

BUILD

your own workstation

A step-by-step guide to designing and assembling your own workstation. It's easier than you may think but not for the faint of heart, says expert Lance Evans

The world's first computer kit was the famous Altair 8800, which is said to have launched the consumer computer revolution almost 40 years ago. It was followed by the Apple I kit a year later. Back then, if you wanted a computer you pretty much had to build it yourself. That quickly changed, however, and building your own workstation has largely been the preserve of hobbyists and those with a technical bent.

The main reason people build their own box is due to simple economics: it is generally much cheaper to build your own

computer. A carefully assembled build can deliver a box with specs that might cost up to twice as much from a branded vendor – and usually the built unit will contain better quality components as well. These components all come with their own warranty, so you are still well protected. And should something falter, like a drive or memory chip, you can pop it out, send it back and keep your workstation working.

The range and quality of computer you can put together yourself rivals what you can go out and purchase pre-built. But before you begin, you should be

aware that putting a sophisticated modern computer together for the first time can be daunting. We found many manuals obtuse, and despite all our pre-planning some parts were a challenging fit.

Let's start with the basics. A computer, no matter how cutting-edge, is pretty much made up of the following parts: motherboard, CPU, memory, hard drive, power supply and a case to hold it all together. Then there's the peripherals, like keyboard, mouse and monitor. And while many computers no longer include them, optical disks are still very useful, especially for a build. »



ARTIST PROFILE

Lance Evans

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CHOOSING THE CORRECT COMPONENTS

Pick the exact parts you need to give you the performance you want

When you sit down to choose the actual components that will go into your electronic offspring, it can be overwhelming. Taking a logical, step-by-step approach will help you to narrow things down a bit. Reading reviews online is a great

way to discover specific components, and get a feel of what might best suit your particular build.

But take heart in the fact that no matter what components you choose, real clunkers are few and far between these days. We got to work with some of the best manufacturers out there, and the components were a real pleasure. Here is some of the thinking that went into our computer design process, and why we chose the items that we did.

PRE-MADE VERSUS DIY

We love the specs and design of the system we ended up with, but when we add up all the items on our build list (omitting peripherals) it comes in \$945 / £581 over budget, at \$3,945 / £2,438. But the unit costs \$3,350 / £2,068 when we only count items

that are comparable to a pre-built box. And if we went with the lower priced CPU, it would cost \$2,950 / £1,823.

The question is what would it cost to get those same specs in the pre-made market? At www.dell.com we could customise a box from its Precision line to approximate our build. It would have a slightly slower six-core Xeon chip, and a smaller 3TB HD that runs a bit faster. The resulting quote for this box is over \$6,300 / £3,895, but it did include an instant \$1,500 / £930 discount – to bring it in at about \$4,800 / £2,970. That's still \$1,850 / £1,147 more than what we paid for our parts. A similar build from Boxx's website came in at over \$6,300 / £3,895 as well, but without any discount – so the Boxx unit is almost twice the cost of our build.

START WITH A FIXED BUDGET

1

We wanted a kicking computer, but not one that would prevent us from paying the mortgage. So our goal was to keep this build to about \$3,000 / £1,850. Granted, that isn't a cheap computer, but at this price point we are hoping to assemble a workstation that is very powerful, very versatile, and with specs that match much more expensive retail builds. We also wanted one that was suited to a creative content developer.

CHOOSE YOUR PLATFORM: MAC, LINUX OR WINDOWS?

2



Although there are ways to make Mac clones they are not without their technical issues, so we decide to stick with Windows for our box.

Price: Window 8 Pro **\$200 / £124** Linux **Free**



Windows 8

3

WHICH CPU SHOULD YOU OPT FOR?

In the past, I've always built with AMD chips, but at the time of writing Intel seemed to be ahead in the speed game. If we'd had a slightly tighter budget, an AMD chip might have won the toss. With multicore chips, we need to look at both the number of cores, and the speed of them. We are lucky in 3D, as most of our software takes advantage of those cores. But that may only be at the rendering stage – a lot of our day-to-day work gets done using just one core, so raw speed is still important, even with many cores.

“You could opt for a more affordable quad-core system, but it might not give as much room to grow as new CPUs come out”

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BASE YOUR CHOICE OF CHIP ON CPU SPEED TESTS AND THE PRICE

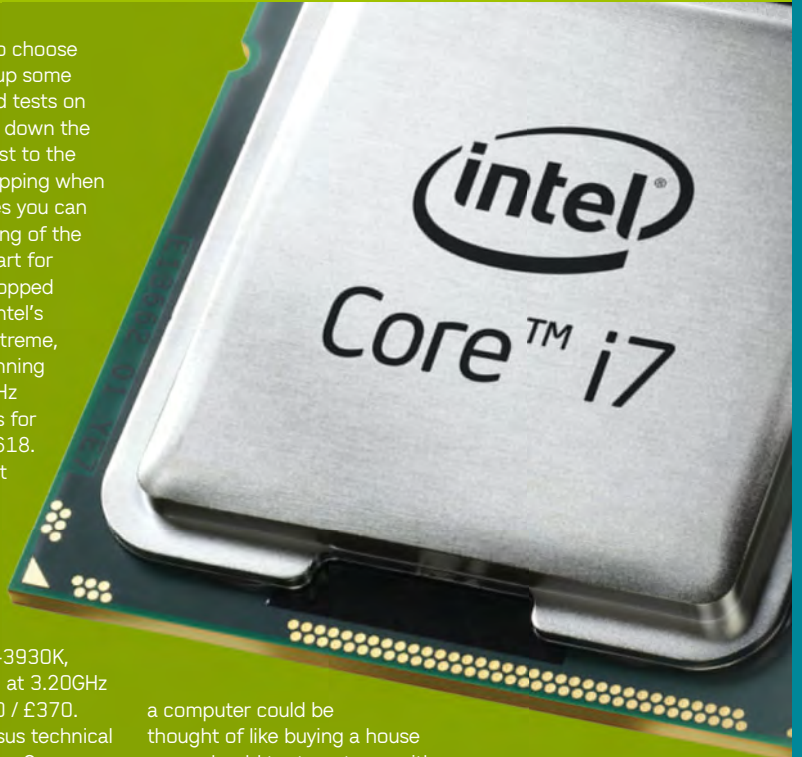
The easiest way to choose a chip is to bring up some reliable CPU speed tests on the web and scan down the list from the fastest to the slowest chips, stopping when you reach the ones you can afford. Our scanning of the PassMark CPU chart for high-end chips stopped when we got to Intel's Core i7-3970X Extreme, a six-core chip running at 3.50GHz (4.0GHz in Turbo) that sells for about \$1,000 / £618. The few chips that were faster were much more expensive. Going further down the list, the first significant price saving was the i7-3930K, a six-core running at 3.20GHz that sells for \$600 / £370.

According to Asus technical representative Juan Guerrero, other than going down the Xeon server/workstation route, Intel's Core i7-3970X Extreme is today's go-to chip for the high-end content creator. But Juan understands that not everyone can justify spending that much on a chip, and suggested that designing

a computer could be thought of like buying a house – you should try to get one with room to grow. While you could opt for a more affordable quad-core system, it might not give as much room to grow as new CPUs come out. Juan's suggestion is to buy the less expensive i7-3930K six-core chip now, and upgrade to the Core i7-3970X Extreme (or whatever

replaces it) next year. You should note though, that the Core i7-3970X Extreme is a very power-hungry chip that runs at 150 Watts. This will cost more to run, and be more challenging for the cooling system we have to design.

Price: **\$1,000 / £620**



WHICH MOTHERBOARD SHOULD YOU CHOOSE?

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Now that we know what chip we want, we need a motherboard (MB) that supports its LGA 2011 socket. Still working with the Asus representative, Juan showed us MBs that his company designed to work best for content creation tasks. His pick was the new P9X79-E WS, because it was designed from the ground up with people like us in mind.

The list of features is impressive: eight memory slots (up to a maximum of 64GB), 12 SATA connections (eight at 6GB/sec, four at 3GB/sec), enhanced graphics capabilities that include 4-Way GeForce SLI and CrossFireX for running multiple GPUs, dual server-grade gigabit LAN/Ethernet (great for heavy sharing of content), seven PCI Express 3.0 x16 slots, enhanced overclocking controls, SSD cache for data speed boosts, and enhanced audio quality/processing. The fan-less design is silent, which is important if you do sound recording.



At just under \$500, this board isn't cheap. If we were on a tighter budget we could certainly find cheaper units that would do the job. But few offer this combination of expandability and cutting-edge technologies, so we opted for this.

Price: **\$500 / £310**

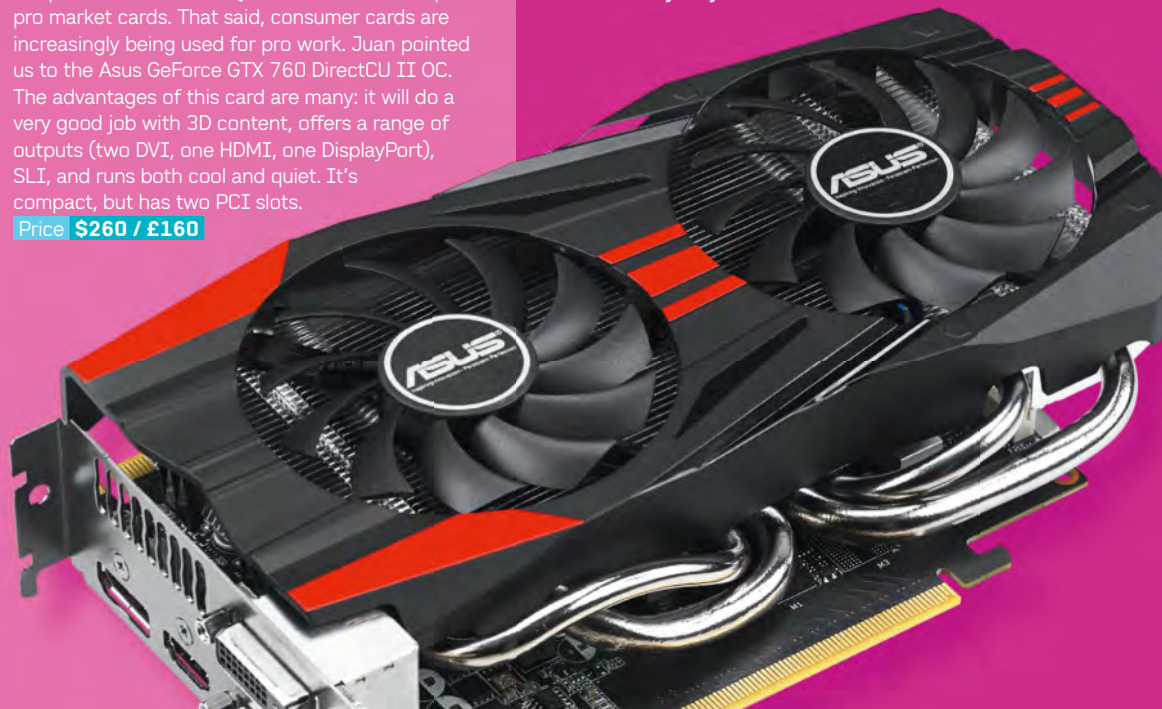
WHAT VIDEO CARD/GPU SHOULD YOU CHOOSE?

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The GPU market is generally divided into two segments: the consumer and/or gamer market, and the pro market. Nvidia's Quadro line is an example of pro market cards. That said, consumer cards are increasingly being used for pro work. Juan pointed us to the Asus GeForce GTX 760 DirectCU II OC. The advantages of this card are many: it will do a very good job with 3D content, offers a range of outputs (two DVI, one HDMI, one DisplayPort), SLI, and runs both cool and quiet. It's compact, but has two PCI slots.

Price: **\$260 / £160**

▼ Choosing to use a consumer card is a viable way to save money on your build



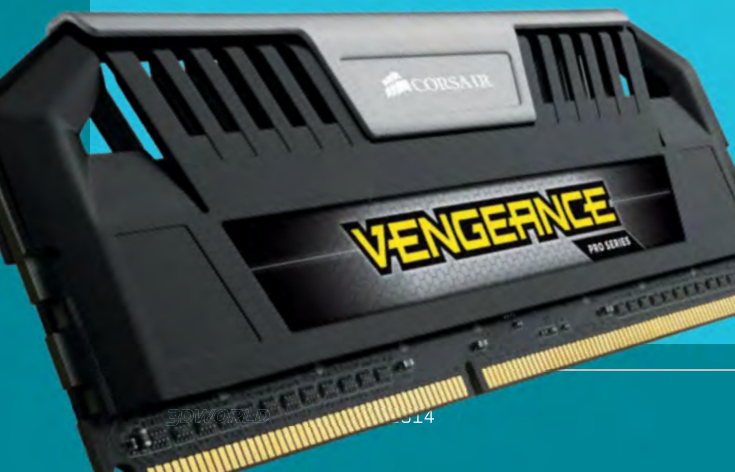
"[The Obsidian Series 550D] was designed from the ground up with cooling and noise reduction in mind"

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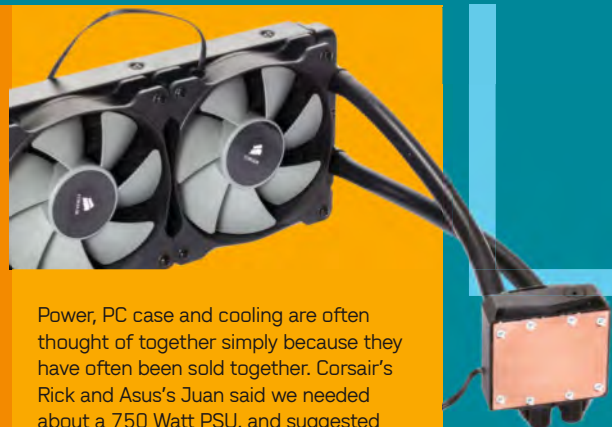
WHAT RAM WILL WORK BEST WITH THE MOTHERBOARD YOU'VE CHOSEN?

Memory manufacturer Corsair is qualified to work with Asus MBs. Corsair's Rick Allen explained that each core in the CPU needs discreet RAM to do its work. He suggested at least 4GB per core; we rounded up to 32GB of memory. We got four 8GB DDR3 modules from the Vengeance Pro Series.

Price: **\$400 / £245**



WHAT POWER, CASE AND COOLING SYSTEM IS BEST?



Power, PC case and cooling are often thought of together simply because they have often been sold together. Corsair's Rick and Asus's Juan said we needed about a 750 Watt PSU, and suggested Corsair's fully modular AV860, which gives us plenty of juice at 860 Watts. The AV860 also contains technology that offers unusually quiet operation.

Price: **\$230 / £140**

For a case, Rick suggested the Obsidian Series 550D, a large mid-tower case standing 19in tall. This is a case that was designed from the ground up with cooling and noise reduction in mind. The basics include six hard-drive bays with integrated 2.5in SSD support, all with tool-free trays and noise-reduction silicon mounts; four optical drive bays with removable trays, front panel USB 3.0 and audio connections, three 120mm fans with room to add more, and room for additional cooling systems. The case is lined with sound-dampening material.

Price: **\$150 / £92**

We chose Corsair's Hydro Series H100i water cooler. This will help a powerful CPU run cooler, standard or overclocked.

Price: **\$110 / £68**

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WHAT HARD DRIVE, SSD AND OPTICAL DRIVE SHOULD YOU GET?

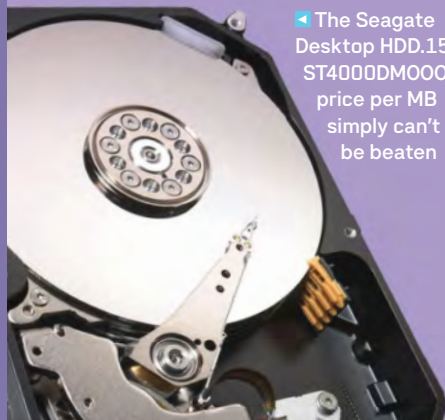
There's no limit to what drives you can add to a system, and today the hot choice is a solid state drive (SSD). Something of a hybrid between RAM and a traditional hard drive, SSDs are really fast and can significantly reduce hard drive access times. Booting into Windows from an SSD boot disk is super-fast, as is running programs and file-management chores. We took a conservative approach by using separate drives for different uses: a 256GB drive as our main OS drive, and another two at about the same size intended for active work-in-progress storage, or perhaps one for active storage and the other for use as a program cache drive. However, with 32GB of RAM, we're not sure how much a cache drive is going to be needed.

We tried out three of today's top-rated drives: Samsung 840 Pro (\$240 / £150), OCZ Vector (\$260 / £160), and SanDisk Extreme II (\$230 / £142). Our real-world tests were impressive, but we won't walk away from traditional HDs just yet. Seagate's Desktop HDD.15 ST4000DM000, a 4TB drive with 64MB cache SATA 6.0GB/s internal unit, proved a good option at this price.

Price \$170 / £104

With optical drive prices plummeting, we went first class and opted for the Asus BW-14D1XT.

Price \$100 / £61



◀ The Seagate Desktop HDD.15 ST4000DM000's price per MB simply can't be beaten

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WHAT AUDIO CARD SHOULD YOU INVEST IN?

Our Asus motherboard sports some nice enhanced audio, but as we are primarily creative content producers, a specialised card seems in order. We went with Creative Lab's Blaster Z card, model SB1500.

Price \$95 / £58



"There's no limit to what drives you can add to a system, and today the hot choices are solid state drives"

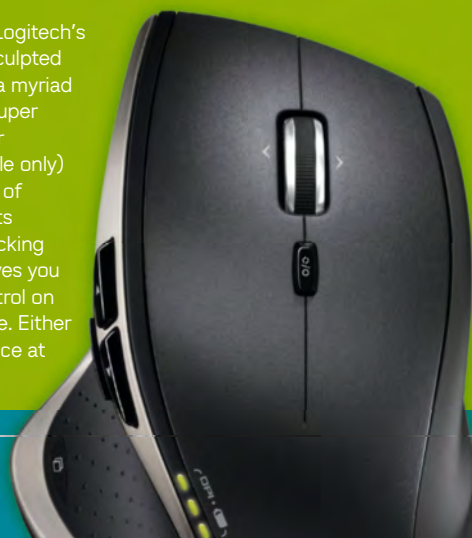
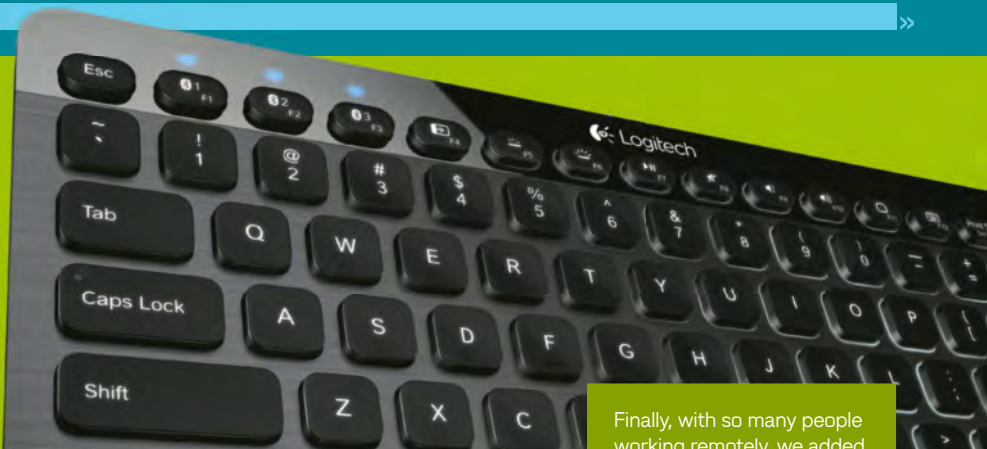
WHAT OPTIONAL ACCESSORIES SHOULD YOU CHOOSE?

To round out the build we went to Logitech. Its ultra-cool illuminated wireless (via Bluetooth, so we needed a desktop adapter) K810 keyboard is very stylish. While it seemed small at first because it lacks a keypad, it actually fitted extremely well on our desk, which is jammed with graphic tablets and other gadgets.

We also looked at Logitech's Performance MX sculpted mouse, which has a myriad of controls and a super ergonomic grip (for right-handed people only) that ensures hours of comfortable use. Its Darkfield Laser Tracking technology also gives you precise cursor control on virtually any surface. Either item is a great choice at about \$100 / £60.

◀ Logitech's Performance mouse MX has a sculpted shape which cradles your (right) hand

Finally, with so many people working remotely, we added Logitech's 930 wireless headset for Skype-type computer calls (\$105 / £65), and the C920 high-definition Pro webcam, which connects using USB 2 or 3, for \$90 / £55.



TIME TO PUT IT TOGETHER

Before you begin to assemble your new workstation, read these pointers...

HAVE ENOUGH TIME TO TINKER

Putting unfamiliar components together, often with unclear instructions, isn't a fast process. Ensure you have time to confirm any questions on the web or with the manufacturer.

GETTING STARTED

Work in a well-lit, clean environment, with ample non-metal tabletop space to lay things out. A small flashlight might be needed to see inside the case. An average-sized Phillips head screwdriver was the only tool we needed, but this can vary. Also, having an old-fashioned PS/2 keyboard and wired mouse is often needed.

GOOD WORK HABITS

Keep your hands off contacts and other exposed electronic parts, like on the motherboard or underside of the hard drive. Wear a grounding strap to avoid passing a static charge to the parts. Wear rubber-soled shoes and try not to work over a carpet. Having said all that, the odds of you zapping and damaging components are very low.

READ THE MANUALS

Please keep in mind that the following build guide is not meant to replace the manuals that come with the components. It is also not meant to cover each detail of assembly – it is just meant to give you the basic understanding of the steps and a first-hand look at how easy it can be, as well as things to look out for in your journey.



▲ Carefully unpack the case and open it up to start to assemble your DIY workstation

1 START WITH THE CASE

Unpack the case and open it up on your worktable. Take note of the sound-insulated cabinet and venting options. The PSU goes at the bottom, leaving plenty of room for the motherboard above. In this instance, the case only came with a quick-start manual.

2 OPEN THE MOTHERBOARD

The manual that came with the motherboard is extensive and helpful. It also comes with a large number of extra parts, not all of which we will use in this build. Next, lay the case down and place the MB inside to see how things fit. I did this and at the time it seemed perfect, but read on. Remove the MB and clear some space to work on it.

▼ Open the motherboard and familiarise yourself with the layout



⊕ On the left is the unpacked CPU socket. You can open it by swinging open both left and right levers, and then the cover, to expose the CPU socket's very delicate array of contacts.

3 TAKING CARE WITH THE CPU

Open the CPU socket using the levers. Unpack the CPU and check for damage. Keeping your fingers on the edges, place it into the socket. Ensure the CPU is oriented so the corner arrow/triangle is aligned with the same icon on the socket. Put the cover back and swing the levers back. The cover will now pop off in this socket, leaving the chip exposed.



⊕ There is no absolute right or wrong order to do these steps. I wanted to install the Corsair H100i liquid cooling system for the CPU next, which only requires basic assembly.

4 PREP THE CASE

Next install the Corsair H100i liquid cooling system for the CPU. First screw the two fans to the underside of the radiator. After removing the case's top vent panel, screw the fan/radiator to that vent. Connecting the water pump/heat sink on the other end to the CPU will have to wait until the MB is installed. Put a rubber band around the pump's plastic cover to prevent it from falling off. Then install the power supply into the bottom of the case. Note that most mounts have noise/vibration reduction padding, so tighten but don't overdo it or you'll lose some of its benefits. Finally, snap the MB's rear faceplate into the rear of the case.



5 POP IN THE DISK DRIVES

Slip the Asus optical drive into the form of the case and then screw down to the chassis from the sides. Then centre the three SSD drives and screw them down to their removable drive bay holders. The Seagate HD snaps into its tool-free drive bay holder. Then attach each drive to its own SATA cable; this will be connected to the MB later. Finally, attach each drive to a power cable.

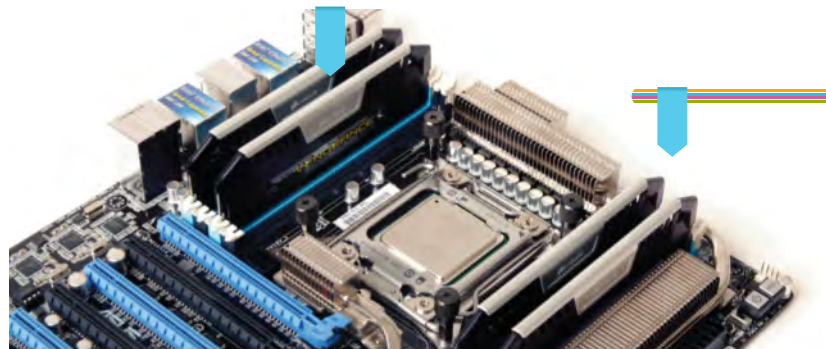


Putting many drives into the case involves a lot of movement around the case, so it's safer and easier to do it before the MB is put in place.



8 MOUNTING THE MB

When mounting the MB in the case, work with the case on its side. Make sure the board is not touching the back metal wall. This is usually done using stand-offs, but the Obsidian 550 has stand-offs built in. Align the board with all the screw holes, and also make sure all the rear ports are in alignment, and then screw it down using most or all of the screw holes. Don't overtighten the casing.



6 ADDING THE MEMORY

Go back to the MB to install the four modules of Corsair Vengeance Pro memory. Use the MB's manual to follow the proper configurations. Here, the four sticks needed to be installed in alternating slots. Look at the connectors and align any notches properly.

"I wanted to be sure this was a safe configuration, so I contacted Asus who assured me it was. Always check..."



7 PLACING THE MOTHERBOARD

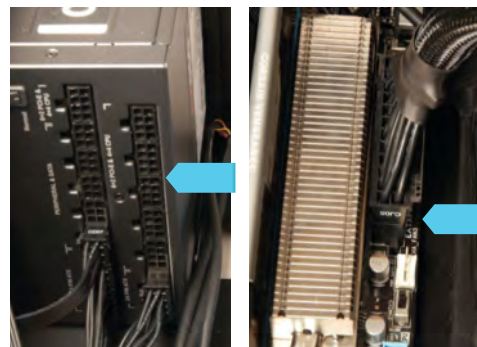
When it came time to put the MB in the case, I hit a snag: it wasn't fitting with the H100i cooler in place. I soon realised that if I removed the cooler and put the MB in first, the unit could then be put back in place. To fit, the plastic fan needed to butt against a silver heat dispersion unit on the MB. I wanted to be sure this was a safe configuration, so I contacted Asus who assured me it was. Always check – you don't want a dangerous computer.

9 CPU/COOLER CONNECTIONS

Next, connect the cooler to the CPU. After cleaning the CPU, put the mounting bracket over the head unit, carefully align it over the CPU without touching it, and go straight down for a firm contact. Place the corner thumb-screws on and tighten them by hand, then give an extra twist with a screwdriver. Then the cooler needs to have various power and controller connections made all over.



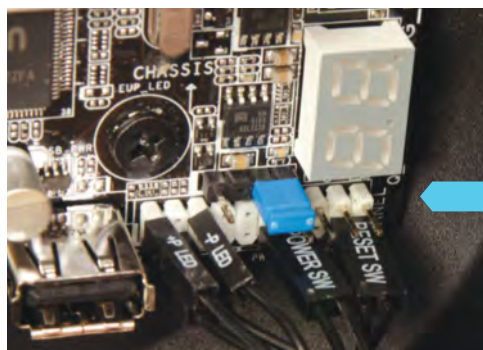
Now we can connect the Corsair H100i Cooler's water pump head to the CPU. Use a lint-free cloth and some isopropyl alcohol to clean the surface of the CPU, so it will be in perfect contact with the pump head's thermal part. Anything over 70 per cent should do you just fine.



10 POWER CONNECTIONS

There are three power connections between the MB and the PSU. One in the main ATX 24-pin connector, that connects to the large plug along the right side of the MB (right), and then splits into two plugs to connect on the PSU side (left). Another (not shown) is the ATX 12V that attaches to the MB on the left of the memory sticks. This is hard to reach once the MB is in place and should be connected prior to mounting.





11 OTHER CONNECTIONS

In the photo we see a row of front panel connections for the case. It wasn't until later that I realised there was an adapter block included with the MB that made these fiddly connections easier, but I left it as is. There was also a USB 3.0 plug that came from the case front panel, which received preference over one on an expansion port in back, and the audio connection's upfront too.



12 SATA/MB CONNECTIONS

Finally, I was ready to connect all the drive's SATA cables to the MB and was stunned to find the lower row of SATA outlets (those closest to the MB) were blocked by a recess in the case designed to hold the MB. The upper outlet of each stack was accessible and allowed me to install all five drives in my build, with one to spare. But this was still a problem and I consulted Asus and Corsair. The upshot: The MB appears to be "larger than the standard ATX board, perhaps an EATX". It appears I should have gone with a larger case. If I want to use those extra SATA connections, I will need to swap cases or cut an opening to allow access.

The motherboard sits slightly sunken, blocking the lower six of 12 SATA outlets. The upper outlet of each stack was accessible and allowed me to install five drives in my build, with one spare.

13 ADDING EXPANSION CARDS

Now it's time for the expansion PCI-e cards to go in. I only had two: the Asus GeForce GTX 760/DirectCU II OC went in first, and I placed it in the uppermost slot. Remember it's double-wide taking the space of two slots even though it only plugs into one. It also needs additional power connections. I skipped one slot to leave room for the video card fan's exhaust to work unencumbered. The Creative Labs' Blaster Z card went into the third PCI-e slot.



The Asus card is double the width of other cards, so takes up two slots even though it plugs into one

BOOTING AND TESTING

Tailoring this box resulted in high performance with virtually no noise



OpenGL	Details
1. 6C/12T @ 3.51 GHz, GeForce GTX 760/PCIe	86.90
2. 4C/8T @ 2.79 GHz, Quadro K4000/PCIe/S	67.71
3. 4C/8T @ 4.40 GHz, Quadro 4000/PCIe/SSE	65.33
4. 6C/12T @ 3.30 GHz, GeForce GTX 460/PCIe	59.86
5. 12C/24T @ 2.66 GHz, ATI Radeon HD 5770	57.08
6. 4C/8T @ 2.60 GHz, NVIDIA GeForce GT 6500	52.75
7. 4C/8T @ 3.40 GHz, GeForce GT 620/PCIe/S	19.04
8. 2C/4T @ 1.70 GHz, Intel(R) HD Graphics 4000	9.00

Cinebench is a real-world cross-platform test suite that evaluates your computer's performance capabilities

The test procedure consists of two main components – the graphics card performance test and the CPU performance test

While there are some leftover parts for many things we are not implementing right now... we are done. Time to turn it on and pray we didn't muck things up. Take heart that most of the time things go smoothly, as it did here.

I plugged in the PS/2 keyboard and wired mouse, connected the monitor, and pushed the power switch. I heard the whir of the fans start up, but then go virtually silent; I thought something was wrong, but then realised that this was the quietest computer I've ever heard.

"Take heart that most of the time things go smoothly, as it did here"

I went into the MB's BIOS settings to set the optical drive as the boot, and to fix some CPU fan error messages that occurred because I wasn't actually using a CPU fan. I put in the Windows 8 disk and rebooted, bringing up the Windows 8 installer application. I encountered other issues, like Windows saying it couldn't be installed on any of my hard drives (magnetic or SSD). After exhausting my options I simply unplugged all drives but the one I wanted to put Windows on,

and disregarded the warnings. Windows installed without a problem. I rebooted, changed the boot drive in the BIOS, and booted into the C drive. Putting the Asus disk into the optical drive, I installed all the MB drivers and went from there. It is helpful to have another computer at the same location connected to the internet, so you can use it to download the latest drivers and software, and search for answers to problems.

This was not a hassle-free build: there were issues, but that's to be expected. While I have built a few boxes in my life, and hacked away at many a Frankenstein-style upgrade, I make no claims to being a computer tech guru. I feel my way a few feet at a time and scratch my head trying to solve some of the hardware sand traps. If you are like me, you may find building your own box fun too. ■