PC MAGAZINE

How Ransomware Conquered the World

Samsung Galaxy S7 Tips and Tricks

VIRTUAL REALITY NO LONGER SUCKS

DIGITAL EDITION
MAY 2016

PC MAGAZINE

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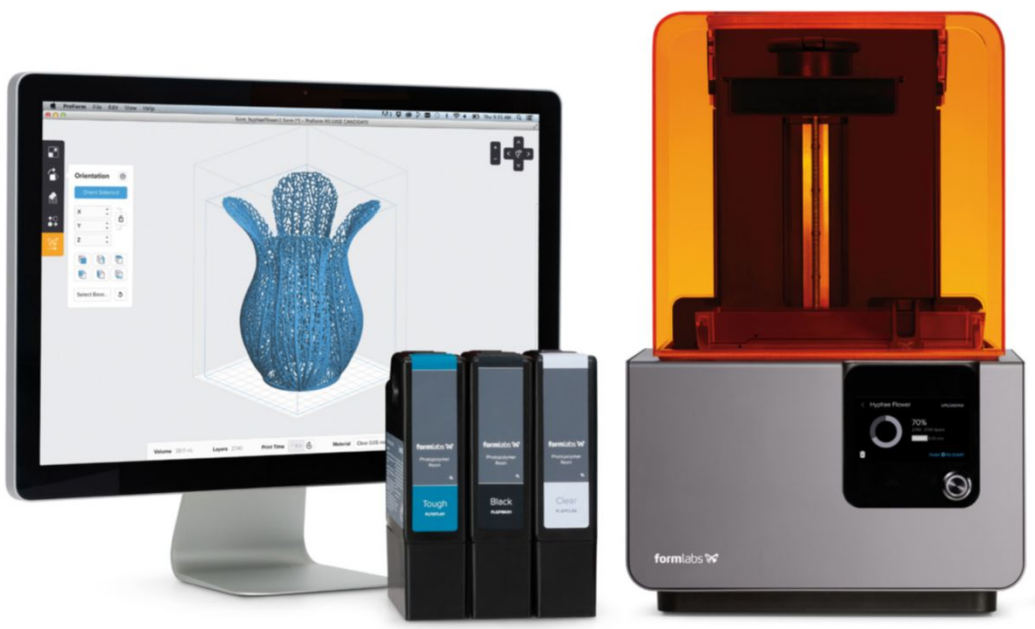
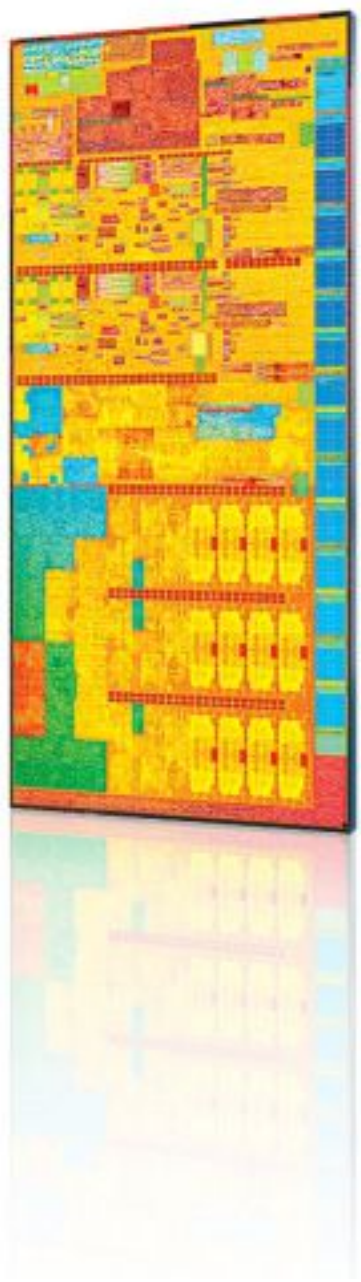


FormLabs Form 2

WHAT'S NEW NOW



INTEL'S "TICK-TOCK" MODEL IS WINDING DOWN

A new strategy for CPU development could change Intel and its products for the better.

WANT A NEW VIDEO CARD? WAIT A FEW MONTHS

AMD's and Nvidia's latest graphics technologies are poised to deliver big improvements by 2017.

RESISTIVE COMPUTING: BASED ON THE HUMAN BRAIN

The synapse was the model for a new design that could open many exciting doors.

DRONE AVIATION 101

A new school in New Jersey is teaching new drone owners how to fly—and bigger plans are in store.

TOP GEAR

OPINIONS

> **The publicity would be terrible, especially if it entailed cussing at small children.**

JOHN C. DVORAK
Last Word

DIGITAL LIFE

DAN COSTA

Virtual Reality Is No 3D TV

There are three cardinal sins in technology journalism. The first is buying into the vendor-manufactured hype surrounding a new technology. Avoiding it isn't easy. I was in many a room when Steve Jobs was pitching products, and he made you *believe*. The second sin is being so cynical about the industry that you lose sight of the fact that these innovations really are changing the world right before our eyes. The third sin, quite simply, is not knowing what you're talking about. I've done my best to avoid all of these traps in my career, so believe me when I tell you that virtual reality is not the next 3D TV.

In case you've forgotten, 3D television was one of the biggest technological flops of the last ten years. You wouldn't know that if you read a lot of the early reviews. Vendors pushed 3D hard, and a lot of writers drank the Kool-Aid. *PC Magazine* recommended 3D TVs, but we were always honest with our readers about their limitations. Although 3D was an innovative technology and an entirely logical evolution in entertainment, it never quite worked as advertised or the way the tech press said it did. As a result, a lot of the 3D-capable TVs currently in homes have never been in 3D mode.

Virtual reality will be different. It will start with gaming, but it will eventually transform the way we work and interact with each other, too. In fact, a recent Goldman Sachs report projected that VR hardware revenues could reach $182 billion by 2025—making it bigger than the TV market.

In this issue, we look at the Oculus Rift and HTC Vive, the two major VR systems that are shipping

now. Both require a powerful PC to run, so get ready to upgrade that old desktop. Having used both systems, it's difficult for me to pick a winner. (We haven't even named an Editors' Choice yet.) The Vive tracks your movements across a larger area, but the Oculus seems to have an edge when it comes to titles and support. Both systems are getting software updates and bug fixes, and the amount of VR content available is pretty minimal. At this point, VR is just for early adopters with money to burn. But just you wait.

This issue also covers another new product category: drones. As anyone who buys one quickly learns, flying a drone isn't easy. Sure, you can figure it out, but can you do so before your drone hits that tree? Even our resident drone analyst, Jim Fisher, has had some drone mishaps. So we sent him to James Barnes' Drone Academy in Ringoes, New Jersey, for some lessons. If you own or plan to own a drone, Jim's story will prove useful and insightful as a look at things to come.

Finally, we have the scary story about the increasing prevalence of ransomware online. The bad news is that once you get ransomware on your system, there's nothing you can do to get your system back other than paying the ransom. The good news? Paying the ransom usually works—and any good security software will likely keep you protected in the first place. Check out Brian Heater's excellent feature for more grim reality.

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On the Case

I really need to build a small PC due to extremely limited space. I want to pack in both 5.25- and 3.5-inch drives, without having any external stuff if at all possible. This is just what I want to build, a space away from my hubby and son who monopolize the big gaming PC in the family room.
—Nancy Drew

OUR ANSWER:

This sounds like a terrific project, Nancy. The more computers, the merrier, I always say.

Pretty much the best place to start when scoping out any build is Newegg.com. Beyond having an incredibly wide range of computer hardware for sale, it's also one of the Web's best research tools for learning anything you could want to know about it. Its product entries are loaded with useful spec information (and a lot of it that's almost too arcane to be useful at all).

This means that when you're searching for components, you can get really granular and focus on whatever quality is most important to you—such as a case's size or external drive access options. On Newegg, open the component category you're interested in and specify your most important characteristics using the drop-downs on the left. The results that pop up on the right will all match your conditions, so start looking through them until you find one that best fits your preferences and budget. (If you have any doubts, the user ratings can be helpful, too.)

In general terms, however, look for a microATX case to get the best balance between size and usability. Mini-ITX cases are smaller still, but have even more restricted features and expandability. In any event, remember that the case's size determines the motherboard you need. As long as the form factors match for both, you should be good. Best of luck with your build!
—Matthew Murray, Managing Editor of Digital Editions

GAME OF DRONES

The review for the DJI Phantom 4 [in the April 2016 issue] was interesting, but lacked some very basic information: How long does it take to charge? Is it possible to have supplementary batteries that can be charged apart from the drone itself? And is there an option for the drone to go back to "base" when it feels its battery is left with just enough charge to do so?

—Jean-Pierre Frankenhuis

OUR ANSWER:

To answer your questions, in order:

(1) The drone charges in about an hour.

(2) Yes, the flight battery is removable and can be replaced in less than a minute.

(3) Yes, the app will start the drone flying home when its battery is low. But it's not a feature I'd rely on. The best practice is to keep an eye on the battery level and start bringing it home if you're at all concerned about how much time in the air you have left. You can set different thresholds for auto return to home in the flight app.

—Jim Fisher, Senior Analyst, Digital Cameras and Drones

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.

What's New Now

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DRONE AVIATION 101

TOP GEAR

Intel's "Tick-Tock" Model Is Winding Down

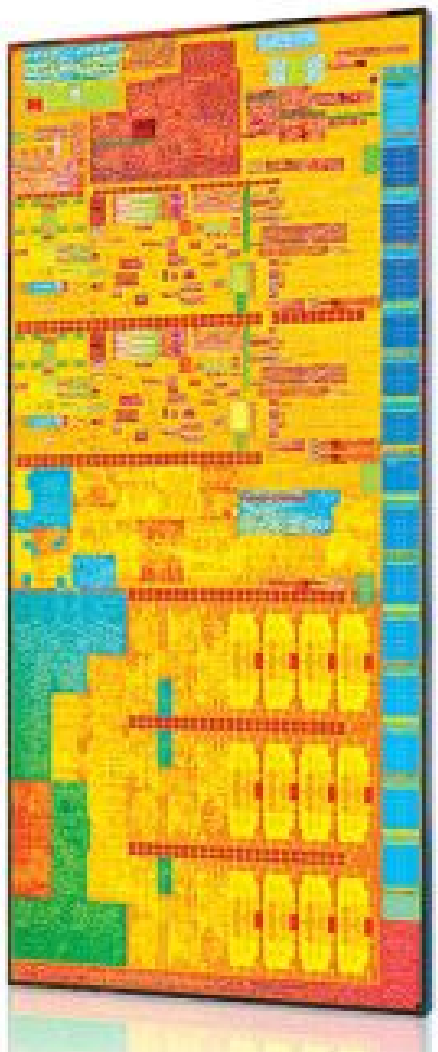
BY JOEL HRUSKA

Nearly ten years ago, Intel formally unveiled the new design and manufacturing process it would use for its microprocessors. Before 2007, there was no exact, predictable alignment between the deployment of new manufacturing techniques at smaller process nodes and the debut of new architectures. From 2007 forward, Intel followed a distinct cadence: New process nodes would be designated as "ticks," and new architectures built on the same process node would be called "tocks."

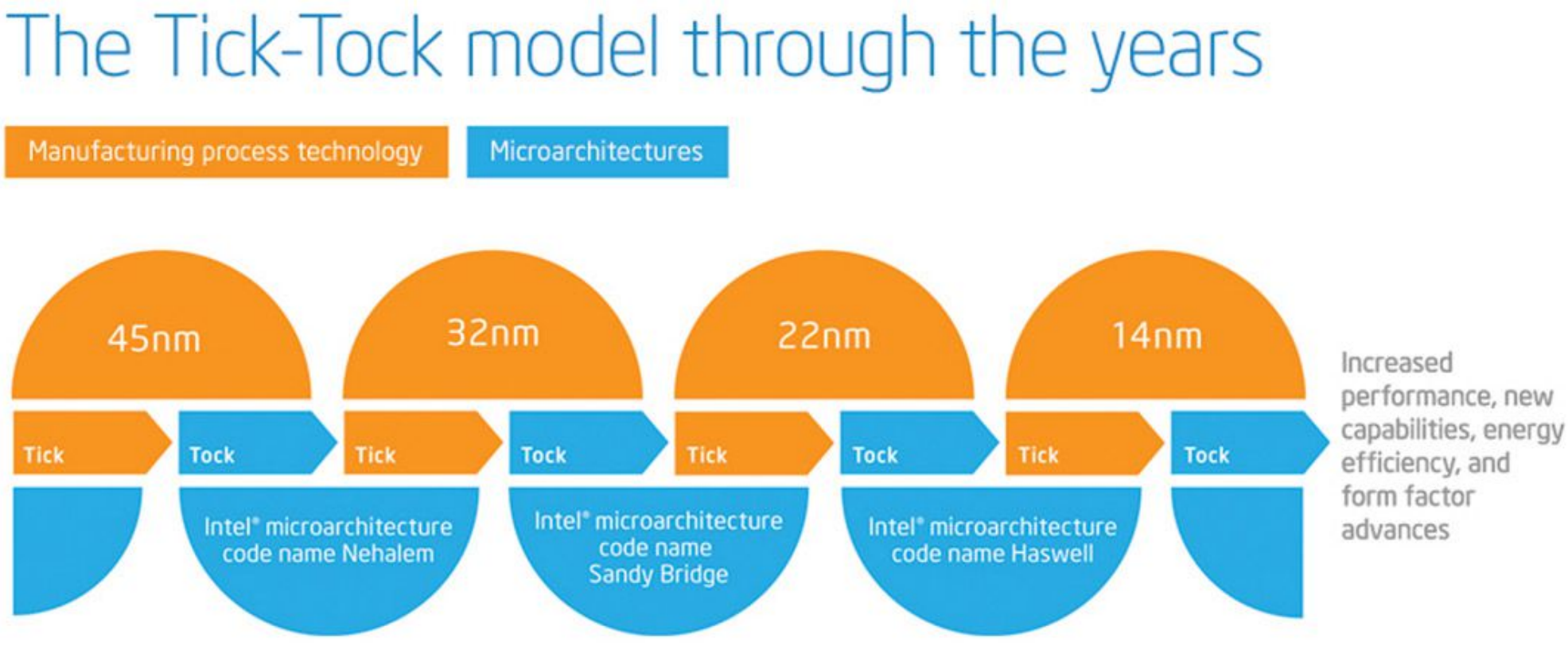
This approach ensured that Intel was never attempting to build a new CPU architecture at the same time it ramped a new process node, and gave the company almost a decade of steady (if slowing) progress. That era is over.

In its recent 10-K filing, Intel stated the following:

> *As part of our R&D efforts, we plan to introduce a new Intel Core microarchitecture for desktops, notebooks (including Ultrabook devices and 2 in 1 systems), and Intel Xeon processors on a regular cadence. We expect to lengthen the amount of time we will utilize our 14nm and our next generation 10nm process technologies, further optimizing our products and process technologies while meeting the yearly market cadence for product introductions.*



TOCK OF THE TOWN NO MORE
Intel is abandoning its long-standing "tick-tock" method of defining its processor revamps by way of alternating a new process technology with a new microarchitecture.



Intel went on to state that it intends to introduce multiple product families at future nodes, with advances integrated into those architectures in ways that aren't communicated by node transitions.

> *We also plan to introduce a third 14nm product, code-named "Kaby Lake." This product will have key performance enhancements as compared to our 6th generation Intel Core processor family. We are also developing 10nm manufacturing process technology, our next-generation process technology.*
>
> *We have continued expanding on the advances anticipated by Moore's Law by bringing new capabilities into silicon and producing new products optimized for a wider variety of applications. We expect these advances will result in a significant reduction in transistor leakage, lower active power, and an increase in transistor density to enable more smaller form factors, such as powerful, feature-rich phones and tablets with a longer battery life.*

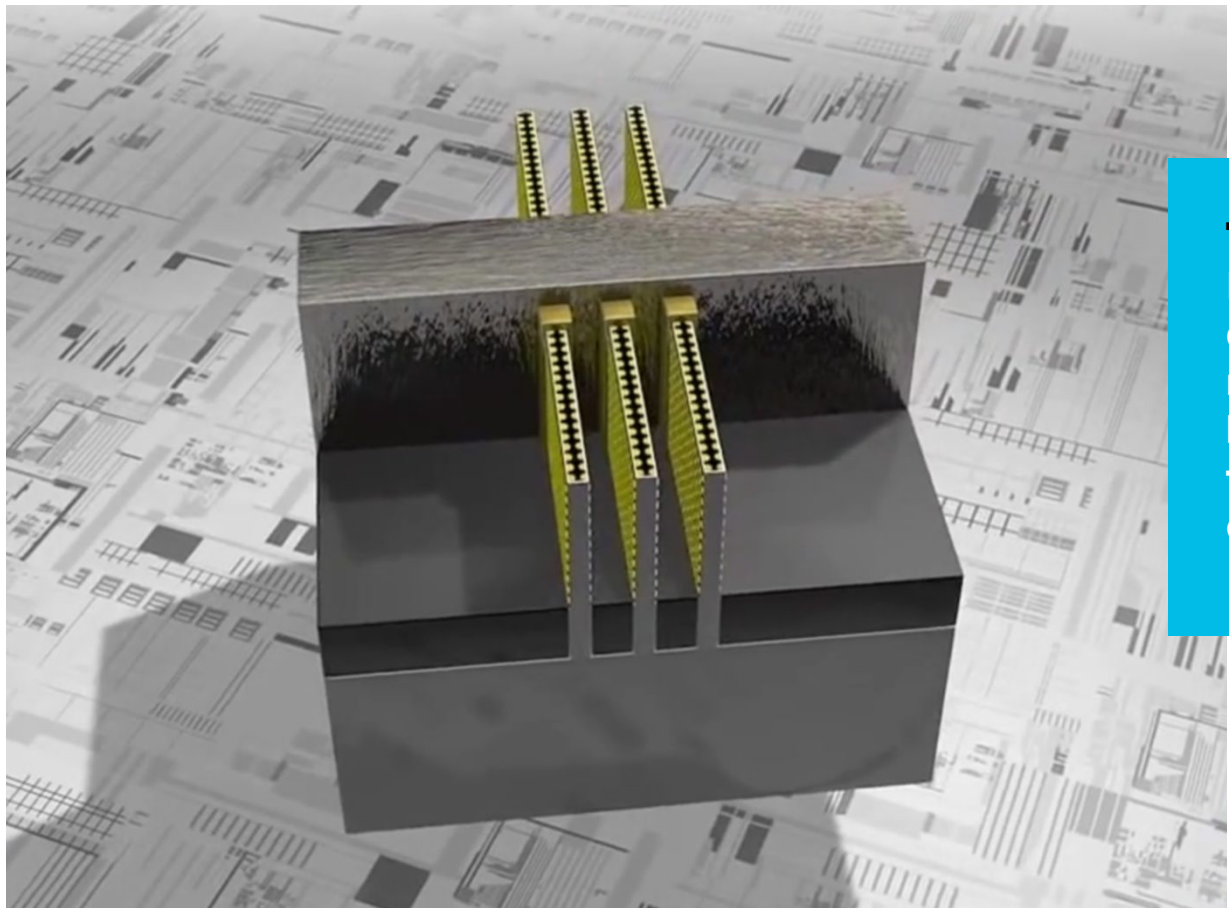
In other words, Intel believes that it can offer improvements in different areas that correspond to better user experiences—and it may be right.

THE EVIDENCE OF ITERATION

In recent years, ARM, AMD, and Nvidia have all introduced architectural improvements that substantially improved on power consumption and performance despite being built on the same node.

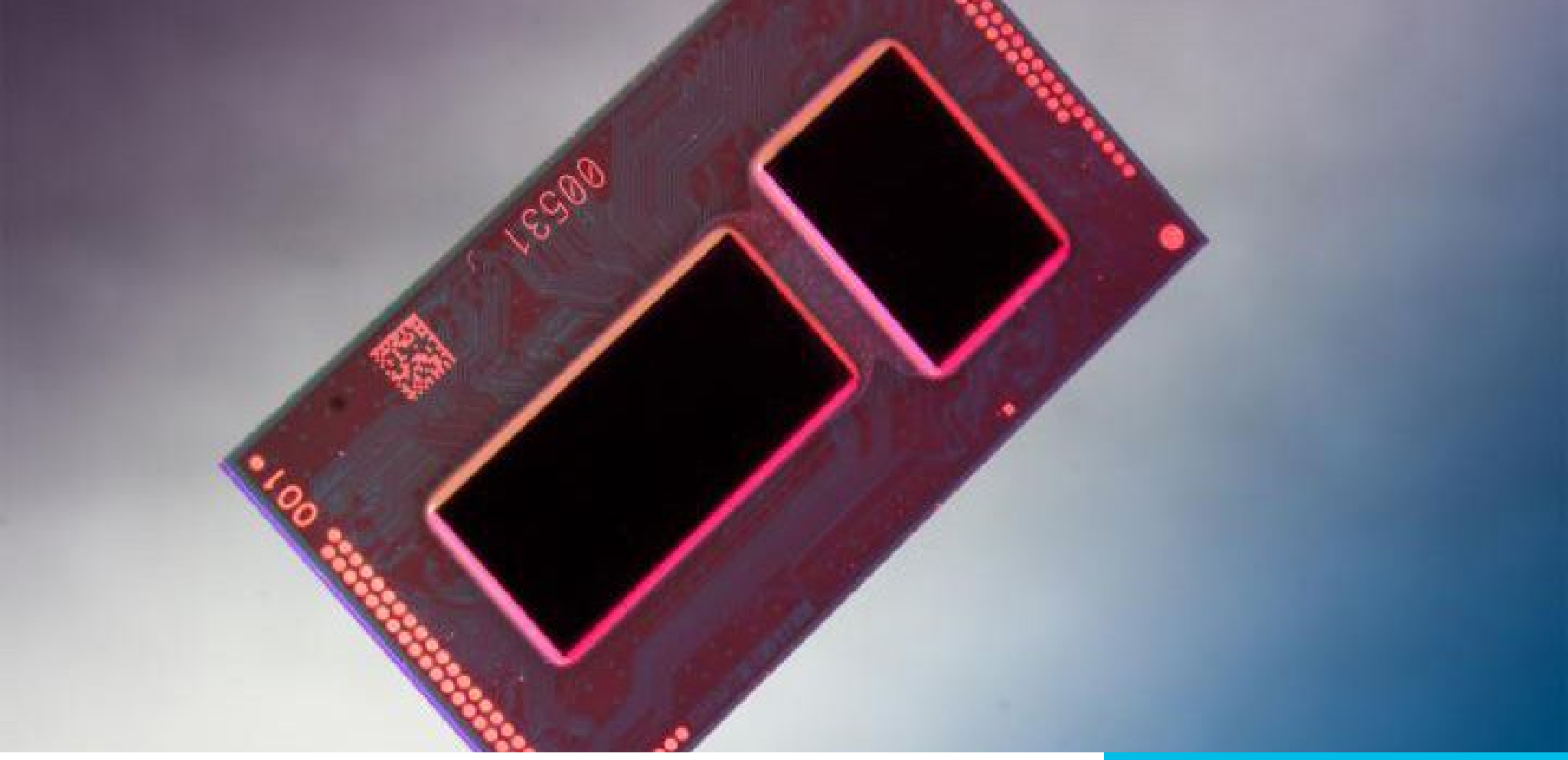
In AMD's case, Carrizo offers substantially better CPU and GPU performance at low TDP compared to the Kaveri APU it replaces. Although it's true that AMD's APUs often aren't shown or priced to best effect by OEM system designs, Carrizo is a notable improvement over AMD's previous offerings. Part of this is likely due to AMD's decision to use Adaptive Voltage and Frequency Scaling instead of the Dynamic Voltage and Frequency Scaling on which Intel (and AMD, historically) have both relied.

ARM tends to be a bit more closemouthed than Intel when it comes to aspects of CPU design, but it claims that its architectural enhancements to the Cortex-A9 improved its per-clock performance by nearly 50 percent, over and above any frequency enhancements. When combined with improvements via process node and CPU clock, the final chip was nearly three times faster than the first models that debuted on 40nm.



THROUGH THE GATE
Intel's Tri-Gate processor design was used in the recent 14nm process node, but the company is looking to reducing it to 10nm and even below.

Finally, there's Nvidia. Although we hesitate to draw too much from GPU manufacturing, given the vast differences between CPU and GPU architectures, Nvidia's Maxwell was a huge leap forward in



BRINGING IT DOWN
The Core M processor family, designed by Intel for use in Internet of Things (IoT) devices, are low-power devices created using the 14nm production process.

performance-per-watt well beyond what Kepler offered. The end result was higher frame rates and a more efficient architecture, all while staying on TSMC's mature 28nm process.

Each of these companies took a different route to improving power efficiency. AMD introduced new types of power gating and binning while simultaneously making architectural improvements. ARM took an iterative approach to fixing performance-sapping issues without declaring the later revisions of the Cortex-A9 to be different processors. Nvidia built a new architecture on an existing, mature node, blending some approaches it had used with Fermi with its existing Kepler architecture, then adding better color compression and other enhancements to the GPU stack.

Intel's 10-K goes on to mention other long-term investments the company is making into extreme ultraviolet litography (EUV), and the firm has previously discussed how it sees a path forward to 10nm and below without relying on that next-generation system. The firm isn't giving up on process node scaling, but it's just not going to try to hit the same cadence that it used to.

THE COUNTERARGUMENT

There is, however, a counterargument to the optimistic scenario laid out above. Unlike AMD's or ARM's, Intel's x86 processor designs are extremely mature and highly optimized. Carrizo may introduce some innovative power management techniques, but AMD had to find a way to stuff Bulldozer—an

architecture designed for high clock speeds and high TDPs—into a 15-watt power envelope. (It's no surprise that it took the firm multiple iterations on the same process node to do it.) ARM's Cortex-A9 was a fabulous mobile processor in its day, but it was also arguably ARM's first stab at a laptop- or desktop-capable CPU core. There was going to be low-hanging fruit to fix, and ARM, to its credit, fixed it.

Nvidia's Maxwell GPU might demonstrate the performance and efficiency gains of advances to one's graphics architecture, but Intel has actually made some significant strides in this area already. Modern GPU designs also aren't as mature as their CPU counterparts. Intel has been building out-of-order CPUs since the Pentium Pro in 1995; the first programmable GPU debuted in the Xbox 360 in 2005 (AMD) or Nvidia's G80 (2006), depending on how you want to count.

This view would argue that the modest clock-for-clock performance improvements to Haswell and Skylake over their predecessors reflect neither laziness nor market abuse, but a more fundamental truth: Intel is currently building the best, most power-optimized processor it knows how to build, with no near-term amazing technology other than process improvements to push the envelope further.

Whichever view is more precise, it's not particularly surprising to see tick-tock passing into history. It's getting harder and harder to hit new node targets, and Intel typically sets density and gate length requirements that are harder to hit than its competitors'. Even now, Intel's 14nm node is more dense than the hybrid 14-20nm approach offered by Samsung and TSMC; TSMC's 10nm node in 2017 is expected to hit the same densities Intel achieved in 2015. The question is: Does leading the industry in such metrics actually give Intel enough of an advantage to justify the cost?

Intel's decision to transition away from the tick-tock model is a tacit recognition that the future of semiconductors and their continued evolution is considerably murkier than it used to be. The company is retrenching around a more conservative model of future progress and betting it can find complementary technologies and approaches to continue to deliver steady improvement. Given the time lag in semiconductor design, it'll be a year or two before we know if this approach worked.

Want a New Video Card? Wait a Few Months

BY JOEL HRUSKA

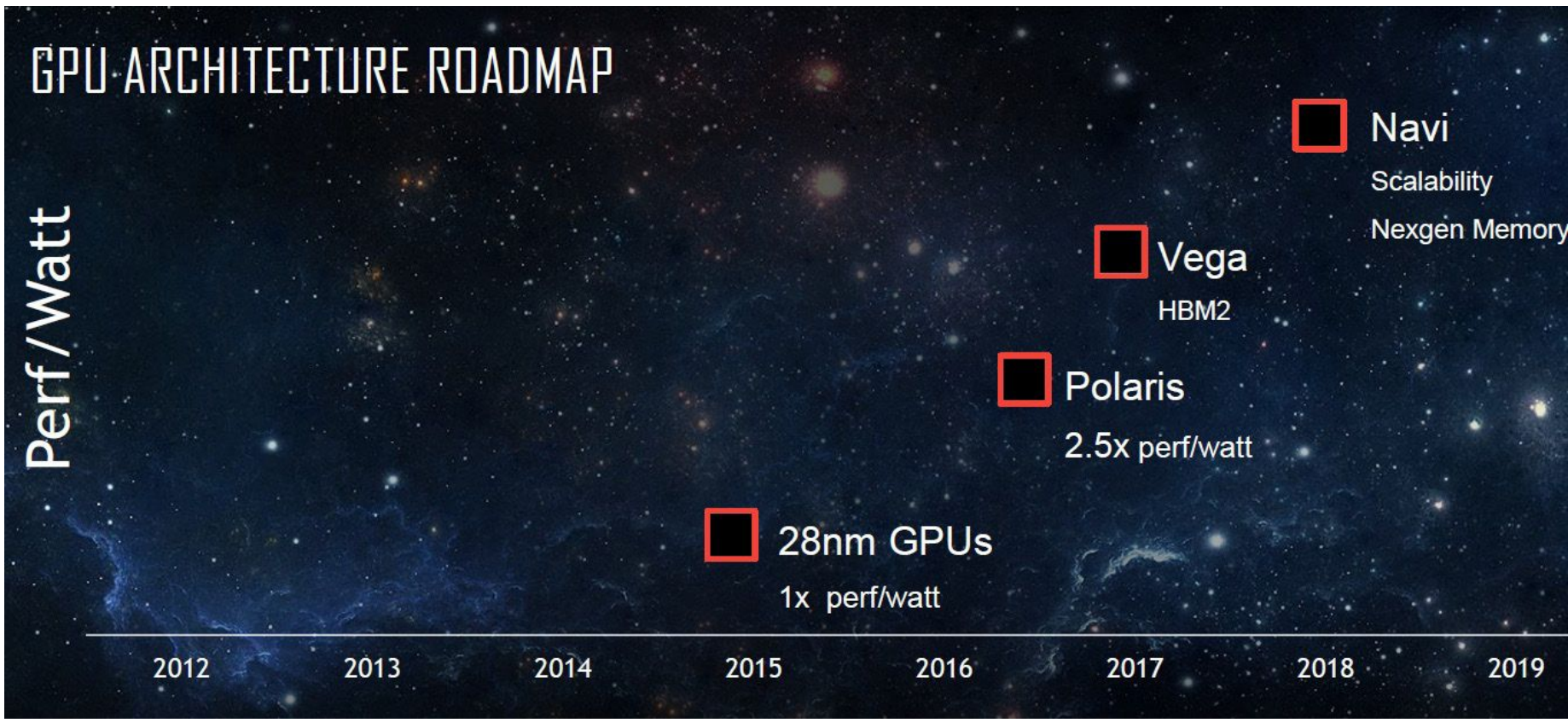
In early April, Nvidia took the wraps off of its new GP100 GPU and gave us a look at what its top-end high-performance computing (HPC) configuration would look like come early 2017. Although this new card is explicitly aimed at the scientific computing market and Nvidia has said nothing about future consumer products, the information the company revealed confirms some of what we've privately heard about next-generation GPUs from both AMD and Nvidia.

If you're shopping for a new video card or just eyeing the market in general, we'd recommend waiting at least a few more months before pulling the trigger. It may even be worth waiting until the end of the year based on what we now know is coming down the pipe.

WHAT TO EXPECT WHEN YOU'RE EXPECTING (A NEW GPU)

First, a bit of review: We already know that AMD is launching a new set of GPUs this summer, code-named Polaris 10 and Polaris 11. These cores are expected to target the sweet spot of the add-in-board (AIB) market, which typically means the $199-$299 price segment. High-end cards like the GTX 980 Ti and Fury X may command headlines, but both Nvidia and AMD ship far more GTX 960s and Radeon R7 370s than they do top-end cards.

Polaris 10 and 11 are expected to use GDDR5 rather than high-bandwidth memory (HBM), and AMD has said these will boast improved performance-per-watt of as much as 2.5 times compared with their predecessors. The company's next-generation Vega GPU family, which arrives late this year, is rumored to be the first ground-up new architecture since Graphics Core Next debuted in 2012 with 4,096 shader cores and HBM2 memory.



We don't know yet what Nvidia's plans are for any consumer-oriented Pascal cards, but the speeds and core counts on GP100 tell us quite a bit about the benefits of 16nm FinFET and how it will impact Nvidia's product lines this generation.

With GP100, Nvidia increased its core count by 17 percent, while simultaneously ramping up the base clock by 40 percent. The baseline TDP for this GPU, meanwhile, increased by 20 percent, to 300 watts. The relationship between clock speed, voltage, and power

THE FUTURE ACCORDING TO AMD

AMD's plans for further developing and improving its GPUs begin this summer with the release of Polaris 10 and 11.

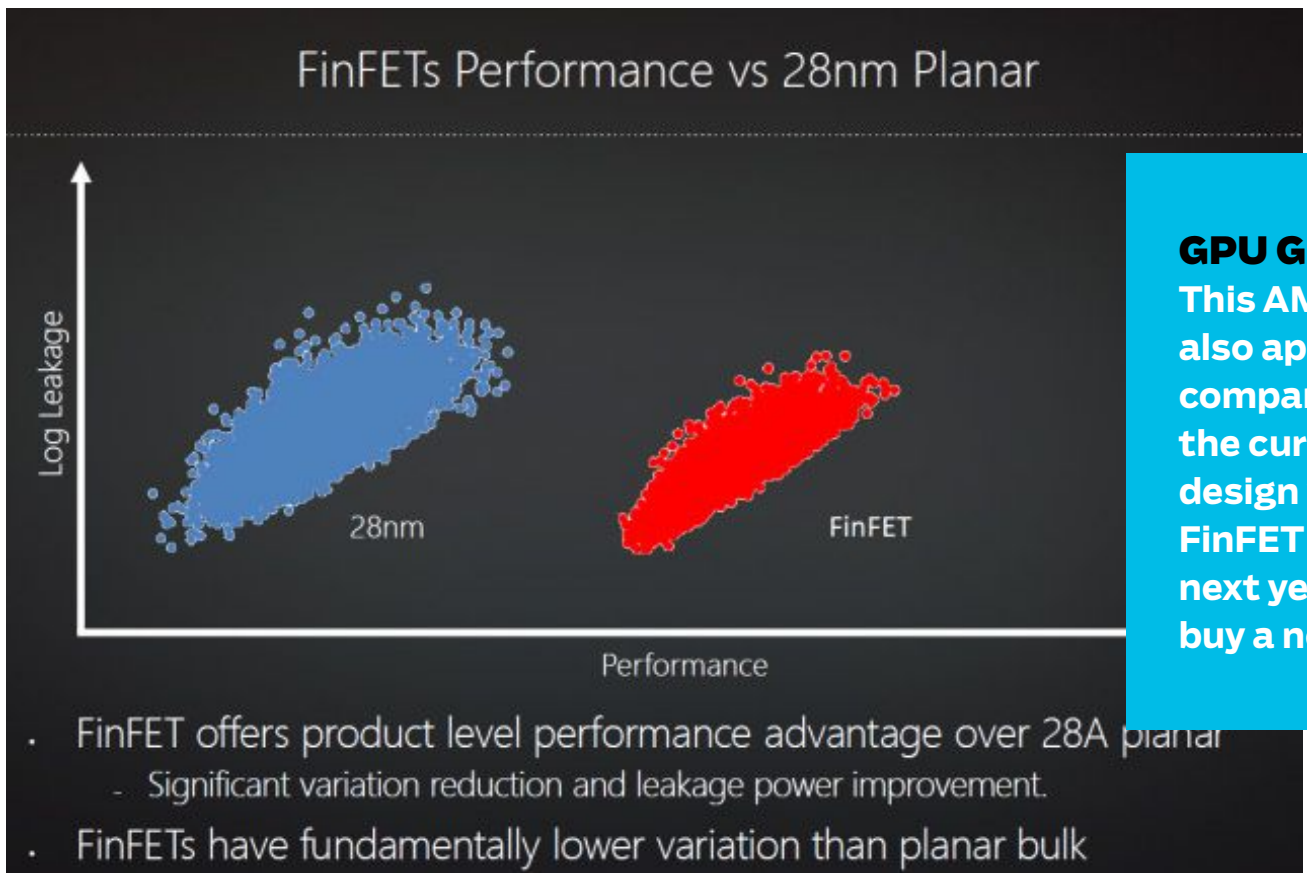
consumption is not linear, but the GTX Titan X shipped with a base clock of 1GHz, only slightly higher than the Tesla M40's 948MHz. The GP100 has up to 60 SM units (though only 56 are enabled), which puts the total number of on-die cores at 3,840. That's 25 percent more cores than the old M40, but the die is just 3 percent larger.

The implications of all this are straightforward: Nvidia should be able to deliver a high-end consumer card with 30 to 40 percent higher clocks and significantly higher core counts within the same price envelopes that Maxwell occupies today. We don't know when Nvidia will start refreshing its hardware, but it will almost certainly be within the next nine months.

Here's the bottom line: AMD is going to start refreshing its midrange lineup this summer, and it would be unusual if Nvidia didn't have new cards of its own to release in response. Both companies will likely follow with high-end refreshes toward the end of this year or the beginning of next year, again probably around the same time.

WHEN WAITING MAKES SENSE

One of the most tried-and-true clichés in the tech industry is that it's foolish to try and time your upgrades because technology is always advancing. Ten to 12 years ago, when AMD and Nvidia were nearly doubling their top-end performance every year, this kind of argument made sense. Today, it's much less valid. Technology advances year-over-year, but the rate and pace of those advances can vary significantly.



GPU GPS
This AMD graphic (which also applies to Nvidia) compares the benefits of the current 28nm GPU design with the 14 and 16nm FinFET node coming in the next year. In short: Wait to buy a new card if you can.

The 14 or 16nm node is a major stepping stone for GPU performance because it's the first full-node shrink that's been available to the GPU industry in more than four years. If you care about low power consumption and small form factors, upcoming chips should be dramatically more power-efficient. If you care about high-end performance, you may have to wait another nine months, but the amount of GPU you'll be able to buy for the same amount of money should be 30 to 50 percent greater than what you can get get today.

There's also the question of VR technology. We don't know yet how VR will evolve or how seriously it will impact the future of gaming; estimates range from total transformation to a niche market for a handful of well-heeled enthusiasts. Regardless, if you plan on jumping on the VR bandwagon, it behooves you to wait and see what kind of performance next-generation video cards can offer.

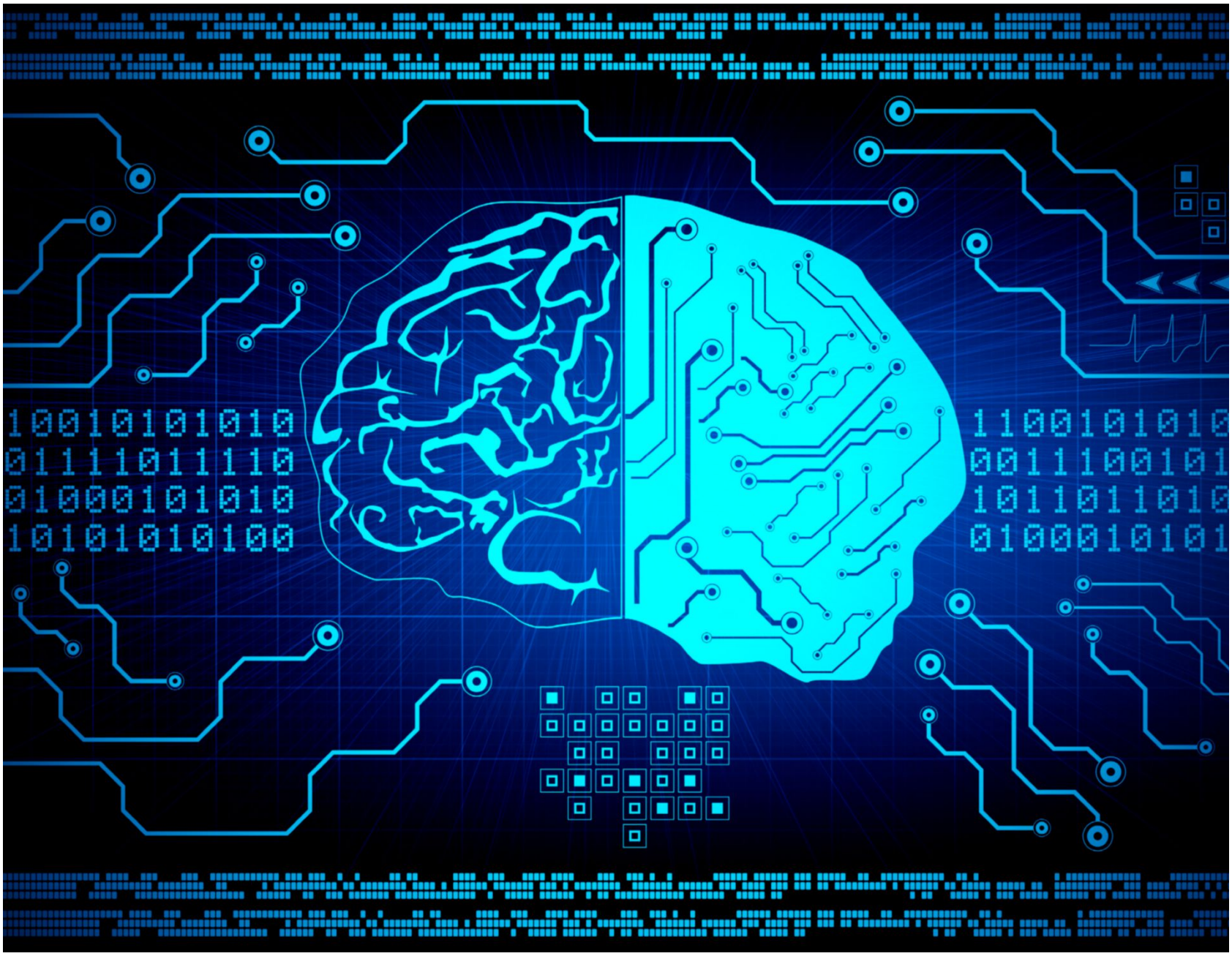
Remember this: VR technology demands both high frame rates and extremely smooth frame delivery, and this has knock-on effects on which GPUs can reliably deliver that experience. A GPU that drives 50 frames per second (fps) where 30 is a minimum requirement is pushing 1.67 times more frames than the user demands as a minimum standard. A GPU that delivers 110fps where 90 is a minimum requirement is only 1.22 times above the target frame rate. It doesn't take much in the way of additional eye candy before our second GPU is bottoming out at 90fps again.

The final reason to consider delaying an upgrade is whether you plan to upgrade to a 4K monitor at any point in the next few years. After all, 4K pushes roughly four times as many pixels as 1080p monitors, and modern graphics cards are often 33 to 50 percent slower when gaming at that resolution. Waiting a few more months to buy at the beginning of the new cycle could mean 50 percent more performance for the same price and gives you a better chance of buying a card that can handle 4K in a wider variety of titles.

If your video card dies tomorrow or you can't stand running an old HD 5000 or GTX 400-series card one more day, you can upgrade to a newer AMD or Nvidia model that's currently available and still see an enormous performance uplift—but customers who can wait for the next-generation refreshes to arrive will be getting much more bang for their buck. Even if we don't yet know what the exact specs will be for any specific AMD or Nvidia next-gen GPU, the advancements sound encouraging. If you can wait for a new video card, you almost certainly won't regret it.

Resistive Computing: Based on the Human Brain

BY DAVID CARDINAL



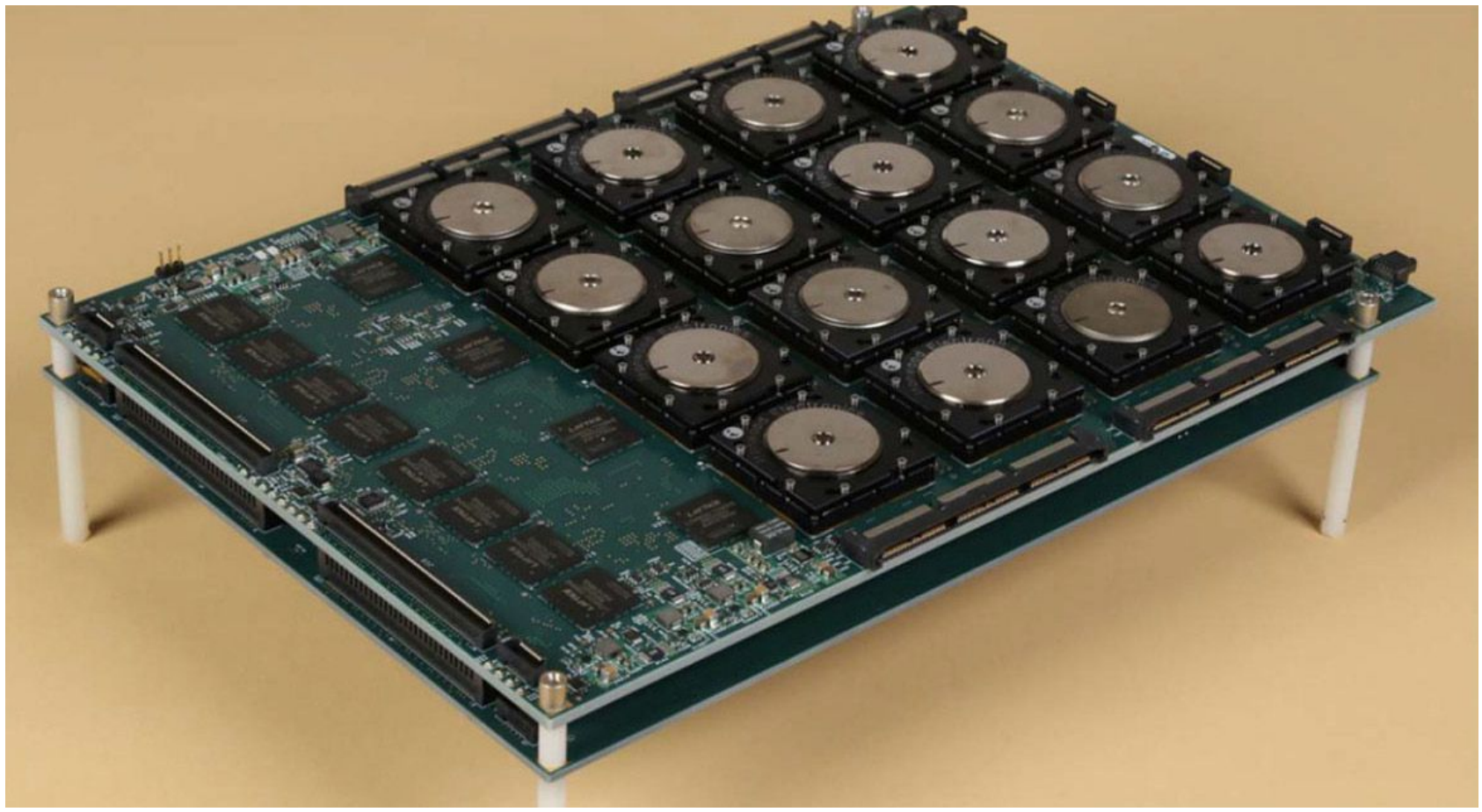
With the recent rapid advances in machine learning has come a renaissance for neural networks, computer software that solves problems similar to the way the human brain does: by employing a complex process of pattern matching distributed across many virtual nodes, or "neurons." Modern compute power has enabled neural networks to recognize images, speech, and faces, as well as to pilot self-driving cars and win at Go and *Jeopardy!*. Most computer scientists think that is only the beginning of what will ultimately be possible. Unfortunately, the hardware we use to train and run neural networks looks almost nothing like their architecture. That means it can take days or even weeks to train a neural network to solve a

problem—even on a compute cluster—and then require a large amount of power to solve the problem once they're trained.

NEUROMORPHIC COMPUTING MAY BE KEY TO ADVANCING AI

Researchers at IBM aim to change all that by perfecting another technology that, like neural networks, first appeared decades ago. Loosely called resistive computing, the concept is to have compute units that are analog in nature, small in substance, and can retain their history so they can learn during the training process. Accelerating neural networks with hardware isn't new to IBM. It recently announced the sale of some of its TrueNorth chips to Lawrence National Labs for AI research. TrueNorth's design is neuromorphic, meaning that the chips roughly approximate the brain's architecture of neurons and synapses. Despite its slow clock rate of 1KHz, TrueNorth can run neural networks very efficiently because of its million tiny processing units that each emulate a neuron.

FINDING TRUENORTH
This 16-chip DARPA SyNAPSE board uses IBM's neuromorphic TrueNorth chip.



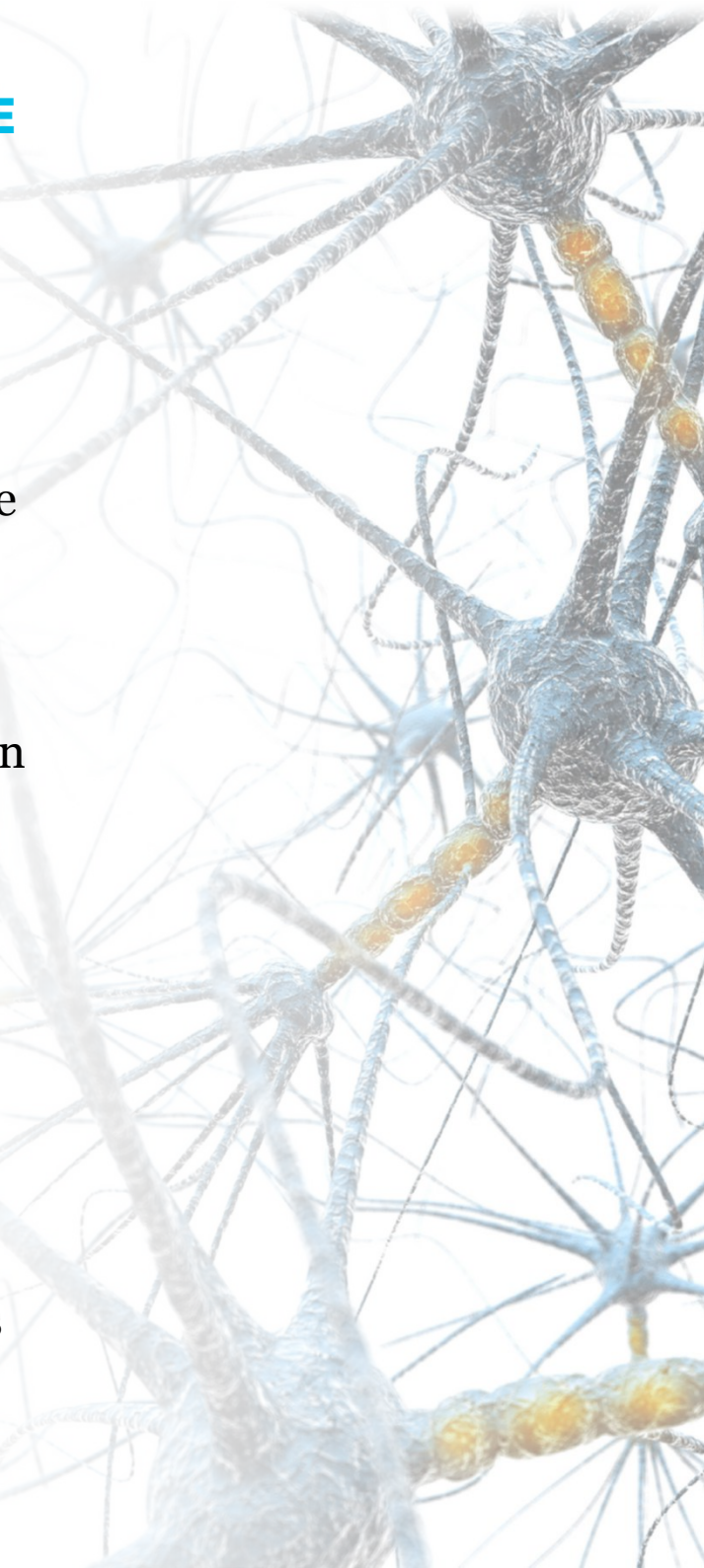
Until now, though, neural network accelerators like TrueNorth have been limited to the problem-solving portion of deploying a neural network. Training—the painstaking process of letting the system grade itself on a test data set, and then tweaking parameters (called weights) until it achieves success—still needs to be done on traditional computers. Moving from CPUs to GPUs and custom silicon has increased performance and reduced the power consumption required, but the process is still expensive and time-consuming. That is where new work by IBM researchers Tayfun Gokmen and Yuri Vlasov comes in. They propose a new chip architecture, using resistive computing to create tiles of millions of Resistive Processing Units (RPUs), which can be used for both training and running neural networks.

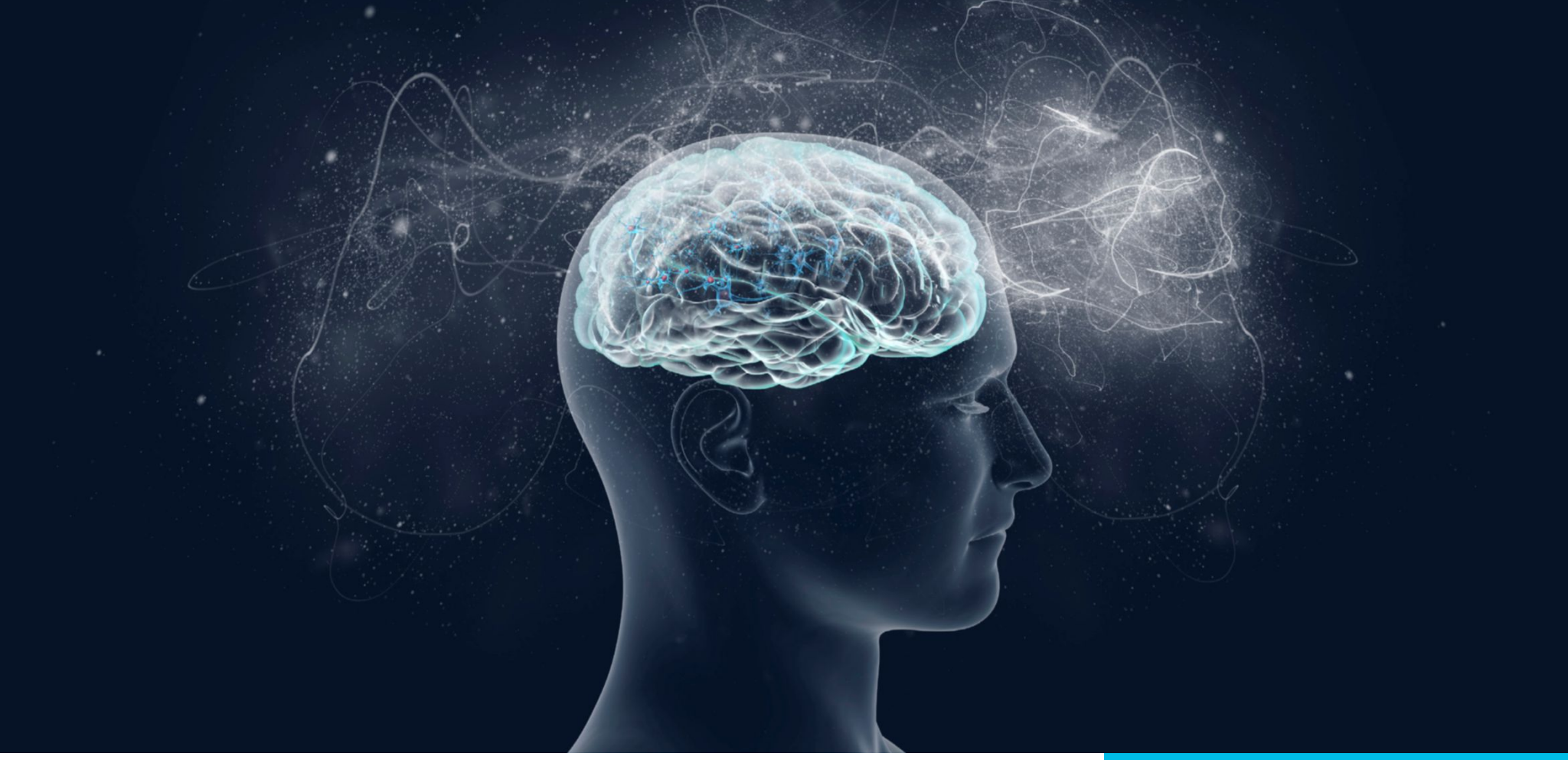
> **In the IBM design each small RPU mimics a synapse in the brain.**

USING RESISTIVE COMPUTING TO BREAK THE NEURAL NETWORK TRAINING BOTTLENECK

Resistive Computing is a large topic, but roughly speaking, in the IBM design each small RPU mimics a synapse in the brain. It receives a variety of analog inputs—in the form of voltages—and based on its past "experience" uses a weighted function of them to decide what result to pass along to the next set of compute elements. Synapses have a bewildering, and not yet totally understood, layout in the brain, but chips with resistive elements tend to have them neatly organized in two-dimensional arrays. For example, IBM's recent work shows how it is possible to organize them in 4,096-by-4,096 arrays.

Because resistive compute units are specialized (compared with CPU or GPU cores) and don't need to either convert information from analog to digital or access memory other than their own, they can be fast and consume little power. In theory, a complex neural network—such as the kind used to recognize road signs in a self-driving car—can be directly modeled by





dedicating a resistive compute element to each of the software-described nodes. But because their analog nature and a certain amount of noise in their circuitry makes RPUs imprecise, any algorithm run on them needs to be made resistant to the imprecision inherent in resistive computing elements.

Traditional neural network algorithms, both for execution and training, have been written assuming high-precision digital processing units that could easily call on any needed memory values. Rewriting them so that each local node can execute largely on its own, and be imprecise while producing a result that is still sufficiently accurate, required a lot of software innovation.

For these new software algorithms to work at scale, advances were also needed in hardware. Existing technologies weren't adequate for creating "synapses" that could be packed together closely enough, and operate with low power in a noisy environment, to make resistive processing a practical alternative to existing approaches. Runtime execution happened first, with the logic for training a neural net on a hybrid resistive computer not developed until 2014. At the time, researchers at the University of Pittsburg and Tsinghua University claimed that such a solution could result in a three-to-four-order-of-magnitude gain in power efficiency at the cost of only about 5 percent in accuracy.

THE THINK SYSTEM

Resistive computing adopts the model of a synapse in the brain by using its previous experience to determine how to process new inputs it receives.

MOVING FROM EXECUTION TO TRAINING

This new work from IBM pushes the use of resistive computing even further, postulating a system where almost all computation is done on RPUs and traditional circuitry is only needed for support functions and input and output. This innovation relies on combining a version of a neural network training algorithm that can run on an RPU-based architecture with a hardware specification for an RPU that could run it.

As far as putting the ideas into practice, to date resistive compute has been mostly a theoretical construct. The first resistive memory (RRAM) became available for prototyping in 2012, and isn't expected to be a mainstream product for several more years. And although those chips will help scale memory systems and show the viability of using resistive technology in computing, they don't address the issue of synapse-like processing.

IF RPUS CAN BE BUILT, THE SKY IS THE LIMIT

The proposed RPU design is expected to accommodate a variety of deep neural network (DNN) architectures, including fully connected and convolutional, which makes them potentially useful across nearly the entire spectrum of neural network applications. Using existing CMOS technology, and assuming RPUs in 4,096-by-4,096-element tiles with an 80ns cycle time, one of these tiles would be able to execute about 51 gigaops per second, using a minuscule amount of power. A chip with 100 tiles and a single complementary CPU core could handle a network with up to 16 billion weights while consuming only 22 watts (only two of which are actually from the RPUs—the rest are from the CPU core needed to help get data into and out of the chip and provide overall control).

That is a staggering number compared with what is possible when chugging data through the relatively lesser number of cores in even a GPU (think about 16 million compute elements, as opposed to a few thousand). The researchers claim that, once built, a resistive-computing-based AI system using chips densely packed with these RPU tiles could achieve performance improvements of up to 30,000 times compared with current architectures, all with a power efficiency of 84,000 gigaops per second per watt. If this becomes a reality, we could be on our way to realizing Isaac Asimov's fantasy vision of the robotic positronic brain.

Drone Aviation 101

A New Jersey driving range has become the country's first training school for drone pilots. BY JIM FISHER

PILOT PROGRAM
James Barnes's Drone Academy in Ringoes, New Jersey, is teaching new drone owners how to handle their aircraft—and that's only the beginning of what he has in mind.

When James Barnes was a boy, his most cherished outdoor hobbies were racing slot cars and shooting off model rockets. Determined to get a new generation of kids excited about these simple activities—and get them away from their smartphone screens—Barnes opened Jersey Hobby after he retired from a career in the construction industry. But although Barnes still sells model rockets at his store, they're not the hottest products on the sales floor. What are? The devices that could (maybe) be considered their 21st-century equivalents: drones.

Jersey Hobby has been offering drone classes for about a year. If you buy a ready-to-fly model from the store, you'll get a free lesson on using it. An instructor walks you through downloading to your phone any apps that may be required, calibrating the aircraft's internal compass, and applying any firmware updates. You also get some flying time, along with instructions on how to take manual control of the drone in the event of a loss of GPS signal, compass error, or other unexpected situation that can hamper assisted flight.

These classes (dubbed "Out of the Box") have been so popular that Barnes and his wife and business partner Angela realized that the need for expansion was in the air. They're currently in the process of converting an old driving range and miniature golf complex into a training camp for drone pilots. And they're bringing on more staff to handle the demand: Barnes is working with the Urban League of Hudson County, through its Helmets to Hardhats program, to put veterans in those positions, and paying instructors a fair wage of $25 per hour.

Jersey Hobby has been offering drone classes for about a year.

IT'S A BIRD, IT'S A PLANE
Drones fly above what was once a driving range and is now part of a tree farm.

TECHNICAL INSTITUTE

At the Drone Academy, Barnes has 3D printers and flight simulators available for his students' use.

The facility, located along U.S. Highway 202 in Ringoes, New Jersey, is multi-use. It's owned by a local farmer. Trees are planted on the driving range grounds. The bulk of the parking lot is filled with factory-fresh BMWs, overflow parking for a dealership lot. The Drone Academy currently occupies a small office space that's lined with training simulator workstations, 3D printers, and workbenches, all adjoining a conference room with seating for about 20.

It's a work in progress. When I visited in early March, the nets surrounding the main training field were not yet raised. The golf course, which will eventually turn into a race course for first-person view (FPV) pilots, was overgrown with brush. And, although the offices are accessible by wheelchair, the upper and lower flight decks of the driving range are only accessible via stairs. Rectifying that is on Barnes' to-do list.

But that's a minor aspiration; contractors and concrete can make a ramp. And, as useful as flight lessons for hobbyist pilots may be, Barnes is also working on programs that go well beyond that.

Barnes is currently in talks with several school districts to put shrink-wrapped "pencil drone" kits into

classrooms. With the kits, students will be taught to assemble, program, and fly these tiny quadcopters (they measure only a few inches on each side), and learn vital skills that will help them in further Science, Technology, Engineering, and Mathematics (STEM) courses of study. He also offers on-site classes, part of his Level 1 package, to provide the same instruction. If students want to go further, Level 2 classes cover camera installation and ground stations that display a feed from the lens. And Level 3 courses have students installing a GPS-guided flight system and programming fully automated missions.

There are also programs in the works for professionals. The Drone Academy has entered into a strategic partnership with the New Jersey Institute of Technology (NJIT) in order to train first responders. Dr. Michael Chumer, a research professor at NJIT, is developing protocols for drone use in firefighting and other emergency management fields, and sees the Drone Academy as a place where professionals can safely learn to use the technology to save lives.

A large ready-to-fly aircraft like the Yuneec Tornado H920 can carry about five pounds of equipment. That makes it possible to include a traditional camera as well as infrared and thermal modules. Chumer sees firefighters using a package like that to fly over buildings and identify hot spots from the air.

A network of what Chumer calls multimedia workstations—rack systems with a hard-line connection to the Internet and enough processing power to display multiple video streams at once—already exists in New Jersey. Connected via a VPN, this system allows law enforcement, municipalities, and private entities that use this type of workstation (there are more than 200 in New Jersey) to share video feeds easily.

During Hurricane Sandy in 2012, the casinos on the boardwalk at Atlantic City were able to turn their security cameras to the shoreline and flooded streets,

“Barnes is currently in talks with several school districts to put shrink-wrapped “pencil drone” kits into classrooms.”

DRONE MASTER
Barnes kneels as he flies a small drone from the concrete deck that overlooks the Academy's main flight field.

and send live footage to teams who would be responsible for storm cleanup. Chumer wants to achieve the same level of immediacy and information sharing with drone footage. The Drone Academy is the testing ground.

In addition to its role as a training center, the Academy is a hub for drone enthusiasts and professionals. Take, for example, Kenneth Volpe. A structural engineer by trade who turned a love of photography into a business, Volpe is now expanding into the world of drones. He has a Section 333 exemption from the FAA, which allows him fly drones professionally—but he's not a licensed pilot. Whenever he wants to depart from recreational or personal use of his DJI Inspire 1, say to inspect a bridge or capture an aerial view for a wedding video, he has to hire a professional pilot to handle the flight controls.

The FAA is of the opinion that, if you're going to fly a drone professionally, you should also have the skills to man the yoke of a Cessna—a requirement from which hobbyists are excluded. Barnes's Academy is not in the business of giving out piloting licenses, but rather helping make amateurs the best and safest they can be. After all, even a small UAV can be powerful and dangerous, so a hands-on training course—even if it's not legally required—is a good idea for everyone who wants to take these little craft into the great blue yonder.

We're likely to see how-to courses for novice pilots pop up as quadcopter use becomes more popular. But it's the ambitious reach of the New Jersey Drone Academy that makes it an important waypoint at the beginning of this era of personal flight, and the dedication of its founder—who, after all these years, is still pursuing the outdoor hobbies he loves—that makes it unique.

What We Love Most This Month

BY STEPHANIE MLOT

CUBE

Summer is nearly upon us, and what's a more fitting way to ring in the season than an evening barbecue and outdoor movie showing? Whether lounging in your own backyard or on a friend's lawn chairs, the Cube mobile projector lets you take the fun anywhere. Plug in any HDMI-compatible device to turn a 5-inch screen into a 120-inch display. The Cube also gives you the freedom to view any kind of content, from streaming videos to photo slideshows to PowerPoint presentations (not suitable for weekend pool parties).

$299 rif6.com

What We Love Most This Month

BY STEPHANIE MLOT

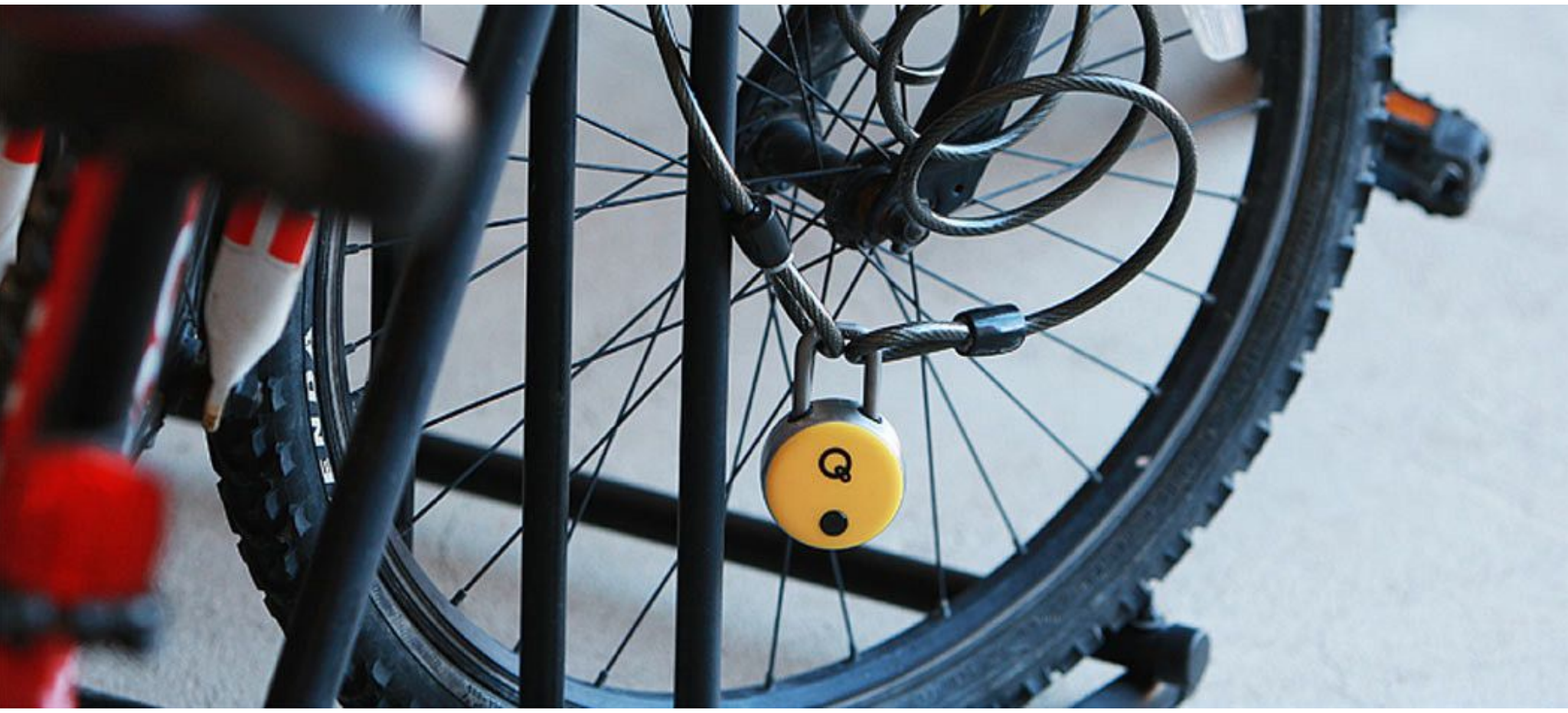
LUMO LIFT

No one likes a slouch: The Lumo Lift coaching wearable device aims to reset your poor posture. Clip the miniature sensor onto your clothing, calibrate it, and go about your day. Each time you slump over, the device sends a vibration reminding you to sit up or walk straight for a healthier back. And although it won't map your daily runs or track your food intake, the Lumo Lift's iOS and Android apps do record posture, steps taken, distance traveled, and calories burned.

$79.99 lumobodytech.com

What We Love Most This Month

BY STEPHANIE MLOT



QUICKLOCK PADLOCK

Numeric codes are easy to break (especially when your birthday is the password). So Quicklock ditched the digits in favor of near-field communication (NFC)—the same technology that powers mobile payment systems like Apple Pay. The Padlock opens with a card, fob, or ring, ensuring that only those people with the right accessories can release it. Also supported are Bluetooth, RFID, and access control via a smartphone app, so even if you lose the NFC-compatible doodads, you won't be locked out forever.

$69.99 thequicklock.com

What We Love Most This Month

BY STEPHANIE MLOT

QWERTYWRITER

Typewriters aren't just for hipsters, bookshop owners, and Tom Hanks. Qwerty Toys gave the old-fashioned machines a modern facelift to create a Bluetooth-compatible wireless keyboard. Connect Qwerkywriter to any iOS or Android smartphone or tablet, Windows slate, Apple desktop or laptop, or other devices for a blast from the past. Industrial-strength clicky mechanical switches, vintage-inspired key caps, and a return bar provide the same feel and sound as the antiques.

$349 qwerkywriter.com

What We Love Most This Month

BY STEPHANIE MLOT

SAVER EMERGENCY BREATH SYSTEM

A fire extinguisher comes in handy when the cat accidentally sets the drapes aflame by knocking over a burning candle. But it won't do much good if your entire house is blazing. Instead, the Saver Emergency Breath System can prevent smoke inhalation, and barricades you from carbon monoxide and toxic gases for up to 5 minutes. Just remove the plastic cover, apply the nose grip, remove the orange cap, plug in the mouthpiece, and breathe normally. An add-on LED flashlight and alarm help whether you're waiting for rescue or attempting a heroic escape.

$69 mysafetyiq.com

Opinions

MATTHEW MURRAY

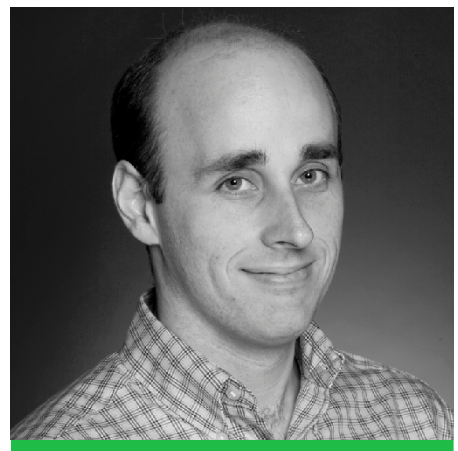
EVAN DASHEVSKY

TIM BAJARIN

Only *I* can build my ideal computer. Anything else is settling.

MATTHEW MURRAY
WE WILL ALWAYS NEED TO BUILD

We Will Always Need to Build



Matthew Murray, *PC Magazine*'s managing editor, has edited its hardware, software, and consumer electronics content, and previously served as an editor at *Computer Shopper*.

It's not easy to be a desktop lover these days. Every day brings a new wave of depressing news about that segment of the industry. PC shipments are way down. Intel just laid off 12,000 employees. AMD is struggling to gain any consumer market share at all. And if you prefer building computers to buying them, it's even more dispiriting. Most of Apple's products are designed to keep purchasers out of them, and PC makers more intent on aping everything that comes out of Cupertino rather than actually innovating aren't helping. Even as the world as a whole is encouraging more individual action toward environmental responsibility—my mother, who has never cared about such things, has started composting!—computer culture is becoming increasingly disposable: You use a device for a year or two, then you junk it and buy a new one. Repeat *ad infinitum*.

Although this is a far cry from the way personal computing started some 40 years ago, when systems may have been held back by advancing technology but in most cases could hang on for the better part of a decade, it's just the latest development in a war that's been waging since the very beginning of the era. When they were developing the original Apple computer, Steve Wozniak and Steve Jobs had a fundamental disagreement about its nature. Wozniak, a tech guy down to his marrow, wanted everyone to

have full ownership of their computers inside and out, and be able to change as much or as little of the hardware as they wanted at any time. But Jobs, the visionary, wanted to ensure that all Apple owners received exactly the experience he conceived of for them, which wouldn't be possible with a near-infinite number of hardware permutations. Although Wozniak may have won the earliest battles, through his amazing force of personality Jobs has been winning over most of the last two decades, and each new sunrise threatens to bring us closer to the day he delivers the decisive blow from beyond the grave.

I understand why that idea is appealing to so many people. Even though computing devices of all sizes and stripes are ubiquitous today, most of them are still bizarre and mysterious under the hood, with their innards hardly resembling the user-friendly GUIs that are now *de rigueur*. When you turn on your phone or tablet, you just want it to work and work instantly—this is the peace of mind Apple offers, and delivers so well. And if your needs are simple, or perhaps merely simply categorized, that's a fine way to go.

But *my* needs aren't simple. I'm the only one who knows why Adobe Photoshop and Audience are two of my most-used programs, or the ways I use them. No prefab system configuration can take into account the nature of my job, and explain the amount of desktop real estate I need, how I use it, and what my multitasking on it involves. And although I've worked with a lot of terrific people at companies like Dell, Asus, and Maingear, not a one of them has ever inquired what games I play in my downtime and what's the lowest level of graphical fidelity on them that I'm willing to put up with.

In other words, only *I* can build my ideal

computer. Anything else is settling. And I don't like to settle when I don't have to.

I can't say I've never been disappointed during the 27 years I've been doing this, and I can't say that things have always worked exactly the way I expected them to the first time. But when I ran into problems, I learned how to fix them. And when my needs changed, I could address those changes by pulling out this component or popping in that new one rather than tossing the whole setup into the trash and starting over. That made me a better computer user and—dare I say it?—a better person.

That's because, beyond providing me with my perfect final product, it addresses a need I have for self-sufficiency that I can't sate many other ways. Okay, I can and do cook and bake my own food. But if you told me to make a table and put me in a room with a log, a saw, and some nails, you'd probably have to carry me out on a stretcher. Or if you gave me a big wad of clay and a turntable, the chances are I'd turn myself into a statue long before I'd ever make a recognizable bowl. But when I sit down in front of *my* computer, where I spend most of my work and leisure time, I do it with the same satisfaction a carpenter does dining off a table he made or a potter eating from a bowl she sculpted. I'm caring for my own needs, I'm making what's best for me.

If the prospect still sounds intimidating, know this: Unlike with carpentry or pottery, the experience barrier to entry on system building is very low. If you can shop online and operate a Phillips screwdriver, you can build your own desktop PC—and, given the wide array of tool-free components available these days, you won't even need to use that screwdriver that much. You'll need to research the parts, and assembling

If you can shop online and operate a Phillips screwdriver, you can build your own desktop PC.

them may take you a couple of hours the first time, but when you're finished, you'll have something you can be proud of, something that will last for years, and something will be uniquely yours in a way no phone or HDTV can ever be.

A few embers of my hope that more people will recognize this have been rekindled over the last couple of months. My PC building primer from our June 2015 issue inspired young people from around the world to email me about how they can get started and what else they should know—the most recent came in just in March, from a high school senior who was building his first-ever PC for a class project. And right before this issue went to press, I heard from a woman who wanted to run through some ideas about building the ideal small desktop for her husband and children.

This may be a small, highly unscientific sample, but it's a reminder of something that's all too easy to forget as the tech industry zooms by around us. Building is already a challenge, and it's bound to get tougher as it becomes even more a "niche" activity. But like theater, which has endured even as movies, television, and now Web video have gained unheard-of levels prominence, building will always be here because we need it to be—it offers a fulfillment we just can't get any other way. It's where computers came from, and it's where the human spirit lies, whether we know it or not. That part of history may fade away into the fog of modernity, but it can't be extinguished altogether. And, until my dying breath, I'll be glad to be there fanning the flames of this activity that is as rewarding and as inspiring as anything else you can do with technology.

"Building will always be here because we *need* it to be—it offers a fulfillment we just can't get any other way."

matthew_murray@pcmag.com

Evan Dashevsky

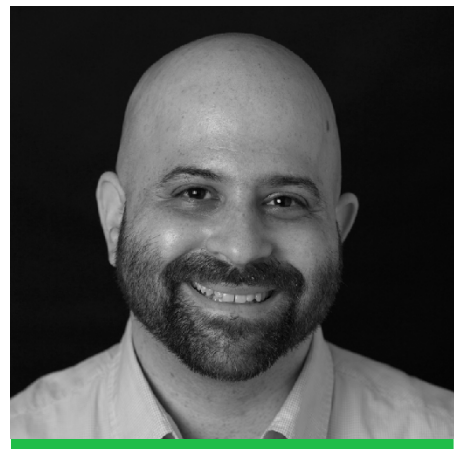
How Twitter and the NFL Just Broke Television

The National Football League recently announced that its Thursday night matchups will be broadcast live in full on the thought-sneeze platform known as Twitter. Yes, Twitter. This move will surely bewilder the non-digital natives out there, but it may also prove to be one of the most seismic shifts in recent media history. Although the games will still be broadcast over the air on NBC and CBS, the fact that Twitter, of all platforms, has the exclusive digital rights can't be ignored.

Recent years have seen a mass migration of prime content onto nontraditional digital outlets (a headline containing the words "Emmy" and "Amazon" would have seemed absurd two years ago). The broadcast TV paradigm has been on shaky ground for some time, but the NFL moving games to a social network on which a recent trending topic was #NationalDeepDishPizzaDay may mark the beginning of the end.

I cut the cord a year ago and have been mostly fine replacing the NBCs, AMCs, and TNTs with Hulus, Amazons, and Netflixes. The one shortfall has been live sports. I've been forced to put my Philadelphia Eagles and Brooklyn Nets fandom on hold as my options for watching sports at home is needlessly limited.

All my life, live sports content was delivered to viewers through a central, always-on live channel. But this doesn't need to be the case in 2016. With



Evan Dashevsky, a features editor for *PC Magazine*, has been writing about tech since 2010 for such publications as *PC World*, TechHive, ExtremeTech, and Digital Times.

the advent of high-bandwidth data networks, mobile devices, and smart TVs or set-top streamers connected to older TV models, anything can be a network.

So it makes perfect sense that viewers would be able to watch a Thursday night football match somewhere on Twitter.com or via an over-the-top (OTT) app on the big screen. Facebook was reportedly in the running to broadcast NFL games, but dropped out. In the not-crazy-distant future, however, it probably won't be so foreign an idea to see top-notch content on digital platforms. Perhaps NBA games will be viewable on Snapchat, the Academy Awards live on Instagram, or the Olympics on eBay.

THE NFL AS WEATHER VANE

There are few things more American than the NFL. It's undeniably our nation's most important spectator sport. Professional football manages the rare trick of spanning the many barriers that divide us. NFL games are perpetually some of the nation's highest-rated broadcasts, and therefore have regularly commanded multibillion-dollar broadcast rights (the Twitter deal to simulcast the ten regular-season games is reportedly only worth $250 million).

NFL fandom has been so ingrained into our culture that we can track the evolution of media in the way that NFL broadcasts have migrated throughout the years. The NFL was a purely network phenomenon until the late 1980s. That's when the first Sunday Night games made their way to ESPN, heralding the era of basic cable. In the early 1990s, things shifted again when the rights to NFC Sunday afternoon games—the crème de la content crème—were awarded to the upstart Fox network.

Evan Dashevsky

If you're old enough to remember, that migration to Fox was a big deal. I can recall a *Saturday Night Live* sketch from 1994 that imagined how Fox—then most famous for *Beverly Hills 90210*'s teen shlock and *Married... With Children*'s bottomless toilet of crass humor—would present the NFL. The mock presentation was peppered with commentary by an angst-ridden Luke Perry, non-sequitur *In Living Color*–style DJ interludes, and a bewildered John Madden (played by the late Chris Farley) stuck in the middle of it all. Fast-forward 20 years and the NFL on Fox is part of America's media fabric.

From a technical vantage point, Twitter, or any other digital platform, could successfully handle an exclusive digital streaming deal (Yahoo! simulcast CBS's coverage of an NFL game last year without a hitch). The main reason that the networks are still in the mix (well, aside from the fact they are still willing to fork over billions for the rights) is that connected televisions don't yet have the ubiquity that the NFL would need to satisfy this mass-appeal product.

But the trends are undeniable. This year, analysts expect the majority of households already online to have connected TVs as well. All-digital broadcasts can't be far behind. Will these future agreements stymie some lagging viewers? Yes, in a manner similar to the way that it hampered users who hadn't yet jumped to cable when the first games made their way to ESPN. But the takeaway from this deal is that the traditional networks are nearing their end. The NFL surely knows that even if the rest of America doesn't quite yet.

“Connected televisions don't yet have the ubiquity that the NFL would need to satisfy this mass-appeal product. But the trends are undeniable.”

evan_dashevsky@pcmag.com

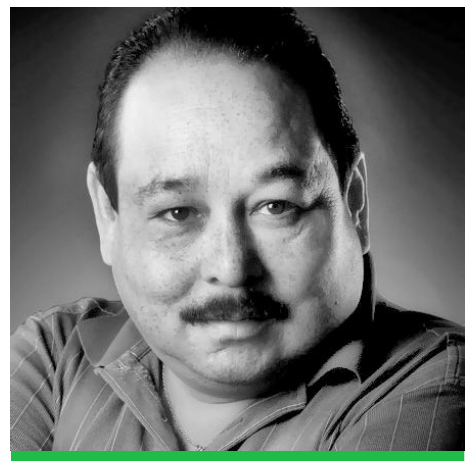
Intel Needs to Keep an Eye on Nvidia

As I listened to Nvidia CEO Jen-Hsun Huang's keynote at the company's developer conference in April, I was struck by how much Nvidia has changed since I first started covering it 15 years ago.

The company began by creating video cards and processors, and was initially focused entirely on the PC industry. But over the last ten years, as its processors became more powerful and energy-efficient, Nvidia has branched out into supercomputers and high-end graphics machines, and with its Tegra chip launched an all-out assault on the mobile space. In short, Nvidia has evolved into one of the most important semiconductor companies in the world

Intel is still by far the biggest chip maker, but Nvidia has taken its research in GPUs and made these processors the centerpiece of a new company whose products go well beyond the traditional PC. During his keynote, Huang announced a new GPU SDK for programmers who use Nvidia's processors for supercomputers, gaming, VR, design, and autonomous vehicles. This is a powerful set of new development tools that works across all of its processors and will give customers much more power to create new types of systems and applications.

Huang also announced new tools for VR creation and ray-tracing VR, which will create photo-realistic VR worlds. Nvidia plans to be a



Tim Bajarin is the president of Creative Strategies and a consultant, analyst, and futurist covering personal computers and consumer technology.

major supplier of hardware and software for creating all types of VR content and will make VR one of the core focuses of its growth.

Nvidia is also creating new chips for use in data centers. Part of this program is focused on AI-based platforms and its new chip, the Tesla P100, which basically double the speeds of processors currently used in these types of applications.

One of the most important announcements at the conference was the DGX-1, the world's first supercomputing system dedicated to deep learning. This system stacks up to eight Tesla P100 processors on top of each other and delivers 170 teraFLOPS in a box, or 2 petaFLOPS in a rack—and at a breakthrough price of $129,000.

The last thing introduced was an updated version of Nvidia's Drive PX system for use in autonomous vehicles. Dubbed the Drive PX 2, this is basically a supercomputer on a board that can sit in the trunk of a car. A demo showed a car that was able to learn to drive on main roads as well as uncharted dirt roads by itself with only 3,000 hours of training. It includes HD mapping tools and can sense, plan, and react to all types of road and driving conditions.

Nvidia is clearly charting a new course for itself, one that will continue to make it one of the most strategic chip companies in the world. Its reach into AI and deep learning, and its potential impact on the world of autonomous cars especially make it stand out from the crowd and position it well for serious growth.

Reviews

CONSUMER ELECTRONICS

Moleskine Smart Writing Set

LG Signature OLED65G6P

HTC 10 (Unlocked, 32GB)

Apple iPad Pro (9.7-inch)

HARDWARE

Samsung Galaxy TabPro S

Dell XPS 15 Touch (9550)

Origin EON17-X

Formlabs Form 2

SOFTWARE

Webroot SecureAnywhere AntiVirus

Notebooks Don’t Have to Be Electronic to Be Smart

PC MAGAZINE EDITORS’ CHOICE

Moleskine is essentially synonomous with notebooks, and the Moleskine Smart Writing Set brings the classic journal brand firmly into the 21st century. The Smart Writing Set is an analog-to-digital note-taking solution that consists of a Paper Tablet notebook, a Pen+ smart pen, and the free Moleskine Notes app. With all this, you can take physical notes on real paper with an ink-equipped pen and sync them to your phone or tablet. You can edit notes, transcribe handwritten words into digital text, and share files with yourself and others through a variety of apps and cloud services. Although the set is a bit pricey, it works well and boasts several advantages over its close competitor, the Wacom Bamboo Spark.

Moleskine Smart Writing Set

$199

●●●●◐

DESIGN AND SETUP

The Paper Tablet looks a lot like your standard Moleskine notebook, the type you expect to see an artist hunched over in the corner seat of a café. It's a hardcover journal that measures 8.50 by 5.25 inches (HW) and has an elastic strap to keep it closed. The design differs from a standard notebook's in that the pages stick out about half an inch beyond the cover and have curved edges, which Moleskine says is meant to mimic the look of a tablet. Inside, the pages are covered in a dotted grid pattern embedded with technology that recognizes the smart pen's position on the page.

Moleskine Smart Writing Set

PROS Classic notebook design. Smart pen includes on-board memory, infrared camera. Takes standard ink refills. Automatic page detection. Wide array of file format, sharing options.

CONS Expensive.

TABLET THROWBACK
Although it contains paper rather than metal and chips, Moleskine designed the Paper Tablet with the soft curves of a computing tablet.

Unlike the Bamboo Spark, which has a smart panel that can use any type of paper, the pages in the Paper Tablet are all firmly bound, and you can't swap in a regular sheet of paper and expect it to work the same way. You get 173 usable pages in the notebook, so you won't run out of room quickly, but you will need to purchase a new Paper Tablet (for $29.95) when you do.

As for the Pen+, it's a nicely built aluminum writing instrument with three flat sides and a tip that resembles a fountain pen's. It takes standard ink cartridges, so refilling it is simple and inexpensive. There's an LED status indicator for charging and syncing, a Power button, and a cap with a metal clip. It also has a micro USB power port, and comes with a micro USB cord for charging. That's another difference from the Bamboo

Spark, as here it's the pen that needs to be charged, not the writing surface. The pen should last for 5 hours of continuous writing, though it seemed to hold up longer than that in my tests.

The Moleskine Notes app is attractive and easy to use. It's available for both Android and iOS devices, and displays all of the notes you take in the Paper Tablet. Once the app is downloaded, you can sync the Pen+ by following some on-screen instructions that only take a few seconds to complete. After some quick tutorial screens, you're ready to go.

FEATURES AND TESTING

The Pen+ uses an infrared camera near the tip that tracks what you write. On-board memory holds up to 1,000 note pages, which lets you digitize your notes later when your phone or tablet isn't handy. You can see the pen's remaining memory and battery charge at any time by pressing an icon in the top-right corner of the app.

As you write in the Paper Tablet with the Pen+, your scribbles appear on a digital page in the app in nearly real time; the Spark only loads once you sync it. Although the Pen+ writes in black ink on the page, the app greatly expands your possibilities. You can change pen thickness and select digital ink color on the fly. There's a full color wheel of options, which is a major benefit over the black-only Spark, particularly for artists. Pen tracking is accurate, with a good sense of how much pressure you're exerting on the page.

INK, YOU THINK
The Pen+ uses real ink and an infrared camera to track what you put on paper. Then fire up the Moleskine Notes app to make the most of your words.

Another benefit to the Smart Writing Set is that it can recognize when you're writing on separate pages, thanks to the use of the smart paper in the Paper Tablet. If you write on one page and then switch to another, both pages will be entered as separate files in the app. On the Spark, writing in the same spot on a new page makes the new writing appear on top of the old writing in the app.

Moleskine's app has a bevy of useful sharing and editing features, including the ability to digitally transcribe handwritten text so you can copy and send it

through email or other apps. The accuracy of this feature is impressive—it rarely misinterpreted my writing, which isn't exactly the neatest. You can also label notes with tags to make them easily searchable and record voice notes that can be played back later. There's also an edit function for highlighting or writing on your digital notes.

There's no shortage of ways to send notes to yourself or someone else. When you're finished taking notes, you can export the file in multiple formats through various services, a process that the app makes very simple. You can choose to export writing as text, send it as a PDF or image, or upload it to cloud services like Dropbox or Evernote. There's also an email icon in the top corner of every Paper Tablet page; tapping it with the Pen+ activates a prompt to instantly email the page to someone.

CONCLUSION

The Moleskine Smart Writing Set is an impressive note-taking solution, combining the familiar tactile feel of writing in a notebook with convenient modern technology. The Wacom Bamboo Spark offers a similar experience, but Moleskine has a few key advantages: multiple ink colors, a more advanced pen that uses standard ink refills, automatic page detection, and that classic notebook styling. Some of these features are app-related, and can theoretically be added to the Bamboo Spark, but the current state of Moleskine's app, Pen+, and Paper Tablet at release is fantastic. The Smart Writing Set is my preferred method of analog-to-digital note-taking.

MATTHEW BUZZI

This Ultrathin, Ultra-HD TV Is As Sweet As a Set Gets

PC MAGAZINE EDITORS' CHOICE

LG's trend of producing thoroughly excellent, wildly expensive televisions using high-performance organic light-emitting diode (OLED) panels continues in 2016 with the Signature G6 line. LG also adds high dynamic range (HDR) to its ultra high-definition (UHD, or 4K) panel, and offers support for both Dolby Vision and HDR-10. All of that, combined with a built-in soundbar and an impossibly thin design, will cost you; the 65-inch OLED65G6P we tested retails for $7,999.99. Even so, this is one of the all-around most impressive TVs we've tested.

LG Signature OLED65G6P

$7,999.99

●●●●●

LG Signature OLED65G6P

PROS Superlative picture with 4K HDR. Incredibly slim panel. Base features built-in soundbar. Loads of connected features.

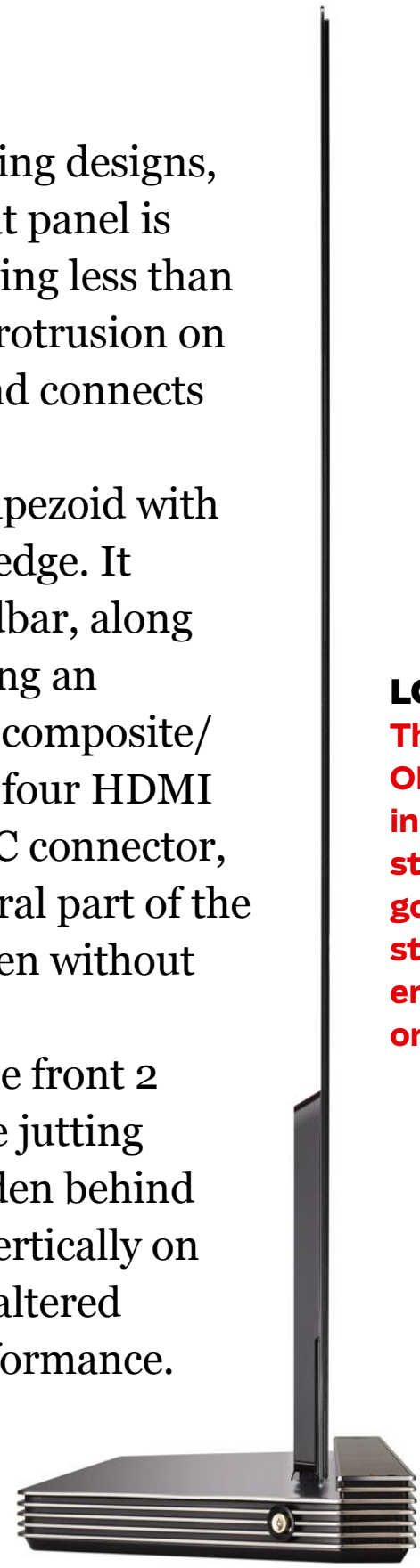
CONS Expensive.

DESIGN

Many LG OLED televisions have had striking designs, but the G6 outdoes them all. The entire flat panel is mounted on a single sheet of glass measuring less than a quarter of an inch thick. A rectangular protrusion on the back houses some of the electronics and connects the panel securely to the base.

The base is a stylish, 2-inch-tall near-trapezoid with horizontal metal strips running along the edge. It conceals a 60-watt Harman Kardon soundbar, along with the G6's various connections, including an antenna/cable connection, a combination composite/component video input, an Ethernet port, four HDMI inputs, an optical audio output, an RS232C connector, and three USB ports. As such, it's an integral part of the television itself, and you can't use the screen without the base installed in some way.

When used as a stand on a table, only the front 2 inches of the base are visible as a rectangle jutting forward from the screen. The rest sits hidden behind the panel. The base can also be installed vertically on the panel for wall mounting; LG says this altered orientation won't hurt the soundbar's performance.

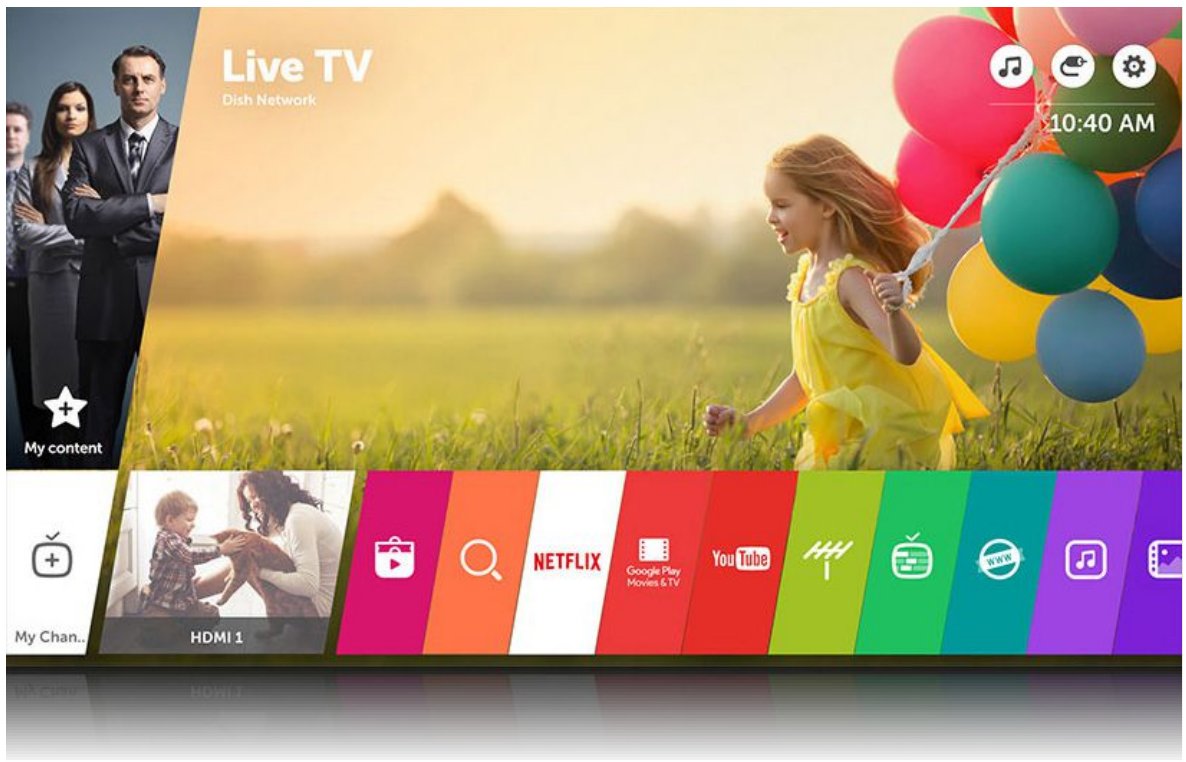


LOVE ME SLENDER
The LG Signature OLED65G6P is incredibly thin and stylish, so it will look good whether it's standing in an entertainment center or mounted on a wall.

FEATURES

The G6 uses LG's newest connected television platform, WebOS 3.0. It's similar to earlier versions of the OS in terms of interface design and available features. It uses the same angular menu bar along the bottom of the screen that displays apps, services, sources, and other functions in a single line. It also offers the same collection of apps, including 4K streaming services like Amazon, Netflix, Vudu, and YouTube.

WebOS 3.0 adds a new My Content feature that lets you pin your favorite movies and shows to a quick-access menu on the left side of the screen. Any content you select as a favorite will appear on the menu, with quick access through streaming services that offer it. A My Channels menu has also been added right below My Content, letting you select up to ten favorite channels to access quickly. The G6 is compatible with most set-top boxes, and integrates channel navigation into its menu system. It also supports 3D content, and includes two pairs of passive glasses.



SCREEN-WIDE WEB
The WebOS 3.0 connected TV platform powers the OLED65G6P's smart features, which include apps, favorite channels, and more.

REMOTES

LG includes two remotes with the G6. The larger remote is a redesigned, Signature-specific version of the Magic Remote LG has included with previous WebOS

televisions. It's an 8.8-inch silver candy bar wand covered in black buttons, with a navigation pad featuring a clickable scroll wheel in the center. The number pad and Channel, Power, and Volume buttons sit above the wheel, and playback controls are below it. Like LG's other Magic Remotes, this wand functions as an air mouse, moving an on-screen cursor when navigating the television's WebOS 3.0 interface.

The second remote is smaller (5.5 inches), simpler, and silver. It contains only a navigation pad, volume and channel controls, and basic buttons (Back, Home, Input, and Power). This remote doesn't function as an air mouse the way the larger Magic Remote does, but it's suited just fine for paging through menus and streaming services.

PERFORMANCE

We test televisions with a DVDO AVLab 4K test pattern generator, a Klein K-10A colorimeter, and SpectraCal's CalMAN 5 software. Like all other OLED televisions we've tested, the G6 is capable of displaying perfect black, emitting absolutely no light. We measured its peak possible brightness at 386.17 candelas per square meter, excellent performance for an OLED panel, and about the same as the LG 65EF9500. Because of its perfect black levels, the G6's contrast ratio is "infinite" (meaning it can't be mathematically calculated).

The television can reach well beyond expected color measurements while not showing much noticeable skewing of any given color. The 65EF9500 also showed excellent range, but the G6 seems to reach a bit further more consistently, particularly with greens and reds.

VIEWING EXPERIENCE AND CONCLUSIONS

Thanks to the strong contrast and excellent colors, the G6's picture is incredible when watching HDR 4K content. I tested the set's HDR-10 functionality with the Ultra HD Blu-ray version of *Mad Max: Fury Road*. The red sand of the wasteland and the blue-white skies looked vivid and full of subtle shifts in hue and tone. Dark details on vehicles and in shadows appeared crisp without looking remotely washed out. Simply put, the G6's picture is fantastic when displaying 4K HDR video.

Other content dazzles, too. I watched *X-Men: Days of Future Past* on both Ultra HD and standard Blu-ray to see how the television upconverts 1080p video. Upconversion can't produce new details where there are none in the original source material, but the film nonetheless looked crisp and detailed scaled up to 4K. The dark, purple-neon-lit landscape had plenty of clarity in the shadows, and the bright orange of the inhibitor devices and the red of Wolverine's cigar's embers popped out. The standard Blu-ray obviously wasn't this sharp, but it still showed loads of detail on the G6, without any blotchiness or noticeable artifacting of less-advanced upconversion processes.

The built-in soundbar is an appreciable improvement over the speakers found in most HDTVs. The fight scenes in *Days of Future Past* were forceful, with the impact of gunfire and punches sounding definitive against the drumbeat of the soundtrack. Dialogue also came through clearly. The soundbar can't replace a larger, more powerful multipiece speaker system in terms of how much sound it can put out or even how much it can make the walls shake, but compared with other HDTV speakers we've heard, it sounds very good.

Once again, LG has produced a television with the best possible picture thanks to OLED technology. Perfect blacks, excellent color reproduction, and support for both HDR-10 and Dolby Vision HDR standards add up to an incredible display that's only made better by the thin design and superior sound quality. If this set is out of your price range, the Samsung UNJU7500 series offers a feature-rich 4K viewing experience with an attractive design, and the Vizio Du series, though not nearly as stylish or powerful, offers an excellent value for users looking to get into 4K for the first time. But if you're looking for the best television money can buy right now, then that television is the LG Signature OLED65G6P.

WILL GREENWALD

The Best Unlocked Phone You Can Buy

PC MAGAZINE EDITORS' CHOICE

A funny thing happened while I was testing the new HTC 10: I couldn't stop listening. HTC's latest flagship is the best smartphone for audio I've heard in a long time, although you need to pair it with some really good headphones for the advantages to come through. It's also the first Qualcomm Snapdragon 820–powered unlocked phone available in the U.S., which makes it the most powerful unlocked phone on the market. When you combine these benefits with a sleek design and attractive software enhancements, you get our new Editors' Choice for unlocked phones.

HTC 10
(Unlocked, 32GB)

$699

PHYSICAL FEATURES AND BATTERY

The HTC 10 feels like a big slab of metal at 5.74 by 2.83 by 0.35 inches (HWD) and 5.68 ounces, although it's actually smaller than the Samsung Galaxy S7 Edge (5.94 by 2.86 by 0.30 inches); all that matte aluminum gives the impression that it's bigger than it is.

The front of the phone is mostly a 5.2-inch, 2,560-by-1,440 Super LCD 5. It looks about as bright as the AMOLED display on the regular Galaxy S7, but lacks the intense contrast. It isn't always on, but that feature doesn't work well on LCDs anyway. Below the screen there's a combination Home button and fingerprint sensor, which is flanked by capacitive back and multitasking buttons. The body is slightly water-resistant, but not waterproof—don't dunk it.

HTC 10
(Unlocked, 32GB)

PROS Awesome audio. Good-looking software. Fast performance. Attractive design.

CONS Expensive. Wi-Fi performance is a bit slow. Some camera focus issues in low light.

YOUR PRINTS WILL COME
HTC claims the HTC 10's fingerprint sensor is the fastest in the industry. Maybe so, but you'll be hard-pressed to tell for sure.

HTC says the fingerprint sensor is the fastest in the industry, and we found it to be slightly faster than the Galaxy S7's, unlocking the phone in 0.4 second as opposed to 0.5. In practice, though, the speed difference isn't really noticeable. The sensor is more accurate than the S7's, though.

The back of the phone is an ultra chamfera: a relatively large, shiny, angled slide that comes down to a more conventional right angle at the edge. I'm not sure how I feel about it, but it definitely stands out. The back is domed enough that the phone will rock on a table if you push it. On the side, the Power button is ridged to make it easy to find. That's a really useful touch.

The phone has a microSD card slot that had no trouble with a 200GB Lexar card, and it charges with USB Type-C and Qualcomm's Quick Charge 3.0 technology. HTC says the phone can charge 50 percent of its 3,000mAh battery in 30 minutes, and it also supports dual-standard wireless charging.

Battery life is good. We got 6 hours, 4 minutes, of video streaming time, which is solid, if not up to the Galaxy S7's 9 hours. That isn't the whole picture, though: HTC's software bleeds somewhat less battery in standby than Samsung's does, and the phone comes with an app called Boost+ that sips power by reducing the screen resolution when you're playing games. After seven and a half hours in standby, a Samsung Galaxy S7's battery had dropped by 8 to 10 percent, but the HTC 10's battery had only dropped by 2 to 3 percent.

STYLE TOUCHES
A rounded back panel and a ridged Power button give the HTC 10 a distinctive look and feel.

CALLING AND NETWORKING

The unlocked model of the HTC 10 supports LTE bands 1/2/3/4/5/7/12/13/17/20/28/29/30 and LTE Category 9, which means it will get the fastest speeds and best coverage that AT&T and T-Mobile have to offer. We found this true in our tests, where LTE speeds and coverage were on par with those of the Galaxy S7 Edge. Qualcomm's TruSignal antenna tuner helps the HTC 10 recover from connection drops much more quickly than last year's devices. The phone will also work perfectly on Canadian networks, although it lacks CDMA so it can't authenticate on Sprint or Verizon.

Wi-Fi performance is fine, although it isn't up to Galaxy S7 levels. We got about half the speed we saw on a Galaxy S7 at various distances from our Verizon FiOS test router: 20Mbps down instead of 40Mbps, for instance, or 2Mbps instead of 4Mbps. It was still usable, especially at closer distances. A software update we received in the middle of our testing process bumped up speeds—they were originally even lower—so this may be something that can be further improved in firmware.

Call quality is very good, thanks to vigorous speakers and excellent LTE connectivity. Test calls were clear, loud, and sharp, and the bottom-ported speakerphone was easy to hear outside. Noise cancellation was also effective. The phone supports VoLTE and Wi-Fi calling, and it will support T-Mobile's enhanced EVS codec for even better call quality in a software update, HTC said.

SOFTWARE

The HTC 10 runs Android 6.0 Marshmallow with HTC's latest version of Sense. HTC said it's trying to slim down duplicate apps, and that effort is appreciated. The apps HTC kept are a mix of its own and Google's: HTC's camera, Google Photos, HTC Mail, Google Calendar, and Google Play Music, for instance. True, there are apps for Facebook, Facebook Messenger, and Instagram, but you'll probably use them anyway. This is on the unlocked version, of course; expect U.S. carrier versions to be loaded with redundant carrier apps.

There are two major, obvious changes from Google's stock Android here. First, if you swipe to the left of the home screen, you get HTC's Flipboard-like News Republic aggregator. And second, in HTC's Theme Store you can download new Freestyle themes, which are so open that they're almost disturbing. There's no icon grid. You can place icons, widgets, and stickers (oversized icons) willy-nilly. The one Freestyle theme available to start is travel-themed, and way too low-contrast, but it's safe to say this is the least iPhone-like layout I've seen in a long time.

Of the 32GB of internal storage, about 25GB is available. You can always add a microSD card, and unlike the Galaxy S7 or the LG G5, this phone supports Google's Adoptable Storage mode to make the card look like internal storage.

In terms of performance, the HTC 10 is on par with other Snapdragon 820 devices like the Samsung Galaxy S7 and the LG G5, with one notable exception: If you use the HTC 10's Boost+ software to knock screen resolution down to 1080p in games, you'll boost your frame rates, too.

LISTEN UP

Instead of front-facing speakers, the HTC 10 has a front-facing tweeter up by the earpiece, and a woofer that doubles as the speakerphone along the bottom. This creates mono sound that's a little hard to measure, because it's radiating from the whole phone rather than coming out of a specific point. It sounds less tinny than most phones, but not room-filling.

But when you plug in headphones: wow. The 1-volt headphone amp, more powerful than in the Galaxy S7 or the iPhone 6s, can drive high-end headphones like no other phone can. The payoff is in gorgeously round, textured, detailed sound across all genres of music. It only gets better as you turn up the volume. The difference is less noticeable in mediocre headphones, so it pays to invest (and you'll have to, as HTC doesn't include any headphones at all).

Headphone audio quality is further improved by a Personal Audio Profile (PAP), which surveys your aural faculties and enhances the frequencies where your hearing is slowly fading. The result for me was discovering that there are bass notes in some of my favorite songs that I just hadn't been noticing at all. I almost can't work when using the phone to listen to music. It's that good.

“I almost can't work when using the phone to listen to music. It's that good.”

But it gets even better! This is the first Android phone to officially support Apple's AirPlay, the formerly proprietary Wi-Fi streaming protocol that a number of wireless speakers support. In a panel in the Settings menu, you can quickly connect to Chromecast, Miracast, and AirPlay devices. The phone can stream video via Chromecast and Miracast, but only do audio through AirPlay. That's fine. It's a cherry on top of the best audio playback phone available.

CAMERA AND VIDEO

The story with the HTC 10's camera is more mixed than with the audio, and is where the Galaxy S7 pulls ahead a bit.

The HTC 10 can shoot Raw or JPEG stills, its camera app has some Pro Mode controls, and it can record up to 4K video at 30 frames per second (fps). It has built-in slow-motion and hyperlapse modes, too. Both of its cameras have optical image stabilization to smooth out videos. It also records high-quality audio up to twice as loud as other phones without clipping.

The main camera is a 12-megapixel unit with 1.55µm pixels, which are larger than the 1.4µm pixels in the Samsung Galaxy S7. That should make for better low-light performance, right? Alas, no. The Galaxy S7's f/1.7 aperture (slightly larger than the HTC 10's f/1.8) and its added focus pixels seem to make a detectable difference.

In good light, photos look excellent. The differences come out when the lights go down. On a cloudy day, the S7's shots look just a bit brighter and sharper. Very low-light shots on the HTC 10 are a bit noisier than on the S7, but more important, the phone has trouble focusing in situations where the S7 has no issues, and focus in general is slower. Tapping to focus doesn't change the

exposure, which can make taking photos with a dark foreground and a bright background difficult. In addition, the HTC 10 would also occasionally throw an error about me blocking the laser autofocus when I wasn't; HTC says this will be improved in a software update.

The front-facing, 5MP camera, with 1.34µm pixels, has good if somewhat noisy performance. It's a little soft in low light, but at least it doesn't do the irritating super-smoothing thing that Samsung and LG phones do, and it's less noisy than the iPhone 6s.

> **The HTC 10 is the best music phone on the market.**

COMPARISONS AND CONCLUSIONS

The HTC 10 is the best music phone on the market, and a strong performer all around. Its solid, all-metal body, quick performance, and fast fingerprint scanner make for an elegant experience. Aside from the audio quality, though, we still like the Samsung Galaxy S7 Edge a bit better. It packs an even bigger screen into an only slightly wider body, it has a larger battery, and more important, it has a better camera. Low-light camera performance is a hugely important feature, and the S7 and S7 Edge lead the pack right now.

That said, LG and Samsung hurt themselves by not making available unlocked versions of the G5 and the Galaxy S7. If you're looking for a high-end unlocked phone with no carrier bloatware in the U.S., your best choices were previously the Google Nexus 6P and the Motorola Moto X Pure Edition. The HTC 10 outpaces both. Its Snapdragon 820 chipset is much faster, and its newer modem handles connection drops far better than the other models. Although it isn't running stock Google Android, HTC's Sense has relatively few superfluous apps and is full of new, useful features like AirPlay support. The HTC 10 may be more expensive than its competitors, but you're getting value for that money. That makes the HTC 10 our new Editors' Choice for unlocked phones.

SASCHA SEGAN

Good As It May Be, This iPad Can't Replace Your Laptop

Apple iPad Pro (9.7-inch)

$599 and up

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The iPad has now gone as far as its software will let it. The new 9.7-inch Apple iPad Pro is a powerful, portable tablet with high-end features and a price to match. But the limits of iOS and iOS apps mean it's no laptop replacement. Like its 12.9-inch big brother, it's more expensive than the iPad or Android tablets, but isn't as capable as Windows two-in-ones in the $800-$1,000 price range. The iPad Pro 9.7 has a terrific processor and a gorgeous screen, and is more affordable than the larger iPad Pro. But the apps available for iOS don't justify its high price.

PRICING AND PHYSICAL FEATURES

The 9.7-inch iPad Pro comes in six models. Wi-Fi–only versions are $599 for 32GB, $749 for 128GB, and $899 for 256GB. Cellular versions cost $729 for 32GB, $879 for 128GB, and $1,029 for 256GB. The Smart Keyboard cover adds $149, and the Apple Pencil stylus is $99.

This Pro is the exact same size, shape, and weight as the iPad Air 2: 9.40 by 6.60 by 0.24 inches (HWD) and 0.96 pound. It comes in dark gray, gold, rose gold, or silver. The most visible change from the Air 2 is how the camera lens slightly protrudes from the tablet body,

Apple iPad Pro (9.7-inch)

PROS Fast. Top-notch Pencil stylus, keyboard accessories. Loud speakers. Great-looking screen.

CONS Expensive. iOS apps fall short of Mac and Windows apps in traditional business functionality.

because the Pro is using the 12-megapixel iPhone 6s camera rather than the 8MP iPhone 6 camera seen on Apple's other recent tablets. (No, it doesn't rock when it's set down on a table.) The front camera has been upgraded to the 5MP unit from the iPhone 6, too. If you look along the edges of the tablet, you can see the new quad-speaker setup. As with other iPads, the only port is a single Lightning connector.

KEYS TO THE KINGDOM?

Although the $149 Smart Keyboard cover helps, the 9.7-inch iPad Pro still isn't ideal for many professional applications.

The True Tone display is new, too. It's the same 2,048-by-1,536 resolution screen you get on the Air 2, but it's less blue because of ambient light sensors that change the display's white point to respond to surrounding lighting. You can turn that feature off; it's nice, but far from a must-have. Apple also claims that the screen has a wider color gamut than previous iPads, though I found that difficult to see.

The most useful advance that I found from the Air 2 is the new speaker arrangement. Not only are the speakers about 6dB louder than the Air 2's, their more diverse placement makes for a richer, more immersive sound.

ACCESSORIES AND NETWORKING

My review unit came with Apple's Smart Keyboard cover, which docks to a magnetic connector on the bottom of the tablet. It's a lightweight and very usable keyboard. It's narrower than the 12.9-inch iPad Pro keyboard, but Apple kept the overall space around the letter and number keys the same by shrinking the function keys around the edges. That's smart, and it makes for an unusually pleasurable typing experience—I had less finger fatigue than I do typing on Logitech's Ultrathin Keyboard Cover, our favorite keyboard for the iPad Air.

The Pro also works with the Apple Pencil, which is smoother and better than other available tablet styli. The more expensive Surface Pro 4, for instance, comes with a pen that clips right onto the side of the tablet, but it feels cheap and chunky, and the tablet's screen flexes a bit when you press hard. The Apple Pencil is much more solid and better balanced, feels more realistically grippy on the screen, and has options for tilt and shading sensitivity that other styli lack.

Like the iPad Pro 12.9, the Pro 9.7 has dual-band 802.11a/b/g/n/ac Wi-Fi with MIMO. In practice, I got the same excellent Wi-Fi speeds and performance on this iPad as on the 12.9-inch Pro, and significantly better performance than I saw on the Air 2. That tablet topped out around 120Mbps on a 150Mbps connection, but the Pro models were able to get 150Mbps; they were also significantly faster at the edge of the Wi-Fi cell, sometimes to the tune of 60Mbps versus 10Mbps.

For LTE connections, the Pro 9.7 has the embedded Apple SIM, which lets you activate the tablet with day passes or monthly subscriptions on AT&T, T-Mobile, Sprint, or GigSky, a roaming provider. Unlike all previous iPads, the Pro 9.7 includes band 12, which extends T-Mobile's suburban and rural coverage, and band 30, which alleviates congestion in some AT&T cities. But I don't find those additions blockbusters the way they are for the iPhone SE, because cellular service is mostly a supplement to Wi-Fi on iPads, rather than its primary form of Internet access.

PERFORMANCE

The iPad Pro 9.7 uses a 2.26GHz Apple A9X processor with 2GB RAM, which provides performance in between the Air 2 and the 12.9-inch iPad Pro. With Geekbench scores of 3,081 single-core and 5,294 dual-core, it's still faster than any Android tablet. The Pro 9.7 benchmarks better than Intel Atom-based Windows tablets or the 12-inch Intel Core M–based MacBook, and competitively with a two-year-old MacBook Air. Its graphics hardware is also strong, notching 32 frames per second (fps) on the GFXBench OpenGL ES 3.0 Manhattan test, just as the 12.9-inch iPad Pro did. In other words, this is laptop-class hardware, able to crunch numbers and generate images as well as Macs or Windows devices.

The 12MP camera on the new iPad is very similar to the one on the iPhone 6s and the iPhone SE. The standout new features are 4K video recording and continuous autofocus. With tablets, don't think about the main camera as a way to capture family snapshots—think of it rather as a tool for computer vision or augmented reality. More pixels can really help there.

WHEN THE CHIPS ARE DOWN
Powerful processing and graphics hardware ensure top-notch, laptop-quality performance.

The front-facing camera on a tablet, meanwhile, is for video conferencing and live streaming, among other things. Although the sensor has bumped from a grainy 1.2MP up to 5MP, it's still only capable of 720p video, which is disappointing. There's no obvious reason for that, especially given that most conferencing and live streaming platforms now support 1080p or better.

In our battery test, which streams a video over Wi-Fi at maximum brightness, this iPad Pro lasted 5 hours, 38 minutes. That's much better than the 3 hours, 51 minutes, I got on the 12.9-inch version, and slightly better than the Air 2's 5 hours, 15 minutes. Remember, cutting the screen brightness to half—as you do most of the time in real-life usage—generally almost doubles that, giving you the 10 hours of battery life that Apple predicts.

BUT IS IT PRO?

Apple is pushing the iPad Pro as a laptop replacement, but it isn't. The iPad Pro simply doesn't do the kind of work we do on laptops as well as a laptop does. But it does new kinds of work, tablet-centric work, that's still relatively inchoate and hasn't entirely been defined yet.

Big-name professional apps are now appearing on iOS, but they're generally de-featured in some way. Microsoft Office is ideal for basic document creation, but it doesn't include everything you find on Office for Windows. (I rely a lot on Excel macros, for instance.) Pro artist apps like Photoshop, Procreate, and Sketches have basic document creation down pat, but fall short when it comes to the kinds of layering, correction, editing, and export tasks that many artists need to finish their jobs. None of the many PostgreSQL database clients is quite as convenient to use as Postico on the Mac. You can absolutely edit multiple 4K video streams, but the workflow in the touch-only iMovie is awkward when you're managing a large library of clips (and you can't attach an external hard drive with footage). And in the professional world, there's also a huge library of line-of-business apps that have always been custom Windows solutions.

The best "pro" apps I've seen on the iPad are usually designed to be used standing up or walking around, including point-of-sale apps, airline or hotel check-in apps, architecture and real estate CAD or viewing apps, astronomy apps, and others. These never worked well on laptops anyway, and they're better suited for the 9.7-inch iPad than the 12.9-inch iPad, because it's more portable. The 12.9-inch model is fine if you're working on a drafting table or at a desk, but it's unwieldy to hold in the crook of your arm. The 9.7-inch model can be used with the Pencil to take notes while standing up without awkwardness, for instance. So on one level, it is more Pro than even its bigger sibling.

THE LESS PRO, THE BETTER

The smaller, more portable iPad Pro is easier to use in most business settings than its 12.9-inch older sibling.

COMPARISONS AND CONCLUSIONS

The 9.7-inch iPad Pro is more powerful than the iPad Air 2, but I'm having trouble justifying the increased price for most buyers. For $499, you can get a 64GB iPad Air 2 with similar size, shape, and performance. The Pro's sweet spot is the 128GB model, which costs $749 (or $879 with cellular). Add the keyboard and Pencil to take advantage of the tablet's "pro" features, and you're up to $997 (or $1,127 with cellular).

If it cost as much as the iPad Air 2, the Pro would be a good buy. But the Pro lives in a sort of uncanny valley of the tablet market, where it's priced about the same as high-quality Windows two-in-ones like the Microsoft Surface Pro 4 and the HP Spectre x2, but can't run fully featured business apps—which, generally speaking, are also still designed for a mouse-and-keyboard paradigm. Most business and vertical iPad apps, meanwhile, don't need the Pencil support, quad speakers, or screen tweaks you get with the Pro, and so they'll work perfectly well on an iPad Air 2.

The big exception here is if you intend to draw or take notes with the Pencil, which provides an unmatched stylus experience. I'd also suggest the price premium might be worth it if you intend to use the internal speakers frequently, as the new quad speakers are a major improvement over those in the iPad Air 2. But although the 9.7-inch iPad Pro is a very good tablet, the iPad Air 2 and the Surface Pro 4 remain our Editors' Choice picks.

SASCHA SEGAN

Samsung's Windows Tablet Is Thin (In Several Ways)

Samsung Galaxy TabPro S

$899.99 (as tested)

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As the Windows tablet category continues to grow, new players want to make their mark. Samsung is the latest manufacturer to step in to the ring, with its Galaxy TabPro S, and it certainly makes a lasting impression, with a thin and light build, bundled keyboard cover, colorful AMOLED screen, and compatibility with Samsung phones. But its other limitations keep it from being ideal for everyone, unless you're firmly enmeshed in the Samsung ecosystem, or want one of the thinnest Windows tablets you can buy.

DESIGN AND FEATURES

It is difficult to overstate just how thin and light the TabPro S is. At a positively svelte 0.25 by 11.43 by 7.83 inches (HWD) without the included keyboard cover, it's leaner than the HP Spectre x2 (0.31 inch) and the Microsoft Surface Pro 4 (0.36 inch). It weighs a mere 1.52 pounds (the keyboard cover adds about 13 ounces). That makes the slate itself a little lighter than the Microsoft Surface Pro 4 (1.73 pounds), minus the cover. The TabPro S has a magnesium-alloy frame with curved, metal edges and a glass display. The back is made of plastic, but doesn't feel at all cheap or flimsy. The TabPro S's looks recall those of Samsung's design schemes for its phones, such as the Galaxy S7, and its tablets, like the Galaxy Tab S2 9.7. It is available in both black or white.

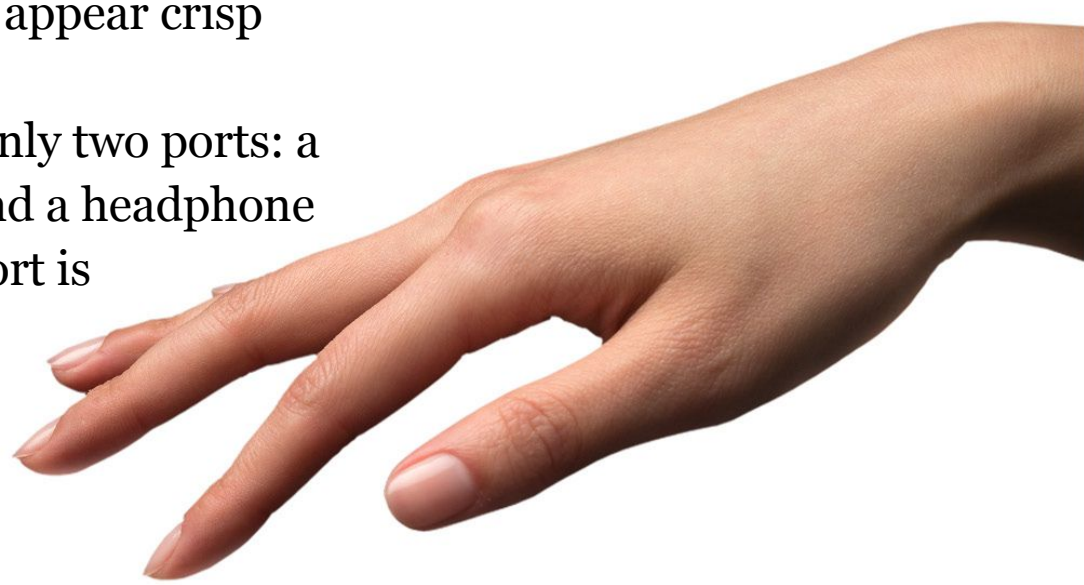
Samsung packs a 12-inch display into the TabPro S's 11-inch frame by giving it a very slim bezel. The screen is a standout feature; it's the first Super AMOLED display we've seen on a Windows tablet and has the ability to turn off pixels completely, making blacks deeper and other colors brighter and more vibrant. It also gives the system the ability to reserve battery power. The 2,160-by-1,440-resolution screen is not as sharp as the 2,736-by-1,824 one on Microsoft's Surface Pro 4, but photos and full-HD videos appear crisp and vivid.

The tablet's slim frame allows for only two ports: a USB Type-C port on the right edge and a headphone jack just below it. The USB Type-C port is used for both charging the tablet and connecting peripherals (similar to the Apple MacBook), so you'll have to make sure your battery is charged before plugging in

Samsung Galaxy TabPro S

PROS Slim, lightweight. Polished metal, glass design. High-quality Super AMOLED screen. Best-in-class battery life. Bundled keyboard cover.

CONS Processor can't match performance of CPUs in competing systems. Contains only one port. No bundled USB Type-C adapter. Lacks stylus, expansion slots.



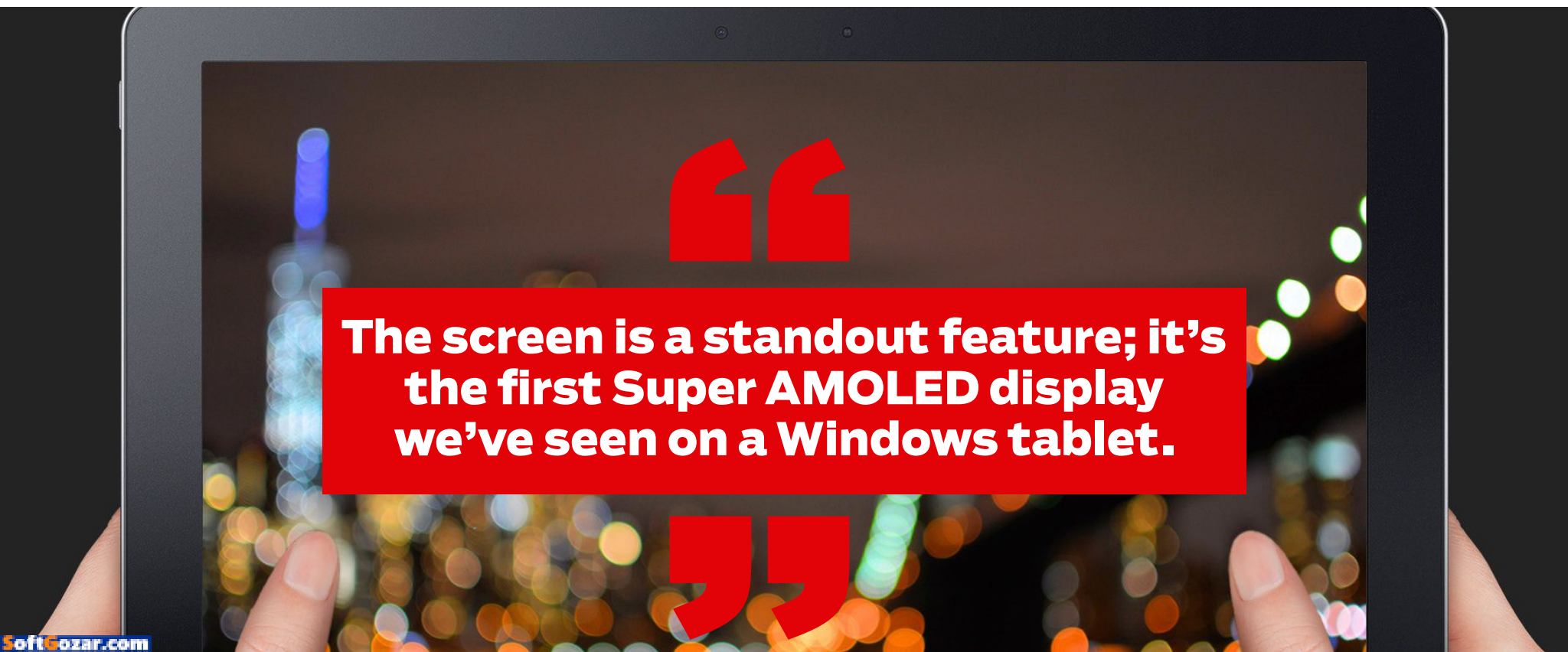
anything other than the charger. The TabPro S doesn't currently include an adapter for the port, and Samsung doesn't sell one, so you'll have to purchase one separately from a third party. Another problem: The port isn't Thunderbolt-compatible and there's no slot for expanded storage. The Surface Pro 4 has many more connectivity options, including a full-size USB 3.0 port, a microSD slot, a Mini DisplayPort jack, and a separate charging port.

For wireless connectivity, you get 802.11a/b/g/n/ac Wi-Fi and Bluetooth 4.1, but no 4G/LTE support, which the Spectre x2 offers.

The Power and Volume buttons jut out slightly from the top edge of the metal frame. On the back and front are 5-megapixel cameras. The rear camera takes clear, bright shots, and the front-facing camera is more than capable for selfies and video calls. A small speaker grid sits on the right edge right above the ports, and one other speaker grid is on the left edge of the tablet, along with a Windows button. Because the speaker grids are so small, they sound a little hollow and tinny, especially when the volume is turned up.

Unlike the Surface Pro 4, the Galaxy TabPro S ships with a keyboard cover. The keyboard is full-size and strongly resembles the Type Cover for the Surface Pro 4, and feels rather cramped. The keys exhibit shallow travel, and it can be difficult to type quickly because of the constrained space. The touchpad on the keyboard cover is small, but very smooth, with integrated mouse buttons.

The keyboard cover attaches magnetically to the back of the Galaxy TabPro S. To connect the tablet to the keyboard, you open the cover and move the bottom of the tablet forward until it docks with the connector on the keyboard. No hinged stand pops out of the back of the tablet, as on the Surface Pro 4, so there are only two ways to position the tablet on the keyboard: straight up or leaning back slightly. The connection to the keyboard is sturdy; you can pick up the tablet in one hand with



the keyboard attached, and the keyboard will not fall off.

The TabPro S comes with Windows 10 Home, which lacks the deeper security features of Windows 10 Pro but runs full desktop programs. The Surface Pro 4 bundles in a stylus, making that tablet a much more viable choice for artists and designers, though Samsung says it will be releasing a stylus for the Galaxy TabPro S in the near future. Another feature due to be introduced soon is Samsung Flow, which creates a connection over a Wi-Fi hotspot between the tablet and your Galaxy phone so you can unlock your TabPro S from your phone and push notifications to your tablet. It should be a draw for Samsung devotees who would like to see the same compatibility and synchronicity that you get with Apple products.

Our review unit came with a 128GB solid-state drive (SSD), with 119GB available out of the box. Samsung bundles a one-year limited warranty.

PERFORMANCE

The TabPro S runs on an Intel Core m3-6Y30 processor and 4GB of RAM, which explains the system's mediocre productivity performance. Scoring 2,380 on the PCMark 8 Work Conventional test, it clocked behind the Surface Pro 4 (2,612), which uses an Intel Core i5 processor, and the Spectre x2 (2,841), with its Intel Core m7 chipset. The TabPro S performs basic productivity tasks like working in Microsoft Office well enough, but will struggle and slow down when you are working in multiple browser windows or have several programs operating simultaneously.

Performance in our multimedia tests was average, with the TabPro S finishing the Handbrake video encoding test in 3 minutes, 54 seconds, and scoring 189 on CineBench. It didn't fare as well as the Spectre x2, which took 3:17 for Handbrake and scored 221 on CineBench. The Surface Pro 4 is still the best multimedia tablet among the competition, with a time of 2:20 in Handbrake and a 307 CineBench score. The TabPro S took 6:46 to complete the Photoshop CS6 test, behind both the Spectre x2 (4:36) and the Surface Pro 4 (3:10).

With its integrated Intel HD Graphics 515, the TabPro S scored a respectable 3,908 on the 3DMark Cloud Gate test and 263 in Fire Strike Extreme. The Surface Pro 4 and the Spectre x2 both beat out the TabPro S soundly in these graphics tests, with the former scoring 5,715 in Cloud Gate and 388 in Fire Strike Extreme, and the latter scoring 4,735 in Cloud Gate and 318 in Fire Strike Extreme.

In the gaming tests, the TabPro S averaged 12 frames per second (fps) in Heaven and 13fps in Valley, at medium quality settings. Again, the tablet was

beaten by the Surface Pro 4 (21fps Heaven, 23fps Valley) and the Spectre x2 (16fps Heaven, 17fps Valley), its results were on par with those of the Surface Pro 3. The TabPro S isn't geared toward serious gamers, but it's more than adequate for playing simpler titles.

The combination of the 5,200mAh battery and the energy-efficient Super AMOLED display help the TabPro S achieve long battery life, scoring 11 hours, 13 minutes, in our rundown test. The only Windows tablet that comes close is the Surface Pro 4 (10:19). The TabPro S outlasted other Windows-based competitors like the Spectre x2 (9:38) and the Surface Pro 3 (8:55). Its better-than-all-day battery power should come in handy during long trips.

CONCLUSIONS

The Samsung Galaxy TabPro S is a thin and stylish slate tablet, with a vivid Super AMOLED screen and top-notch battery life. Like the HP Spectre x2, it comes with a keyboard, but lacks the HP tablet's 4G/LTE capability and expansion slots, and its Intel Core M processor doesn't yield top performance results. Its USB Type-C treatment—only one port and no bundled adapter—is another negative. The Microsoft Surface Pro 4 remains our Editors' Choice for Windows tablets, given its stronger performance, broader port selection, bundled stylus, and higher-resolution screen. Still, if you want a super-thin Windows slate with an excellent display and strong battery life, or if you want a Windows tablet that will work in tandem with your Galaxy S7, the Galaxy TabPro S is an attractive, relatively affordable choice.

BEN RADDING

With This Dell Laptop, Make Quick Work of Multimedia

PC MAGAZINE EDITORS' CHOICE

The latest Dell XPS 15 Touch answers one of the questions I get asked quite often: Which laptop is the best for visual arts like photography and video? With its brilliant 4K screen and the power to make quick work of multimedia creation tasks, this desktop replacement laptop is the answer. Yes, it's pricey, but it's worth it when you consider its high build quality, top-notch features, and excellent performance.

Dell XPS 15 Touch (9550)

$2,129 (as tested)

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DESIGN AND FEATURES

The XPS 15 Touch's lid and base are made of aluminum, with carbon fiber in the palm rest and keyboard deck.

Using the same body and screen as the Dell Precision 15 5000 Series mobile workstation, the XPS 15 Touch looks and feels expensive. The case measures 0.66 by 14.06 by 9.27 inches (HWD), and weighs a relatively light 4.48 pounds. That's smaller than both the Asus ZenBook Pro UX501J-DS71T, a top pick, and Apple's 15-inch Retina display–equipped MacBook Pro, though all three are similar in weight.

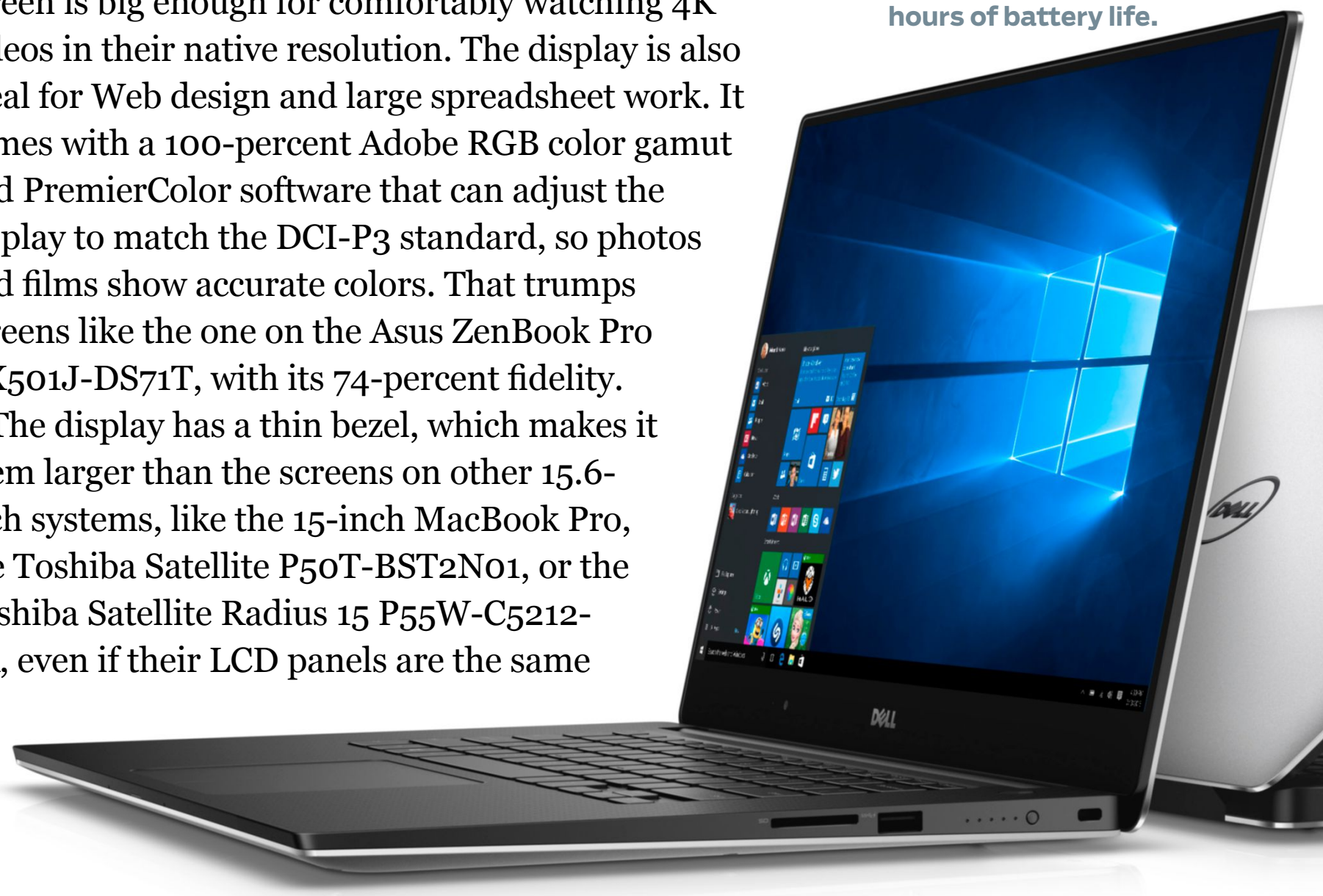
The 15.6-inch, 3,840-by-2,160-resolution touch screen is big enough for comfortably watching 4K videos in their native resolution. The display is also ideal for Web design and large spreadsheet work. It comes with a 100-percent Adobe RGB color gamut and PremierColor software that can adjust the display to match the DCI-P3 standard, so photos and films show accurate colors. That trumps screens like the one on the Asus ZenBook Pro UX501J-DS71T, with its 74-percent fidelity.

The display has a thin bezel, which makes it seem larger than the screens on other 15.6-inch systems, like the 15-inch MacBook Pro, the Toshiba Satellite P50T-BST2N01, or the Toshiba Satellite Radius 15 P55W-C5212-4K, even if their LCD panels are the same

Dell XPS 15 Touch (9550)

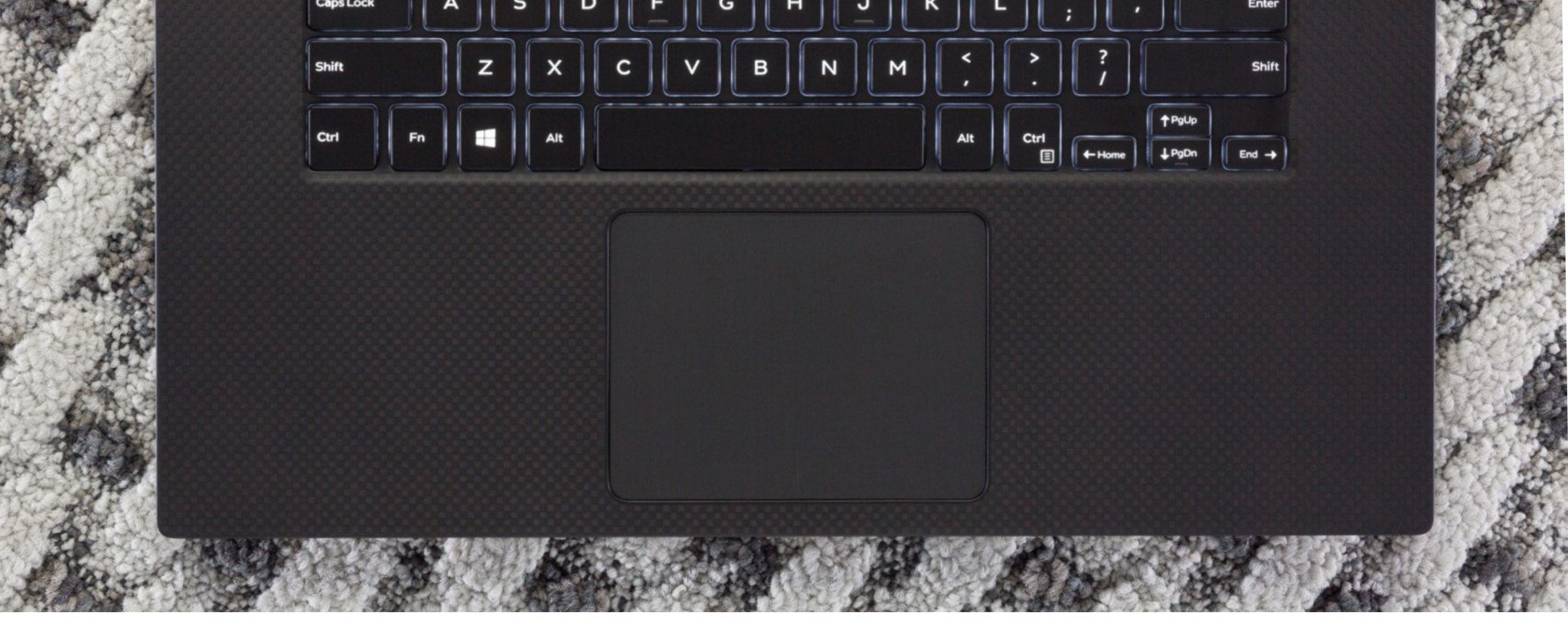
PROS Premium construction. Stunning display. Powerful hardware, including USB Type-C port, large-capacity solid-state drive.

CONS Pricey. Sealed chassis. Less than 6 hours of battery life.



physical size. Because of the smaller bezel, the system's HD webcam is situated below the display, next to the laptop's hinge, instead of centered above the screen.

The chiclet-style keyboard has full-size keys that feel solid, though their key travel is shallow compared with what we experienced on the previous version of the XPS 15 Touch. The keys are quite visible in the dark, thanks to two levels of backlighting. The XPS 15 Touch's one-



piece touchpad is comfortable to use and supports Windows 10 multitouch gestures. The system's speakers are loud and clear, and their volume will fill a medium-size room.

There's a 512GB PCIe-based SSD, which is a large capacity for flash-based storage. That's double the space on the 15-inch MacBook Pro, though the same as the UX501J-DS71T and the Satellite Radius 15. There are a few preloaded apps, like Adobe Photoshop Express and Flipbook, but much less bloatware than we saw on the UX501J-DS71T.

Connectivity options on the laptop are excellent. The XPS 15 Touch has an HDMI port, a headset jack, the power connector, a USB Type-C port with Thunderbolt 3, and a USB 3.0 port on its left side. On the right, you'll find the system's battery status button with light indicators, a Kensington security slot, an SD/SDHC/SDXC card reader, and another USB 3.0 port. For wireless connectivity, you get dual-band 802.11ac Wi-Fi and Bluetooth 4.1. The system comes with a one-year warranty.

PERFORMANCE

An Intel Core i7-6700HQ processor, 16GB of system memory, and gaming-ready Nvidia GeForce GTX 960M discrete video contribute to both the XPS 15 Touch's high performance and hefty price tag. The CPU can handle eight computing threads simultaneously, which translated to class-leading results on our Handbrake (1 minute, 6 seconds) and Cinebench (679) tests. That's better than the UX501J-DS71T (1:16 on Handbrake, 644 on CineBench), the Asus machine just edged past the XPS 15 Touch on our Photoshop test (3:18 versus 3:20). Both laptops were faster than competing systems, like the 15-inch MacBook Pro, the P50T-BST2N01, and the Asus ZenBook NX500. You'll be happy to use the system for photo and video work.

On the PCMark Work Conventional productivity test, the XPS 15 Touch returned a solid score of 2,493, though most of the competition ran ahead by a few points. (The ZenBook Pro UX501J-DS71T, for example, scored 2,775.) In any case, all of these systems will work fine on day-to-day tasks like Web browsing and video conferencing.

The system excelled on our 3D tests, winning both 3DMark Cloud Gate (14,500) and 3DMark Fire Strike Extreme (2,004). It returned smoothly playable frame rates on the Heaven (66 frames per second, or fps) and Valley (81fps) tests at medium quality settings, so you can certainly play modern AAA games at moderate quality and resolution settings. But gameplay at 4K native resolution at maxed-out details was just too much for the XPS 15 Touch, as was also true of the 4K UX501J-DS71. At least it's smoother at medium settings than laptops with integrated graphics, like the 15-inch MacBook Pro or the Satellite Radius 15.

Unfortunately, like other 4K systems, the XPS 15 Touch can't quite endure all day on only the power its sealed battery pack provides. The laptop was only able to last 5 hours, 56 minutes, on our battery rundown

GET IN TOUCH

Watch our video review of the Dell XPS 15 Touch (9550).

MULTIMEDIA MAVEN
With its superb screen and fine performance, the XPS 15 Touch is ideal for creative professionals.

test. That's still pretty good, considering that the UX501J-DS71T and the Satellite Radius 15 lasted an hour less. Our class leader is the MacBook Pro, which lasted an astonishing 11:31 thanks to its lower-resolution screen and larger-capacity battery.

CONCLUSION

The Dell XPS 15 Touch is a multimedia powerhouse that can serve both media professionals and prosumers quite well. It may cost more than similarly outfitted systems, but its 100-percent Adobe RGB color accuracy, stronger performance, longer battery life, less bloatware, and forward-looking technology like the USB Type-C port with Thunderbolt 3 make it worth the premium. Given those factors, it replaces the Asus ZenBook Pro UX501J-DS71T as our top pick for high-end desktop-replacement laptops.

JOEL SANTO DOMINGO

Elevate Your Game With Origin's High-End Laptop

PC MAGAZINE EDITORS' CHOICE

The Origin EON17-X is a premium gaming laptop with the hardware to provide smooth performance at the highest detail settings. In addition to a powerful Core i7 desktop-class processor, it features a potent video card and plenty of memory, extra features such as a customizable keyboard, and a wealth of connectivity options. When you factor in its top-notch build, generous screen space, and USB Type-C port, as well as a price that undercuts much of the competition, the EON17-X is a deserved champion among high-end gaming laptops.

Origin EON17-X

$2,692 (as tested)

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DESIGN AND FEATURES

This 17.3-inch laptop is large and hefty, but it isn't an unsightly slab. We like the sleek pair of vents on the back end that accommodate the desktop CPU, for instance. The lid on our test unit was white, which looks pretty striking with the simple black Origin logo and black plastic body. The EON17-X measures 1.53 by 16.46 by 11.1 inches (HWD) and weighs 8.6 pounds, making it a bit slimmer than the Asus ROG G751JY-DH72X (1.7 by 16.5 by 12.5 inches, 9.06 pounds), a gaming system that also has a 17.3-inch display. Another competitor, the 18.4-inch MSI GT80 Titan SLI, is monstrous by comparison at 1.93 by 17.95 by 13.02 inches and 9.9 pounds.

Origin EON17-X

PROS Costs less than most competitors. Overclocked desktop-class processor. Good gaming performance. Many storage space, connectivity options, including USB Type-C. Customizable keyboard backlighting.

CONS Wide. Heavy. Short battery life. Poorly placed fingerprint reader.

ALL THE ACTION
The Origin EON17-X boasts a 1,920-by-1,080 display and Nvidia G-Sync technology to make games look their best and play their smoothest.

The display features full HD (1,920-by-1,080) resolution and Nvidia's G-Sync technology, which provides a visually smoother performance when activated. Origin's 15-inch EON15-X, the ROG G7, the MSI GT80, and the Aorus X7 Pro all share the same screen resolution. Though some notebooks offer 3K or 4K displays, laptop hardware is generally not strong

enough to compensate for those demanding resolutions when gaming, which significantly slows performance. That means full HD is still the sweet spot for gaming laptops, at least until hardware improves. The EON17-X's screen has an antiglare coating. This dulls the picture somewhat, but cuts out distracting reflections.

The laptop's width provides plenty of room for a spacious keyboard with a number pad. The curved keys don't have spacing between them, which may take some getting used to. But they're responsive and make satisfying clicks when pressed. The keyboard is backlit with customizable lighting, and software is included that lets you change the colors across three sections—the left, middle, and center zones. This is a nice bonus feature, though it's not the unique per-key backlighting we saw on the Razer Blade Stealth. The EON15-X has the same lighting scheme as its newer sibling, but the ROG G7 offers only red backlighting.

> **Full HD is still the sweet spot for gaming laptops, at least until hardware improves.**

FIND YOUR KEYS IN THE DARK
With the configurable backlighting on the EON17-X, you can customize colors across three zones so your keyboard always looks just the way you want it to—even when all the lights are off.

The touchpad is responsive, and finger scrolling is smooth. A fingerprint scanner is located between the left- and right-click buttons, below the touch surface. I occasionally pressed on the sensor instead of clicking the button I was aiming for, but became accustomed to

it over the testing period. The system's speakers, located in a long raised bar just under the bottom of the display bezel, get very loud, and quality doesn't suffer at maximum volume.

You get a 256GB solid-state drive (SSD) as a boot drive and a 1TB solid-state hybrid drive (SSHD) for the majority of the storage. In comparison, the EON15-X has the same combination (though the boot drive is 240GB), and the ROG G7 includes a 512GB boot SSD and a 1TB hard drive. The MSI GT80 has a speedy combination, with a pair of 128GB SSDs in RAID Level 0 running as a single 256GB boot drive, and a 1TB hard drive.

Connectivity options are excellent. The left side holds an Ethernet port, two USB 3.1 ports, a USB Type-C port with SuperSpeed+, an SD slot, and an eSATA–USB 3.0 hybrid port. On the right are the audio jacks (microphone, headphone, audio line in, and S/PDIF output) along with another USB 3.1 port and a Kensington Lock slot. The rear of the chassis has three video ports (two DisplayPort, one HDMI), along with the pinned power jack. Origin protects the system with lifetime tech support and a one-year parts-replacement warranty.

PERFORMANCE

The EON17-X includes an Intel Core i7-6700K, a desktop CPU overclocked from a 4.0GHz base speed to 4.5GHz; an 8GB GeForce GTX 980M video card; and 16GB of memory. This is a powerful and fast combination, as you'd hope for from a pricey high-end system. It scored 3,936 on the PCMark 8 Work Conventional productivity test, edging out the EON15-X (3,900) and handily beating the ROG G751JY-DH72X (3,369) and the MSI GT80 (3,439). The EON17-X was fast on multimedia tests as well: It finished the Photoshop test in 2 minutes, 36 seconds, and the Handbrake encoding test in 58 seconds, and it

scored 781 on CineBench. The EON15-X is a little faster all around, but the EON17-X easily beats out the other two laptops, putting it among the best picks for multimedia projects.

Given that G-Sync technology has an impact on gaming performance, we ran our gaming tests on the laptop with the setting both on and off. The scores were generally lower with it enabled, but G-Sync is worth keeping on as long as performance doesn't drop below playable levels. The best frame rate you can hope for with G-Sync activated is 59 frames per second (fps) to 60fps, as it's designed to run optimally at that speed. When a game is struggling to run with G-Sync on, or the frame rate is noticeably reduced, turning G-Sync off leads to better numbers.

On the 3DMark Cloud Gate and Fire Strike Extreme tests with G-Sync on, the EON17-X scored 12,444 and 3,360, respectively. With G-Sync off and the performance uncapped, the system scored 27,630 on Cloud Gate and 4,395 on Fire Strike Extreme. The EON17-X's numbers with G-Sync on were low compared with what we saw on other systems—the EON15-X scored 25,794 on Cloud Gate and 4,448 on Fire Strike Extreme. But the EON17-X was right in line with the competitors with the setting turned off, and it outperformed the ROG G7. The Aorus X7 Pro and MSI GT80 were both well ahead on one of these tests: The MSI scored 24,726 on Cloud Gate, but a very high 7,368 on Fire Strike Extreme; the Aorus scored 22,828 on Cloud Gate and 5,960 on Fire Strike Extreme.

We saw similar results for the EON17-X on the Heaven and Valley gaming tests. G-Sync capped the frame rate at 59fps for both tests at medium quality settings, but the laptop reached 160fps on Heaven and 151fps on Valley with G-Sync off. This is on par with or better than the other systems, and the EON17-X also performed well when the settings were maxed: With G-Sync enabled, it managed 50fps and 55fps on Heaven

PUT YOUR OWN LID ON IT
Origin offers a number of unique designs for the laptop's lid, or you can submit one of your own and have a system's even more uniquely you.

and Valley, respectively. Turning G-Sync off bumped those numbers up to 54fps and 60fps, respectively, as with the EON15-X and ROG G7. The Aorus X7 Pro did a little better (78fps on Heaven and 83fps on Valley, both at high quality), and the MSI GT80 led the pack at 98fps (Heaven) and 91fps (Valley) thanks to its dual GPUs—though because it costs about $700 more than the EON17-X, the Origin laptop is the best deal in the bunch.

Because of their fast, power-hungry hardware, most gaming laptops don't shine when it comes to battery life. The EON17-X doesn't break the mold: It lasted only 2 hours, 49 minutes, on our rundown test. The EON15-X lasted only 2:24, the MSIGT80 2:30, and the Aorus X7 Pro 2:20. The Asus ROG G7 lasted a little longer than the others at 3:04. But given its size, you'll probably use the system with its power adapter plugged in most of the time, anyway.

CONCLUSION

With the EON17-X, Origin used the same formula as it did on the EON15-X—a desktop CPU, a beefy video card, and a wide range of connectivity options—to create an even more powerful system. The EON17-X has a sharp-looking design and performs very well, offering smooth 1080p gaming performance at the highest graphics detail settings. It outperforms the highly rated Asus ROG G751JY-DH72X and costs less; and it will run you only about $100 more than the EON15-X, while offering similar or better performance and a larger screen. For its design, features, port selection, and gaming performance, the Origin EON17-X is our new Editors' Choice for high-end gaming laptops.

MATTHEW BUZZI

Formlabs Form 2

$3,499

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A 3D Printer That's Good Enough For Professionals

PC MAGAZINE EDITORS' CHOICE

The Form 2 is a marked redesign from the first generation of Formlabs 3D printers, from which we reviewed the Form 1+. It incorporates a wide range of improvements, including a larger build volume, a more powerful laser, a touch screen, Wi-Fi connectivity, an automatic resin-feed system, new resin types and cartridges, and a revised finishing system. The results are big improvements in the printer's capabilities and user experience—and magnificent print quality.

STEREOLITHOGRAPHY 3D PRINTING

Like the Form 1+, the Form 2 is a stereolithography (SLA) 3D printer. Unlike the more common fused filament fabrication (FFF) 3D printers that print from spools of plastic filament, SLA printers use an ultraviolet laser to trace a pattern, corresponding to the layers of the object to be printed, in a vat of

photosensitive resin. The resin hardens where the laser touches it, forming, layer by layer, into the intended object. Unlike an FFF 3D printer, in which an object is built upwards on the build platform, the object in an SLA printer grows from the bottom of the build platform, which descends into and rises from the resin tray. This technique can produce incredibly detailed prints, but it's messier and requires you to deal with the sticky resin and isopropyl (rubbing) alcohol, and the choices of resin color are limited.

DESIGN AND FEATURES

The Form 2 measures 20.5 by 13.5 by 13 inches (HWD) and weighs 28 pounds. The printer's cover swings upward when you open it, so you will need at least a foot of additional vertical space. The build area measures 6.9 by 5.7 by 5.7 inches, slightly larger than the 6.5-by-4.9-by-4.9-inch dimensions of the Form 1+ and similar in total volume to the XYZPrinting Nobel.

Formlabs Form 2

PROS Superb print quality. Automatic resin feed. USB, Wi-Fi, Ethernet connectivity. Touch screen. Several custom resin types available.

CONS Printer couldn't detect one resin cartridge in our testing. A few confusing error messages. Takes time to master printing.

PHOTO FINISHING
Stereolithography printing techniques help the Formlabs Form 2 produce some of the best-looking 3D-printed products we've seen to date.

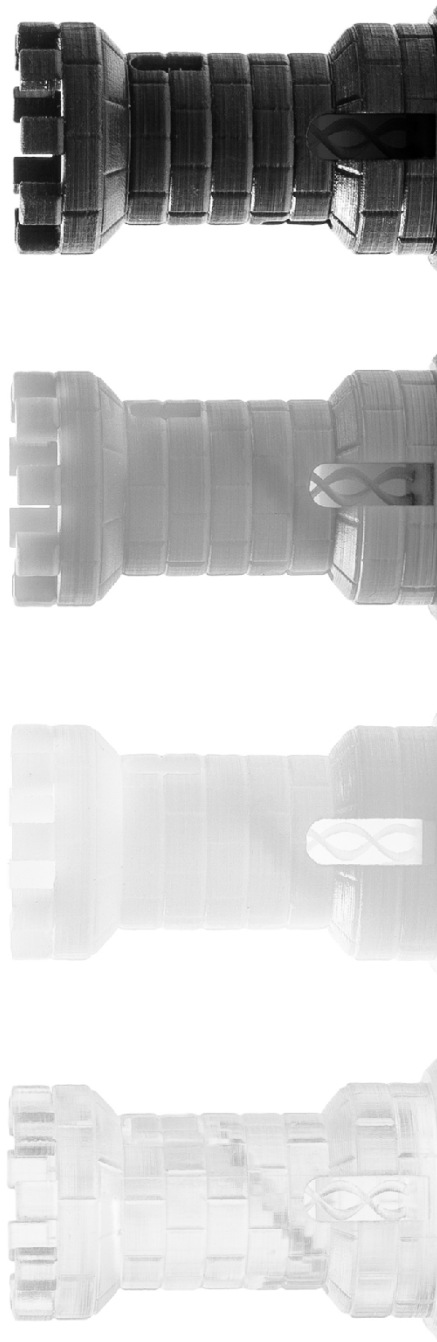
Its build volume is smaller than the 5.9 by 7.8 by 9.9 inches we saw in the Editors' Choice MakerBot Replicator, an FFF printer. Like the Form 1+, the Form 2 offers very high resolutions, of 25, 50, and 100 microns for standard resin. The printer is controlled through a 4.3-inch touch screen.

The Form 2 features a revamped and automated resin-feed system, with an improved resin tray, and resin cartridges instead of the bottles from the first generation of Formlabs printers. The cartridges, which each hold a liter of resin, fit in a compartment in the back of the printer. Before inserting one, you remove a valve cover and push down on one side of the cartridge's cap. The printer should detect when a cartridge is in place and identify the type and color of resin by means of a microchip in the cartridge. When you launch a print job, the resin will flow from the cartridge into the tray until it reaches a preset level.

The new resin tray design adds a wiper that periodically agitates the resin, helping to prevent clots of hardened resin from forming and eliminating the need to manually comb through the resin to remove hardened bits. You need to use a separate tray for each color or kind of resin you use. When a resin tray is not in use, it should be capped and stored away from light. The printer comes with a single resin tray, as well as a liter of clear resin. The Form 2's cover is translucent orange, which acts as a UV filter to help prevent the resin from being accidentally cured and solidifying. Unlike with the Formlabs Form 1+, with which resin would easily harden, I didn't experience any issues with unwanted resin hardening with the Form 2.

Formlabs offers four colors of Standard resin—clear, white, gray, and black—as well as several specialty resins: Tough (rugged and durable), Castable (for jewelry casting), and Flexible (compressible and bendable). Formlabs sells the Standard resin for $149

TRUE COLORS (AND MORE)
Make it your way: Resin for the Form 2 is available in multiple different colors and styles.

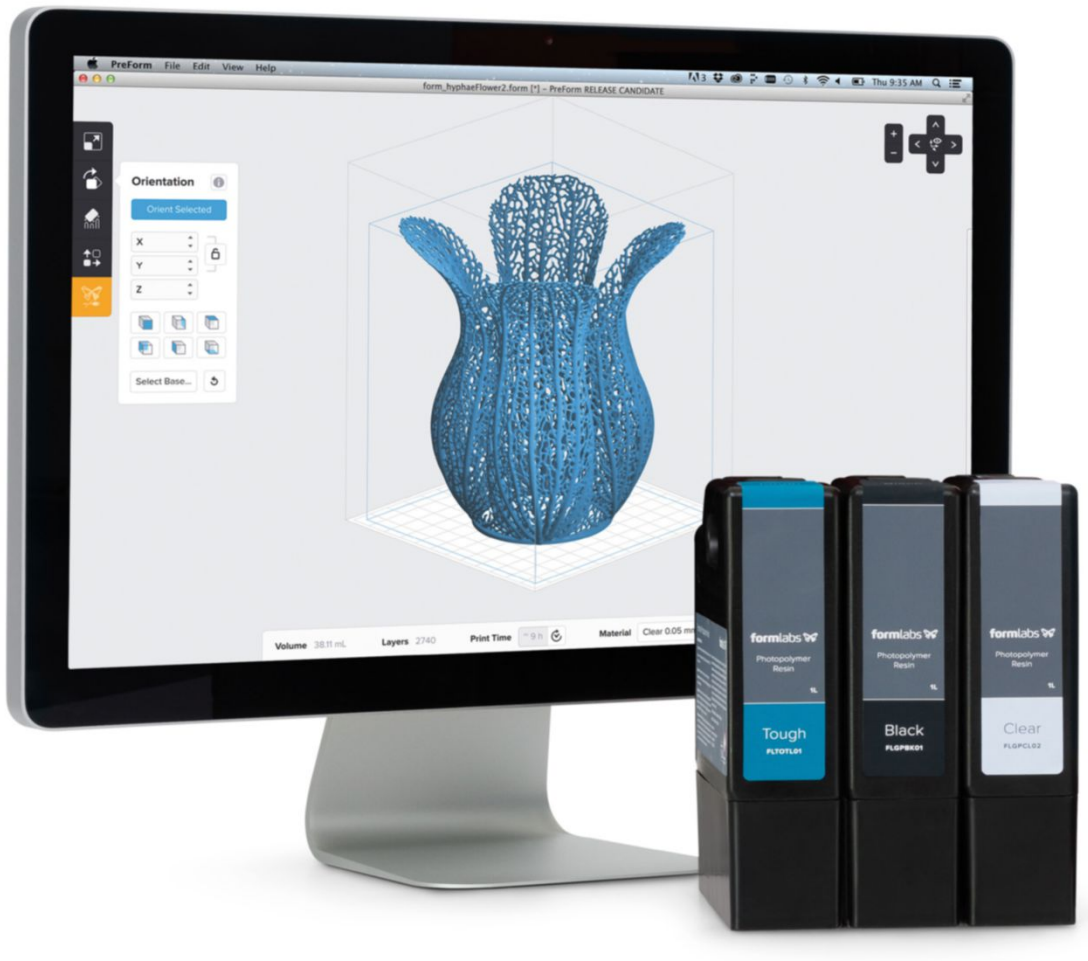


for a 1-liter bottle, which by my estimates is somewhat higher than the cost of the polylactic acid (PLA) and acrylonitrile butadiene styrene (ABS) plastic used in other 3D printers. The specialty resins are still more expensive: $175 per liter for Tough, $199 for Flexible, and $299 for Castable. You need a separate resin tray ($59 from Formlabs), for each type or color of resin you use. The Form 2 also supports the use of third-party resins, which you need to pour into the tray by hand.

With the Form 2, you can print via USB 2.0, Ethernet, or Wi-Fi. I did all my testing over a USB connection, and successfully set up a Wi-Fi connection on the printer as well. The Nobel prints over a USB connection or from a USB thumb drive; the Replicator prints from a thumb drive, or over a USB, Ethernet, or Wi-Fi connection.

Shipped along with the printer is a finishing kit. When a print is completed, you put on a pair of plastic gloves (many are included), remove the build platform and put it into a jig (holder) on a provided tray, and remove the object from the platform using a scraper or other tool. There are two vats that you fill with isopropyl alcohol (not included). You put the object into a rinse basket and dunk it in the alcohol for 30 seconds, moving the basket up and down, and then close the lid to the vat and let the object sit for 10 minutes. Finally, you repeat the rinse process using the second vat, remove the object, and let it dry.

MAKING RESIN-VATIONS
You have your choice from a selection of different resin colors and types when printing with the Form 2, but specialty resins are more expensive, and you'll need a separate $59 resin tray for each type you want to use.



SOFTWARE

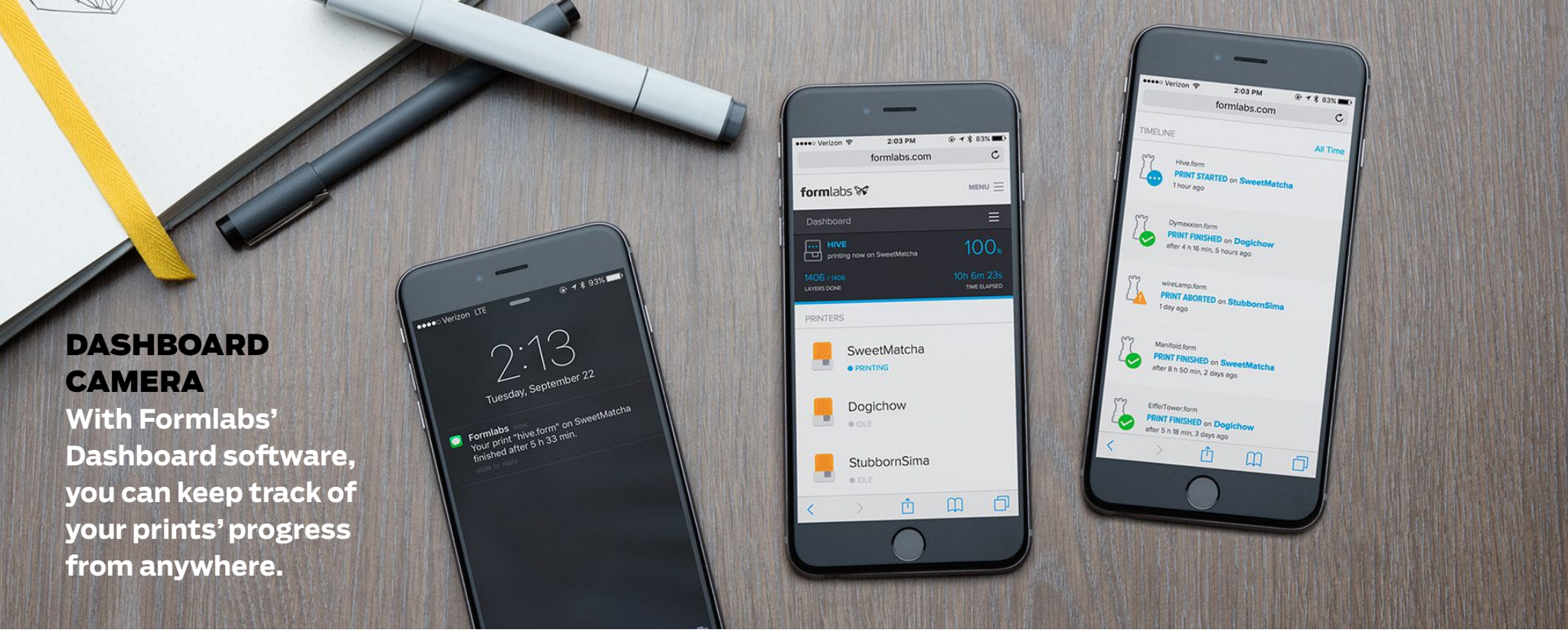
The Form 2 uses the company's PreForm software, which is downloadable for either Windows or Mac from the Formlabs website. Once you load an object file, you can move it, scale it, duplicate it, and add or remove supports (as well as editing specific support points). When you're done, you press a print icon, verify that the resin type matches what's installed in the printer. Then you can send the job over your preferred connection type to the printer, and save a copy of the file for reuse.

The Dashboard feature lets you track the progress of your print jobs remotely through the Formlabs site. Once you set up a (free) Dashboard account with Formlabs, you link your printer to it. Then you can log into the Formlabs site, click on the My Dashboard link, and see the status of ongoing print jobs and a record of past prints.

SETUP AND PRINTING

After setting up the finishing kit, actually getting the printer up and running is easy. You download and install PreForm, turn on the printer, and connect it to a computer via USB cable. After that, you pour resin into one of the tanks, slide the tank into its slot in the bottom of the printer, attach the build platform, and

“After setting up the finishing kit, actually getting the printer up and running is easy.”



lock it into place. Then you launch the software, select a file to print, resize and move the object (if necessary), launch the print from the software, and press the Print button on the front of the printer.

Once you send a file to the Form 2, its upload progress will appear on the printer's display. Depending on the size of the file, this can take a few minutes. Once the upload is complete, you tap the screen and then press the button in the lower right; printing will start once the resin is heated to the proper temperature of 30° Celsius. The estimated time remaining will be displayed on the screen.

I printed about 15 test objects with the Form 2, using Tough, Flexible, and Standard black resins at the printer's default resolution of 100 microns. Print quality for nearly every object was excellent. A floral-looking lampshade designed to use the printer's entire build area was stunning: It was translucent, deep green (as is the case of all the prints using the Tough resin), huge and gossamer, flexible yet strong. A holder for a GoPro Hero4 action cam, one of several objects I printed with supports, had enough flex that I could pull two clasps far enough apart to insert the camera and then close them tight again to secure the camera in place.

One of our standard test object consists of raised text and a variety of geometric shapes protruding from a nearly vertical surface. The Form 2 did the best job we've seen on this test from any 3D printer. The print did have one blemish, a slight bend in a vertical support near the top of the object, though it was far milder than the buckling in the same support that we saw with the Ultimaker 2+.

I had a problem with the Standard black resin cartridge that Formlabs sent us. When I inserted it, the printer wouldn't recognize it, and cartridge status on the display was listed as "missing." Our Formlabs contact sent us a replacement

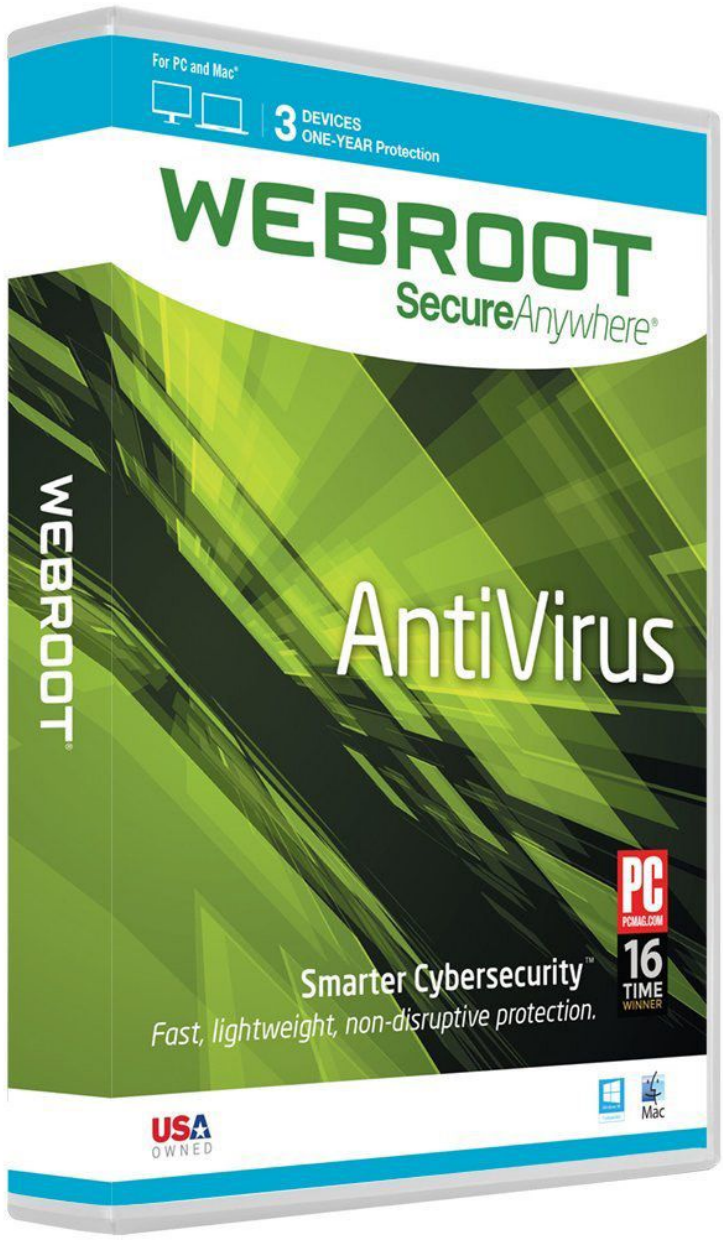
black cartridge, and the printer had no trouble at all recognizing that one.

Although I experienced some problems in printing, most—if not all—of them were avoidable newbie errors. Manually centering objects on the build platform helped me do away with botched prints, I didn't always spend enough time determine whether supports were best for the objects, and I learned to work around issues with printing multiple objects at once. Because the Form 2 is complex, there's a learning curve, but it's one that experience can conquer.

A PRINTER GEARED TOWARD PROS

As an SLA printer, the Formlabs Form 2 presents some unique advantages and disadvantages over 3D printers that use plastic filament. Both its high resolution and its hefty price tag put it into the realm of professional printers, although hobbyists, art and technical schools, and consumers with deep pockets may also take a gander to it. The resin-feed system has been automated, but the print process is still messy. For these reasons, most individuals, schools, and hobbyists will probably be better off with the easier-to-use MakerBot Replicator, our Editors' Choice for high-end general-purpose 3D printers. But for top-of-the-line, professional-quality printing, the Form 2 is a superb choice.

TONY HOFFMAN



Powerful, Innovative Virus Protection For Your PC

PC MAGAZINE EDITORS' CHOICE

Most people have at least a vague idea of how antivirus software works. It calculates some kind of fingerprint of a file, checks that against its list of bad files, and raises the alarm if there's a match, right? In reality, almost all products use additional layers of security, but they still retain old-school signature-based detection. Webroot SecureAnywhere AntiVirus takes a seriously different approach, one that lets it scan quickly, consume only a tiny amount of resources, and still offer powerful protection. And the results knocked our socks off.

Webroot SecureAnywhere AntiVirus

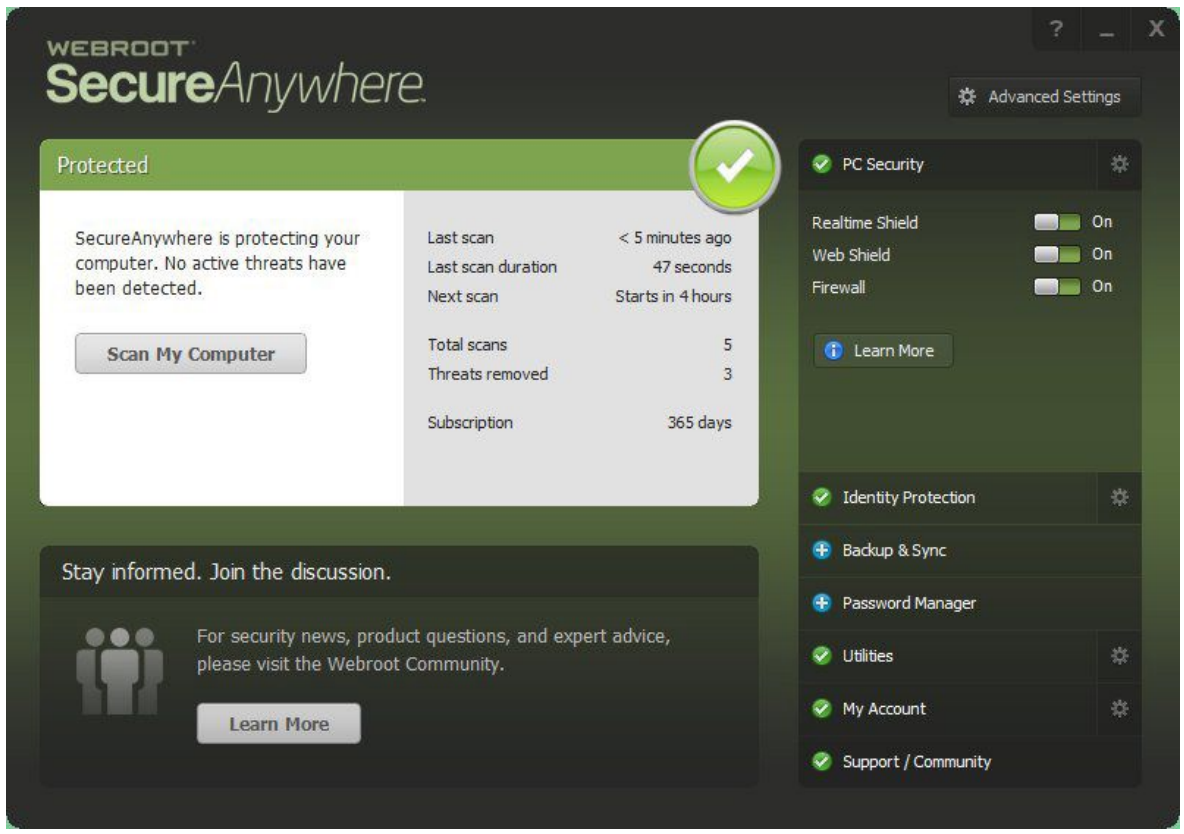
$39.99 (one PC or Mac for one year)

$49.99 (three PCs or Macs for one year)

●●●●◐

THE ROOTS OF WEBROOT

The green-toned main window is dominated by a lighter panel that includes statistics about recent antimalware scans and a button to launch an immediate scan. Even if you never click that button, Webroot makes a full scan during installation and runs a scheduled scan every day. Another sizable panel touts the Webroot Community forum, with a button to join the discussion. Access to the rest of this product's significant feature collection is handled in a panel at the right.



Webroot maintains a giant database of known programs, good and bad, which your local Webroot installation queries about the programs it sees on your system. When the software encounters one it doesn't recognize, it sends detailed telemetry to Webroot for analysis and starts monitoring that program. Every action by the suspect gets journaled for possible rollback, and Webroot doesn't let the program perform any action that can't be undone (such as transmitting data to an outside source). In some cases, correlation rules let the server match the unknown app to an existing threat, resulting in a real-time response. In

Webroot SecureAnywhere AntiVirus

PROS Scored highly in our tests. Uses unique protection techniques. Can recover files encrypted by ransomware. Tiny. Scans quickly. Includes firewall.

CONS Few independent lab test results available.

DOUBLE-CHECK DASHBOARD
From the main window of Webroot SecureAnywhere AntiVirus you can verify security protocols, view malware scanning statistics, launch scans, and more.

others, teams of human researchers around the globe dig into the unknown file.

Once the program has been analyzed, the server notifies Webroot on your computer. If the program turns out to be legit, its probation ends. If not, Webroot terminates the program and reverses all of its actions. And if another user encounters that same now-known threat, Webroot can smack it down right away.

Note that Webroot's system doesn't jibe with current tests from my usual group of testing labs, so I have no results to report. The London-based MRG Effitas includes Webroot in its regular testing, however, and recently awarded it Level 2 certification: Although some malware samples did run, their effects were completely remediated on or before the next reboot. Only Kaspersky Anti-Virus received Level 1 certification, meaning none of the samples even got a foothold.

If the program turns out to be legit, its probation ends. If not, Webroot terminates the program and reverses all of its actions.

THOROUGH PROTECTION

Webroot's installer is tiny, less than a megabyte, and the full installation takes little more than that much space. The installer performs a variety of optimization and configuration tasks, including a scan for malware. Most products couldn't swing that, but Webroot's scan takes just 3 or 4 minutes. That's quite a contrast with the current average, which is closer to 45 minutes. After any scan that detects and cleans up malware, Webroot scans again, just to be sure everything is clean now.

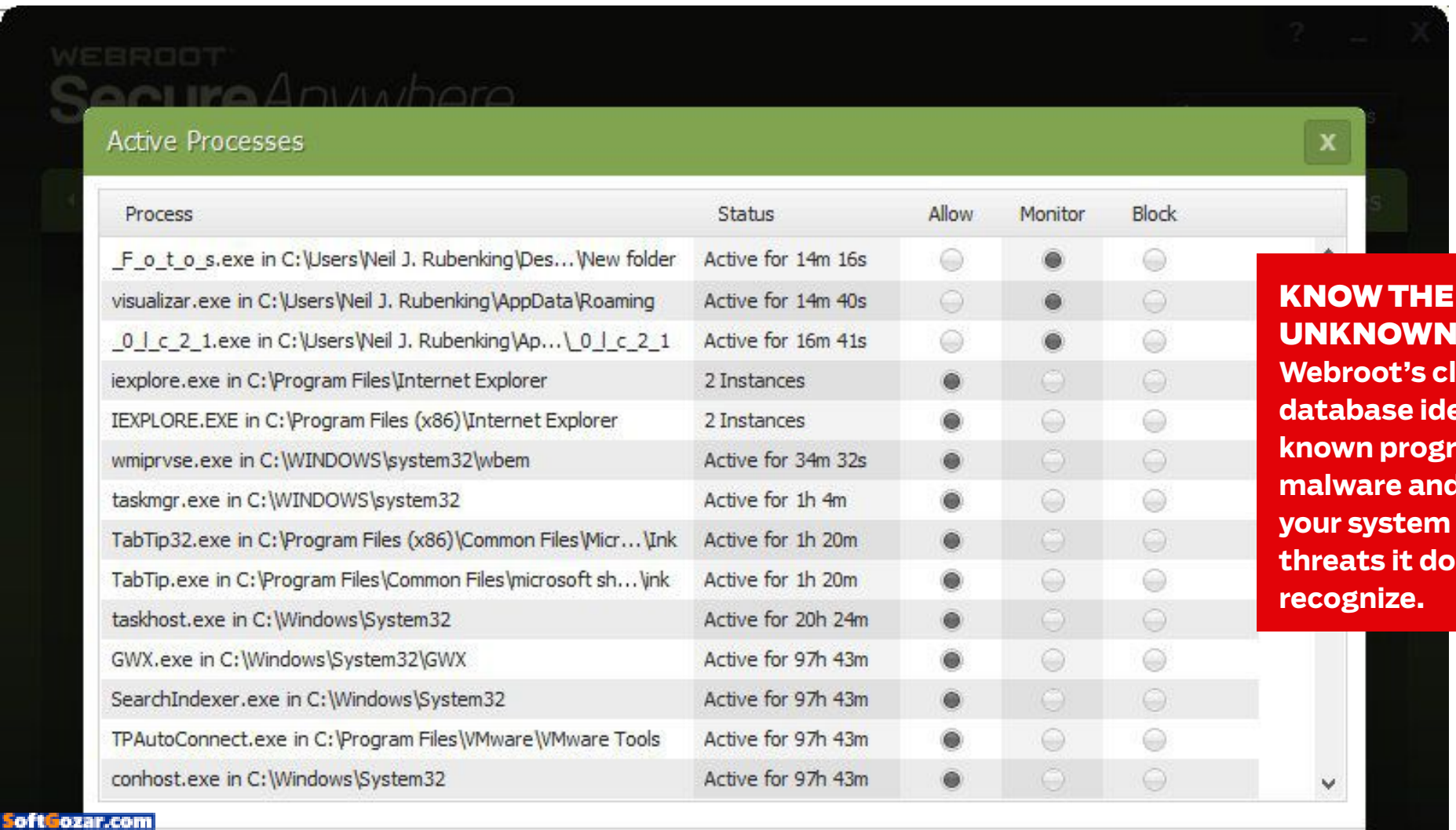
When I opened the folder containing my collection of malware samples, Webroot didn't react immediately, but moving them to a new folder got its attention. It detected and removed some of the samples, displaying a transient notification of its actions. After a short while, the main window turned red and displayed a list of other samples. It requested a scan to remove those. On completion, it rescanned and found some more. A third scan came up clean.

At this point, every single sample was gone from the folder, but all of the legitimate files that I store alongside the samples were intact. That's 100 percent detection and a perfect 10 for malware blocking—the same score Webroot received the last time I tested it. Because Webroot eliminated all of my regular samples, I unleashed some hand-tweaked versions. The software wiped out 40 percent right away, and blocked some samples when I launched them and requested a cleanup scan for others. The remainder it let run with monitoring, and eventually identified them all as malicious. Three scans, and all my modified samples were gone, too.

To test how well Webroot handles dangerous websites, I tried to navigate to 100 newly discovered malware-hosting URLs. Webroot blocked 84 percent of the dangerous downloads. That's pretty good, but I tested Avast simultaneously using the same list of URLs, and it blocked 99 percent of them, all at the URL level. On the downside, Avast supports just Chrome and Firefox, not Internet Explorer; Webroot works with all three.

For my antiphishing test, which uses a fresh collection of known-fraudulent websites, Webroot beat current champ Norton by 1 percentage point. The only other recent product to beat Norton was Bitdefender, by 2 percent.

Webroot's journaling and rollback feature should be able to recover from almost any attack, even encrypting ransomware. I pulled out a simple program I wrote to simulate that kind of attack. Webroot naturally started monitoring its behavior and let me keep my system protected.



KNOW THE UNKNOWNS
Webroot's cloud database identifies known programs and malware and guards your system from threats it doesn't recognize.

OTHER FEATURES

Webroot's antivirus product includes a firewall, but it's a bit different than most: It lets the Windows Firewall handle most traditional duties, and the software's regular proection guards against errant programs. (You can tweak this behavior, if you like.) But when Webroot detects an active infection, it clamps down on network traffic by unknown programs, without keeping you from normal activities like Web browsing. One thing's for sure: A malware coder isn't going to disable Webroot's protection. It doesn't expose any settings in the Registry. Its two processes are protected against termination. And I couldn't stop or disable its single Windows service.

Identity Protection prevents a wide variety of typical malware attacks including man-in-the-middle, browser process modification, and keylogging. It can apply protection to specific applications that you choose; Internet Explorer is on the protected list by default.

A set of antimalware tools lets you repair collateral damage, like malware-modified wallpaper, screen savers, or system policies. You can also use it to quickly reboot into Safe Mode, or perform an instant reboot. If you have strong tech skills, you can manually remove both malware and its associated Registry data. And if necessary, you can run a removal script created by Webroot tech support.

If you really want to see what Webroot is doing, you can open the Reports page and check its current activity or history. You probably won't want to read the available scan log or threat log, but tech support may ask for them. You can even view all active processes and see which ones Webroot is monitoring.

One of the most advanced features in Webroot is SafeStart Sandbox. If you're a trained antivirus researcher, you can use it to launch a suspect program under detailed limitations that you specify. If you're not, just leave it alone.

STILL A WINNER

It's been a while since I put Webroot SecureAnywhere AntiVirus to the test. I'm happy to say that it's still a winner, even though the antivirus testing labs mostly can't handle it. It remains an Editors' Choice for commercial antivirus, an honor it shares with Bitdefender Antivirus Plus 2016, Kaspersky Anti-Virus, and McAfee AntiVirus Plus.

NEIL J. RUBENKING

Features

THE MANY VIRTUES OF VIRTUAL REALITY

HOW RANSOMWARE CONQUERED THE WORLD

THE MANY VIRTUES OF VIRTUAL REALITY

Virtual reality's biggest and longest-awaited headsets, the HTC Vive and the Oculus Rift, are good enough to make even the most skeptical people optimistic about the future of VR.

BY WILL GREENWALD

I've been doing some unexpected things lately. I've watched Netflix movies on a towering screen. I've taken sightseeing jaunts on a rolling hillside and through a Venetian plaza. I've sculpted figures in clay and covered them with glowing streamers. Although I haven't seen attack ships on fire off the shoulder of Orion, I've blown up dozens of enemy fighters in outer space. And I've done all of this without leaving New York—thanks to virtual reality.

We've been watching the development of the latest wave of VR technology for several years now. It's taken some time, but the endless parade of crowdfunded headsets has finally evolved into consumer products. And now that the big VR names have made their cases, with the HTC Vive ($800) and the Oculus Rift ($599) first out of the gate, it's clear that the concept of VR is at last much more than a gimmick or a toy.

The technology still has a way to go, but the Rift and the Vive are already proving that VR has a real place in our homes—and maybe even our offices—and that things are only going to get more amazing from here on out.

WHAT YOU NEED

The Vive and the Rift have nearly identical system requirements. Both systems recommend an Intel Core i5-4590 or better CPU (the Vive also cites an AMD FX 8350 or better as workable), and an Nvidia GeForce GTX 970 or AMD Radeon R9 290 or better video card. In addition, the Vive wants 4GB of RAM, HDMI 1.4 or DisplayPort 1.2 video output, and a USB 2.0 port; the Rift asks for 8GB of RAM, an HDMI 1.3 output, three USB 3.0 ports, and one USB 2.0 port. Both headsets also need at Windows 7 SP1 or later.

VIVE LE VIVE

The Vive headset is a large, black plastic visor shaped almost like a rectangular mushroom. It has a curved front that bells out to hold the 32 motion-tracking sensors all over its surface and the single optical camera located in the lower center of the panel. A button and indicator LED sit on the left side of the headset, and a small knob on the right side can adjust pupillary distance (the distance between your pupils) to help adjust focus. The Vive uses a single 2,160-by-1,200 LCD with a 90Hz refresh rate, paired with two lenses that separate the display into 1,080-by-1,200 images for each eye.

Three wide elastic straps secure the headset to your head with hook-and-loop fasteners, a design that helps ensure a stable fit. The mounts where the side straps connect to the headset are also part of the focus system; pulling a rubber ring back or pushing it forward on the mount lets you change the distance between the LCD panel and the lenses, though it's an awkward adjustment to make because the two sections are connected very stiffly. Fortunately, you can also wear glasses with the Vive, which should make the default focal length work just fine. A ring of foam padding runs around the edge of the headset's face mask. It's connected with hook-and-loop fasteners, and can be easily removed for cleaning if it gets sweaty.

A triple cable runs over the top strap and down the back of your head to connect to the Vive's link box, which then connects to your PC. The cable is about 10 feet long, and includes HDMI, power, and USB connectors. A fourth, shorter cable reaches just to the back of your head and contains a 3.5mm

POETRY IN MOTION
The HTC Vive's advanced motion-control hardware lets you turn an entire room into your own personal VR studio.

headphone jack. The Vive comes with a pair of earphones with an incredibly short cable (just 14 inches) that often popped out of my ears when I turned my head. Fortunately, you can also use your own pair of earphones or headphones.

The link box is a small black device about the size and shape of a Sony PlayStation TV. One side holds DisplayPort, HDMI, power, and USB connectors marked in black, indicating they connect to the PC or a power outlet with the included wall adapter (the Vive works with both HDMI and DisplayPort; you don't need to connect both). The other side holds HDMI, power, and USB connectors marked in orange, indicating they connect to the headset's cable. An

adhesive rubber foot comes with the Vive to secure the link box to a desk or table; without it, the tiny box will flop around at the slightest cable tug.

The two included controllers are identical 8.5-inch wands that are loaded with motion and positioning sensors. Each features a prominent circular touchpad on top, flanked by Menu and VR buttons; the Menu buttons bring up a menu in whatever software you're running, while the VR button opens up the SteamVR interface. A large trigger sits on the underside of the wand, and two grip buttons sit lower on either side of the handle. The top is a large ring containing the positioning sensors that let the Vive track the location of the controller.

Finally, the Vive depends on two base stations to determine the positions of the headset and controllers. They're rounded black boxes measuring 3 by 3 by 2 inches (HWD). The front of each base station is glossy, and contains an indicator light, a small alphanumeric LED display, and an array of infrared LEDs. The back of each holds a Mode button, a power connector, and a 3.5mm port. The base stations should be able to detect each other wirelessly if they're configured properly, but if not they can be physically connected with the 3.5mm port thanks to an included, extremely long sync cable.

Aside from the major components of the system, the Vive comes with power adapters for the link box and headset and the base stations, two USB power adapters and USB-to-micro USB cables for the controllers, HDMI and USB cables for connecting the link box to your PC, a second foam face mask pad, wall-mounting hardware for the base stations, and the aforementioned earphones and sync cable.

Because of the multiple parts, especially the two base stations, setting up the Vive can be complicated. Fortunately, the setup software provides direct, clear instructions on how to get started. It takes about 20 minutes to download all the necessary software and get everything running. First you need to install the Vive setup software itself. It walks you through connecting the link box and headset to your computer, setting up the controllers, then adding the base stations. Through this process the software will install Steam (if necessary) and make

sure that SteamVR is up to date.

For whole-room VR, HTC recommends a space at least 6.5 by 5 feet, with the base stations positioned roughly at opposite corners of the play area, mounted at head level or higher. The base stations can work up to 16 feet apart from each other. If you don't have the space, you can set up the Vive for just "standing" VR, but that will obviously limit what you can do. Once you've set up your space, you can optionally define boundaries of that space for the SteamVR Chaperone feature. It projects a set of virtual walls on the edge of your play area, letting you know when you're about to step out of bounds and bump into anything.

Assuming you place the Vive's base stations correctly, Chaperone works well. The virtual walls consistently appear when the headset or a motion controller

BACK ON BASE
The Vive's two base stations are integral parts of its motion control feature, and can turn out amazing full-room VR if they are set up correctly.

gets near one of the boundaries you set, and if you enable the camera, the headset will display objects around you as glowing monochrome outlines as soon as you get close to the edge of your play area. The camera view is entirely for your benefit, by the way—Chaperone is based on the Vive's head tracking, which uses the base stations and the nonvisual sensors grouped around the front of the headset.

If the base stations don't have a reliable line of sight to each other (and aren't connected with the sync cable to make up for it), the Vive won't consistently show the virtual walls you set where you actually set them. Poor base station placement can even mess with the Vive's perception of the floor and ceiling, leading to some very disorienting bugs.

Cables are the biggest nuisance of the Vive. The cable that runs from the headset might be long (about 10 feet), but it's still easy to get caught on if you don't keep track of where it is. This is a bigger issue for whole-room VR than it is when you're using the Vive standing or sitting. Wireless VR headsets with the same feature set are still a few years away from reaching consumers, and currently the Vive is the only device that offers whole-room VR. As long as you're careful, it's a very interesting experience. It's just a shame that you can't get fully immersed in it when you're dedicating part of your attention to not tripping on the cable.

JUMPING INTO THE RIFT

The Oculus Rift headset is simple and understated. It's a plain black rectangular visor with rounded edges and little visual flair. The front panel is completely flat, marked only with an Oculus logo. The sides of the visor are similarly flat, and connect to arms that pivot slightly up and down and attach to the three-strap harness for securing the device on your head.

A strap extends from each arm around the sides of your head, with a third strap extending from the top of the visor over the top of your head, meeting at a padded triangle in the back. The straps are held in place with hook-and-loop fasteners, and can be easily adjusted. A set of on-ear headphones sit on the arms, able to separately pivot and flip up and down to properly fit on your ears. On its own, the Rift headset is fairly light and comfortable. You can wear glasses with the Rift, but it will make the fit a bit tighter, and could hurt your ability to wear the headset for long periods of time.

The headset connects to your PC directly through a lengthy cable that splits off near the end into HDMI and USB 3.0 connectors. The cable winds down the left strap before running clear of the headset. It's a little more awkward than the Vive's over-the-top-of-the-head cable, and I struggled to find a comfortable position where the cable didn't sit distractingly on my shoulder. But it's not nearly as big a concern in use as the HTC Vive's cable, as the Vive is designed to work when you're walking around a set area.

The Rift uses a single external sensor, a black cylinder that sits on a nine-inch-tall metal desktop stand. The sensor can tilt up and down, and must be placed where it can maintain a clear view of the headset when in use.

Once you're up and running, a 2,160-by-1,200 OLED panel is used to produce a 1,080-by-1,200 picture for each eye, separated by the lenses in the headset (just like the Vive). The lenses can be adjusted using a small lever on the right underside of the visor.

RIFT TRACTS

Although the Oculus Rift requires using less out-of-the-box hardware, you don't have the motion controls you do with the Vibe. But it does give you access to a bigger game library.

Oculus plans to offer Touch motion controllers separately later this year, but the headset still comes with some control options, including the Oculus Remote. It's a small, rounded remote control with a large, circular navigation pad and Back, Menu, and Up/Down buttons. The remote helpfully features a lanyard to keep it attached to your wrist when you're using the Rift. In the box you also get a Microsoft Xbox One wireless gamepad, along with a wireless receiver for the gamepad.

Setting up the Rift is simple. You need to download the Oculus setup software, which walks you through the relatively few steps necessary to get going. First, plug the headset and sensor into your computer, using an HDMI and two USB 3.0 ports. Second, sync the remote by pulling out the battery tab and pressing a button. Finally, pair the Xbox One wireless gamepad with the receiver. Once these steps are complete, you can slip on the headset and jump into the Oculus software.

At this point in the setup process, you can play any software available on the Oculus Store, but by configuring the Oculus software to load apps from unidentified sources, you can get the headset to work with SteamVR, just like the HTC Vive uses. The Rift lacks the motion controls of the Vive, but that isn't a problem for navigating the SteamVR interface; it works perfectly well with the Xbox One gamepad. That said,

SteamVR titles that actually require motion controls simply won't work with the Rift. That might change when Oculus launches the Touch motion controllers.

The Rift also doesn't support whole-room VR like the Vive. You can use it while sitting or standing, but the included external sensor is for head tracking, so it doesn't actually track your place in space. This is a small sacrifice compared with the lack of motion controls. The Rift's head tracking works very well in the sitting/standing confines of intended use. Just as the Vive's did, the Oculus headset followed my motions smoothly and accurately in testing.

THE EXPERIENCE

Because both the Rift and the Vive share the same resolution and refresh rate, the experience of using both is quite similar. Each produces a crisp picture with smooth motion and head tracking, though the power of your computer determines exactly how things will look. In both cases, the 3D objects truly look like they're right in front of you. So software becomes a major differentiating factor.

The Vive relies on Valve's SteamVR platform, which lets you browse and load VR games either directly from the Steam client on your desktop, or through a virtual space displayed in the Vive headset. The virtual space serves as a loading dock, displaying either a blank white area or scenic vistas, with the outline of your defined play area clearly projected on the floor. By pressing the VR button on one of the motion controllers, you can bring up a version of the Steam Big Picture interface directly in front of you. From here, you can use the motion controller as a pointer, aiming it like a laser at your desired menu items. It's a fairly intuitive system, though it's tempting to try to use the motion controller's touchpad, which doesn't actually do anything in this particular situation.

HTC also provides its own Vive Home VR software, which displays a similar virtual space. You can choose between a modern loft setting or a sci-fi space station as your background, and the projected menu system is much simpler than

the Big Picture mode used with the SteamVR interface. Vive Home will offer widgets in some form, but they weren't enabled when I tested the Vive.

The Vive can't access VR titles from the Oculus Store, which is only available on the Rift. Rift users can, however, access SteamVR, though they're limited by the Rift's lack of motion controls, which means certain SteamVR titles won't work.

To compare the headsets, I played Adventure Time: Magic Man's Head Game on SteamVR. It's a simple third-person platformer in which you control Finn the Human as he runs through dangerous environments and fights magic sandwiches summoned by the evil wizard Magic Man. The VR hook is that you, the player, take the role of Tiny the Balloon. You're an active character as the game's third-person camera, getting pulled along by Finn and Jake with a string as you float, massive and silent, above them. Third-person games like this aren't ideally suited for VR, but Adventure Time makes an admirable try, and both the Vive and the Rift handled it well. The sense of being completely surrounded by the landscape of Ooo as you watch Finn and Jake chase Magic Man is unique, and something you can't get from a standard screen. On the other hand, your view is still fairly fixed; you can turn your head and look in different directions, but you can't easily pan around the action the way you can with a conventional third-person platformer that uses an analog stick to move the camera.

Next I tried Virtual Desktop, which projects your computer's screen in front of

MOBILE VR

WANT VR WITHOUT THE HEFTY WALLET HIT? THESE MOBILE HEADSETS USE YOUR PHONE'S PROCESSOR AND SCREEN TO DELIVER THE BASICS.

GOOGLE CARDBOARD ($20 AND UP) IS THE BROADEST, MOST AFFORDABLE, AND MOST ACCESSIBLE VR PLATFORM AVAILABLE; MOST OF THE MANY AVAILABLE HEADSETS ARE EMPTY SHELLS MADE OF EITHER PLASTIC OR LITERAL CARDBOARD AND WILL ACCEPT ANY ANDROID SMARTPHONE THAT FITS.

THE **SAMSUNG GEAR VR** IS A POWERFUL PLATFORM BASED ON OCULUS TECHNOLOGY, AND OFFERS BETTER FIT, DESIGN, AND ELECTRONICS THAN CARDBOARD, AND A GOOD SELECTION OF APPS AND GAMES. BUT IT'S PRICEY ($99), AND YOU CAN ONLY USE IT WITH A FEW RECENT SAMSUNG PHONES.

THE **360 VR** IS LG'S UPCOMING SLIM-AND-LIGHT CARDBOARD-LIKE HEADSET THAT CONNECTS ONLY TO ITS G5 SMARTPHONE VIA A USB TYPE-C CABLE. IT WILL PLAY BOTH 360-DEGREE VR CONTENT AND STANDARD 2D MOVIES, AND YOU CAN SHOOT YOUR OWN VR FILMS WITH THE OPTIONAL 360 CAM.

you in virtual space. You can have your computer screen appear as a massive, curved display in space, a canvas floating in an art studio, or a television mounted on the wall of a home theater. There are several options for adjusting how you look at your desktop in VR. Putting on a VR headset just to use your computer normally sounds counterintuitive, but it has some very compelling potential uses. If you don't have a big screen at home, you can watch movies on a virtual one, as if you were in a theater. (And if you want to watch a video that's not available on a client for the Oculus Rift or on SteamVR, you can just load it with Virtual Desktop.) If your desk doesn't have enough room for a big monitor, you can surround yourself with a virtual screen almost as large as you. Virtual Desktop isn't perfect: It doesn't use the Vive's motion controllers, so you need to keep track of your mouse; you need to tell the software exactly where your games are located on your hard drive so it can launch them manually; and its virtual screen is smaller than the headsets' per-eye resolution, so text can appear blurry and grainy unless you find a sweet spot from which to look at the screen.

I also looked at The Lab, Valve's in-depth, multisituation VR demo that uses minigames and other scenarios to really show off what the Vive can do. You wander through a large, detailed lab space is filled with balls that represent individual VR activities; you can load one by picking up a ball with the motion controllers and holding it up to your face. I virtually walked around a Venetian plaza, explored a model of the solar system, and played a shoot-'em-up where I moved the spaceship in front of me as if it was a toy, pointing it at targets and keeping it out of the way of enemy fire. The Lab is loaded with little gags and bonuses for exploring the space—such as a round of fetch you can play with a

LAB "WORK"
Valve's playful, detailed VR demo The Lab shows off the full potential of the HTC Vive.

robot dog and a Galaga-like arcade game—as well as wry references to Valve's own acclaimed Portal series, though the program can be particularly taxing on your hardware.

Job Simulator, a humorous recreation of everyday modern jobs (such as selling hot dogs at a convenience store or shredding documents in an office) as envisioned by robots attempting to show them off in a museum of the future, feels a lot like another tech demo to show off the Vive and its motion controllers. But the jokes based around your bosses and customers are amusing, and playing with the game's physics is oddly addicting.

Many of the Rift's platform-specific titles are worthy of note. EVE: Valkyrie is the star of the launch lineup, an online, multiplayer space dogfighting game sent in the EVE universe; it's enjoyable and immersive if not complex, though its VR aspect is unnecessary given that all you can really do with it is look freely around your cockpit. Lucky's Tale, a standard cartoony third-person platformer in which you control a cartoon fox as he runs through different levels trying to rescue his pet pig, is another eye-catching title that doesn't need VR at all—in fact, because you can't readily move the camera to get a better view of your character, it can be difficult to align your jumps to collect the lines of coins floating through 3D space. Farlands is a mellow xenobiological playground in which you search for, study, and feed new life forms on an alien planet, a concept that seems ideal for motion controls.

PLAYSTATION VR

THIS YEAR'S MOST EXCITING VR CONTENT MAY NOT BE FOR THE OCULUS RIFT OR THE HTC VIVE, BUT FOR THE PLAYSTATION VR. SONY'S HEADSET, WHICH WILL BE AVAILABLE FOR $399 IN OCTOBER, IS DESIGNED EXCLUSIVELY FOR ITS PLAYSTATION 4 CONSOLE, AND WILL INCLUDE A 5.7-INCH OLED DISPLAY AT FULL-HD (1,920-BY-1,080) RESOLUTION AND A 90-120HZ REFRESH RATE. IT ALSO BOASTS LATENCY OF LESS THAN 18MS, SUGGESTING—TO NO ONE'S SURPRISE—THAT THE PLAYSTATION VR IS DESIGNED FOR GAMING.

INTERACTION WITH THE PLAYSTATION VR IS SIMILAR TO THAT OF VIRTUAL DESKTOP: A PROJECTED DISPLAY THAT LETS YOU NAVIGATE THE PS4'S MENUS AND RUN NON-VR GAMES AND APPS. YOU DON'T HAVE MANY OPTIONS, BUT YOU CAN SELECT FROM BETWEEN THREE VIRTUAL SCREEN SIZES.

WE ALSO GOT AN EARLY LOOK AT HOW THREE WILL WORK WITH THE PLAYSTATION VR: REZ INFINITE, AN UPDATE OF THE CLASSIC PLAYSTATION 2 RAIL SHOOTER; DRIVECLUB, A RACING GAME RELEASED LAST YEAR; AND BATTLEZONE, A TANK COMBAT SIMULATOR BASED ON THE 1980 ARCADE GAME. ALL THREE OFFERED INTENSE IMMERSION AND MADE USE OF THE VR ENVIRONMENT IN WAYS THE RIFT AND THE VIVE ARE STILL STRUGGLING TO ACHIEVE.

CONCLUSIONS

What strikes me most about these VR headsets is that, even after I'd finished testing them, and despite the initial headaches and awkwardness, I wanted to put them back on and keep playing. I want to see how feasible it is to do a day's worth of normal work in Virtual Desktop. I want a networked virtual theater where I can watch a movie next to my friends across the country, riffing with them as we look up at the same screen from adjacent virtual seats. I want to wander around a virtual arcade, looking down at pinball tables and the screens of virtual cabinets and handle the virtual controls of classic games. I want more VR.

I can envision actual games and apps in the pipe for these devices, beyond the endless parade of visually compelling but mechanically simplistic tech demos designed solely to show what VR can be. There's enough substance here to support the next Elder Scrolls or Fallout game. That's promise I want to see realized.

Early adopters have a difficult choice to make. If you want motion controls right now, as well as the ability to physically walk around a virtual world, then the HTC Vive is the way to go—even if it's a lot more expensive. There's just no other way to get a full VR experience, complete with a virtual space to move around in, in one package. But if you can wait on the motion controls until later this year and want access to the most VR software available, then the Oculus Rift is a better bet. Right now, it's a waiting game to see whether publishers and developers focus on one platform over the other, and how eagerly they start releasing titles on both.

There will be hiccups. The fact that the Rift and Vive have to be physically connected to computers via a cable can make virtual experiences awkward and break immersion. And, of course, enough compelling software needs to be developed and released to make VR more worthwhile. But from what I've seen of these first two real headsets, we're at the start of something exciting.

“There's enough substance here to support the next Elder Scrolls or Fallout game. That's promise I want to see realized.”

How Ransomware Conquered The World

Ransomware can hit anyone, but hackers are increasingly targeting people who are more willing to pay up. BY BRIAN HEATER

It's been a strange few years for Alina Simone. In 2011, she released her fourth full-length record, *Make Your Own Danger*, to critical acclaim, and followed it with a book of essays and her debut novel (*You Must Go and Win*), all while maintaining a journalism career and raising a young daughter. But it's likely a 2015 opinion piece for the *New York Times* that garnered the most recognition for the Brooklyn-based artist. "My gravestone will say, 'Her mom got hacked,'" she says with a laugh.

Published in January of that year, "How My Mom Got Hacked" earned Simone a deluge of media appearances, from prime-time news programs to an episode of the popular public radio program Radiolab. The story details her mother Inna's struggles with a mysterious form of malware and the strange and surprisingly cloak-and-dagger story that unfolded in its wake.

"My mom called me one night, and she was ranting about needing to pay a ransom," she tells *PC Magazine*. "I had my laptop open but was also watching TV and half listening. I thought it was a typical mom rant about her hardware crashing [and] having to pay the repair people $500 because her computer crashed. I thought she was talking in air quotes. She kept saying, 'No, Alina, listen. I mean ransom.'"

By the time Simone got the call, there was less than a day left before the deadline. Her mother had attempted to withdraw the full amount for the ransom, but a combination of the Thanksgiving holiday, the long weekend, a snowstorm, and the highly volatile value of Bitcoin had caused her payment to fall $25 short. A failure to pay would cause the $500 ransom to double.

Simone dropped everything the following morning and made a beeline to the nearest bitcoin ATM. "I had a full-time job and a toddler at home," she explains. "I had a busy morning, but I canceled everything and got a sitter. I ran over to

Greenpoint, where this bitcoin ATM was located in a shared workspace building. The ATM didn't work and it gave me the spinny wheel. We were freaked out by the virus, but Bitcoin gave it this extra level of terror. It just freezes your brain—it's just another thing to figure out."

The story has a happy ending—at least as far as those things go. "She didn't make the deadline, and they were going to charge her double the ransom, [but] she pleaded with them and they let her go," Simone says. Mom got her files, the hackers got their money, and everyone who read the story in the *New York Times* learned about the phenomenon of ransomware, a strange, steadily growing form of malware that all but holds a user's computer files at electronic gunpoint.

YOUR MONEY OR YOUR FILES' LIVES
In ransomware attacks, hackers threaten to destroy everything on your computer if you don't give them the money they want.

Simone's mother is not the only victim, of course. In a piece published late last year in *Infosecurity Magazine*, G Data Software Security Evangelist Andrew Hayter posited that 2016 will be "the year of ransomware," a sentiment that's seemingly been confirmed by similarly titled pieces subsequently published in big media outlets like the *Los Angeles Times* and security firms like Symantec.

The year has already been dotted with increasingly high-profile examples, including, most notably, the case

of Hollywood Presbyterian Medical Center, a 434-bed hospital in Los Angeles whose network effectively ground to a halt in early February when hackers breached the system. After relying on pen-and-paper records briefly, the hospital paid the 40-bitcoin ($17,000) ransom to regain control of its network.

More recently, the Columbia, Maryland–based MedStar Health and Methodist Hospital in Henderson, Kentucky, were hit with similar attacks, and the targeting of such larger institutions appears to be part of a growing movement.

"We're absolutely seeing that trend," explains Grayson Milbourne, Security Intelligence Director for Internet security firm Webroot. "It's true that there's an increase in focus on attacking corporate entities.

"The value of my personal files and pictures caps off somewhere," he continues. "But [if] I encrypt the backend of your corporate system and prevent you from processing payments, that has a tremendous value. And if the hacker can recognize the value of what he has, the ransom can be more dynamically set based on the content of the data."

Hayter concurs, but notes that, although hackers have been planning large-scale attacks for some time, "public companies never could admit that they had malware because it would hurt their stock. They kept security quiet. I think they've been hit all along, but they just don't talk about it."

What does seem certain is that high-profile payments like the one issued by Hollywood Presbyterian add fuel to the fire.

Among the many ways ransomware is unique is in the moral quandary it presents its users. Thus far the malware's encryption has proven largely bulletproof, meaning that, once infected, the end user has one of two options: either pay the ransom, thereby funding the activities of the criminals, who hacked into the system, or lose the files forever.

Among the many ways ransomware is unique is in the moral quandary it presents its users.

“At first I was really shocked that my mom wanted to pay it,” explains Simone. “I told her not to. [I told her], ‘You’re funding these people. You might be funding terrorists. It’s morally wrong, your files don’t matter that much.’ She said, ‘They do to me. I’ve done my research and it’s the only way to get it back.’”

Inna Simone was not alone in her decision. In the majority of cases, all is essentially lost once ransomware takes hold. A month after Simone paid the ransom, a police department in Tewksbury, Massachusetts, made a $500 payment after enlisting the help of the FBI. In fact, the encryption has proven so hard to crack that even agents at the FBI have essentially thrown up their hands in defeat.

“The ransomware is that good,” Joseph Bonavolonta, the assistant special agent in charge of the FBI’s CYBER and Counterintelligence Program, told Boston’s Cyber Security Summit in October. “To be honest, we often advise people just to pay the ransom.”

FBI MIA
Even the FBI is helpless against many ransomware threats, and primarily advises computer users to take security precautions to avoid exposing themselves in the first place.

The FBI declined a follow-up request, telling us that Bonavolonta was “unavailable,” and instead offering up the following decidedly more noncommittal statement: “The FBI works closely with the private sector so that companies may make informed decisions in response to malware attacks. Companies can prevent and mitigate malware infection by utilizing appropriate backup and malware detection and prevention systems, and training employees to be skeptical of emails, attachments, and websites they don’t recognize.”

The damage, however, was already done—at least as far as the security community was concerned.

"I think that the FBI has not helped the situation at all by coming out and saying that people should pay the ransom," says Hayter. "To me, that goes against everything we know about dealing with malware, bad guys, and cybercrime. You don't want to keep funding them, and that's what paying the ransom does. And they keep putting more funding into development, which seems to be what they're doing right now."

Milbourne concurs. "They set a precedent of that being the only option." Small-scale individual user payments of $200 to $300 have already funded hackers to the tune of hundreds of millions of dollars, though Milbourne acknowledges that, in real life, things are rarely so black and white.

If it means people's lives, $17,000 is a reasonable price to pay to get your business back online. Does that mean it's a good precedent to be setting? No.

"It's a personal decision," he explains. "[Webroot's] stance is that we don't believe what the FBI has told people to do is the right approach. That said, the hospital has a business to run. If it means people's lives, $17,000 is a reasonable price to pay to get your business back online. Does that mean it's a good precedent to be setting? No."

It's easy enough to pass judgment until one comes face-to-face with ransomware boldly announcing its presence. "Your files are encrypted," boasted the Cryptowall 2.0 lock screen that greeted Inna Simone, adding—in that fake-helpful ransomware way—that the "special software" CryptoWall Decrypter could be purchased for a limited-time offer of $500. All of that was ominously underscored by a clock counting down the seconds until the ransom doubled.

If there is an upside to the ransomware phenomenon, it is consumer awareness. And every party can agree that the best way manage malware is to simply avoid getting hit in the first place.

Ransomware comes from a growing number of sources, largely through Internet connections, with a smaller percentage arriving through physical vectors like USB sticks. In most cases, however, the real breakdown occurs at a similar point of vulnerability: humans.

The same month the Hollywood hospital was hit, the Baltimore-based Independent Security Evaluators issued the eerily prescient results of a two-year study involving a dozen health care facilities. In one scenario, researchers dropped 18 USB sticks loaded with simulated malware across various floors of a hospital. Within 24 hours, one unsuspecting user plugged one of the sticks in to a computer, requesting malware from ISE's servers. This was just a test, thankfully, but the scenario highlights the inevitable fact that a computer's security system is only as effective as the person using it.

"There's still terrible USB hygiene around the world with people still using XP Service Pack 1," says Milbourne. "There are a lot vulnerable systems. But primarily [ransomware proliferates] through Web exploit kits and direct email campaigns that trick people into being dumb and infecting themselves."

Like much of the malware out there, ransomware

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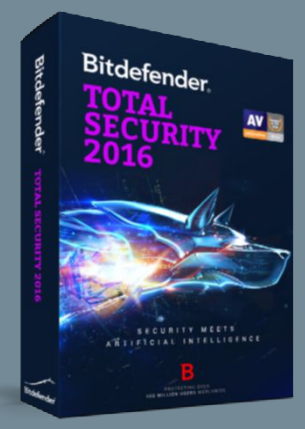
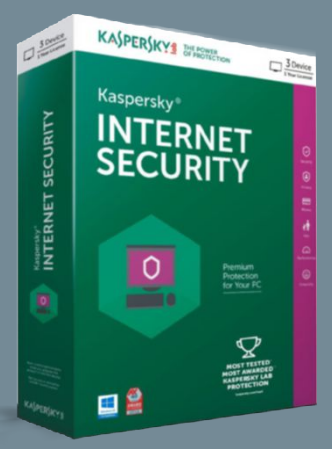


Bitdefender Total Security 2016

EC ●●●●◐

$89.95 (for three devices)



Kaspersky Internet Security

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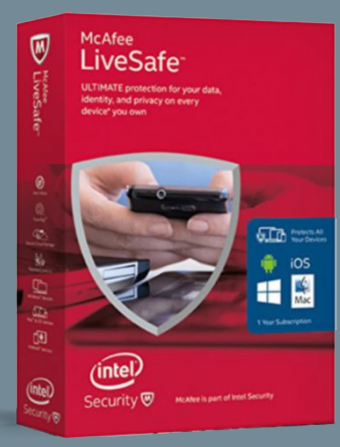


McAfee LiveSafe

EC ●●●●◐

$89.99 (for unlimited devices)

finds its way onto systems through untrusted sites and attachments. So the major tenants of avoiding an infection are similar to those for avoiding malware in general: Install security software, keep your operating system and applications up to date, and don't visit any suspicious sites or open email attachments from unknown sources.

Hayter recommends getting rid of potential malware gateways like Flash and Silverlight, and OpenDNS Security Analyst Kevin Bottomley suggests installing ad-blocker and NoScript browser add-ons, as online advertisements become an increasingly popular vector for the malicious malware's spread.

Some websites use ad services "that generate revenue through attracting ad distributors, and they provide a lot of flexibility to those distributors with respect to how they code their ads to display on pages," says Milbourne. "It'll open in the background; the user has no idea."

This type of scenario recently hit a number of mainstream sites run by some of the most prominent names in publishing, from the *New York Times* to AOL, and potentially exposed tens of thousands of users to ransomware in the U.S. alone within a 24-hour time period.

Equally disturbing is the speed with which ransomware is capable of spreading once a system has been compromised. According to Bottomley's research,

> **By the time you're finished grabbing a cup of coffee, ransomware has already had more than sufficient time to do its thing.**

“It’s usually [a] sub-3-minute infection-to-encryption time.” By the time you’re finished grabbing a cup of coffee, ransomware has already had more than sufficient time to do its thing. And as it’s evolved, ransomware has become increasingly effective at propagating across a network.

The newly identified ransomware Locky, for example, has discovered how to identify and gain access to unmapped network shares. “You want to disconnect that endpoint from the network and limit any potential spread,” says Milbourne. “And then it comes down to what got hit and what’s infected. In a lot of cases, it’s just an end user. When we start to see problems is when these things propagate and start to hit resource servers and things that really impact the flow of business.”

As ransomware and its developments become more sophisticated, the likelihood increases that even the most thoughtful users are at risk of getting hit, highlighting the importance of backing up files online and off. Restoring those files is admittedly inconvenient, but ransom seekers don’t hold much sway when you have unencrypted copies as a backup. It might sound like overkill, but ransomware is “becoming more and more prolific,” says Hayter.

The phenomenon has been around in some form other at least since the late 1980s, when the AIDS trojan demanded users send $189 to a Panamanian post office box, lest their “conscience may haunt [them] for the rest of [their] life... and [their PC would] will stop functioning normally.” Things have grown exponentially since those early shady days of the PC Cyborg Corporation. In a report issued in late 2015, McAfee noted a huge jump of late, from 257,357 new ransomware samples in the first half of 2014 to 380,652 in the second half. By the first half of 2015, that number jumped 5.3 times, to over 2 million.

The security company added that the rapid growth is likely to continue, due in no small part to the relatively new phenomenon of “ransomware-as-a-service.” Between the hundreds of millions of dollars extorted from smaller targets and the increasing focus on corporations and institutions, ransomware has proven to be an extremely lucrative business model—and one with decidedly less risk of bodily harm and capture than more traditional crime.

“Cyber criminals have figured out that they can make money more easily than with drug deals,” says Hayter. “They’re turning to cybercrime for their income. And then they can use that income to do more development and get into other forms of crime—or just make more money and buy more Ferraris.”

One perhaps unexpected turn in the ransomware game is that hackers are adopting some traditional business tactics, like customer service. Simone’s mother, for example, was able to negotiate with the ransom seekers, who agreed

to accept the final $25 a little after the deadline without doubling the ransom.

People "won't pay the ransom if they think they're f**ked anyway," Simone says. "It's e-commerce. They've taken all of the lessons of e-commerce from legitimate businesses and applied it to ransomware."

As McAfee noted, hackers have also developed custom malware solutions built to spec for potential ransomers—a sort of black-market version of Squarespace, if you will.

"You pay a certain amount," explains Hayter, "you get the ransomware, you customize it to yourself, you direct the payments where to want to direct them, you get 24/7 customer support for your ransomware product."

Part of the malware business's expansion model has involved the targeting of new platforms. Once largely the realm of Windows PCs, security analysts have been aware of the presence of Android variants for a number of years. This March also marked the first known instance of a ransomware attack on Mac users, as KeRanger demanded users pay one bitcoin (about $400) to rescue files locked down after the installation of BitTorrent software, Transmission.

"It's a sign that the criminals are seeing that there is some value in making Mac malware," explains Hayter. "In the past, the Mac just wasn't an attractive target because there wasn't the profit margin there. Now that they got through once, I think Apple is going to do a better job protecting the walled garden."

Apple was able to quickly address the issue by revoking the software's app development certificate and updating its malware protection, but it's hard not to see this first breach as a sign of more ominous things to come.

For all their concerns, the security experts we spoke with are hopeful. "In the 40 years that malware has been around, we've found ways to defeat families of malware," says Hayter. "Catching up with the bad guys has always been the problem. They always seem to be one step ahead. But I think there's hope on the way in a very short amount of time. The antimalware industry cannot wait. This is a rush job. This is an emergency."

GET ORGANIZED

Maintaining the Digital Divide Between Home and Work

TIPS

Become a Galaxy S7 Superstar

HOW TO

Back Up the Rest of Your Data

CONNECTED TRAVELER

Take a Virtual Vacation Before You Take a Real One

Digital Life

Maintaining the Digital Divide Between Home and Work

BY JILL DUFFY

Information workers (like me) often check work email on the weekend. Or they might make headway on an important presentation late at night from home, if that's when their most productive hours are (or if they are running behind on a project). They are equally prone to answering personal messages while at work, or perhaps scanning a home insurance document on the office copier. If you fall into this category, chances are you probably like this flexibility. But if you're not careful about how you separate your work and personal files, you could be getting yourself and your data into trouble.

Risky behaviors in the gray area between work and life can put sensitive data at risk. For instance, although you might scan a personal document at the office occasionally, you wouldn't want to scan anything sensitive, because, unless you're the head of IT, you have no idea where the multifunction printer saves

copies of files it scans. They're probably on the hard drive of the scanner itself, and they might be saved to unsecured shared servers, too.

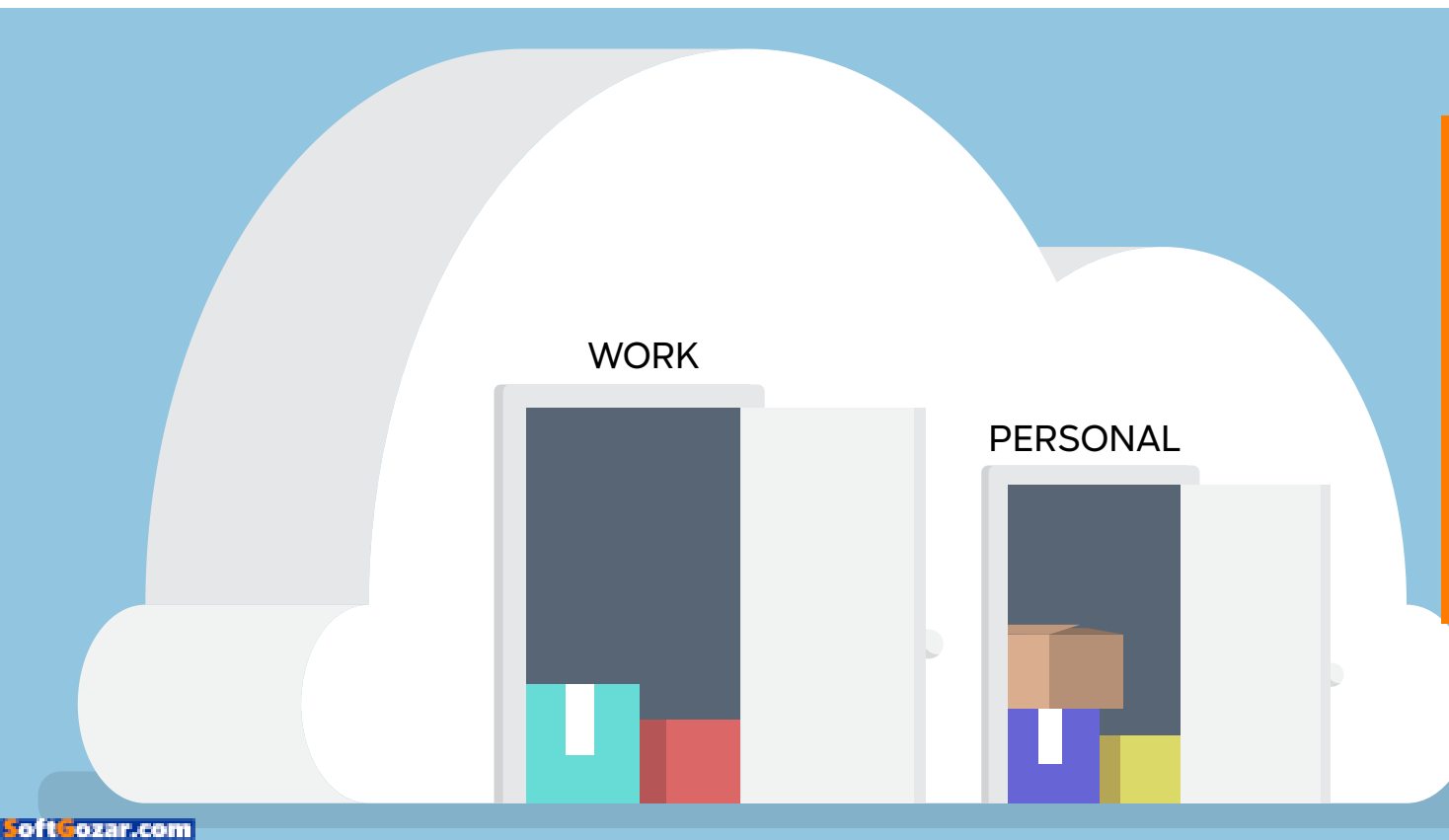
Additionally, to maintain some semblance of work-life balance, it's helpful to have cues that remind you when you're doing one kind of work while you're on the other clock. Let's say you're catching up on some emails three days into a family vacation. You might appreciate that you're able to deal with any urgent problems that have arisen, but you might also want to get back to enjoying Splash Mountain with your kids. With a few simple strategies for separating your personal and work files, you'll never get sucked into doing work for too long when you're enjoying your personal time—and vice versa.

COMPARTMENTALIZE

The main trick to separating work and personal files is to compartmentalize them. Keeping specific things in dedicated places creates not only order, but also certainty. It works both in the physical world and the digital world. If you always put your keys in your right pocket and your phone in your left, you never end up searching your jacket for either item.

With digital files, the principles are the same, but the reality is a little different. You could keep all of your work files in one folder and personal files in another, but do they live on the same server, computer, app, or mobile device? Do you want them to?

Over the years, I've developed some strategies to help me better compartmentalize my work and personal files. I make sure that they're always separate and accessible no matter where I am—but that it's also slightly inconvenient for me to access work files when I'm in home mode and home files when I'm in work mode.



EVERYTHING IN ITS PLACE
One of the best ways to protect your data (and your job) is to keep your work and personal files in totally separate locations that are also easily accessible from anywhere you need them.

USE DIFFERENT INTERFACES FOR DIFFERENT WORK

First let's talk about common file types, such as word processing documents, spreadsheets, presentations, PDFs, and images.

The easiest way I've found to keep documents separate and yet accessible is to store them in an online syncing service, and to use different services for different types of information. I use Dropbox to store, back up, and sync my personal files, and I rely on Google Drive for work. There are plenty of other options, too, but the point is to start by separating your files.

Why wouldn't I choose my favorite storage service and create two different accounts instead of using two different services? Because having two different interfaces helps me maintain the boundaries I need between work and personal files.

If I look at the Google Drive Web interface, I feel like I'm working. If I stare at Google Drive while I'm on vacation, however, bells go off in my head that remind me I'm doing work when I should be lounging by the pool. But if I'm tooling around Dropbox on the weekend, organizing my personal photos, my brain doesn't give me that same "you're working" signal. Over time, I've developed a strong association between each interface and what I do in that interface. For me, it's even more important to have clear work-life boundaries because I work from a home office. When I did work full-time in an office building, I used similar strategies to the same effect.

Having two different interfaces helps me maintain the boundaries I need between work and personal files.

CREATE VISUAL CUES IN YOUR OS AND THEMES

Some storage services, such as those that integrate tightly with your operating system, don't look like anything at all (unless you use the Web app). They don't necessarily have a distinct interface. Another way you

could be compartmentalizing without even realizing it is by using a different operating system at work and at home. If you have a Windows machine in the office and a Mac at home, you might already experience the same sensation of being hyper-aware when you're doing office work at home on the Mac.

Another problem might be that you use some of the same tools in your work life and personal life because you like them. You don't want to choose two different tools or interfaces. You want to use the one you like best for both. Some of my friends, for instance, use Slack for both personal communication and work. In that situation, I'd recommend changing the color schemes of your two Slack accounts so that they physically look different. You'll quickly associate one color scheme with work and one with private personal chatter.

RUN MULTIPLE WEB BROWSERS

Another option for compartmentalizing your work and creating visual cues that remind you what type of work you're doing is to stick to one kind of Web browser at work and another one at home. The visual cues might be subtler, but you'll still get into the habit of launching, say, Chrome for work and Firefox for personal stuff.

It's also beneficial to use two separate browsers for keeping your Web history separate. For instance, you might be more vigilant about clearing the browser cache for work files because they contain sensitive company information, but you might actually want to keep your personal Web history so you can quickly look up sites you hit a few days ago.

COLOR MY WORLD

Using different colored themes for programs like Slack can let you instantly know whether you're looking at work or personal information.

USE EMAIL CLIENT APPS TO YOUR ADVANTAGE

On mobile phones, there's a really easy way to separate work email from personal email, no matter if you use the same email service, such as Gmail, for both work and home. The solution: Use different email clients.

Gmail has a standalone app, but you don't necessarily have to choose it as the app you use to access Gmail. On the iPhone, you could use the stock Mail app. Or on any type of phone, you can install a third-party email client app that works with Gmail, such as Boxer or Inboxcube.

I like to use separate apps for work and personal email. I get the same benefit of having two distinct interfaces. Plus, when I am trying to not get sucked into work, I can quit and close my work email while keeping my personal email more easily accessible.

It might be the case that you just really like one email client app, and you want to use it for both your work and personal email. With many apps, you can have multiple accounts authenticated and switch between them at will. It provides an ease of use that you actually might not want, however. You lose the benefit of having two distinct interfaces, and you lose the ability to quit the app with whichever account you want to make less tempting at the moment. Maybe you want your technology to be slightly less user-friendly for the sake of your own psychology.

BETTER WORK-LIFE BALANCE

If you're in need of clearer boundaries between your work life and your personal life, compartmentalizing your data into different apps, services, operating systems, and browsers helps tremendously.

Having two distinct virtual spaces where you access your files creates cues, associations, and barriers of entry that can help you minimize working on your off time or doing personal chores while you're at work, while still allowing you to get them done when it's necessary.

Become a Galaxy S7 Superstar

BY SASCHA SEGAN

Samsung's new Galaxy S7 and Galaxy S7 Edge phones look a lot like last year's Galaxy S6 devices, but they don't quite work the same. There are some hidden features and extra tricks buried beneath the glossy screens that can give you a surprising amount of added functionality. Here are some of our favorites.

1. CARD STACKING

The Galaxy S7 phones have up to 32GB of built-in memory, which under most circumstances will probably be enough. But if you need more storage space, it's easy to get by way of a microSD card. (This is a welcome return of a feature that was missing on the S6.)

To insert a card into your Samsung Galaxy S7, take a SIM card tool and pop the SIM slot out halfway. You'll see that the top of the SIM slot is a microSD card slot. Press your card into the slot, and slide it back into the phone.

To move downloaded apps (not built-in apps) onto the SD card, go to Settings > Applications > Application Manager. Tap on the app you want to move, tap Storage, and tap Change. That will let you move the app onto the SD card. Use the My Files app to keep track of what's on your card.

Although the Galaxy S7 doesn't support Marshmallow's special storage mode that makes the SD card look like part of internal memory, it does support cards up to 200GB. So record as much 4K video as you want. The S7 can take it.

2. CLEAN CALLING

Both the regular S7 and the Edge are IP68 rated, which means they are completely resistant to dust and can be continuously immersed in water deeper than 1 meter. This is good news for swimmers, but even better news for those who tend to drink something while using their phone.

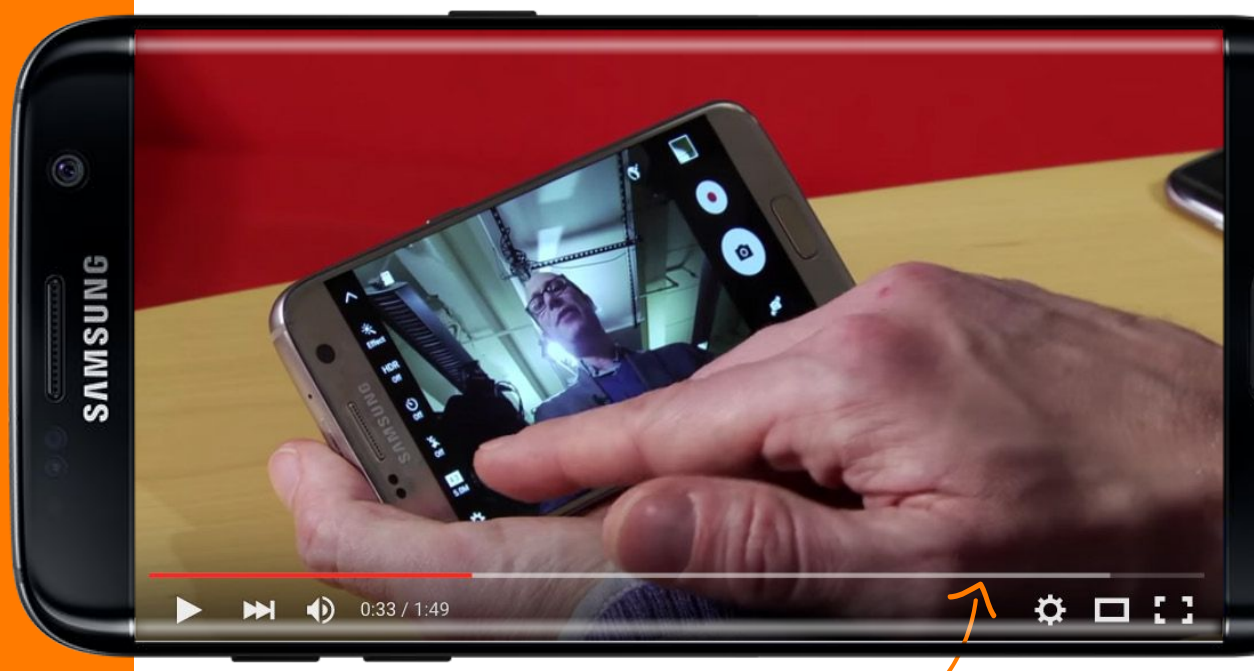
If you spill something on your S7, the best idea is to wash off your phone (please don't use soap) and then dry it with a paper towel or soft cloth. The phone's touch screen doesn't work underwater, but if you get it into the camera mode when it's dry, you can use the volume keys to take pictures.

3. MOVING PICTURES

Motion Photos are a new feature of Galaxy S7's camera. Superficially, they're a little bit like HTC's Zoe or Apple's Live Photos, but they're actually quite different. To turn on motion photos, go into the camera mode and touch the settings wheel. Then turn Motion photo to On.

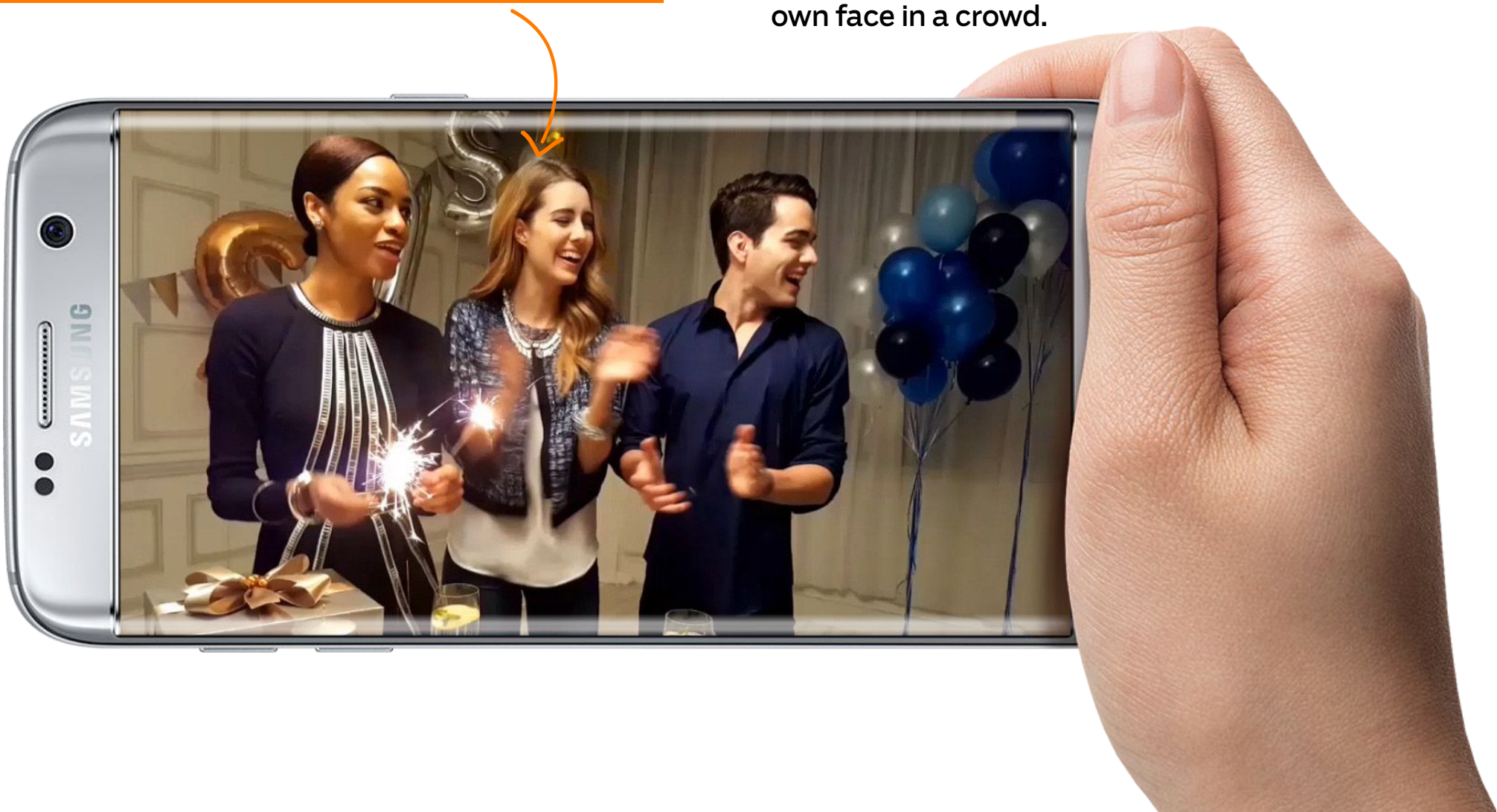
When you go into the Gallery app and look at an individual photo, it will have a Motion Photos icon in the upper-right corner. Tap it to see the motion. You can't really export or use the video clip anywhere else, though—its real purpose is in case you missed the photo you intended to take. You can scrub through the Motion Photo, hit Capture, and get a clip of what you missed. It'll only be 960 by 720, but that's better than nothing, right?

As of this writing, there are no other ways to share Motion Photos. When you share out an image, all you get is the original JPEG.



4. SNAPPIER SELFIES

The S7's 5-megapixel front-facing camera has several new features to improve your selfies. For starters, it's brighter than it used to be. That will help some in low-light situations. But what will do even more is a selfie flash, like we've seen on some other phones. To turn on the S7's, just tap the Flash icon on the left until it says On. Then, when you take a selfie, it will light up the screen while it's shooting the picture, which functions as a flash. After you've taken your selfie, there are some odd editing tools in the S7's gallery. The Spotlight tool is the most useful, as it brightens up your own face in a crowd.



5. PILING ON

The Samsung Galaxy S7 has an always-on display that just lights up the bits it needs to show you the time and date. By default, it'll show you the time, date, battery life and some basic notification information. But it can do a little more.

If you go into Settings > Display and wallpaper > Always On Display, you can pick different content to show on the Always On Display. There are several clock styles, a clock with a calendar, or a few custom image designs. How do you get more? You go to Themes in Settings and download a new theme with an Always On Display option. When you apply the theme, it will have more selections for background images. No, you can't use your own images as the backgrounds.

6. EDGE WALKING

The S7 Edge phone has a much more useful edge than the S6 Edge did. To use it, swipe in from the right. You'll initially see the Apps Edge; you can add your favorite apps to it.

Swipe to the right again for the Tasks Edge. This one has macros, for doing things like starting a text message to one of your favorite people or adding an alarm. There's a list of set macros, but you can also add shortcuts you've created on your home screen. One more swipe to the right brings up the People Edge, which has five of your favorite contacts.

Now you get to the customizable edges. This is the new stuff, which is really old stuff because it's how the original Galaxy Note Edge worked. You can install a news panel, a compass and a ruler, weather, sports scores, and more. Hit the Download button to see more panels you can install from Samsung's store. The edge panel SDK will be open to third parties, so hopefully, we'll see many more panels in the future.

7. BOOST BATTERY

The S7 has better battery life than the S6 did, but you still might want to use some of the built-in features to optimize the time you can spend away from your charger.

If your battery is running low, first turn down the screen brightness. Then try power saving mode, which you can find under Settings > Battery > Power saving mode. That turns off most background data, which means that stuff like email won't get automatically updated unless you go into the app. It saves a lot of battery, but you have to remember the feature is on while you're using your phone.

Want to take your battery usage to the next, worst-case-scenario level? Ultra power saving mode is for you. That turns the screen black and white, kills background data, and only lets you use the phone, Chrome, texting, the calculator, clock, memo pad, and Samsung's own email app (not even Gmail).

Back Up the Rest Of Your Data

BY ERIC GRIFFITH

It might seem like enough to point your backup software to the folders in which you keep your documents, pictures, videos, and music. But your computer contains a lot of other information and files that also need to be saved, but that you might not think about on a daily basis—and all of that could be just as important. Here's what you need to do to protect the data that you may be ignoring during your regular backup routine.

EMAIL

It's unlikely that your email client software—if you're still using that instead of a Web-based system like Gmail or Outlook.com—places your email data files in a convenient place for backup. So it's up to you to seek them out and back them up yourself.

Users of Outlook (the software that comes with Microsoft Office) have to keep track of a file called the PST (short for Personal Storage Table), which could be located in a couple of different places, depending on which versions of Outlook and Windows you are running. To find it, open Outlook, go to the File tab, select Account Settings on the right, then click it. Go to the Data Files tab, click any entry, and Open Folder Location. You also need to make sure that you can See Hidden Items—in Windows 10 File Explorer, go to the View menu and there's a checkbox to make sure.

You can back up the PST file manually, of course, but because it can get big, that's not always easy. Outlook has an Import and Export option that helps. For Outlook 2007, 2003, and 2002 there's also an add-in from Microsoft called Personal Folders Backup that does just what its name implies; you can download a tool from Microsoft's website that will let the add-in work in

BABY GOT BACKUP?
Any data that a program stores can be backed up. And if that information is in any way important, whether e-mail, browser favorites, drivers, or more, keeping it safe will keep you calm and collected if there's a crisis.

Outlook 2010, too. For simplicity's sake, try a third-party backup tool like Safe PST Backup (safepstbackup.com).

If you're using a different desktop email client, your email may not be stored in one single file. In Thunderbird, for example, it's spread across many .EML files in mailbox folders. Thunderbird supports plug-ins that can help.

If you do use Web-based email, you could also use desktop software like eM Client to get access to them, all while in discrete desktop software, which lets you actually back up the messages on those services. The eM Client software, which supports Gmail, Google Apps, iCloud, Outlook.com, and others, has its own backup settings under Tools > Settings > Backup, to create a folder for you regular backup software to check regularly.

Why back up your window to the Web? You've carefully cultivated your bookmarks or favorites; that's reason enough.

BROWSERS

Why back up your window to the Web? You've carefully cultivated bookmarks or favorites; that's reason enough. But let's not forget all those passwords and delicious cookies that make access to sites easier. You don't want to lose them in a crash.

Mozilla has backup and sync with encryption built into the Firefox browser. Access it from the hamburger menu (the three stacked lines in the upper right), set up an account, and then set it up on all your Firefox-enabled computers and also Firefox for Android or iOS.

Google Chrome has a similar sync feature, which saves browser settings (bookmarks, extensions, themes, even apps) to your Google account if you desire; changes are synced whenever you use that account with Chrome on other computers.

But who only uses one browser? Xmarks (xmarks.com) is a popular way to sync browser data across multiple browsers, including Firefox, Chrome, Internet Explorer, and Safari. It can ensure the same (or at least similar) browsing experience no matter what browser you're using. Any change you make is backed up to the Xmarks servers and added to your other browsers when you open them.

DRIVERS

If you have peripherals, you have drivers—the software that makes your computer talk to video cards, printers, scanners, and the like. Simple Windows software apps like DriverMax (drivermax.com)—which installs extra toolbars, so watch it during install—or SlimDrivers (slimwareutilities.com/slimdrivers.php) will back up your current drivers and also search out current versions of drivers that are out of date. If you neglect to back up these handy files, you might have to rummage through every manufacturer's website to get them when you're performing a restore—but to be honest, that might be the better way to go, so you have the most up-to-date drivers all digitally signed. It will take more time, but might benefit you in the long run.

SOCIAL NETWORKS

It may seem weird to back up info that you don't keep on your hard drive, but do you seriously trust Facebook and Twitter to never, ever suffer a catastrophic data loss? Be prepared. It's not like you'd use these backups to restore them to online use in most cases, but better to have a redundant copy for your records than risk losing it all.

On Facebook, go into General Account Settings when logged in on the desktop, and you'll see a link at the bottom: "Download a copy of your Facebook data." It's the same deal: Facebook starts creating an archive and emails you a link for downloading it when it's ready. You'll get everything you've ever posted, plus some of your friends' names and emails (if they share them). You do not get friends' status updates and photos, even if you're tagged in them, or pithy comments you've made on other people's posts.

For Twitter, you don't need a third-party tool anymore. Sign in via the desktop browser and go to your account settings. Scroll down and click "Request your archive." You'll be emailed a link with the full file of all your tweets and uploaded photos in a short time.

On LinkedIn, go to Privacy and Settings—you'll have to confirm your login. Click the Account tab at the bottom, then click the "Request an archive of your data >>" link. Again: You'll be emailed a link. You're informed that it could take up to 24 hours, but I got mine in about 5 minutes—but only for an archive of messages, connections, and imported contacts. I had to wait a while for a second link to download an archive of activity and account history.

Take a Virtual Vacation Before You Take a Real One

BY SOPHIA STUART

When you're preparing to drop a significant amount of cash on a lavish vacation, you expect your destination to have suitably high-end promotional materials, like 360-degree photos and videos that give you a taste of what's to come.

But what if you could really experience the place via virtual reality before you book? You know: Put on a head-mounted device, take a stroll around the upper deck of an ocean liner, peer into the State cabins, gaze out over the cityscape, and see exactly how many fluffy white towels are piled up next to the sumptuous tub.

It's unlikely that hotel chains will hire in-house VR dev teams to accomplish this, at least not in the short term. But they could buy a Matterport Pro 3D Camera and create a showcase to persuade high-end travelers to book now.

PC Magazine went to Silicon Valley to meet Matterport CEO Bill Brown and find out more. Brown joined Matterport from Motorola Mobility, where he was general manager of the Converged Consumer Solutions, responsible for

AROUND AND AROUND
The $4,500 Matterport Pro 3D Camera takes elaborate photos that are stitched into what CEO Bill Brown calls a "real 3D experience."

connected home, device management, and mobile video solutions. Brown was brought in to steer the company by cofounders Matt Bell and Dave Gausebeck, who had a passion to create true-to-life 3D experiences using the latest technology, but at a price that made sense.

The camera costs $4,500, which isn't exactly cheap, but it has clever innards. While it's engaged in visual capture, its 2D and 3D sensors are busy doing on-the-fly calculations to record all elements of a space, including objects, textures, and colors. The camera measures 9 by 10.25 by 4.38 inches (HWD), weighs 6.5 pounds, supports Bluetooth 4.0 and 802.11b/g/n Wi-Fi, and has a reported battery life of 8 to 10 hours.

Matterport also offers rendering services and cloud storage starting at $49 a

month for three free 3D models, 100 hosted models, and up to five users on the account.

This is not just stitching photos together, Brown said. "Matterport's algorithms and machine vision are essentially building a blueprint and inserting the visual imagery to build a real 3D experience, one that is dimensionally accurate, complete with geometry, which allows you to navigate through the space so it feels totally real."

Companies already signed up to Matterport's service include Momofuku in Washington D.C., which created a 3D walk-through of its private dining room for upscale events and the Starwood Group's Hotel St. Regis. The latter ordered a 3D rendering of the luxurious presidential suite at its resort in Mexico (at almost $5,000 per night, it attracts the sort of guest who likely wants a good look at the facilities before they book).

"Other companies who use our hardware and software include cruise lines, residential and commercial real estate firms, high-end hotel chains, and more," added Brown. "We even somehow have quite a nicely growing yacht business.

"We are fast replacing the current 2D photographic galleries which are used by hospitality and travel professionals with our 3D models," he continued. "The growth from 3D to VR all depends on how quickly VR headsets and mobile form factors get out there, but our 3D models easily convert to VR. As VR becomes more pervasive, we expect to see our customers converting their 3D models to VR."

Some treasured landmarks are recording sacred spaces using Matterport's technology. One of the temples in the ancient city of Bagan in Myanmar, dating from before the 13th century, is fascinating when viewed on screen, but something else entirely when experienced via an immersive VR setup.

Wearing a Samsung Gear VR, I tried a Matterport

The growth from 3D to VR all depends on how quickly VR headsets and mobile form factors get out there.
—Bill Brown

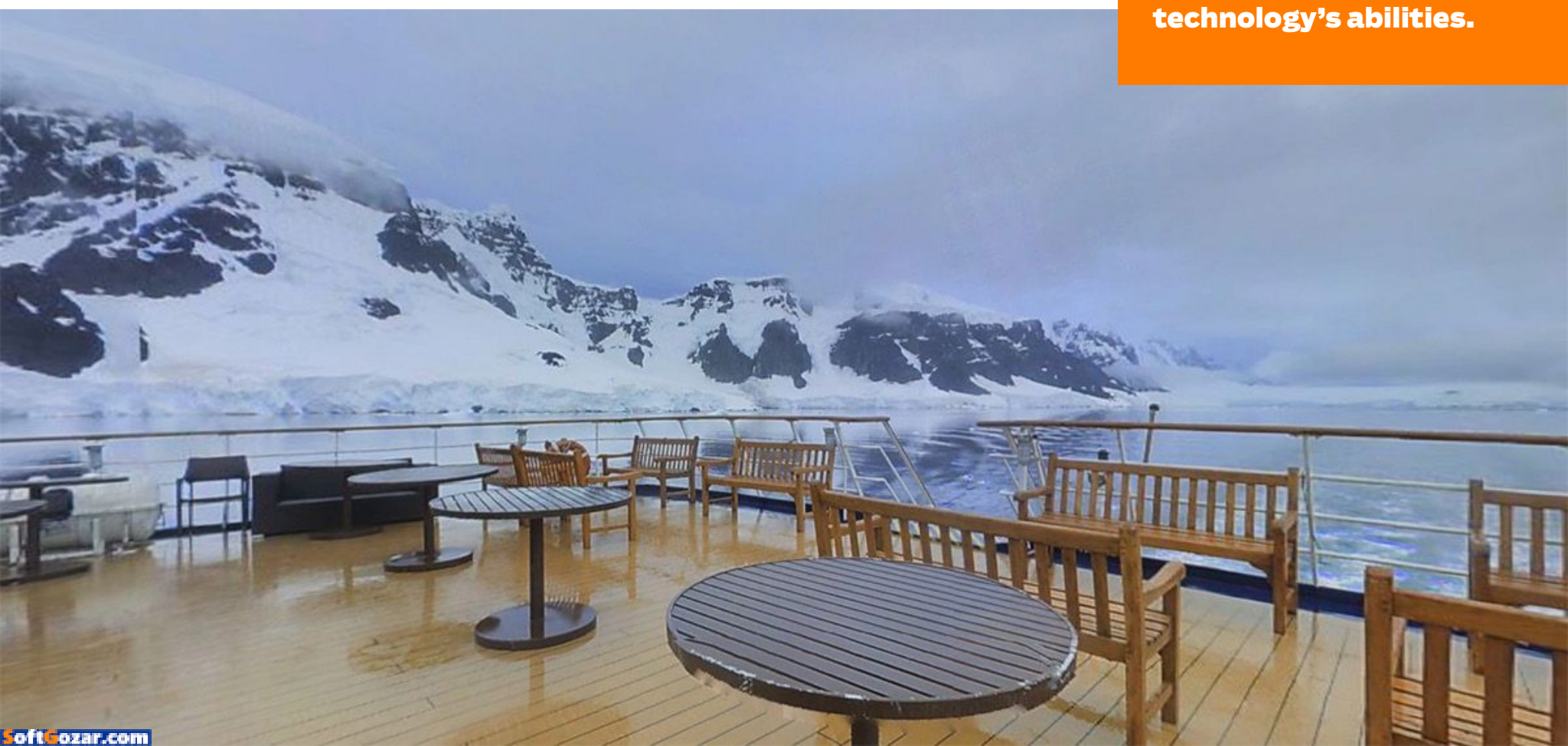
demo captured aboard a yacht sailing in Antarctica. It was incredible. You could almost taste the salt in the air as icy waves lapped the side of the boat. I did slam into a few portholes before I got the hang of navigation, I'll admit. But it sure beat reading a brochure online.

International markets are key for this technology. "The language barrier falls away when you can deliver the experience of being there," Brown pointed out.

At Matterport's new offices in Sunnyvale, California, Brown had a camera mounted on a tripod in the corner of a conference room and showed us how it works. It was simple: Move the tripod, capture, repeat. It automatically detects everything—even doors, windows, and oddly shaped room sets.

It's not just high-end photographers who will be using Matterport's gear. "It's just like the photography market today," explained Brown. "There are professionals who spend a fortune on equipment, buying high-quality D-SLRs because it's their job. They wouldn't show up with an iPhone to do big assignments. Those people, we believe, are the market for our full Matterport Pro 3D

ICE AND EASY
Headsets like the Samsung Gear VR (above) are used to display 3D demos like the Antarctica one (below) Matterport uses to showcase the extent of its technology's abilities.



Camera package. But there's also a regular consumer market."

Those who sign on for Matterport's services will have a new option: Mattertags.

"These will let users create spatial annotations within a model, anchored to a point in the 3D geometry of a Matterport Space," he said. They can be used to draw attention to special features within an environment, like five-star niceties in a hotel room.

So does the company think those of us on Instagram happily capturing sunrises and sunsets are going to migrate to immersive 3D?

"Definitely," said Brown. "As you start to get 3D sensors in mobile devices you'll see more OEMs incorporating Matterport technology, so all of us can transition from taking 2D pictures to generating true-to-life immersive captures, 3D spaces, of the world around us."

So if you were wondering what's next after Instagram, this is it.

"Leading companies are adopting it as a short-term advantage," Brown said. "But within a couple of years it's going to be table stakes, just to be in the game."

If you were wondering what's next after Instagram, this is it.

JOHN C. DVORAK

Good Assistants Are So Hard To Find

Microsoft held its fabulous annual Build Conference recently, and during it promoted the future of Cortana, pushing it as some sort of companion for anyone who spends life locked up in the basement.

In the future you'll have a lot of semi-imaginary friends: Siri, Alexa, Google, Cortana. You can be sure others will soon appear—if anyone really needs more.

I should find these gimmicks annoying and you should expect some seething rant from me. But no. These voice recognition and interactive modules are actually quite useful (although I could just as easily do without them; I can look up the weather without having to ask anyone or anything). Mostly, I just question their long-term reliability.

For example, I use the "Okay Google" module on my Android devices all the time. It's good for, among other things, searching specific terms, finding addresses, and writing short messages. These are not interactive chores. The interaction is something the module does on its own, but generally not in the form of a conversation. The "conversations" I get into with customer-service robots are along the lines of this: "Do you mean yes? Or no?" "Say yes or press 1."

A lot of people are going gaga over the Amazon Echo and talk about it incessantly, but it's still just a gizmo. If it took dictation and did it well, I'd be impressed. But it doesn't. It just plays music and reads from Wikipedia.

One of the problems I've had with these devices has to do with the environment. Siri, Google, and

Cortana cannot deal with serious street noise, for example. It's a joke to use these things while walking in Manhattan.

But let me get to the part that concerns me the most: people hacking into the things. This has not yet happened to any extreme, but it will when the more creative hackers out there discover the potential humor of the idea.

I can envision the Amazon Echo being programmed to randomly sing "Daisy Bell" (memorably crooned by HAL 9000 in *2001: A Space Odyssey*) or the classic "There's a Fungus Among Us." (Or, more amusing yet, if it returned a string of gross epithets when asked a question.)

And many people suspect that the crazy "Tay" chatbot Microsoft unleashed on Twitter in March produced all the vile tweets it did because it was hacked. Microsoft denies Tay was hit with malware, of course. But there is no alternative explanation. If it was an in-house hack, then it's possible that Cortana is the next target.

This is not the sort of thing any of these companies want to consider because the publicity would be terrible, especially if it entailed cussing at small children like a madman at a bus stop.

Hackers could also deliver purposely misleading answers to questions or wrong driving instructions. You can imagine. The possibilities are endless, and I can guarantee that they will happen sooner rather than later.

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