist or caused trouble. We've installed strange coolers and built in a constraining case, but the parts in this desktop are straightforward. Because of that, I wasn't especially wary going in—but you never know what a build will throw at you.

The case we chose is a big part of keeping things simple, as it's fairly roomy, without many restrictive design flourishes. Removing the tempered glass panels through hand screws was easy, and from there, we had plenty of room to work. There was a moment of hesitation about how to install the power supply—a white shroud covers its install location—but it was simple enough to remove the other side panel and slot it in that way.

Since the PSU isn't modular, its many cables are unwieldy, so we tucked them into the shroud until we were ready for them. Because there's no hard drive in this build, we also removed the drive bay, which was making the cable area a bit cramped.

With the PSU in place, the build resumed normally. I came to appreciate the case the more we worked in it—it was one of the components we splurged on in a budget-conscious build, and I was pleased with the aesthetic and quality in person. Since we and the audience spent so much time looking at it, I was glad it was attractive!

Next, we installed the motherboard, which is admittedly one of the least exciting parts of the build. When you're simply screwing in multiple tiny screws, there isn't much to say, and you start to become very conscious of the entertainment factor.

This is a step the audience had some comments about, though. One viewer stated that we should have installed the motherboard before the power supply. With the case we used, though, it truly made no difference whether we installed the power supply or motherboard first.

People also thought we should have installed components onto the motherboard before screwing it into the tower. Though we've done that in the past, it's not usually necessary—this case provides plenty of room to maneuver inside, so it wasn't difficult to install the memory, CPU, and cooler while the board was already inside. In my opinion, it also helps give a better idea of cabling if everything is already in the case.

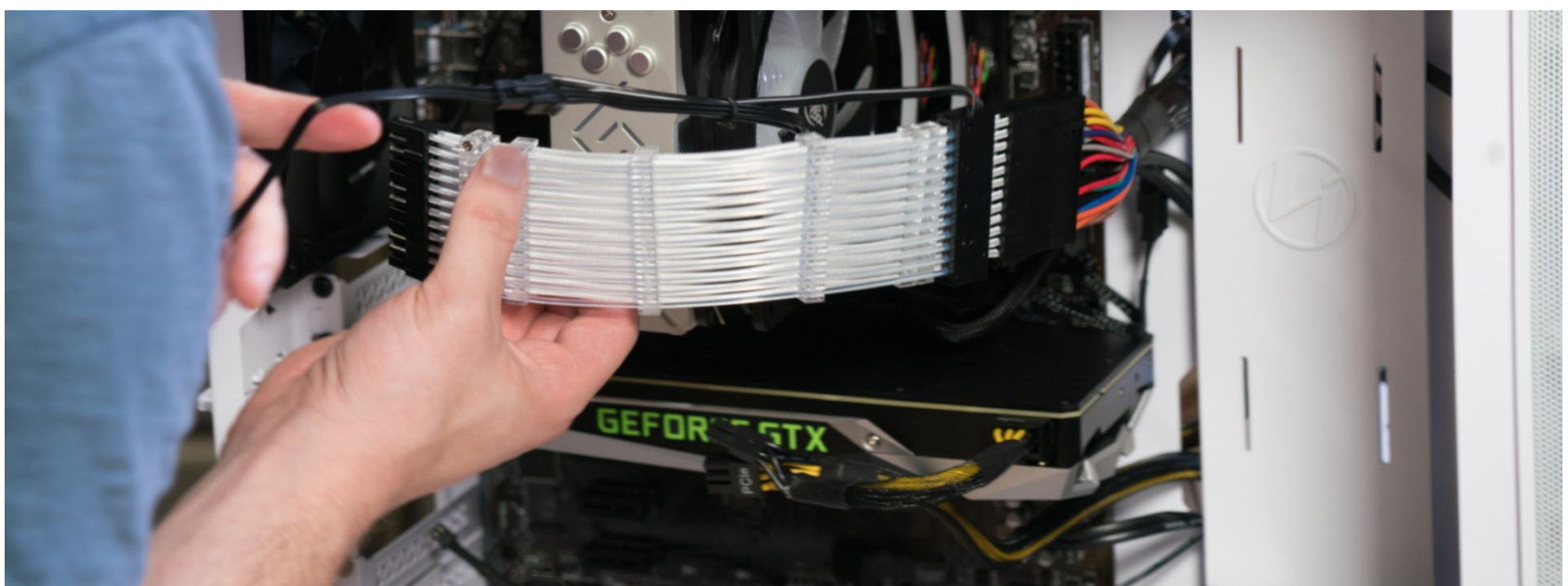


Lian Li's Alpha tower includes a small pedestal for storage, and it was strangely satisfying to mount the SSD to this little metal stand and screw it into the case, propped up like a trophy. The SSD isn't the most eye-catching item, but it gains some celebrity when it's on display like that. Hiding the cables leading up to this lone plinth is a little hard once it's plugged in, but it's a nice touch. The RAM was similarly easy to install, and we wanted to get it in there before it was made difficult to get to by other components.

The component that gave us the most trouble was the CPU cooler. It didn't stump us, fortunately, or stop the build, but it required some trial and error. We used the Deepcool Gammaxx GT RGB, which we had on hand in the office. The Core i5-8400's included stock cooler is adequate for cooling at no additional cost, so you absolutely don't need the Gammaxx, thus its exclusion in the pricing. Since we had it around, though, its RGB-laden logo and fan seemed like a no-brainer inclusion.

We paid for it in effort, though—the Gammaxx isn't an abnormal air cooler, but its bracket orientation was confusing, and we started screwing them in out of order. This had a slight domino effect during the build; we had to backpedal a few steps, and it took longer than it would have otherwise.

With the thermal paste applied, the brackets oriented and screwed in correctly, and the cooler attached, we went about the rest of the build with ease. Slotting in the graphics card is one of the simplest steps, despite its importance, and connecting cables is a somewhat tedious but straightforward process (consult your motherboard manual if need be). The case was helpful for cable management, generally speaking, with an interesting hinged door in the back for hiding and holding them in place. All told, there were enough hidey holes and pass-throughs to tunnel most of the cables through and stash around back before plugging everything in.



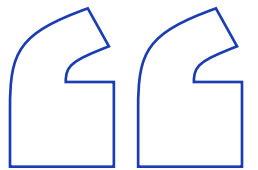
The Gammaxx cooler wasn't our only unnecessary RGB accessory; we installed an even sillier one. Lian Li provided us with its new Strimer product, a 24-pin power cable with colored lighting. It comes in two layers—the white cable itself and a translucent strip of fiber optic lighting that clips on to the top of the cable (it's also connected to the cable by a small wire for power). The 24-pin power cable is plugged into the PSU's motherboard power cable on one end and the motherboard on the other.

The clear lighting is clipped to the top of the cable, facing out to be seen through the case window. When powered correctly, the Strimer's clear clip lights up, changing what is normally a boring (and unsightly) power cable into a cascade of color. It seemed gimmicky at first, but while it's not exactly useful, I actually quite liked the Strimer once the build came to life. It costs another (unnecessary) \$40, if you want to budget it into your plans.

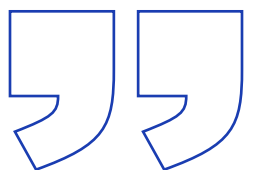
THE MOMENT OF TRUTH

After we connected the cables for the case lighting, fans, and components, we tucked everything away as best we could. From a functionality standpoint, everything looked ready to go, and aesthetically, we managed the cables as much as possible without taking too much time. We were confident, but you're never really sure it will boot up that first time. After screwing the glass sides back in place (the rear panel quietly hiding our cabling sins), we connected our PC to a display and hit the power button.

I was pleased (and, okay, a little relieved) to see the many RGB lights spring to life and the case fans whirr into action. And I was surprised at how good it looked! The lighting on the RAM, cooler, three case fans, and Strimer wasn't synced, but it was pretty striking against the white case. Oh, and the computer successfully booted to BIOS, too. I guess that's important.



**It seemed
gimmicky at
first, but I
actually
quite liked
the Strimer
once the
build came
to life.**





Partially for our own entertainment, we used the remote control to change the fan lights from automatic to a variety of static colors, trying to sync them as well as we could with the cooler (controllable through a physical button, which we accidentally left trapped behind the glass at first) and the Strimer (controlled through a board that sticks out the rear panel). Without any software input, the lights don't exactly match, but they complement each other well enough.

BUILT FOR YOU

The live build took about two hours, including an introduction, conclusion, and pauses to talk or make observations. All considered, that's a decent build time—and it was nearly error free! I'm happy with the build visually, and it's a very solid gaming machine for \$1,000. With the GTX 1070 as its gaming backbone, you're guaranteed well over 60fps in nearly every scenario in HD. And if you intend to play at 1440p, the card is up to the task. We're confident recommending the same parts for anyone looking to build a new PC. If you're pressed for storage, that's an easy upgrade, as long as you can stretch the budget. Whether you're looking to build a similar PC and will use this as a template or just wanted to follow the process, we hope you enjoyed the journey.

FEATURES

WHY SATELLITE INTERNET IS THE NEW SPACE RACE

BY NATHAN HURST



There's a theory (or perhaps a cautionary tale) among astronomers called the Kessler Syndrome, named for the NASA astrophysicist who proposed it in 1978. In this scenario, an orbiting satellite or some other piece of material accidentally strikes another and breaks into pieces. These pieces whirl around the Earth at tens of thousands of miles per hour, destroying everything in their path, including other satellites. It starts a catastrophic chain reaction that ends in a cloud of millions of pieces of non-functional space debris that orbits the planet indefinitely.

Such an event could make an orbital plane functionally useless, destroying any new satellites sent into it and possibly preventing access to other orbits and even all of space.

So when SpaceX filed a request with the FCC to send 4,425 satellites into low-Earth orbit (LEO) to provide a global high-speed internet network, the FCC was reasonably concerned. For more than a year, the company responded to questions from the commission and petitions by competitors to deny the application, including filing an "orbital debris mitigation plan" to allay fears of Kesslerian apocalypse. On March 28, the FCC granted SpaceX's application.

Space junk is not the only thing the FCC is concerned about—and SpaceX isn't the only entity trying to build the next generation of satellite constellations. A handful of companies, both new and old, are leveraging new technology, developing new business plans, and petitioning the FCC for access to the parts of the communications spectrum they need to blanket the Earth in fast, reliable internet connectivity.

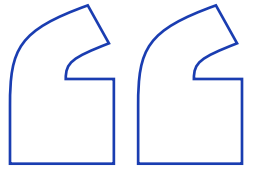
Big names are involved—from Richard Branson to Elon Musk—along with big money. Branson's OneWeb has raised \$1.7 billion so far, and SpaceX president and COO Gwynne Shotwell estimated a \$10 billion price tag for that company's project.

There are big challenges, of course, and a history not exactly favorable to these efforts. Good guys are trying to bridge the digital divide in underserved regions even as bad actors slip illegal satellites onto rocket rideshares. And it's all happening as (or really, because) demand for data has skyrocketed: In 2016, global internet traffic exceeded 1 sextillion bytes, according to Cisco, kicking off the zettabyte era.

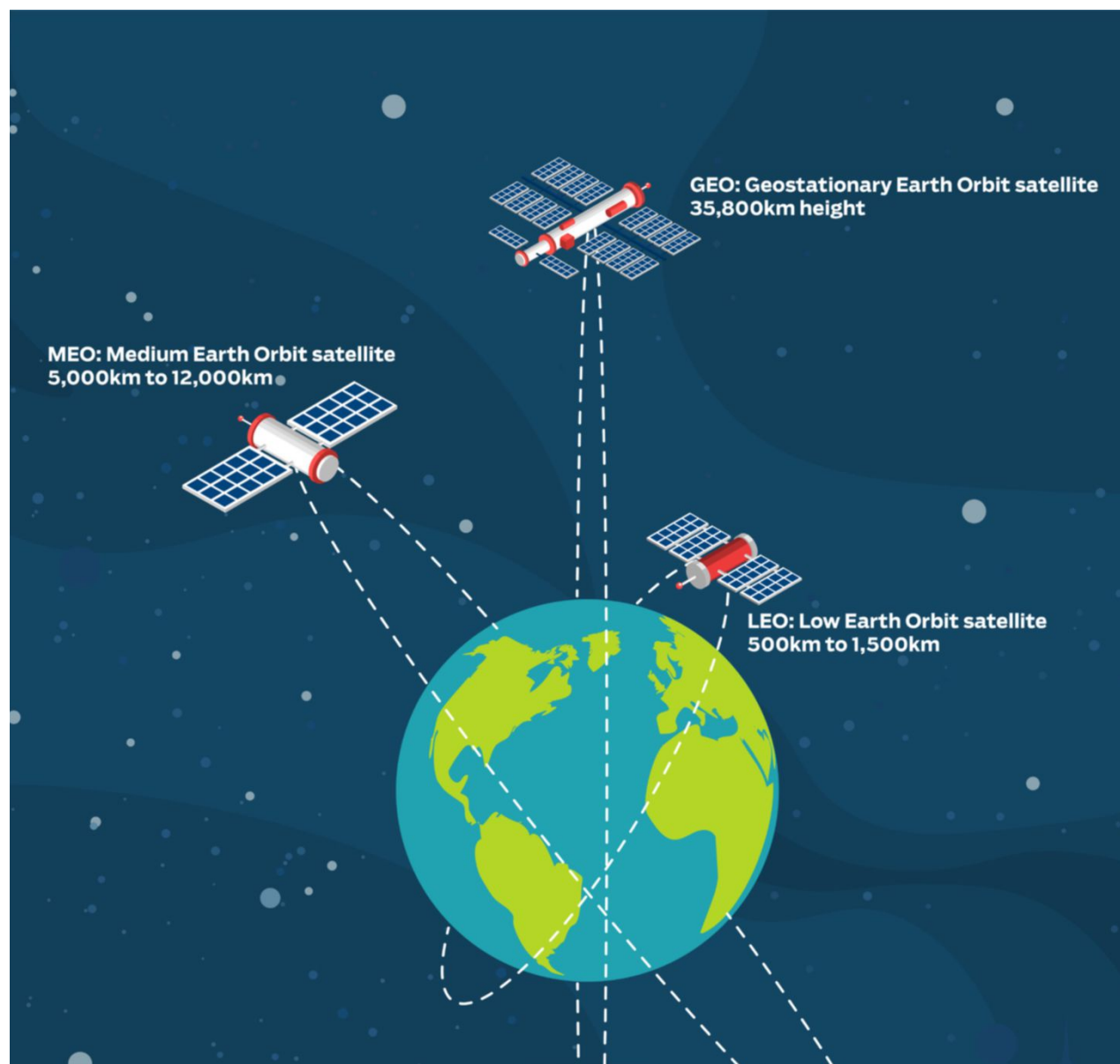
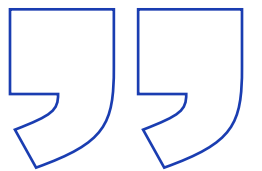
If the goal is to provide (good) internet access where previously there was none, satellites are a reasonable way to achieve it. In fact, companies have been doing this for decades via large geostationary (GSO) satellites that sit in a very high orbit, fixed above a certain point on the Earth. But aside from a few niche applications, including cargo tracking and providing internet to military bases, this kind of satellite connectivity has not been fast, reliable, or responsive enough to be competitive with modern fiber or cable-based internet.

Non-GSOs include MEOs, which operate in medium-Earth orbit from 1,200 to 22,000 miles above the Earth's surface, and LEOs (up to about 1,200 miles). If LEOs aren't all the rage today, at least they're most of it.

Meanwhile, regulations for non-geostationary satellites are decades old and split between agencies within and beyond the US: NASA, the FCC, DOD, FAA, and even the UN's International Telecommunication Union all have skin in this game.



Regulations for non-geostationary satellites are decades old and split between agencies within and beyond the US.



Orbital heights for LEOs, MEOs, and GEOs

There are some big advantages on the technological side, though. The cost to build a satellite has fallen as gyroscope and battery improvements have trickled down from cell phone guts. Launching them has gotten cheaper, too, thanks in part to the smaller size of the satellites themselves. Capacity has risen, inter-satellite communication has made systems faster, and large dishes pointing at the sky are on their way out.

SPACEX STARLINK

On the back of this tech, 11 companies filed applications in the same FCC “processing round” as SpaceX did, each tackling the problem a bit differently.

Elon Musk announced the SpaceX Starlink program in 2015 and opened a Seattle-based division of the company. He told employees there, “We want to revolutionize the satellite side of things, just as we’ve done with the rocket side of things.”

In 2016, the company filed the FCC application, which called for 1,600 (later reduced to 800) satellites to go up between now and 2021, followed by the rest before 2024. These will fly between 1,110km and 1,325km above the ground, circling the Earth in 83 distinct orbital planes. The constellation, as a group of satellites is called, will communicate with one another via onboard optical (laser) interlinks, so that data can be bounced along the sky rather than returning to the ground—tracing a long bridge rather than an upside-down V.



On the ground, customers will mount a new sort of terminal with electronically steered antennas that automatically connect to whichever satellite is currently offering the best signal—similar to the way a cell phone picks towers. Because LEO satellites move relative to the Earth, the system will switch between them every 10 minutes or so. And because thousands will be up there, at least 20 will always be available to choose from, according to Patricia Cooper, VP of Satellite Government Affairs for SpaceX.

The ground unit should be cheaper and easier to mount than traditional satellite dishes, which have to be positioned physically to point at the part of the sky where the corresponding GSO satellite lives. SpaceX described the terminal as the size of a pizza box (though it did not note what size pizza).

The communication will happen within two frequency bands: Ka and Ku. Both appear on the radio spectrum, though at much higher frequencies than anything you'd hear on your stereo. Ka-band is the higher of the two, with frequencies between 26.5GHz and 40GHz, while Ku-band inhabits frequencies from 12GHz to 18GHz. (Starlink has FCC permission to use particular frequencies; typically, uplink from terminal to satellite will be at 14GHz to 14.5 GHz and downlink from 10.7GHz to 12.7GHz, and the others will be used for telemetry, tracking, and control, as well as to connect the satellites to the internet's terrestrial origin.)

Beyond the FCC filings, SpaceX keeps pretty quiet about its plans. And it's hard to tease out technical details, because SpaceX is vertically integrated from the components that go on the satellites to the rockets that get them into the sky. But for the project to be a success, it will depend on whether the service can, as claimed, offer speeds comparable to or better than fiber at a similar price point, along with a reliable experience and a good user interface.

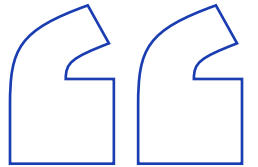
In February, SpaceX launched its first two prototype Starlink satellites. Shaped like cylinders with solar panels for wings, Tintin A and B are roughly a meter per side, and Musk confirmed via Twitter that they were successfully communicating. If the prototypes continue to function, they will be joined in 2019 by hundreds of others. Once the system is operational, the SpaceX will replace decommissioned satellites (and mitigate space debris) on a rolling basis by instructing them to lower their orbits, whereupon they'll fall toward Earth and burn up on reentry.

THE WAYBACK (CIRCA 1996)

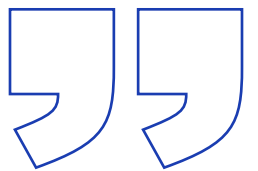
Back in the 80s, HughesNet was the satellite technology innovator. You know the platter-size gray dishes DirecTV mounts on the outside of houses? Those came from HughesNet, which itself came, circuitously, from aviation pioneer Howard Hughes. “We invented the technology that allows us to provide interactive communications via satellite,” says EVP Mike Cook.

In those days, then-named Hughes Network Systems owned DirecTV and operated large geostationary satellites that beamed information down to televisions. Then and now, the company also offered services to businesses, like credit card transactions on gas pumps. Its first commercial customer was Walmart, which wanted to link employees across the country and to its home office in Bentonville.

In the mid-90s, the company built a hybrid internet system called DirecPC: A user’s computer submitted a request via dial-up; it was directed to a web server and completed via a satellite, beaming the requested page down to the user’s dish.



Its first commercial customer was Walmart, which wanted to link employees across the country and to its home office.



Around the year 2000, Hughes began providing its first two-way interactive system. But keeping the cost of the service—including the consumer equipment—low enough that people would buy it was a challenge. To do that, the company decided it needed its own satellites, and in 2007, it launched Spaceway. Though still in use, this satellite was particularly important when it launched, according to Hughes, because it was the first to incorporate onboard packet switching. Its capacity: 10Gbps.

Meanwhile, a company called Viasat spent around a decade in R&D before launching its first satellite in 2008. Called ViaSat-1, the satellite incorporated some new technology, such as spectrum reuse. This allowed the satellite to choose among different bandwidths so it could pump data down to Earth without interference, even when it neighbored the track of another satellite's beam, and then reuse that spectrum in connections that were not adjacent.

It was also faster and more powerful. When it went up, its 140Gbps capacity was more than all of the other satellites covering the US combined, according to Viasat President Rick Baldrige.

“The market for satellites had really been the people that had no choice,” Baldrige says. “If you couldn’t get anything else, it was a technology of last resort. It essentially had a ubiquitous coverage but really, not much data. It had been relegated to things like transactions at gas stations.”

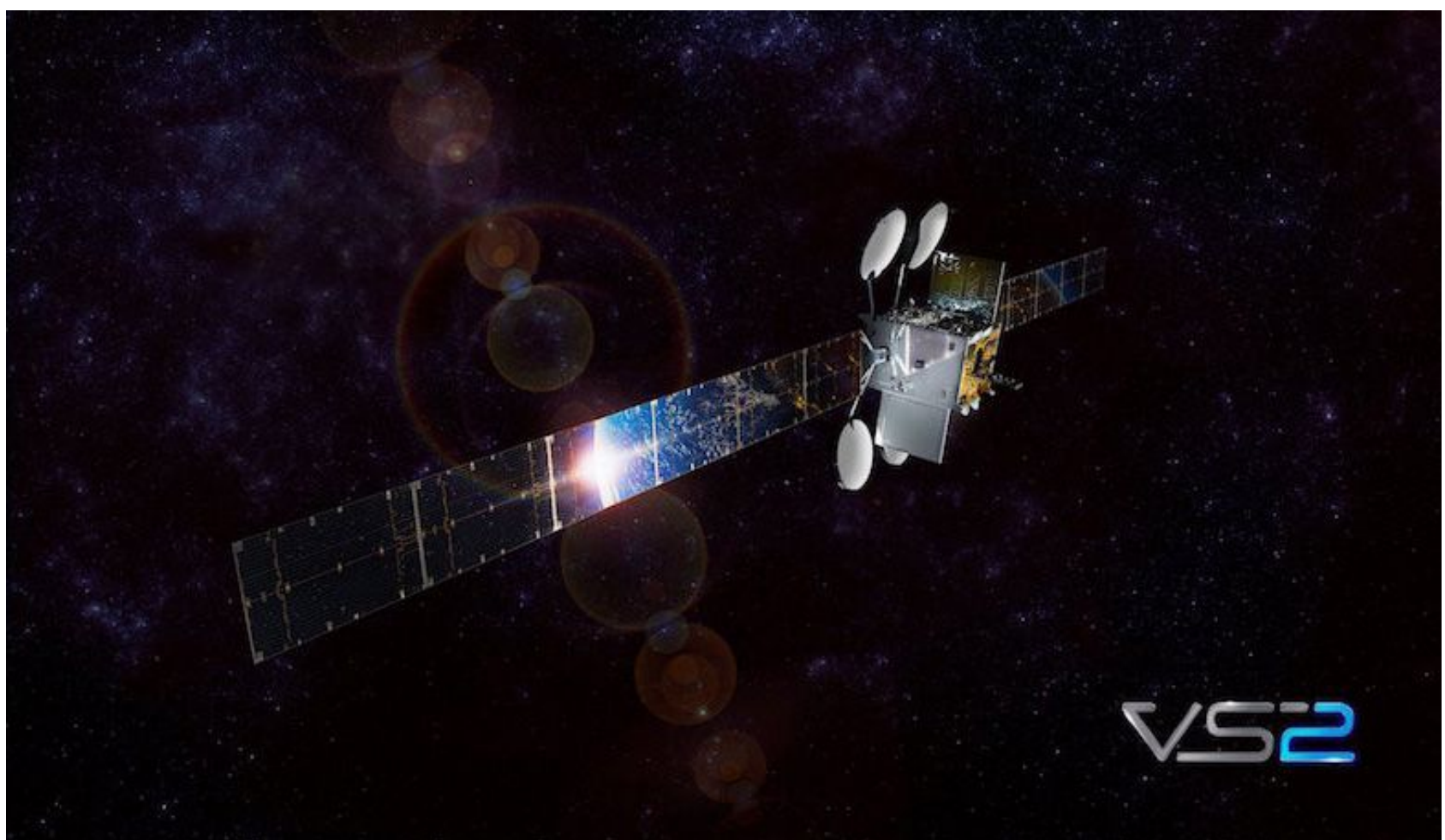


Over the years, HughesNet (now owned by EchoStar) and Viasat put up faster and faster GSOs. HughesNet put up EchoStar XVII (120Gbps) in 2012, EchoStar XIX (200Gbps) in 2017, and plans to launch EchoStar XXIV in 2021, which the company says will offer 100Mbps to consumers.

ViaSat-2 went up in 2017 and now has a capacity of around 260Gbps, and three different ViaSat-3s are planned for 2020 or 2021, each to cover a different part of the globe. ViaSat has said that those three ViaSat-3s combined are projected to have a capacity of a terabit per second, double the capacity of all other satellites circling Earth combined.

“We have so much capacity in space that it is changing the whole dynamic of providing this traffic. There is no inherent limit in terms of what can be provided,” says DK Sachdev, a satellite and telecom consultant who is doing work for LeoSat, one of the companies launching an LEO constellation. “Today, all the things we thought were disadvantages for satellites, one by one they’re shifting away.”

All this speed has come about, not coincidentally, as internet (two-way communication) has begun replacing television (one-way) as the primary service we demand from our satellites.



“The satellite industry is in a very long-time frenzy, figuring out how it will go from predominantly video, to now and ultimately only predominantly data,” says Ronald van der Breggen, chief compliance officer at LeoSat. “There are a lot of opinions about how to do it, what to do, what market to serve.”

ONE PROBLEM REMAINS

There remains one problem: latency. Different from overall speed, latency is the amount of time it takes information from your computer to reach its destination and return. Say you click on a link to a website; that information has to travel out (in this case, up to a satellite and back down), indicate your request, and return the site.

How long it takes the site to download is based on how much capacity the connection has. How long it takes to ping that server and get it started is latency. It's typically measured in milliseconds — not something you'd notice when you're reading PCMag.com but very frustrating when you're playing Fortnite\$59.99 at Humble Bundle and your game lags.

Latency on a fiber system varies based on distance, but it's generally a few microseconds per kilometer. Latency, when you're beaming a request to a GSO satellite, is in the neighborhood of 700ms total, according to Baldrige—light travels faster in the vacuum of space than in fiber, but these kinds of satellites are far away, and it just takes time. In addition to gaming, this is a problem for video conferencing, financial transactions and the stock market, control of the internet of things, and other applications that depend on snappy turnaround.



But how big an issue latency is can be debated. Much of the bandwidth used around the world is for video; once a video is started and properly buffered, latency becomes a non-issue, and throughput is more important. Not surprisingly, Viasat and HughesNet tend to minimize the importance of latency for most applications, though both are working to minimize it in their systems, too. (HughesNet uses an algorithm to prioritize traffic based on what users are looking at to optimize data delivery; Viasat announced an MEO constellation to supplement its existing satellites, which should decrease latency and fill in coverage areas including those at high latitude, where equatorial GSOs have a hard time reaching.)

“We’re really focused on high volume and very, very low capital cost to deploy that volume,” says Baldrige. “Is latency as important as the other features for the market we’re supporting?”

But the point remains; an LEO satellite is still much closer to users. So companies such as SpaceX and LeoSat have chosen this route, with their constellations of smaller, closer satellites, anticipating latency of 20 to 30 milliseconds.

“It’s a trade-off that, because they’re in a lower orbit, you get a lower latency from an LEO system, but you have more complexity in the system,” says Cook. “You have to have at least hundreds of satellites in order to complete the constellation, because they’re orbiting, one’s going over the horizon and disappearing ... and you have to have an antenna system which is capable of tracking them.”

Two episodes before this are worth understanding. In the early 90s, Bill Gates and a few partners invested in a project called Teledesic. It was to use a constellation of 840 (later reduced to 288) LEO satellites to provide a broadband network to regions that couldn’t afford or would never see fiber connections. Its founders talked about solving the latency problem, and in 1994, applied to the FCC for use of Ka-band spectrum. (Sound familiar?)

Teledesic ate up an estimated \$9 billion before it failed, in 2003.

“That idea didn’t work then, but it seems feasible now,” says Larry Press, a professor of information systems at California State University Dominguez Hills who has been tracking LEO systems since Teledesic was new. “The tech was not there by a long shot.”

Moore’s Law and the trickle-down of battery, sensor, and processor technology from cell phones has given LEO constellations a second chance. Increased demand makes the economics look tantalizing. But while the Teledesic saga was playing out, another industry was learning some important lessons about launching communications systems into space. In the late 90s, Iridium, Globalstar, and Orbcomm collectively launched more than 100 satellites into LEO with the purpose of providing cell phone coverage.

“To get the whole constellation up there takes years, because you need a whole bunch of launches, and it’s really expensive,” says Zac Manchester, an assistant professor of aeronautics and astronautics at Stanford University. “In the intervening say, five years or so, the ground-based cell tower infrastructure expanded to the point where the coverage was really good, and it covered most of the people.”

All three companies swiftly descended into bankruptcy. And while each has reinvented itself, offering a smaller range of services for specific applications such as emergency beacons and cargo tracking, none succeeded in supplanting tower-based cell phone service. (In the last few years, SpaceX has contracted to launch satellites for Iridium.)

“We’ve kind of seen this movie before,” says Manchester. “I don’t see anything inherently different about the current situation.”

“
**In the late 90s,
Iridium,
Globalstar, and
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”



THE COMPETITION

SpaceX and the 11 other corporations (and their investors) are betting otherwise. OneWeb is launching satellites this year, with service expected to start next year, and adding several more constellations in 2021 and 2023, with an ultimate goal of 1,000 terabits by 2025. O3b, now a subsidiary of SAS, has a constellation of 16 MEO satellites that has been operational for several years. Telesat already operates GSO satellites but is planning an LEO system for 2021 that features optical links with 30ms-to-50ms latency.

Upstart Astranis also has a satellite up in geosynchronous orbit and will be placing more in the next few years; though it's not addressing the latency issue, the company is aiming to bring costs down drastically by working with local ISPs and building smaller and far cheaper satellites.

LeoSat also plans to launch a first round of satellites in 2019, with completion slated for 2022. These will sail around the earth at 1,400km high, connect to the other satellites in the mesh via optical communication, and beam information up and down in Ku-band. They have acquired the necessary spectrum internationally, says LeoSat CCO Ronald van der Breggen, and expect to receive FCC approval soon.

The quest for faster satellite internet has largely relied on building bigger, faster satellites that can carry more data, says van der Breggen. He calls it “the pipe”: the bigger the pipe, the more internet can gush through it. But companies like his are finding new areas to make improvements by changing the whole system.

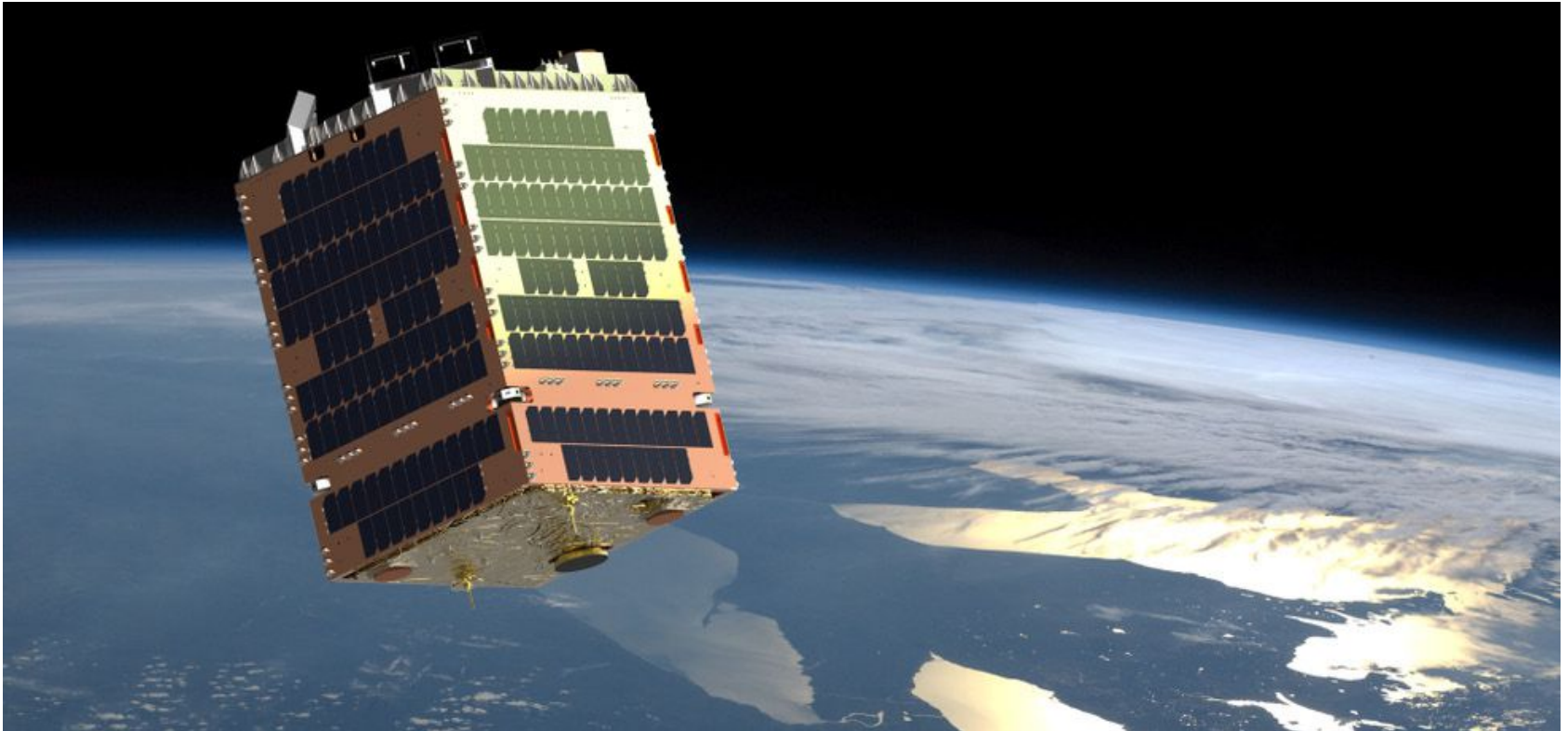
“Imagine the smallest type of network—two Cisco routers and a wire in between,” says van der Breggen. “What everybody in satellites does is to focus on the wire between the two boxes . . . we’re bringing that whole set of three up in space.”

LeoSat is putting up 78 satellites, each about the size of a large dinner table and weighing about 1,200Kg. Built by Iridium, they feature four solar panels and four lasers (one on each corner) to connect to their neighbors. It’s that connection van der Breggen says is most important; historically, satellites would bounce signal in a V shape, from the ground station up to the satellite and then down to the receiver. Because LEO satellites are lower, they can’t project as far, but what they can do is pass data along very quickly.

To understand how this works, it’s helpful to think of the internet as a thing, with a real physical presence. It’s not just data; it’s where that data lives, and how it moves. It’s not just stored in one place; there are servers around the world that hold it, and when you access it, your computer grabs it from the nearest one that happens to have what you’re looking for. Where it is matters. How far away it is matters. Light (a.k.a. information) travels faster in space than in fiber, almost by half. And when you bounce that fiber connection around the face of the planet, it has to take a circuitous route from node to node, with detours around mountains and continents. It winds up taking much longer when the source of the data is far from the consumer, even when you account for the few thousand miles of vertical distance a space-bound signal adds.

Like what van der Breggen describes, the whole industry could be viewed as a progression toward developing a distributed network not unlike the internet itself, just in space. Latency and overall speed are both at play.

While one company’s technology might prove supreme, it’s not entirely a zero-sum game. Many of these companies are targeting different markets and are even helping one another reach the markets they’re after. For some it’s ships, planes, or military bases; for others, it’s rural consumers or developing nations. But ultimately, the companies share a goal: to bring internet where there is none or where it’s insufficient and to do so at a cost that’s low enough to sustain their business model.



“Our view is that this isn’t really a competing technology. We believe that there is a need, in a sense, for both LEO and GEO technology.” says HughesNet’s Cook. “For certain types of applications, like streaming video, for example, a GEO system is very very cost effective. However, if you want to have applications which require low latency ... then LEO is the way to go.”

To wit, HughesNet has actually partnered with OneWeb to provide the gateway technology that manages traffic and interfaces the system with the internet.

You may have noticed that LeoSat’s proposed constellation is smaller than SpaceX’s by nearly a factor of 10. That’s okay, says van der Breggen, because LeoSat intends to serve enterprise and governmental clients and therefore needs to light up just a few specific areas. O3b is selling internet to cruise ships, including Royal Caribbean, and it’s working with telecoms in American Samoa and the Solomon Islands, where wired connections are insufficient.

A small startup from Toronto called Kepler Communications is using tiny CubeSats (around the size of a loaf of bread) to provide “delay-tolerant” data—5GB or more of data in a 10-minute pass, with an emphasis on polar exploration, science, industry, and tourism. According to Baldrige, one of Viasat’s biggest growth areas is in providing internet to commercial airlines; they’ve inked deals with United, JetBlue, and American, as well as Qantas, SAS, and more.

How, then, does this business-first, for-profit model bridge the “digital divide” and provide internet for developing nations and underserved communities, which may not be able to pay as much for it? It has to do with the shape of the system. Because the individual satellites move, an LEO constellation must be evenly distributed around the Earth. The ones that pass out of view inhabit a different part of the sky and are temporarily a sunk cost.

“My guess is, they will have very different prices for connectivity in different nations, and that will allow them to make it affordable in one place, even though it might be a very poor place,” says Press. “Once the satellite constellation is up there, it’s a fixed cost, and if a satellite is over Cuba, and nobody is using it, then any revenue they can get out of Cuba is positive, is free.”

Wherever it may lie, this consumer market may turn out to be the hardest to tap. In fact, most of the success the industry has had so far has been providing expensive internet for governments and businesses. But SpaceX and OneWeb particularly have visions of household customers dancing in their business plans.

To access this market, the user interface is going to be important, Sachdev points out. You have to cover the Earth with a system that is easy to use, effective, and cost-effective. “Covering it by itself is not adequate,” says Sachdev. “What you need is an adequate amount of capacity, but before that, the ability to have consumer equipment that is affordable.”

WHO’S IN CHARGE, ANYWAY?

The two big issues SpaceX had to address for the FCC were how it would share spectrum with existing (and future) satellite communications and how it would mitigate or prevent space debris. The first question falls within the purview of the FCC, but the second seems better suited to NASA or the Department of Defense. Both track orbital objects to help prevent collisions, but neither is a regulatory body.

“There isn’t really a good coordinated policy on what we should be doing with regard to space debris,” says Stanford’s Manchester. “Right now, these people aren’t talking to each other effectively, and there’s no coherent policy.”

The issue is further complicated because the LEO satellites pass over many countries. The International Telecommunication Union performs a role somewhat like the FCC, assigning spectrums; but to operate within a country, a company must receive permission from that country. The important takeaway is that it changes depending on where you are, and so if your satellite is moving like LEO satellites do, it had better be capable of adjusting its communication spectrum.

“Do you really want SpaceX to have a monopoly of connectivity in a given region?” says Press. “Do they need to be regulated, and who can regulate them? They are supernational. The FCC doesn’t have jurisdiction in other countries.”

That doesn’t exactly make the FCC toothless, though. Late last year, a small Silicon Valley startup called Swarm Technologies was denied permission to launch four prototype LEO communications satellites, each smaller than a paperback book. The FCC’s primary objection was that the tiny satellites might be too difficult to track and thus be unpredictable and dangerous.

Swarm sent them up anyway. A launch-services company in Seattle sent them to India where they hitched a ride on a rocket carrying dozens of larger satellites, reported *IEEE Spectrum*. The FCC found out, and now Swarm’s application for four larger satellites remains in limbo, and the company is operating in secret.

For the other new satellite internet companies, and the old ones that are learning new tricks, the next four to eight years will be pivotal—determining whether the demand and technology are here now or whether we’ll see a repeat of Teledesic and Iridium. But what happens after that? Mars, according to Musk, who said his goal is to use Starlink to provide revenue for Mars exploration, as well as to act like a trial run.

“That same system, we could leverage to put into a constellation on Mars,” he told his employees. “Mars is going to need a global communication system too, and there’s no fiber optics or wires or anything.”

How to Create Your Own Successful Podcast

BY TERRY SULLIVAN



My favorite podcast, Fresh Air with Terry Gross, from National Public Radio's WHYY in Philadelphia, has featured many well-known guests, including Ray Charles, Stephen Colbert, Hillary Clinton, and my favorite comedy legend, Mel Brooks. But what draws me in is Gross's warm rapport with her guests. It reminds me, as a journalist, to listen closely to those I interview and ask intelligent, relevant questions.

Today's podcasts aren't all talk shows and interviews; there's a full range of formats. A well-known example is the hit podcast Serial, which tells one long story over the course of a ten-episode season.

It's a great time to experiment, as podcasts are increasingly drawing the attention of media companies. When *The Hollywood Reporter* asked Jim Bankoff, Vox Media's chairman and CEO, which media sectors are experiencing growth, he answered, "Podcasting. We're having enormous success with Today Explained, which is a real hit out of the gate."

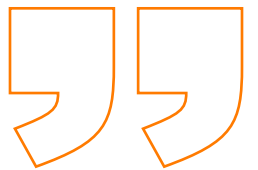
Looking to get into this expanding and potentially lucrative medium? We've done the homework to help you get started.

WHAT IS A PODCAST?

At its most basic, a podcast is simply a digital audio program or recording, similar to a radio or television show, that can be downloaded from the internet or made available to and accessed from various mobile devices. As with most media in the digital age, the format, structure, and content of a podcast often resemble the older analog medium, the broadcast-radio program. Podcasts, like radio, are often created serially and post new episodes regularly.



The format, structure, and content of a podcast often resemble the older analog medium, the broadcast-radio program.



There are important distinctions, though. For starters, the notion of time is different for podcasts: Each listener is in control of when (and on which device) to listen to a podcast, as opposed to radio and television, which run shows at specific times. Additionally, you can make your podcast episode any length you want—five minutes or five hours. As a podcaster, you're in control.

TYPES OF PODCASTS

There are a number of formats you can choose for your podcast. Consider which type is best for presenting your content.

Interview: Like the Fresh Air podcast, this is the most common format. It most often features one host who introduces and interviews guests. A great example of this is Fast Forward with Dan Costa, which features one-on-one discussions with leaders in technology and business. An offshoot of this type is a panel-discussion or roundtable format, with a host who leads the conversation.

Monologue: The commentary-style podcast is built around one personality, which gives the show one voice or a single point of view. Lore, which focuses on the frightening history behind common folklore and told in almost a campfire-like style, is a wonderful example of a solo-style podcast.

Multiple hosts: In this format, the podcast is divided up between several different people, or two or more cohosts share leading the show. For instance, Pardon My Take is a raucous comedic sports podcast featuring two cohosts, Dan “Big Cat” Katz and PFT Commenter (Pro Football Talk Commenter).

Narrative: Unlike the first three, this storytelling style of podcast focuses on how the content is presented. In many ways, this type has fueled the popularity of podcasting recently. And while some of the previously mentioned podcasts, like Lore, could fit here as well, many narrative podcasts have a decidedly linear quality, and generally don't change to another topic or segment. This can be either non-fiction, such as This American Life and Serial, or fictional, such as The Message and Flash Forward.

Mixed: This hybrid format uses various elements of the other four content types. It also may repurpose content from other mediums, such as radio or television.

HOW TO TELL IT'S A PODCAST

Several online-media formats that feature audio resemble one another but aren't all technically podcasts.

Podcast: As defined above, a digital file that focuses on audio content and can be downloaded from a website or the cloud.

Video podcast: Sometimes called a “vidcast,” it’s similar to a podcast but includes a visual component, which might be a slideshow of still images or actual video.

Webcast: The distinguishing factor for webcasts is that they generally include live segments.

Vlog: A vlog, or video blog, uses a blog-style format (the most up-to-date episode is shown first) but presents the content in a video format (on a platform such as YouTube).

For more on podcast types, podcast strategy, news, and more, see these online resources:

The Podcast Host [<https://www.thepodcasthost.com>]

Podcasters’ Roundtable [<http://podcastersroundtable.com>]

Podcasting Tools [<http://podcasting-tools.com/what-is-podcasting.htm>]



Podcast Insights [<https://www.podcastinsights.com>]

Hotpod online newsletter [<https://hotpodnews.com/about>]

Creating a Podcast Strategy [<https://www.econsultancy.com/blog/69745-creating-a-podcast-strategy-five-tips-for-brands>]

10 Tips on How to Create a Remarkable Podcast [<https://writtent.com/blog/10-genius-tips-on-how-to-create-a-podcast-your-prospects-love/>]

THE PODCAST EQUIPMENT YOU'LL NEED

Improvements in hardware and software technology have dramatically changed the way podcasts are developed, created, produced, and publicized.

Additionally, laptops, desktops, tablets, phones, and other devices are equipped with more powerful processors and other features that make creating podcasts easier to create and post. There are even new, inexpensive ways to make sure your environment helps you attain the best quality audio.

AUDIO HARDWARE

Your budget will be the biggest factor in determining what equipment you buy. You'll also need to figure out how extensive your recording rig has to be: If you aren't tied to recording in a particular location, you can build a setup that lets you record and edit in one room or even part of a room. But if you need to record in the field, you'll likely need additional gear.

Determining what's essential and what's optional will be different for each podcaster. The following list gives you an idea of what you need to get started.

Microphones: The microphone is the most important piece of equipment for podcasters, since it's responsible for reproducing the voices you'll create on the show. You'll find a wide variety of mics at all kinds of prices.

Condenser vs. dynamic mic: Podcasters have a choice of two main types of microphones, dynamic or condenser. Historically, dynamic microphones were more rugged and didn't pick up as much ambient noise as condenser mics; the latter are generally more sensitive and produce a higher output. Condenser mics can be great for studios, but may pick up too much ambient sound for field use. Dynamic mics may hide some pops or noise from the wind, but may not be as detailed in producing audio.

USB vs. XLR mic: If you're looking to use only one microphone via a computer and you're on a tight budget, a USB mic is a great choice: A preamp and A/D converter are built into the mic itself. In fact, you just have to plug it into your computer and fire up your DAW (digital audio workstation). XLR mics, which carry an analog signal, offer a wider choice of models, but they need an audio interface to connect with a computer.

Models:

The Yeti by Blue, \$129, a very popular, well designed USB mic
[<https://www.bluedesigns.com/products/yeti/>]

The Shure SM58-LC Cardioid Dynamic Microphone, \$99, is a durable SXL style mic [<http://www.shure.com/americas/products/microphones/sm/sm58-vocal-microphone>]

Headphones: There's a vast array of headphones on the market, and they can range widely in price, from \$20 for a cheap pair of earbuds to more than \$2,000 for certain Sennheiser and Audeze models. Here are a few things to consider before you invest in a pair for podcasting:



Quality and comfort: It's important that you get the best-sounding headphones that you can afford, since you'll be using them to monitor your audio in real-time and to listen to playback of your show. But you'll want to make sure that they're comfortable, too. Research reviews online to find both quality and comfort.

Type and design: For podcasting, an over-the-ear closed design is most suitable, since it prevents audio from leaking out from the earcup and being picked up by your microphone.

Wireless and noise-canceling: Many new models on the market are wireless and include noise-canceling features. In some cases, such as working in the field, a pair of wireless headphones is useful, particularly if you're using a mobile device. But for podcasting, active noise canceling may cause problems—particularly when you're conducting an interview in the studio, since it can produce slightly distorted live audio and be distracting when you're trying to carry on a conversation. If your headphones include this feature, turn it off.

Price: Do research to find the best price for the quality and features you need. You should be able to find an over-the-ear pair for \$200 or less.

Models: Here's are two over-ear models to consider for your podcasting needs. The Sennheiser HD280 Pro (\$99) has been around for a while but is still a great model for the price. [[URL: <https://www.pcmag.com/article2/0,2817,1828798,00.asp>]] If you're looking to go wireless, consider the Bose QuietComfort 35 II, \$350 [[URL: <https://www.pcmag.com/review/356392/bose-quietcomfort-35-ii>]]

Laptop and Desktop Computers, Audio Interfaces, and Mixing Boards: There's a lot of variation in price points on all the following gear. Research to get the right system or device for you.

Laptop or desktop computer: All laptops and desktops (both Macs and PCs) give you the ability to record, edit, and produce your podcast. PCMag.com provides great reviews on computers to help you search. But the DAW (digital audio workstation) software you plan to use may influence whether you go with

a Mac or a PC.

Audio interface and mixing boards: If you're not using a USB microphone, you'll need to set up an audio interface on your computer, to convert the analog audio signal from your XLR microphone into a digital signal. In the past, audio interfaces used FireWire, but almost all now connect via USB. Prices start at around \$100. You can buy really elaborate ones, but for podcasting, you can expect to spend between \$100 and \$300. You'll most likely need a mixing board, too, particularly when you have more than one person participating in the podcast. For more on what mixer you might want with your set up, check out the following websites:

- Best Audio Mixers For Podcasting & Music (w/ USB Interface) 2018
[<https://www.podcastinsights.com/best-audio-mixers/>]
- 10 Reasons You Should Get a Mixer for Podcasting
[<https://theaudacitytopodcast.com/10-reasons-you-should-get-a-mixer-for-podcasting-tap124/>]

Accessories: A pop filter can make an important difference in your audio quality: It's a screen that fits in front of your mic and prevents air from making popping sounds on your audio. You'll also want to invest in well-designed mic stands for your studio. When you're in the field, be sure to bring along good-quality backpacks and cases to protect your audio equipment from the elements. And there are some great mobile accessories that let you maximize and even improve the audio quality of your phone or tablet, such as tiny mics



and audio interfaces designed specifically for mobile devices. Last, when you're recording in the field or on location, a portable audio recorder is very useful.

Soundproofing: Another important aspect to recording audio for your podcast is to have a proper audio studio, which should be soundproofed. Professional setups can cost thousands of dollars, but you can also create a budget version. Here are some ideas and links to resources to get your rooms soundproofed properly.

- Do I Need Soundproofing For My Podcast? [<https://www.theshanman.com/blog/do-i-need-soundproofing-for-my-podcast>]
- How to Create a Good Recording Environment [<http://talesuntoldmedia.com/good-recording-environment/>]

SOFTWARE, MOBILE APPS, AND PODCAST HOSTING SERVICES

Software for audio editing: To record your podcast properly on your computer, you'll need DAW (digital audio workstation) software, such as Propellerhead's Reason or Avid Pro Tools, which can cost from around \$100 to over \$600. For Adobe Audition, you need a subscription, which can cost \$20.99 a month (although Adobe often runs special offers). Make sure to check our reviews in "The Best Audio Editing Software of 2018."

For podcast newbies, it's a good idea to download one of the most popular (free) audio apps: Audacity, a versatile two-track editor that includes lots of online tutorials. Garageband software, which comes free on all Mac computers, is also a great option. You can record audio, edit it, adjust tonal qualities, add effects to make it fuller, and perform many other podcasting tasks. You



Professional studio setups can cost thousands of dollars, but you can also create a budget version.



can also import audio clips, including audio you've captured on an external audio recorder, your tablet, or your phone.

Mobile apps: Another option is to use an app to create your podcast. Apple iPhone and iPad owners get Garageband for free, as Mac owners do. As for Android, Pocket Casts (\$3.99) is a fine choice for using your Samsung or LG phone to create a podcast.

For more on getting started with DAWs and audio editing:

- How to Record and Edit a Podcast with Audacity [URL: <https://theaudacitytopodcast.com/tap060-how-to-record-and-edit-a-podcast-with-audacity/>]
- GarageBand: Podcasting [URL: <https://www.lynda.com/GarageBand-tutorials/Podcasting-GarageBand/495274-2.html>]
- Apple's Best Practices in Creating Podcasts [URL: https://help.apple.com/itc/podcasts_connect/#/itc2b3780e76]
- Creating Podcasts with Adobe's Audition–Setup: [URL: https://helpx.adobe.com/audition/using/creating-podcasts.html#recording_setup]

Podcast Hosting

Once you've produced the audio file for your podcast, you'll need to transfer it to a hosting service, so you can get your podcast listed in various directories (iTunes, Stitcher, and so on). This will also generate an RSS feed—important for getting your podcast noticed. Quite a few podcast-hosting services are available;



many offer free trials or free tier options. Well-known services include Libsyn, SoundCloud, BuzzSprout, and Fireside, but others are worth a look. For more, check out the following articles:

- Top 13 Podcast Hosting Sites In 2018 + Free Month Offers [<https://medium.com/@PodcastInsights/13-of-the-best-podcast-hosting-sites-for-2017-cc6df2538611>]
- How to get an Amazon Alexa Skill for your Podcast [<https://www.thepodcasthost.com/websites-hosting/how-to-get-an-amazon-alexa-skill-for-your-podcast/>] This blog post shows you one way of getting an Amazon Alexa skill so listeners can access your podcast via an Amazon Echo speaker, or other Amazon product that includes the Alexa voice service.

TIPS FOR CREATING SUCCESSFUL PODCASTS

Although it's a great time to start podcasting, you should realize that the landscape is competitive, no matter how niche your market is. And podcasts take a lot of time and effort. So don't be discouraged if you've created your dream podcast, but no one's listening yet. There are many things to learn—and most of those lessons come through trial and error. Here are some tips to help you keep inspired:

Keep your podcast focused. While it might be tempting to create a podcast that's all things to all listeners, successful shows tend to have a narrow, focused topic.

Picture your target audience. When writing or producing content, it's helpful to think about the type of audience you're trying to reach with your podcast. Many marketers set up buyer personas, which are fictionalized models of ideal customers. You can develop such models to help you craft your content.

Be consistent. If you want to be taken seriously, post episodes of your podcast regularly and consistently.

Plan your workflow. Should you write a detailed script or simply ad lib? It could work best to have a little of both, but that depends on the podcast. Either way, you'll need some sort of workflow to develop your ideas and bring them to fruition. At the very least, be sure to sketch out the major themes of each show and know your subject thoroughly. When you have multiple voices that you're

interacting with on each show, be sure everyone is comfortable with the process and with how casual or detailed the script needs to be. For more advice, see Planning Your Podcast Script: <https://blog.spreaker.com/2017/12/06/planning-podcast-script/>

Use music segments, but don't infringe on copyrights. Add good intro and outro music to your podcast, but make sure you aren't infringing on anyone's copyright.

Promote your podcast. Once you have your podcast posted on your host service, it's imperative that you promote it. The following articles and websites provide some ideas for you to get your podcast noticed, along with some ways to find out how successful your podcast is:

- 101 Tactics To Promote Your Podcast (The Definitive Podcast Marketing Guide) [<https://www.forbes.com/sites/jaysondemers/2017/08/15/101-tactics-to-promote-your-podcast-the-definitive-podcast-marketing-guide/#4c992b754cda>]
- Hyper Syndication from Lynda.com: Getting Your Podcast on as Many Devices and Screens as Possible [<https://www.lynda.com/Video-tutorials/concept-hypersyndication/508538/567419-4.html>]
- Using social media to promote your podcast [<https://www.entrepreneur.com/article/284274>]
- 4 Ways to Measure Podcasting Success [<https://www.cision.com/us/2015/08/4-ways-to-measure-podcasting-success/>]



Podcast Resources

The following are some helpful resources you can check to help you get started, solve a problem, and keep you inspired as you try to create your podcast:

Some Great Podcasts

- Fresh Air [<https://www.npr.org/podcasts/381444908/fresh-air>]
- Serial [<https://serialpodcast.org>]
- This American Life [<https://www.thisamericanlife.org>]
- The Daily [<https://www.nytimes.com/podcasts/the-daily>]
- WTF with Marc Maron [<http://www.wtfpod.com>]
- Planet Money [<https://www.npr.org/podcasts/510289/planet-money>]
- Anatomy of Next [<https://foundersfund.com/anatomy-of-next>]
- Seth Godin's Startup School [<https://itunes.apple.com/us/podcast/seth-godins-startup-school/id566985370>]
- Lore [<http://www.lorepodcast.com>]
- Pardon My Take [<https://itunes.apple.com/us/podcast/pardon-my-take/id1089022756>]
- LifeAfter /The Message [<https://itunes.apple.com/us/podcast/the-message/id1045990056>]
- Flash Forward [<https://www.flashforwardpod.com>]
- Studio 360 With Kurt Andersen [<https://www.npr.org/podcasts/381444899/pri-studio-360>]

Select Websites on Podcasting

- Audio Journalism: Searching for Free Podcast Advice? Welcome to 'The Masterclass' [<https://www.poynter.org/news/searching-free-podcast-advice-welcome-masterclass>]
- Reveal: A sonic memorial to the victims at Orlando's Pulse nightclub [<https://www.revealnews.org/blog/a-sonic-memorial-to-the-victims-at-orlandos-pulse-nightclub/>]
- Journalist's Toolbox [<https://www.journaliststoolbox.org/category/podcasting>]
- Please, Please, For The Love Of God: Do Not Start a Podcast [<http://thoughtcatalog.com/ryan-holiday/2016/10/please-please-for-the-love-of-goddo-not-start-a-podcast>]

Legal Issues

Other aspects you'll want to be aware of include the legalities of creating and running a podcast. To get up to speed, take a look at the following resources:

- Podcasting Legal Guide [https://wiki.creativecommons.org/wiki/Podcasting_Legal_Guide]
- Podcasting Legal Issues: How to Avoid Infringement with Your Podcast [<https://www.creativelive.com/blog/podcast-legal-issues>]
- Podcast Guest Release Form [https://app.convertkit.com/landing_pages/66941]

Forums

- /r/Podcasts—Reddit [<https://www.reddit.com/r/podcasts>]
- Google Podcasters [<https://plus.google.com/communities/102333709604116814839>]
- Blubrry Community Group [<https://forum.blubrry.com/index.php>]

Books

- “Sound Reporting: The NPR Guide to Audio Journalism and Production,” by Jonathan Kern [<https://shop.npr.org/products/sound-reporting>]
- “Out on the Wire: the Storytelling Secrets of the New Masters of Radio,” by Jessica Abel
- “Copywriting for Podcasters: How to Grow Your Podcast, Brand, and Business with Compelling Copy,” by Laura Petersen

How to Build a Raspberry Pi–Powered Retro Video Game Console

BY WILL GREENWALD



If you like to play retro video games, you have options. You can find plenty of older games ported to newer systems and the PC (the Nintendo Switch is great for Neo Geo games, though oddly not for NES and SNES games). You can get a first-party classic game system, like the SNES Classic Edition. You can get a cartridge-playing retro game system, like the Super Retro Trio+. You can even find an original classic game system and plug it into your TV's legacy video connectors or into an analog-to-HDMI upconverter.

You can also build your own emulation-based retro game system with a Raspberry Pi. It's inexpensive, powerful, and easier to set up than you might think. All you need is a Raspberry Pi board, a microSD card, a micro USB power adapter, and a case to put it all in. And, of course, some form of game controller. Thanks to the developers of open-source software RetroPie, the LibRetro emulation API backbone, and the EmulationStation front-end, turning a \$35 computer board into every video game system made before 2000 is (relatively) fast and easy.

You don't need to solder anything, or write any code, or even deal with command lines unless you really want to. There are plenty of options to explore and menus to dive into, though, so you should have some computer savvy before you begin. If you aren't afraid to poke around computer settings, you'll be fine.

THE HARDWARE

To start, you need a Raspberry Pi board (Raspberry Pi is a series of inexpensive ARM-based microcomputers designed for education and experimentation). This will serve as the core of your retro game system; everything else will feed the Raspberry Pi data, power, or input/output capabilities.



“Turning a \$35 computer board into every video game system made before 2000 is (relatively) fast and easy.”

There are several different versions of Raspberry Pi. For video games, we recommend the most advanced model, the Raspberry Pi 3 Model B+. It has the fastest processor of all the Raspberry Pi boards and includes wireless features such as Bluetooth and dual-band Wi-Fi. Don't worry about a premium price for the premium Pi; it's just \$35.

On its own, the Raspberry Pi doesn't come with a power supply, so you'll need your own. Any micro USB power supply that can output 2.5A should work, and the official power supply costs just \$11. Don't skimp here; even if you can power on the Raspberry Pi with your phone charger, the inconsistent current can lead to glitches and poor performance.

The Raspberry Pi doesn't have any onboard storage to speak of, so you'll also need a microSD card. Again, this is not a big investment: The RetroPie software doesn't take up a lot of space, and most older games aren't particularly large, so you don't need a huge card. You can get by on a 16GB microSD card, but we recommend at least a 32GB card just to be on the safe side. You can pick one up for around \$11.

Finally (for the device itself), you need a place to put the Raspberry Pi. It ships as a plain computer board, and it will run just fine naked, but you should really get some sort of plastic shell to protect it from dust, moisture, and getting knocked around. Raspberry Pi cases are cheap and plentiful. And you can even find Raspberry Pi starter sets that include the board, the power supply, a case, and, usually, a memory card, all in one bundle.

Want to get fancier? You can 3D print a Raspberry Pi case, choosing from a slew of creative models on Thingiverse and other 3D printing sites. You can also order cases separately, with options for creative or nostalgic designs, like the very NES Classic–like Retroflag NESPie. These cases run from \$10 to \$25, bringing the total price for your retro game system to, at most, around \$90.

NECESSARY ACCESSORIES

You also need a game controller. RetroPie is robust in terms of controller compatibility, and if you have a PlayStation 4 or Xbox One, you can use their controllers easily. You can also order retro-style game controllers, with or without analog sticks, wireless connectivity, or other features, from manufacturers including Retro-bit and 8Bitdo.



You should have a keyboard on hand. It generally won't be necessary, but it will help if you want to navigate system menus or change settings on your retro system.

One final detail: You should get a standard USB drive. Any size (bigger is better), any design, any speed. It's the easiest way to put games on the console.

STEP ONE: PREPARE THE OS

Physically putting the system together is the easy part, but without an operating system, you can't actually do anything with it. That's where RetroPie comes in. It's a Raspberry Pi-friendly Linux distribution with a compatible version of LibRetro's RetroArch software overlaid on top, set to automatically jump into the emulation software you want to use without dealing with a lot of Linux command lines on your end.

To start, install the free software 7-zip and Etcher. These will let you put the RetroPie software on your microSD card without requiring any typing or complex commands.

Download

Pre-made images for the Raspberry Pi

The latest pre-made image of RetroPie is v4.4 – released April 14, 2018.

Contributions to the project are appreciated, so if you would like to support us with a donation you can do so here.

[Donate](#)

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 - 2.2 Debian / Ubuntu on a PC
 - 2.3 Ubuntu on an ODroid-C1/C2
 - 2.4 Ubuntu on an ODroid-XU3/XU4
- 3 PetRockBlock Downloads

If you are installing RetroPie for the first time please follow the [OFFICIAL Installation Guide](#)

Click button to download

[Raspberry Pi 0/1](#)

md5sum: 57922a62f18f4bc4df198c35a3c1a6ed

[Raspberry Pi 2/3](#)

md5sum: 56988addb60361a2257a61c69d9fcec

Go to the RetroPie website and download the latest version of the software. Make sure you get the version for the Raspberry Pi 2/3. It will download as a single IMG.GZ file, around 700MB. Use 7-zip to unzip the file to an IMG.

Put the microSD card in your computer. You'll need a reader if your computer doesn't have an SD card slot, or if your card doesn't come with a microSD-to-SD adapter. Don't touch anything on the card, and don't drag any files onto it. To turn this card into a functional RetroPie installation, you need to write a full disc image onto the card.

Open Etcher and select the microSD card drive and the IMG file that you unzipped. Click Start, and the software formats the card properly and writes the disc image to it.

When this is done, Windows might prompt you to format the card in order to use it. Don't do that! It's ready for the Raspberry Pi now, so simply take it out of your computer.



When this is done, Windows might prompt you to format the card in order to use it. Don't! It's ready for the Raspberry Pi now.





STEP TWO: BUILD THE BOX

This can look like a daunting task, because you need to work with a bare circuit board, but it's direct and easy. Unless you're using accessory boards to build complicated custom devices, Raspberry Pis are effectively one-piece and plug-and-play.

First, take the microSD card you wrote the RetroPie disc image to and insert it into the board's microSD card slot. Some Raspberry Pi cases offer easy access to the slot, but just in case, it's easiest to insert the card before you install it, unless you're planning on juggling multiple cards with different disc images (a viable plan for Raspberry Pi users).

Second, screw the Raspberry Pi board into your case, which should come with compatible screws. If you 3D print your own, check what screws are needed. Then close up the case, probably with a few more screws.

Attach an HDMI cable, a game controller, and your keyboard into the appropriate ports. Connect the HDMI cable to a TV or monitor.

That's it! Your box is built.

STEP THREE: TURN IT ON (AND SET UP THE CONTROLLER)

When everything's ready, plug the power adapter into the wall to power on the Raspberry Pi. If you use an optional power switchboard or a case with a built-in power switch, press or flip the switch to turn it on. Without a separate switchboard, the Raspberry Pi powers on as soon as you plug it in.



This manual calibration helps make sure that buttons do what they should be doing.

It might take a few minutes to set everything up the first time. The screen should display a startup process, showing Linux commands getting executed before the RetroPi logo appears.

The system prompts you to set up your gamepad, which should be plugged into one of the Raspberry Pi's USB ports. Follow the instructions to map your controller's inputs to the appropriate commands on the system. This manual calibration helps make sure that buttons do what they should be doing in RetroPi's Linux environment. Don't worry if you press the wrong button; you can reconfigure your controller afterward and have a keyboard as a backup input method if you really need to reset things.

When everything is set up, the RetroPie main menu appears. You can't do much from here now, but if you want to look through the different settings menus, feel free (be careful before making any changes).

Before we move on to the next step, plug your USB drive into the system and wait a minute. Then pull the drive out.

Press the button you configured as Start on your gamepad, select Quit, and shut down the Raspberry Pi. It's important to run through the shutdown process before you turn off or unplug the system; it's just like a regular computer that way.

STEP FOUR: LOAD THE GAMES

RetroPie can play games from several dozen classic computers and game consoles, thanks to LibRetro's back-end. You can play NES, SNES, Game Boy, Sega Genesis, PlayStation, Neo Geo, and even Atari Jaguar and Virtual Boy games, if you can find them.

We can't tell you how, because that's very much a legally gray-to-black area. But if you have a method of pulling game images from your own cartridges, you can put them on the RetroPie easily, putting your entire classic game collection into a tiny box.

You can also play older computer games on the RetroPie, which has many more options for legitimate imaging and importing. Classic DOS games, for example, can be purchased on GOG.com. GOG configures DOS games to run in Windows using the DOSBOX emulator, but the games themselves are completely intact and can be put on the RetroPie.

Besides PC/DOS, RetroPie supports systems including the Commodore 64, MSX, and ZX Spectrum. If you have your original game disks and a drive that can read them, you can use them to create disk images that can be played by RetroPie.



I told you to put your USB drive in the RetroPie system and then take it out to set up the drive for games. RetroPie detects any USB drives you plug in and adds the appropriate folders for all of the game systems it supports. When you plug the drive back into your computer, it should have a new retropie folder. Under that will be three folders: BIOS, configs, and roms.

BIOS is for the system files required by certain emulators. Like game roms, we can't tell you where to find them, but they aren't necessary for every platform.

Configs holds individual emulator configurations. This can be useful if you need to tweak settings, but you don't need to touch them right now.

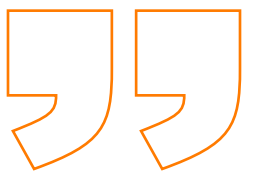
The Roms folder is where the games go. Every supported platform your retro system can currently play will have its own folder. Not every available emulator is installed on RetroPie by default, so if you want to play something really esoteric, you'll need to tell RetroPie to install it first. The most common systems should be available, though.

Whatever game roms or executables you want to play, and however you get them, put the files in their respective folders.

When your USB drive is full, take it out of your computer and plug it into your retro system. Turn the system back on and wait. RetroPie will automatically copy everything from the retropie folder on your drive to the microSD card—and depending on how many games you want to put on it and how big the files are, it can take a few minutes to transfer everything. Unless your USB drive has a read/write light on it, you won't get any indication when it's done, so you might want to get some coffee or something.



**RetroPie
detects any
USB drives you
plug in and
adds folders
for all of the
game systems
it supports.**



After a good wait, pull the USB drive out. Press Start, select Quit, and choose Reset Emulationstation. This will refresh RetroPie's interface and display any games copied to the system.

STEP FIVE: START PLAYING

Now you can play your games. RetroPie organizes the games added to its library onto individual menu screens for each system. Pressing left or right on the gamepad flips between the game libraries of any console or computer RetroPie supports, as long as you uploaded games to it. Empty libraries won't show up, so if you see only the RetroPie screen and can't go to individual systems, repeat step four.

Select a game and press the button you mapped to A to start it. RetroPie will load the relevant emulator and start running the game. From here, any console or handheld game and any computer game that supports gamepad controls should simply work with your controller, since you already mapped the buttons on it.

When you're done playing a game, hold the Hotkey Toggle button (usually Select, depending on how you set up your controls) and press Start. This is the hotkey combination to quit your game and go to the main menu. You can also hold down the Hotkey button and press the right shoulder button to save your game state, or press Hotkey and the left shoulder button to load your game state. The RetroPie Configuration page explains all the hotkey combinations you can use, by default.

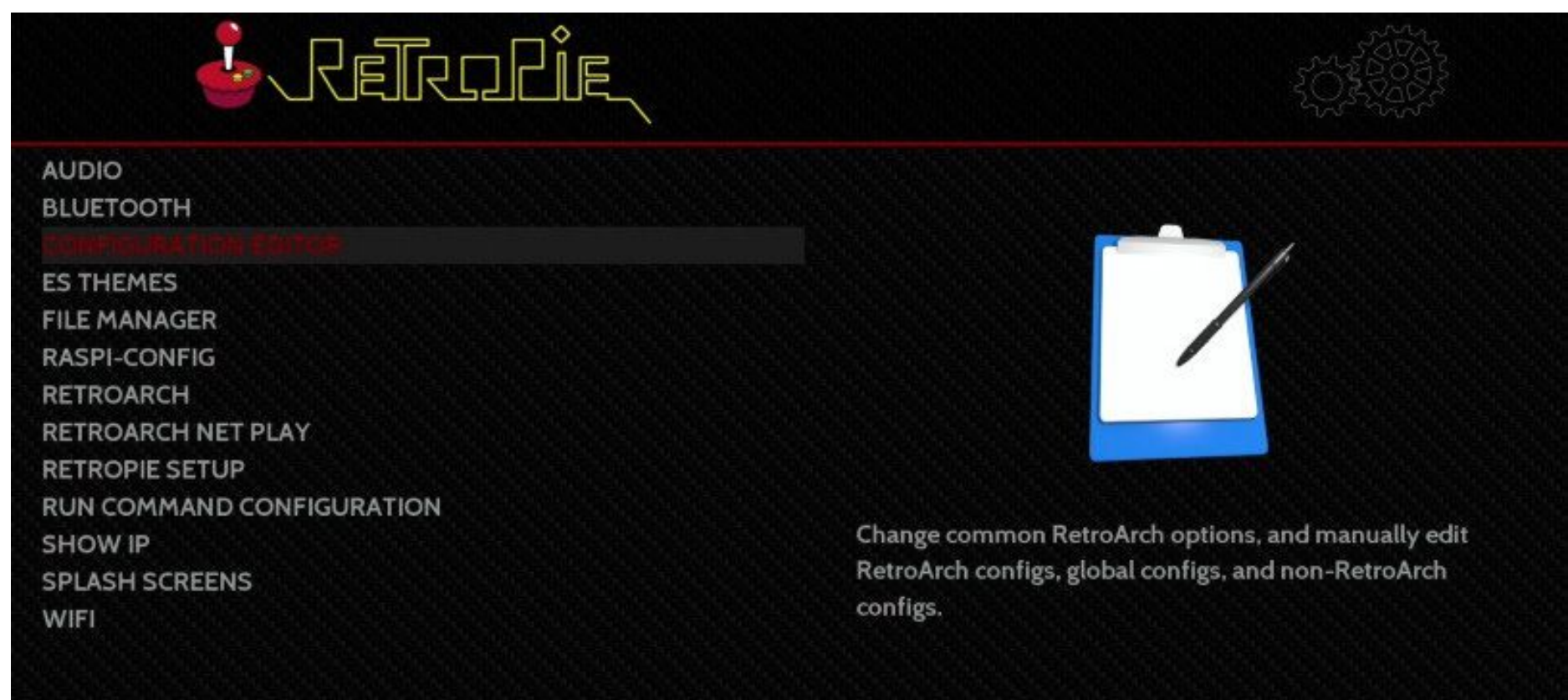


That's it! You now have a retro game system that can play nearly any video game made before 2000 (as long as you can legitimately load it onto the microSD card).

CUSTOMIZING AND FIXING

Now that your retro system is set up, you can start customizing the interface. You also should be aware of how to fix any problems that might come up. In fact, you might have already tried to play a game, and it acted strangely or looked stretched out. These are easy fixes, but you need to dive into RetroPie's menu system. To update RetroPie or any of its emulators in the future or to download themes and customize the look of your menus, you should also set up network connectivity.

You don't need an internet connection to use your retro game system, but it's nice to have for maintenance.



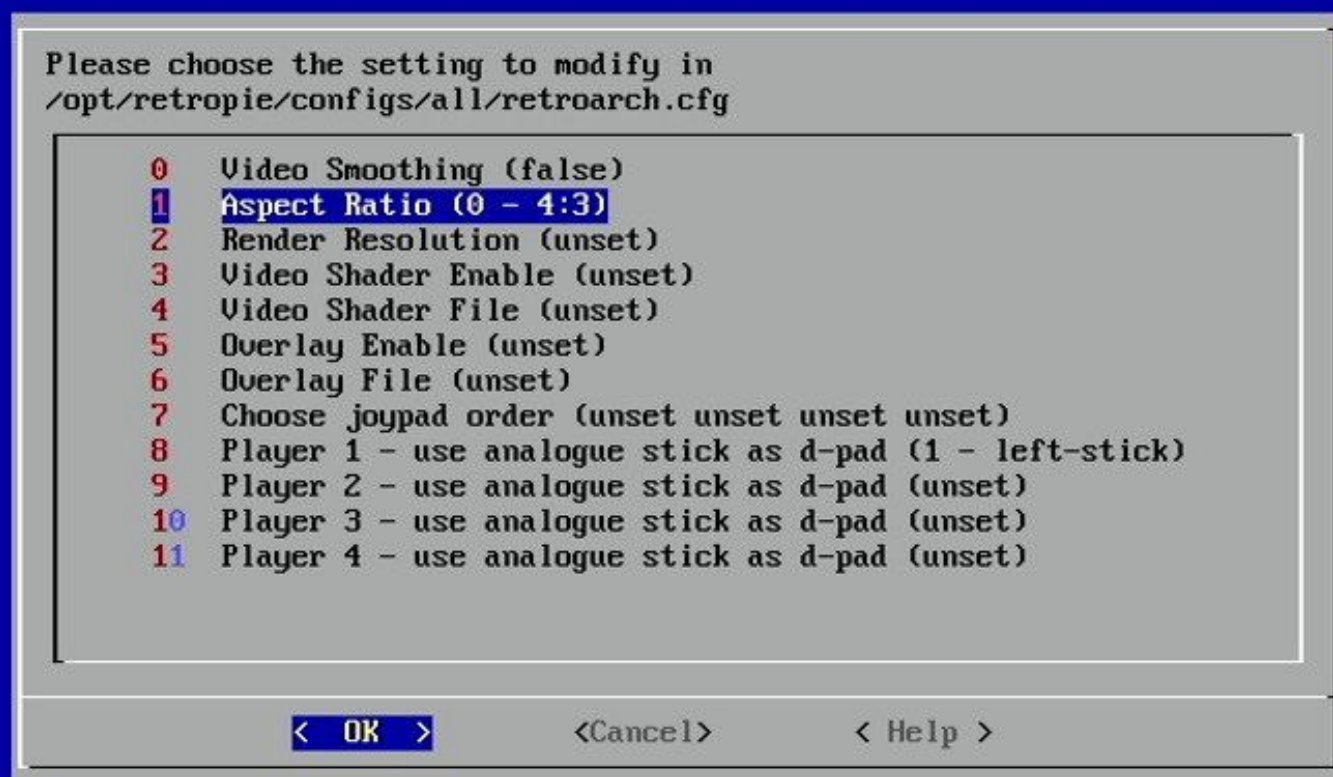
You don't need an internet connection to use your retro game system, but it's nice to have for maintenance.

The RetroPie menu offers access to most configuration and setup options you need to fix and tweak your system. But because this is a Raspberry Pi–friendly Linux distribution running a separate graphical front-end that taps into dozens of separate emulators through a separate API, the menus can appear convoluted.

For system-level settings, including internet connections, select Raspi-Config in the RetroPie menu. This will dump you into a very stark text-based menu system. Don't worry; this is just what Linux looks like naked.

You can still use the direction pad on your gamepad to choose menu items; pressing up and down navigates the active list on the screen, and pressing left and right switches between buttons like OK, Finish, and Cancel. You can also use a keyboard to navigate the menus, if it's more comfortable (and if you want to use the onboard file manager to manually browse files, a keyboard is vital).

Option 2 in Raspi-Config is Network Options. This lets you set up your network connection. If you have a Raspberry Pi 3 Model B or B+, you can connect to your network over Wi-Fi. You need to break out your keyboard for this step to manually enter your network's SSID, then your password. Once that information is in, your system should be able to connect to the internet for updates and downloads. If you have a Raspberry Pi 2 or earlier or want to use a wired internet connection, you can plug an Ethernet cable into the board.



For basic graphical and emulation issues, the Configuration Editor is your go-to menu. It lets you set basic emulator defaults and tweak each individual emulator. The most common issue with a fresh RetroPie system is stretched-out games. RetroPie defaults to emulating games at 16:9, while most classic games were designed to be played at 4:3. This is an easy fix in the Configuration Editor, found in the RetroPie menu. This is another text-based configuration screen, like Raspi-Config. Select option 1, then option 0, then option 1 (Aspect Ratio). Changing 16:9 to 4:3 will fix any stretched-out classic games you want to play. When you're done, press right on the direction pad so the highlighted button says Cancel, and cancel your way back up the menu tree until it puts you back in the EmulationStation graphical front-end.

Speaking of the graphical front-end, when you connect your system to the internet, you can choose different themes to replace the fairly plain default option. In the RetroPie menu, select ES Themes. From here, you can download dozens of different themes. Once they're installed on the system, you can select them in the UI Settings menu. I quite like RetroHursty69/magazinemadness, which gives every game library its own classic video game magazine design.

HAVE FUN

RetroPie is very powerful and flexible, and there are plenty of things to play with to customize how games look and feel. And, of course, you can now play games from dozens of consoles, handhelds, and computers on this little box, and you built it all yourself.



When you connect your system to the internet, you can choose themes to replace the fairly plain default option.



6 Bad Habits That Are Destroying Your PC

BY WHITSON GORDON



Nothing lasts forever—especially tech—but your computer can last quite a few years if you treat it well. If your laptop tends to break down earlier than you feel it should, there's a chance you're helping it along with some especially bad habits. Here are some of the worst things you can do to a PC without even realizing you're doing anything wrong.

LEAVING YOUR LAPTOP ON A PLUSH SURFACE (AND OTHER OVERHEATING PROBLEMS)

Heat is your computer's mortal enemy. If your computer gets too hot, it can reduce the lifespan of the hardware inside, like your processor, fans, and battery—not to mention make your computer loud and sizzling to the touch.

For desktop computers, the solution is pretty simple: Just clean out the dust once in a while with some compressed air and keep it out of any small cabinets. You want air to flow freely through your computer, not to get trapped in a tight space. You can also prevent dust by keeping your computer off the ground and putting filters on your intake fans.

Laptops, on the other hand, require a bit more care. Their portability leads to a lot of bad habits, like putting them on blankets or other plush surfaces. This blocks airflow underneath (where the rubber feet would raise it off a desk) and potentially through the laptop (when the blanket covers the fan vents). When possible, use your laptop on a flat surface, or at least make sure your lap is free of blankets and other things that can block airflow. Lap desks are a good way to ensure things stay cool.



If your computer gets too hot, it can reduce the lifespan of the hardware inside, like your processor, fans, and battery.

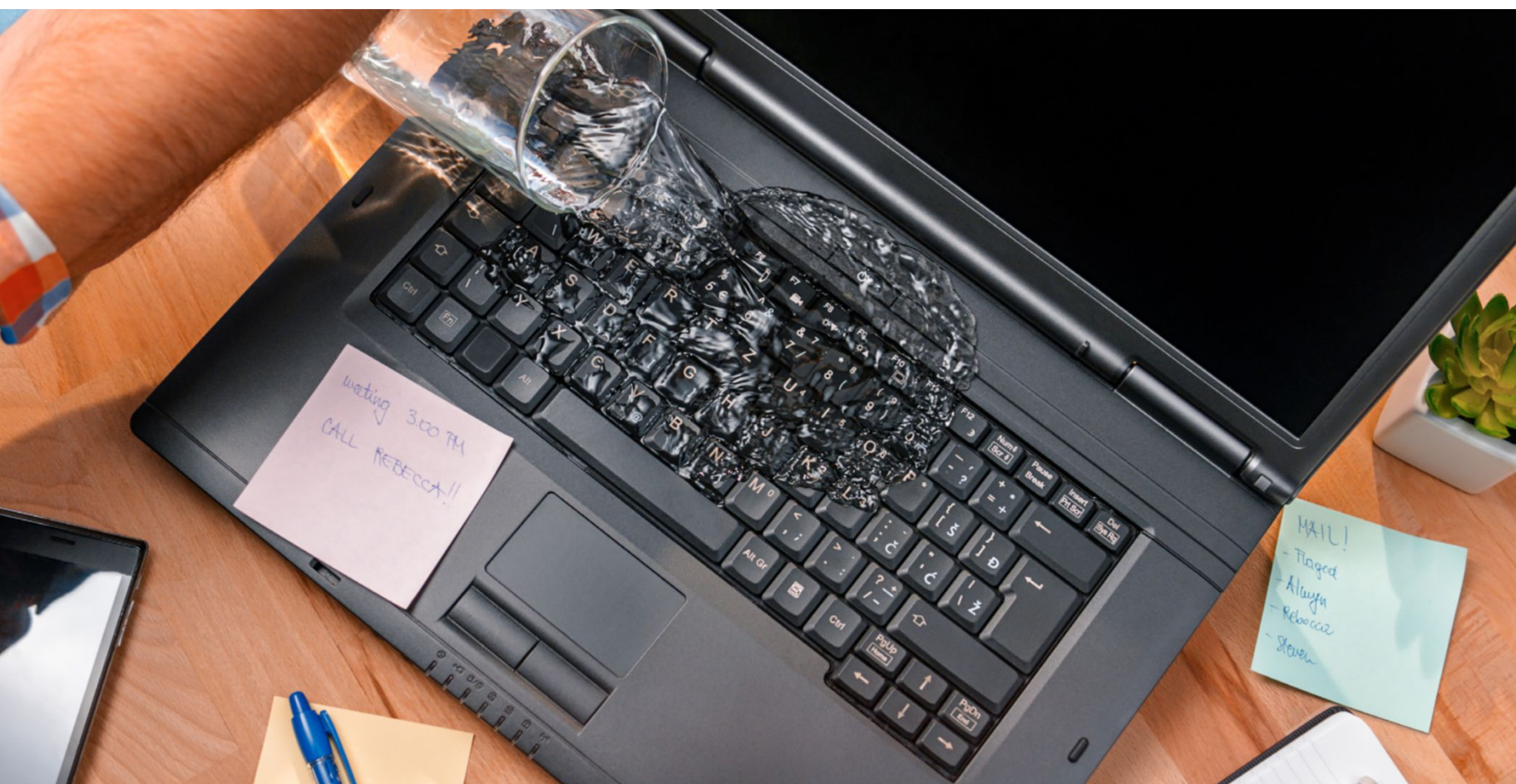


Other than that, the same rules apply to your laptop as your desktop: Don't leave it in hot places (such as a car on a sunny day), and clean it out with some compressed air once in a while. If you can keep it dust-free, the components will run happily for a long time.

HANDLING YOUR LAPTOP CARELESSLY

While desktops have the luxury of sitting comfortably in your office, laptops are subject to all sorts of abuse. I've seen people pick up a laptop by its display, open the hinge from one side with way too much force, and toss a laptop onto the couch from the other side of the room. (Sure, a couch is rather soft, but one day, you're going to miss and hit the table or floor, and you'll be sorry.) I've even seen people use closed laptops as a coaster for drinks, which makes me grit my teeth in anxiety.

Laptops are meant to be portable, and some can be pretty durable—but the more you abuse them, the more likely you are to damage something. At best, you'll have to deal with just a worn-out hinge or a crack in the casing. But if your laptop has a traditional spinning hard drive instead of an SSD, tossing or shaking the computer—especially if the drive is active at the time—can cause its head to dislocate or touch the surface of the disk. It isn't common, but if that happens, you're going to have a bad day, especially if you haven't backed up your data. Your laptop is an expensive piece of property: Treat it as such.



CONSTANTLY DISCHARGING YOUR BATTERY

Just because your laptop's battery starts out with eight hours of battery life doesn't mean it'll stay that way forever. Batteries degrade over time—you may get eight hours on a full charge when you first buy a laptop, but after a few years, that could degrade to six or seven hours. There's no escaping this decline, but if you always run your laptop down to nothing, you may be degrading it faster than necessary. To prolong your battery's long-term health, it's best to perform shallow discharges and recharge it frequently. Don't stress about this, of course—if you're on a plane and need to work, an occasional discharge won't kill your battery—but over time, it's best to err on the side of charging regularly than running it down to empty.



DISREGARDING ELECTRICAL SAFETY

Your PC draws a sizeable amount of power, and it's susceptible to damage from power surges—small, temporary increases in voltage coming through the power line. These can happen after power outages, after turning on another high-power device in your home, or from an unreliable power grid in your city.

The power supply inside your PC includes some basic surge protection, but you'll get longer-lasting protection from a dedicated surge protector. Note that this is different from a power strip, which provides multiple outlets without the protection from surges. Be sure to replace a surge protector every three to five years, too, since that protection wears out over time—if yours is old, there's a good chance it's offering zero protection.

Keep in mind that a surge protector won't protect against high-voltage spikes (such as lightning), but it can protect against smaller surges and extend the life of your PC. When you have a few more dollars to spend, you might want to get an uninterruptible power supply (UPS), which contains a battery backup that prevents your computer from shutting down and losing data during a sudden power outage.

Last, laptops require a bit more care because of their portability. A desktop's power cable can sit stationary for years at a time, but your laptop cable goes with you everywhere—so it's subject to kinking, hard yanks out of the wall, and other mishandling. This can not only make the cable unreliable but it can also pose a fire hazard, so always pull the charger out of the wall holding the plug, not the cable—and don't wrap the cable too tightly.

WASTING TIME ON UNNECESSARY MAINTENANCE

Back in the days of Windows XP, when hardware was limited and computers were slow, personal computer maintenance may have made a difference. But these days, deleting unused and temporary files is unlikely to give you a noticeable speed boost. Many “PC cleaning” utilities are scams meant to scare you into buying their product—and the free, less-scammy ones are still unnecessary most of the time.

Furthermore, certain types of “maintenance” may actually be harmful. Registry cleaners provide almost no benefit, and if they delete a registry entry that you actually need, they can actually cause problems. Similarly, the new “privacy” apps that claim to stop Windows 10 from “spying” on you can break certain features without you knowing why. The internet is full of people confused about why something stopped working only to find that it's the fault of one of these tools. You're better off going through Windows 10's settings, learning what they do, and tweaking them yourself.

But if you still want to clean up your hard drive, use Windows' built-in Disk Cleanup utility and delete any movies, music, and other files you aren't using. And if your computer is running unbearably slow, try removing startup programs or resetting your PC. If that doesn't work, it's probably time to upgrade your hardware.



Contrary to popular belief, ‘common sense,’ while very valuable, should not be your only malware protection.



BROWSING THE WEB UNPROTECTED

Contrary to popular belief, “common sense,” while very valuable, should not be your only malware protection. Even legitimate sites can become infected with malware and then pass those problems on to you; browsing carefully won’t save you. You have to use an antivirus on your computer.

Thankfully, after a few years of sub-par ratings, Microsoft’s built-in Windows Defender feature has gotten quite good. Just leave it on and let it do its job. For extra protection, though, Malwarebytes Anti-Malware is more aggressive with its protection, and I’ve found that it catches a lot of stuff that Chrome and Windows Defender miss. The free version is fine for those who just want to run an occasional scan, but the paid version includes always-running anti-exploit features that block potentially harmful sites. When you use it in conjunction with a traditional antivirus such as Windows Defender, you’ll be set on protection.

On top of that, other basic security practices still apply: Keep your software up to date (both Windows and the programs you use), use a good password manager, and learn how to spot phishing scams. It may seem trivial, but a bad piece of malware or ransomware can cause you a world of hurt.



This Is What's Really Wrong With Facebook

I'm seeing a lot of hysteria over Facebook privacy. It's nonsense, but the company is obliging and potentially ruining what people like about it. This may be a good time to stop and think things over.

First, if people really wanted complete privacy, they would not be on Facebook or social media in at all. The public fell in love with Facebook because you can develop a feeling of community with your circle of "friends." It is particularly useful for keeping up with old pals and relatives. If you don't like any of its features, the answer is simple: Don't use Facebook.

I don't use the product personally, and I never want to. That option is open to anyone. When I see the government getting involved with Facebook, I get concerned. What kind of nanny state wants to legislate all these rules?

That said, there are issues, and they are indeed the fault of Facebook. There are not enough employees monitoring the site for fake accounts and pages advocating violence. Congress brought up some incidents that were not resolved fast enough, like pages that advocated killing Republicans. How hard would it be to take them down the next day? Facebook couldn't do it. Other radical examples abound and seem more important than the appearance of sketchy political ads purchased by a Russian troll farm.

Many modern Silicon Valley operations, from Facebook to Google to Twitter, face a common problem: terrible communication. None of these companies have anyone you can call for help. If something goes astray, you fill out a form and wait. It's an insult to the users. Press inquiries are similarly frustrating; emails sent to generic press inboxes are often ignored.

The best example: Facebook recently took the biggest one-day stock market plunge of any company in the history of the stock market. It wasn't over much more than an earnings warning, but the stock plummeted. Was there not a crisis PR team on hand? How is it possible for a multi-billion-dollar, publicly traded operation to be that clueless?

But they all get away with it, so the approach is creeping over to companies such as Amazon. Microsoft is next, I'd bet. With their stocks skyrocketing, why bother? It's a weird new disdain for the public at large exhibited by a lot of massive corporations pocketing billions.

If Congress and other complainers want to rake these companies over the coals, ask them why can't they afford good customer relations. Privacy protection is not the real issue.

A handwritten signature in black ink that reads "John Dvorak". The signature is fluid and cursive, with the first name "John" and last name "Dvorak" clearly legible.

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