Building a photography workstation

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Digital photography is extremely demanding in computer resources, especially for RAW shooters. A run-of-the-mill home computer will very easily be overwhelmed by the processing power requirements of RAW conversion and the sheer masses of data that make up a RAW image library. Losing your photos because of a computer failure is a real tragedy. Any serious digital photographer should take their digital darkroom at least as seriously as their lenses -- and much more seriously than mere camera bodies. The only way to get the kind of digital darkroom that exactly fits your needs and budget is to build it yourself -- but even though things have gotten much easier over the past few years, box-building isn't for everyone. It takes time, patience, problem-solving, and research, and it's only "worth it" if you actually enjoy doing it. Much like photography itself.

So suppose you've just dropped a grand or two on some new computer components. Suppose you've just assembled them. Suppose you switch on the power. And suppose nothing happens. How do you react?

If your reaction is to march right back to the store that sold you that heap of junk and give them a piece of your mind, building a computer isn't for you. Buy one from Apple [http://www.apple.com/] instead, or if you absolutely have to have a Windows box, from Dell [http://www.dell.com/] or some other huge brand that allows you to customize what you want. In the latter case, you might want to read the first couple of paragraphs in this article -- they describe what I believe a solid photo workstation should look like, and this information will stand you in good stead.

> I am not and do not claim to be an expert system builder. I have built about a half-dozen boxes for myself, friends, and family, and I do try to be conscientious about my research. I also deal with different kinds of computers in my day job a quite a lot. I'm also a severe gearhead, which is a major asset when dealing with something as geeky as computer building. So take this article for what it's worth: the personal perspective of a box-builder who's just past the "complete newbie" stage.

On the other hand, if your reaction is to sigh deeply, take it all apart again, read through all the instructions carefully, connect up the components again one by one, and find out exactly where it went wrong, go for it. You'll very likely spend a few days working on your system, but you will end up with something that runs faster, cooler, quieter, and more stable than anything you're likely to get from a store -- and you'll be able to make it fit your needs and budget *exactly*. You will learn a great deal about what makes a computer tick in the process, and you will have gotten your system for considerably less money too: say, 25 per cent less than a comparatively-specced machine from a major vendor, and you'll be using better components in the places where the major vendors usually cut a few corners. In use, it will be less trouble to maintain, and if something does go wrong, you'll be able to fix it yourself. But don't kid yourself -- even with today's jumper-free configuration and plug-and-play components, putting together a computer is not something even the mildly technophobic should undertake.

> An alternative to building your own is speccing your own with a small-scale "box builder," and having them build and install it for you. However, in my opinion this is not a great idea: they will very likely not be able to resolve all the potential glitches in it, and you'll end up with something that's just a little bit wobbly -- without the skills needed to make it stable again. So my advice is either to buy a "package deal" from a major vendor and get the pretty inexpensive on-site support plan for it, since it will have been pre-configured and tested to run pretty much without trouble, or else go the whole hog and do it all by yourself.

What is a good photography workstation?

To work effectively with photos, you need *storage space* to put them, *processing power* to do stuff to them, *display fidelity* to see what you're doing, and *a backup system* to make sure that you won't lose them due to an equipment failure -- or the perennial favorite, human error. In other words, you need a big disk, lots of RAM, as powerful a CPU as you can afford, and a display that's better than run-of-the-mill.

Main storage

Hard disks are cheap, and they're only getting cheaper. (Or, to be precise, they're getting bigger -- a "standard" hard disk has cost about a hundred euros/dollars for a while now, but the size has gone up from 40 to 80 to 160 to 250 GB at this writing -- and there's no end in sight.) What's more, RAID controllers are no longer exotica. This means that it'll only cost you about a hundred euros more to have an effective insurance against hard disk failure. Therefore, unless you have some other backup system in place that "just works" without you having to think about it, your main storage solution should consist of one or more RAID groups of two mirrored disks. Of course, this won't absolve you from making periodic backups somewhere else -- a RAID pair will only save your data from a hard disk failure, which is not the only nor even the most common cause of data loss.

> Why not a RAID 5 triplet? Because in my opinion it's not worth it. If you screw up configuring or otherwise messing with your RAID 1 pair or if your motherboard croaks, you can just plug in one of them into your regular controller (or even another computer), and your files will all be there, intact. But if you screw up a RAID 5 triplet or your controller configurations so badly that the controller can't rebuild it, you're in much more trouble. RAID 5 is great for server solutions that you set up once and leave running until Doomsday, but more trouble and risk than it's worth on a desktop system that you keep installing new stuff on and otherwise messing with.

If you want to, you can delve into the details of what disk to get (see, for example, Storage Review [http://www.storagereview.com/]) -- but from a reliability and speed point of view, all the major vendors are about the same. However, before you buy, do find out how noisy the disks you're looking at are -- if you have your box under your desk, disk noise is an annoying distraction you'll want to minimize. At this writing, Samsung SpinPoints and Seagate Barracudas [http://www.storagereview.com/articles/200601/250_7.html] are the quietest.

Another question is, "how much is enough?" The answer is "about double what you have now." If your picture library is 100GB, you need about another 100 GB of free space. Don't buy more, because by the time you've filled up your second 100 GB, you can get 500 GB or a terabyte for the cost of 250 GB now. So buy enough storage to keep you breathing freely, but don't go for wild overkill.

Separate system disk

No matter what you use for main storage, it's a very good idea to get a separate, non-RAID drive for your system disk. There are a number of good reasons for this:

1. **It'll improve performance.** Having your programs on one disk and your files on another will make it easier for, for example, Photoshop to shunt data from its own files, the files you're working on, and its swap file. You can do a few very simple tweaks to further improve this behaviour. Moreover, if your system disk is small and chosen for its short seek times, your computer will boot up faster and your big programs will load faster.

2. **It'll improve security.** There's a lot more activity on the system disk than on the data disk. This means that any failure is more likely on the system disk. If your data is on a separate physical volume, it'll be safer both from physical drive failure and from the far more common problems caused by disk data getting grabled.

3. **It's easier.** It's more hassle to make a bootable RAID array than just a plain ol' disk to boot off.

4. **A RAID array won't even help much.** Sure, if you have a mirrored array for your system disk, you'll be able to continue working if one of your disks go pop. However, this is purely a matter of convenience for a fairy rare eventuality, since you won't have any data on your system disk that you won't be able to reconstruct. (Right?) A striped RAID array will improve transfer speeds, but this will actually impact performance less than you'd think, since most programs consist of a large number of small files rather than a small number of large ones. On the other hand, it will double the chance of failure, since once one drive goes, the array goes.

Therefore, my advice is to get a separate disk for your system. If you're on a budget, get a small, cheap drive from the same folks who made your main disk. If you have a bit more room to play with, get a disk especially made for short access times: at this writing, the undisputed king of the S-ATA/IDE access time hill is the 10,000 rpm Western Digital Raptor, [http://www.tomshardware.com/2006/02/06/wd1500ad_raptor_xtends_performance_lead/page9.html] which comes in 36.5, 74, and 150 GB denominations. Paying the same money for a 36 GB disk that would otherwise get you a 250 GB one may seem like a lot -- but remember that you won't actually need more than 36 GB for your system and programs. (Right?)

Finally, memorize the following mantra:

> **Disks are expendable. Data is precious.**

That means that if you have a disk that's acting wonky (making odd noises, making odd noises after you reformat it, directories or files being listed as "permission denied" and so on), *format it, then throw it away.* Or if you can find some use for it that's won't put any important data on it (print spooler?) use it for that. It's just not worth the risk or the trouble to put your precious data -- or even data that isn't precious per se as merely annoying to have to reconstruct -- on disks that may be about to fail. The hundred bucks that a replacement disk costs is a small price to pay for peace of mind. Do be aware, however, that it's far more common for disks to get garbled than physically broken -- if you have a series of system crashes and your disk starts acting off, reformat it and restore data from a backup. If you notice nothing odd in that process, it's almost certainly safe to reuse.

> I picked a Western Digital Raptor 74 GB for my system drive, and a pair of Samsung Spin Point P120 250GB's for main storage.

Processor and memory

On a photo workstation, processing power means basically two things: a faster-than-average processor and enough RAM for it to breathe freely. At this writing, 2 GB seems about right. As to the processor, it's pretty simple: find the list of processors from the big two, look at the prices, and see where it starts to go up exponentially. Then buy the last one before that point... or the one before that.

Oh, single-core or multi-core? For this application, it's a no-brainer -- multi-core every time. While most applications won't work any faster on two processors than one, this isn't true for most power-hungry photoediting programs: multiprocessor workstations have been the norm in professional image processing for years, which means that the likes of Photoshop and Raw Shooter will be able to exploit the power of a dual-core system to the full. What's more, the nature of working with photos means using multiple applications in parallel, which is another thing that a dual-CPU system does well. So while at any given price point a dual-core will lag behind a single-core in most games (although it's hard to find a game that's so CPU-intensive that even a low-end dual-core coupled to a powerful GPU couldn't blaze through them), it will blaze past it in photoediting applications -- and run cooler, quieter, and with less power consumption.

As to the choice of memory, it really doesn't matter as long as it's compatible with your motherboard and CPU, and doesn't come from a completely fly-by-night vendor. The difference between cheap RAM and expensive RAM is that you can overclock and tweak the timings of expensive RAM more, and squeeze a little more speed out of your system -- but if you want to get into overclocking, you're reading the wrong

article; I'll pick stability and value over an extra 10-15% in performance every time.

My processor is an AMD Athlon 64 3800+ X2, and my memory is a pair of 1GB DDR400's from Buffalo.

Display fidelity

Glass CRT's are on the way out. Unfortunately, LCD's still haven't quite caught up to them when it comes to color fidelity and viewing angles. The best are good enough for color work, especially if you make sure you work with them face-on (moving your head will shift color and gamma visibly even on pretty good displays), but not quite as good as CRT's. So, if you have room to spare, get a big enough Trinitron or Diamondtron CRT and you're all set. If not, get a *good* LCD -- most of the ones from Eizo are excellent for color work, and the better ones from Viewsonic, for example, are quite good too.

My pick was the Viewsonic 930P. It's not perfect, but it's good enough.

Speccing or building?

If you're just speccing your own and ordering it from a major vendor, this is about all you need to know. However, if you want to *build* it, read on...

Box Building 101

Before you read any further, get one thing into your head: this article is *not* a definitive resource for box building. Be prepared to do a fair bit of research as you go. Personally, I've found the following sites invaluable:

- Tom's Hardware Guide [http://www.tomshardware.com/] (just about everything when it comes to components)
- AnandTech [http://www.anandtech.com/] (another very broad and comprehensive review site)
- Storage Review [http://www.storagereview.com/] (all about hard disks, RAID arrays, controllers, and so on)
- Extreme Tech [http://www.extremetech.com/] (box building in general, computer cases in particular)
- Silent PC Review [http://www.silentpcreview.com/] (how to make something powerful that won't sound like a vacuum cleaner)

So, now that we've got that out of the way, on with Box Building 101.

Components

A build-your-own computer consists of the following components:

- **The case.** More than just a box to keep the rest in, it determines to a great extent how the computer will sound, how easy it will be to assemble and maintain, how expandable it is, and of course how it will look. A good case is worth every penny -- and they're not even that expensive. Your default choice should be the biggest tower you can easily fit where you intend to put it: they're roomy enough to work in easily and expand to fit your needs, and have better thermal and noise characteristics than more compact designs. I like cases from Antec; my workstation is built in a P180, [http://www.antec.com/ec/productDetails.php?ProdID=09180] while my home server is in a Sonata: [http://www.antec.com/ec/productDetails.php?ProdID=08138] they're well-built, very quiet, stylish in a low-key kind of way, and generally nice to work with. Their only real downside I've come across is

that they have no handles for easy carrying. See the above sites for lots of articles on cases, and before you spring for a P180, make sure your power supply has cables long enough to work in it: I had no trouble with the 500W Seasonic S12 [http://www.silentpcreview.com/article247-page1.html] I picked, even though the 12V ATX connector was only barely long enough -- an inch less and there would have been a problem.

- **The power supply.** The box that supplies power to your computer. It's often bundled with the case. It affects the stability, extensibility, power consumption, heat generation, and noise of your computer. Do not cheap out on the power supply. I picked a Seasonic S12 500W [http://www.silentpcreview.com/article247-page1.html] for my box, largely on Silent PC Review's recommendation. I hear the guy who hosts Silent PC Review contributed to the P180 design, so I figured his choice of PSU was bound to work, as indeed it did.

- **The motherboard.** The circuit board onto which all the other components connect. It determines what kind of processor you can use, what features are available "out of the box," and to an extent the extensibility of the computer. Most of them also have small and noisy fans on them, which you may want to do something about. When choosing a motherboard, check that it has all the connections you want (not all of them have Firewire, although most of them have onboard LAN and all have USB2.0, although the number of USB2.0 connectors varies -- you'll probably want a bunch, since you probably have a quite a bunch of peripherals), a built-in RAID driver (the nForce4 chipset has a very good one), and that it's roomy enough for an add-in CPU cooler ('cause you'll want one). My pick was the ASUS A8N-SLI Premium -- overkill for photography, but great for games (which I do) and it's fanless.

- **The processor.** We already discussed this above.

- **The memory.** This, too.

- **The video card.** This drives your display. If you don't play games, the main thing is that it's fanless and has enough video RAM to feed your (probably pretty big) display. If you do play games, it determines how fast they'll run. I If you have no good reason to do otherwise, pick one where the GPU chipset is from the same manufacturer as your motherboard chipset. I picked a GeForce 7800GT from Club3D, and added a Zalman VF700 AlCu [http://www.zalman.co.kr/product/view.asp?idx=149&code=013] cooler to it. Again, wild overkill for photos...

- **The disk drives.** Also discussed above.

- **The optical drive.** In practice, a DVD+/- RW. Any one from a major brand will do fine. Pick one that fits the color of your box. (I didn't and it bothers me slightly.)

- **Removable storage.** I don't have a floppy drive on my computer. I haven't had one since 2000, and haven't missed it at all. Note, however, that if you want to make a bootable RAID array, you'll need one. However, I do have a USB2.0 15-in-one card reader in the floppy bay, which is very handy. It's from Apacer.

- **Cooling accessories.** This is strictly speaking optional, since the box will run just fine with regular cooling components, but I find it more than worth the money and slight amount of trouble to replace the noisy CPU heatsink and fan with the virtually noiseless and more effective Zalman CPU cooler (7700 AlCu [http://www.zalman.co.kr/product/view.asp?idx=146&code=005] in my case), and do the same for any VGA fan that may be present (fanless heatpipe [http://www.zalman.co.kr/product/view.asp?idx=46&code=013] for the lower-end ones, the VF700 for the high-end ones) and chipset (if applicable; my motherboard didn't have a chipset fan to start with). Personally, I don't like case-front fan controllers: I don't want to have to adjust my fans as I work on the computer, they usually look fussy, they add to the cable tangle inside the case, and they don't give out enough information that I could use them intelligently; if I need to tweak a fan's speed, I add a Zalman FanMate and stick it inside the box where it's out of the way. Adding these widgets will

dramatically bring down the noise level of your box -- and it's precisely for this kind of reason that you'll want to build your own anyway, so why not?

Priorities

A common mistake beginning box-builders make is buying the fastest CPU they can afford and cutting corners with the rest. The choice of CPU should in fact be the most flexible item in your budget. This is because the CPU is almost never the most important bottleneck in making a system run fast -- and moreover, there's a lot more to a computer that's nice to use than mere speed.

I write software for a living. One thing I've discovered very concretely is this: anything you can do in memory is fast, and anything that causes disk access is slow. The same applies to your desktop system as a huge on-line database. If you want to make your system run faster, the most effective way to do it is almost always figuring out ways to get rid of your disk access bottlenecks. In practice, this means either more memory or more hard disks -- or, if you already have enough hard disks, faster hard disks. A low-end processor on a system with two separate physical volumes will make for a much less bumpy ride than a high-end processor on a system with a single physical volume.

Second, by investing perhaps a hundred or two more in things that do not directly impact performance, you can make your computer a much more friendly beast to work with. A cheap case costs a few tens of bucks, while a good case costs about a hundred. A cheap power supply costs a few tens of bucks, while a good one costs about a hundred and a great one about a hundred fifty. A set of Zalman coolers will cost a few more tens of bucks. Cheaping out on them will save you about half the price of a processor upgrade: it's really not worth it. Get a nice case and cooling solution, and you'll have something that's actually nice to work with.

The minimum configuration

Bearing these rules of thumb in mind, it's pretty simple to define a minimum configuration: the cheapest system that's worth building. If you don't have enough budget for it, look on the used market (for example, by substituting the motherboard, memory, and CPU for previous-generation second-hand components you can save big-time and still get something that's, say, 80% as nice.)

- **Two hard disks:** the smallest you can find for the system, and the biggest you can afford for your data. In my opinion, the whole point of putting up with something the size of a mini-tower is that you can eliminate much of the disk bottleneck by putting your programs and your data on different volumes.

- **Enough RAM to comfortably run your software.** Basic "value" RAM is more than good enough, as long as there's enough of it. At this time, 1GB is the minimum, and 2 GB is very nice if you can at all afford it.

- **A nice, quiet case, power supply, and heatsinks/fans.** If your budget is really tight, cheap out on the case but replace the fans: there are some pretty damn cheap ones that take quiet 120 mm fans. You can save a few tens of bucks over a genuinely nice one without compromising much more than ease of assembly.

- **The best motherboard and processor you can afford.** This can be a very flexible item -- even the cheapest AMD processor on the cheapest MSI motherboard will make for a quite a snappy system -- and much snappier than one based on a faster CPU but hobbled by lack of RAM and too few disks.

Where to invest if you can afford it

OK, suppose your budget allows for a bit more than the minimum. Where to put it?

1. **Another hard disk.** Yup, if you have two, add a third to make your main storage a mirrored RAID pair. If you have three, add a fourth for a swap disk. If you have four, add a fifth to make your system disk a RAID 1 pair. If you have five, add a sixth to make your main storage a RAID 5 triplet. If you have six, buy a bigger case.

2. **More RAM.** If you have 2GB, buy another two to make 4. If you already have 4GB, that's enough. (If you only have 1 GB, though, then buy another gig before adding more disks.)

3. **A faster video card.** If, and only if, you play games, that is. Otherwise, it's a complete waste of money, at least until Windows Vista with its Godzilla-grade system requirements shows up.

4. **A nicer case.** Unless, of course, your case is already nice enough, in which case it's cosmetic only.

5. **More features.** This could mean expansion cards or a higher-end motherboard... and only if you actually need these features. Features you don't need are an annoyance, not a benefit.

6. **A faster CPU.** Yup, finally -- if you have enough disks, enough RAM, the case of your dreams, and all the features you want, then, and only then, upgrade your CPU. And if you're actually upgrading an existing system, you'll probably be disappointed at how little difference it makes. Upgrading from a single-core to a dual-core makes more difference in user experience than from a slower single-core to a faster single-core or a slower dual-core to a faster dual-core -- even if the single-application benchmarks would suggest otherwise. On the other hand, a dual-core that's bottlenecked by memory and disk access is just as stuttery as a single-core that's similarly bottlenecked.

Everything else (the keyboard, optical drive, display, and so on) you can scavenge, buy used, or cheap out on. (If you cheap out on the display, though, make it a 19" CRT -- it's much better than a comparatively-priced LCD.)

What about dual-processor setups?

If your budget is roomy, you might be considering a dual-processor system. That is, not merely dual-*core*, but one with two processors with a core or two each, running in two sockets. My recommendation is: *forget it.* Yes, you can put two dual-core Opterons on an ATX-E motherboard, but there won't be any room for a quiet cooling solution -- and it'll still be bottlenecked by the disks, so you'll be wanting to use SCSI instead of IDE, which are faster but also a lot noisier, hotter, and power-hungry, not to mention about four times more expensive. You'll end up with a monster that costs three or four times as much, sounds like a vacuum cleaner, feels like a radiator, and will cause your electricity bill to go through the roof... and while it will be faster, the difference will be less than you may think. There are very good reasons servers are kept locked in sound-proofed and air-conditioned vaults. Trust me, you don't want one running under your desk. If you have a lot of money burning a hole in your pocket, buy the most insanely great display you can find; you'll enjoy it much more.

Putting it all together

Before you even open the boxes, prepare yourself and your workspace. You'll need some clear space on the floor, a Phillips screwdriver, a keyboard, a screen, electricity, and patience. And:

Ground yourself. Static discharge happens, and a single well-placed discharge can fry your mobo, disks, video card, memory, and processor in one fell swoop. Use a wrist strap designed for the purpose: it is shielded to protect you in case you get accidentally in contact with mains power, but will bleed off any static charge quickly enough to avoid damage.

What not to do

Computer components aren't made of antique china, but they aren't armor-plate either, and most importantly, they really are sensitive electronic widgets. It is possible to fry them. Everyone I know who has been messing with boxes for any amount of time has fried at least one component, including yours truly. I haven't compiled any statistics, but in my experience the number-one way to destroy a component is through laziness and carelessness -- after something bad happens, you'll almost always feel guilty because you know you were doing something you weren't supposed to. In particular, you're not supposed to do any of the following -- and I mean it:

- **Mess with the machine while it's running.** Might seem obvious, but for every component ruined when it's not powered, there will be at least a half-dozen fried while they were running. Take my mishap, for example: I dropped a brass screw onto the motherboard while it was running. This was enough to kill it -- now it only says in an alarmed voice "System failed memory test!"

- **Hot-swap stuff that isn't hot-swappable.** Kind of a subset of the above, but still worth mentioning. I just heard of someone trying to hot-swap a video card, with dire results.

- **Hot-swap stuff that's still spinning.** Yes, you can hot-swap SATA disks, but you do have to unmount them first.

- **Mess with stuff without grounding yourself.** It's winter here. The air is dry. I get sparks of static electricity all the time, all over the place. I do not want them on my computer components.

- **Use force.** Almost everything in a computer slots or drops into place without having to use even moderate force. The only tightly-stuck stuff that I can recall are memory modules and built-in heatsinks on VGA cards, and that's it. In particular, the processor just drops into place. If it's not slotting in, something isn't right -- something's the wrong way up, misaligned, or in the way. It takes a quite a bit of force to crack a circuit board, but it can be done -- so don't do it. And if you do come across something that does need force, and you're absolutely certain that it's designed that way, set things up so that the force won't bend the board.

- **Ignore instructions.** If the booklet says not to do something, don't. Bad things will happen.

There's more, I'm sure, but most of it is just common sense. Assume that shorting anything while it's running will kill it, sparking static electricity on anything will kill it, and stepping on it will kill it. Other than that, you probably can't do too much damage. So once you've grounded yourself and have taken the boxes out and placed them in a neat row on the floor, read through the manuals so you know what's in them, and put the box together. Here's how:

1. **Install the CPU and heatsink to the motherboard** especially if using a third-party heatsink -- you may have to do stuff on the back of the mobo, and you can't if it's in the box.

2. **Install the motherboard** into the case.

3. **Install the memory modules.**

4. **Install the video card.**

5. **Connect power to your motherboard and video card and your CPU fan.** On an ATX2.0 motherboard, this means *two* power connectors to the mobo and zero to one to the video card.

6. **Connect a keyboard, plug in the power supply, connect the monitor to the video card, and power up.** You should be able to get into BIOS. Yup, this was just a test -- if you see nothing on-screen, now is the time to figure out what's wrong. Most likely just a bad power connector somewhere.

7. Once you managed to power up into BIOS, **power down,** unplug the power and remove the video card, and continue with the assembly.

8. **Connect all the annoying little bitty wires** -- the front panel connectors (blinking lights, audio, USB, FireWire), any extra ports that go into expansion slots, an internal USB card reader if you have one, and so on. Be neat: tuck any extra wire into recesses in the case, and fix the wires to the case sides using supplied materials, fancy little wire guides, or just strips of duct tape.

9. **Connect fan power,** and fix the chassis fan wires neatly to the walls.

10. **Connect your IDE drives (disk and optical) and floppy drives.** Fold and tuck those flat cables into more case recesses, but don't tape them. Some Antec cases like the Sonata and Sonata II are designed so the flat IDE cable to the main drive bay goes neatly behind it rather than uglily in front, but you need to work a bit threading it. Make sure they sit firmly in the connectors, and don't forget to check the jumpers on your IDE drives -- a drive with the jumper set to Slave won't work if there's no Master in the same cable. I just set the jumpers on all of them to Cable Select and if I only have one disk per cable, make sure to connect it to the end of the cable, not the middle connector.

11. **Connect your SATA drives.** SATA cables are much nicer to connect than IDE or floppy ones, and you don't need to worry about that master/slave nonsense.

12. Once you have all your data cables laid out neatly, **connect the video card (again).**

13. **Connect power to all components.** Spend some time on this: try to keep the motherboard area clear, and make sure that no power connectors or cables get into the fans. When connecting up disks, distribute them evenly across the various cables you have available -- don't put them all on one cable. Start with the two connectors to the motherboard, and proceed with the VGA power, drives, and fans. Then fix the cables to the walls of the case like you did for the data cables, and tuck away any unused cable in recesses in the case. I find that spiral cable collector helps organize the mess of cable no end; you can get it at the same place you bought your components.

14. **Connect the screen and keyboard, and power up.** Make sure all the fans spin, and listen to any odd noises -- it's probably a cable chafing a fan. Sort out any problems, and then move on to BIOS configuration.

BIOS configuration

First off, if you don't know what BIOS means, spend some time researching to find out. There are books about it, and of course the Internet has all the information you could possibly wish for. Tom's Hardware has a good guided tour of BIOS in it, for example. Your motherboard's manual is invaluable: keep it handy and rely on it, and don't panic if you don't understand everything. However, you should know at least what the main headings mean.

> For example, I still don't know what the ACPI suspend type settings actually mean -- but I do know what ACPI means, which means that when my computer refused to power down, I figured that playing with it could solve the problem, and sure enough, changing something from S1&S3 to just S1 did.

BIOS isn't rocket science, but it's not point-and-click easy either, and it *is* possible to get your computer into a state where you can't even get into BIOS the usual way to undo what you just did. In fact, if you really try hard, it's even possible to physically damage components in your computer with bad BIOS settings in the voltage and overclocking department, so "don't screw around," as Chef would say. Especially if you're messing with RAID arrays, do keep an off-line backup of your data (which you should do anyway). However, it's *almost* always possible to get back where you started by zapping the BIOS settings, usually by disconnecting the motherboard battery and moving a jumper -- your mobo manual will have instructions on it. So:

- **Back up your data,** which you should do anyway if you're migrating to a new computer.

- **Don't mess with overclocking settings.** Or if you do, go read up on it somewhere else; this article isn't for you.
- **Find out what you need to do to zap the settings** if you do get your computer into a state where it doesn't wake up.
- **Be patient and use common sense,** and you will be fine. Promise.

Disable Everything You Don't Need

The KISS principle works just as well for BIOS settings as for anything else. Your objective should be to disable everything you don't need, and let the rest take care of itself as far as possible. Most of the time this will get the job done fine: Windows, Linux, and other modern operating systems auto-configure very nicely, which means you shouldn't have to mess with too many settings in there. While most on-board widgets should play well together, anything that's disconnected will certainly not be sending any interrupts to screw up the works -- so if you don't need it, switch it off. My mobo has a huge amount of features on it, but I've switched most of them off.

Integrated Beats Separate (usually)

If you have lots of stuff on your mobo, you may have trouble choosing which of apparently-equivalent features you should pick. For example, my mobo has two RAID controllers, one from the main nForce4 chipset, another a Silicon Image controller added on by the manufacturer. Since I only have three disks (for now), I keep them all in the nVidia controller -- both because it's faster (I looked it up) but mainly because it keeps things simpler: I need the chipset driver anyway, and it's one less component to zap interrupts around.

Settings To Look At

The KISS principle will keep you out of trouble most of the time. However, there are a few settings that have solved some problems for me on occasion:

1. **USB Legacy Support: OFF.** You don't need it, and it just complicates stuff.
2. **ACPI Suspend Type.** As I said, I don't know what this actually means, but I do know that it's helped me solve problems with the system not powering down when I want to.
3. **Parallel port mode.** The exception to the "switch it off if you don't need it" rule. Since I don't use the parallel port, I've tried switching it off -- but it's not trivial to stop Windows from looking for it on occasion, so it's probably safest just to leave it enabled.
4. **Plug and Play OS: ON.** Make sure it's this way, since otherwise you'll have to set the interrupts through BIOS, which is a PITA. Most of the time it works well.
5. **SMART monitoring: ON.** The few times I've had a disk fail on me, SMART monitoring has actually warned me. Make sure it's enabled.
6. **CPU special features: ON.** At this writing, AMD calls it the "Cool 'n' Quiet." Whatever it is, it will (usually) improve the power consumption, noise, and heat characteristics of your box, so you should enable it.

That's it, really. Keep it simple, switch off everything you don't need, if in trouble, change one setting at a time, and if all else fails, zap the CMOS. For the rest, read your manual and research the net. Onwards to system configuration.

Windows configuration

After installing and booting into Windows, you'll still need to set up some stuff in order to get the system running as smoothly and efficiently as possible. I strongly recommend writing an installation and configuration log of everything you've done to it, up to and including the point where you install your basic software -- it'll serve you in good stead the next time you upgrade, and certainly when troubleshooting.

1. **Install/update drivers.** At a minimum, chipset, RAID, video, onboard sound, processor.

2. **Update your BIOS.** Always use the newest (stable) BIOS and chipset drivers (and never buy the first iteration of a motherboard or processor). Otherwise it's likely you'll get bizarre problems like random freezes, crashes, and bluescreens.

3. **Set up your data disk.** From Control panel / Administrative tools / Computer management / Disk management. I prefer to use a single huge partition rather than lots of small ones, because my photo library is a single huge entity. However, I also make a 5 GB partition that I label "swap" -- for the system's swap file. The size of the swap partition should be two times your RAM and then some. Keeping the swap file on a separate partition helps performance and disk management.

4. **Create users.**

5. **Install/update software.** Use your original media, and download any updates from the Net.

Tweaking and finalizing

If you've set up the system more or less as described here -- separate system disk and main storage, many if not most motherboard features switched off -- you still need to do some tweaks to the system to make it run like it's supposed to. Here's what I've done to mine:

1. **Move My Documents (for all users) to your main disk.** Just right-click on it, select Properties, click on Move... and move it.

2. **Move the swap file to the swap partition you created on your main disk.** Do this from Control Panel / System / Advanced / Performance / Advanced / Virtual memory.

3. **Check that Photoshop uses the *system* disk as its scratch disk.** Photoshop works much faster if the scratch file is (1) not on the same volume as the pictures you're working on, and (2) not on the same volume as the swap file. On a two-disk system, the only way to do this is to put the system swap file on your data disk and the Photoshop scratch disk on the system disk. Another reason to move the swap file (above).

4. **Disable unused services.** You'll have daemons like MSN Messenger and Adobe Version Cue running on your system. If you don't need them, disable them. Go to the Startup folder (for All Users and you personally) and remove everything you don't need. You might also want to check Control panel / Administrative tools / Services, but don't disable anything you don't understand; it might cause problems.

5. **Uninstall unused drivers.** It beats me why Microsoft makes us jump through hoops to do this, because they've made it pretty hard: go to Control panel / System / Advanced / Environment variables, and create a system variable devmgr_show_nonpresent_devices with a value of 1. Then go to Control panel / System / Hardware / Device Manager, and select Show Hidden Devices from the View menu: they'll show up grayed-out. Then right-click on any devices you've disabled in BIOS, and uninstall them. (If you uninstall something you'll need later, Windows can find the driver on the install disk, or the Internet.)

6. **Defragment system disk.** All the installation you've been doing will have left it fragmented, so right-click on it, go Properties / Tools / Defragment Now.

Why is Windows a given?

Simple: because you can't (yet) install Mac OS X on anything other than an Apple, and at this time only OS X and Windows have the software support needed for heavy duty photo work. In particular, no other OS that I know of has system-wide color management, and the choice of RAW conversion tools on them is very limited as well. I like Linux as much as the next guy (in fact, I work with it daily and my home server runs on Debian) but for serious photo work it just won't do, at least not at this writing. Nope, not even Ubuntu.

Testing

The main tool for verifying that your system is running as it should is the Event Viewer in Control panel / Administrative tools. In particular, check the System log. If there are any errors, you should figure out what's causing them: it's probably a device driver hanging around with no device to listen to. Make sure (again) such devices are uninstalled, or (e.g. for the parallel port) make sure the device is enabled in BIOS. Keep an eye on the log as you boot up the first few times to make sure it stays clear. After that, your brand spankin' new system is basically ready to go: time to activate Windows. Just don't do it before you've made sure it does, in fact, work -- otherwise you'll need to make some phone calls and listen to elevator music, which is a bit of a drag.

If At First You Don't Succeed...

It's very likely that your first system install will go somehow wrong. Of the half-dozen-or-so computers I've built, I don't think I've ever had a Windows installation go entirely right the first time. (OTOH Linux and Mac OS X installations have never failed to go right the first time, go figure.) You'll have set things up for the wrong devices, or installed on the wrong disk, or you find yourself repeatedly installing and uninstalling stuff. In that case, *start over* as soon as you realize you took a wrong turn. Sure, it's a bit of a drag, but it's even more of a drag to try to fix a system that's somehow fundamentally broken -- at least if it's a Windows system. For what it's worth, I installed Windows on my newest box three times before I liked what I had.

Conclusion: Is box-building for me?

If you've read this far (and Googled any terms you may not have understood), it could well be, no matter what your background. While system building doesn't take any special skills (it's way easier than woodworking, for example), it does take patience and the kind of personality that enjoys research and problem-solving. Approach it like a hobby, and it will pay off -- but approach it like a chore, and you'll grow gray before your time. The process of box-building starts with deciding the intended purpose of the box, then selecting the components that will play well together, then balancing the choices against budgetary constraints, then finding and ordering them, and finally assembling, configuring, and installing it. My latest computer took about five months from idea to execution, and about a week between the time the components were delivered and I had everything set up and running nicely. However, the second box I built on the same platform only took about two calendar days from getting the components to having it nicely running, and the third one I'm about to build should be about the same or less. It gets easier over time. The hardest part is the research: if you can resist the temptation of going with your first impulse, and instead read up more and more, and let your choices mature, you will end up with something rather nice. The box I ended up with turned out to be rather different from the one I originally envisioned, and I'm pretty confident it's a great deal better. Especially for the casual box-builder, patience is a real virtue.

Appendix: Who's Who in Computer Components

There's no substitute for doing your own research, but if you've read this far, here are some final thoughts on some computer component manufacturers I've dealt with and liked. The list is anyhing but exhaustive: for that, see the websites I listed and many others as well.

Cases

Antec [http://www.antec.com/]

Antec is a Californian company that makes mid-priced cases. In my opinion, they're a good candidate for the "best value for money" spot. Their approach is to avoid expensive and exotic materials and manufacturing techniques, but design the cases for silence and cool running, and not cut any corners in finish. However, their cases are clearly designed to be built once and left running: there are a quite a few screws to attach, and if they have to choose between quick installation and good noise or thermal performance, they'll pick performance every time. Antec pays great attention to detail in both design and manufacture: you will find that every detail has a purpose, the finish is excellent, and there is nothing superfluous in their cases. If you want a case that's silent, well cooled, and looks good in an understated way, you can't go too badly wrong with Antec. On the other hand, if you spend as much time in your case as out of it, you'll probably get irritated at their spoilers and weird cable routings.

Lian-Li [http://www.lian-li.com/main.htm]

The Taiwanese company Lian-Li is the Rolls Royce of computer cases: you'll pay easily double the price, and more, on a Lian-Li compared to an Antec, and ten times more than the cheapest box you're likely to find. However, as usual, you gets what you pays for. Lian-Li cases are exquisitely finished, made of heavy-gauge aluminum, and designed for looks and feel at least as much as functionality. If you want your two-grand computer to look like it cost two grand, an extra couple of hundred on a Lian-Li case will sort that out nicely.

SilverStone [http://www.silverstonetek.com/]

A comparatively young Taiwanese manufacturer of high-end aluminum cases, SilverStone is very much like Lian-Li in feel and design priorities: their cases are expensive, and look and feel that way too. They specialize in home-theater PC cases but make standard tower and desktop models as well. SilverStones emphasize cooling power more than silence, and their styling is characterized by straight lines and bold forms. And they look damn good.

ThermalTake [http://www.thermaltake.com/product/Chassis/chassis_index.asp]

ThermalTake is favored by overclockers and high-end gamers who spend just about as much time inside their case as out of it, and whose main priority is keeping their insanely overclocked components cool. They make cases designed specifically for water cooling. ThermalTake has really out-there design in their higher-end cases, replete with fins, blue lights, acrylic side panels, and weird curvy accents. Design-wise, ThermalTake is the diametric opposite of the understated elegance of Lian-Li or SilverStone: unabashedly "look-at-me" teenage-techno-geek in aesthetic sensibility. Makes me wonder if they hired Xzibit as their design consultant...

Power supplies

Antec [http://www.antec.com/]

Antec also makes power supplies, and does a damn good job of it too. Their PSU's are quiet, generally perform very well, and are reasonably priced. Some of their cases are always bundled with a matching power supply. As with their cases, they pay special attention to silent operation: in fact, they make some completely passively cooled power supplies with pretty surprising

wattage ratings. I've had Antec power supplies running several computers with no problems for years, but some people I know have complained that they tend to go wobbly if pushed to the extremes, so if you're going with an Antec power supply, it might not be a bad idea to buy "one size bigger" than you theoretically need.

Seasonic [http://www.seasonic.com/co/index.jsp]

Seasonic also makes quiet power supplies, but rather than trying to go with completly passive cooling, they try to make their active cooling systems as quiet as possible. Seasonic power supplies are extremely reliable even under extreme load. They're also rather pricey but don't look it: they're pure engineering rather than design. I like them a lot.

Enermax [http://www.enermax.com/english/index.asp]

Like Seasonic, Enermax makes pricey power supplies that look just like cheap ones, but are extremely reliable and quiet in operation. I had one running my box for years and it never gave me any trouble.

There are many more power supply makers with very good reputations, such as Fortron, Zalman, PC Power & Cooling, Thermaltake, and so on -- I just haven't had the chance to try them out. In general, anything north of a hundred is bound to be pretty good, and anything costing less than fifty is bound to be pretty suspect. Antec's midrange cases are such good deals largely because they bundle a high-quality power supply -- while it's not quite "buy the case, get the PSU for free" it's pretty close.

Cooling systems

Zalman [http://www.zalman.co.kr]

I've used various cooling widgets from Zalman for years, and wouldn't do without them. Zalman cooling components get the job done, they get it done quietly, they're a snap to install, and they fit most cases and motherboards rather nicely -- both types of Zalman video card coolers I've used were easier to deal with than the factory-assembled heatpipe arrangement on a Gigabyte brand video card I installed in one box I built. I buy a Zalman CPU heatsink and fan, video card cooler, and northbridge heatsink (if applicable) as a matter of course. They do add over fifty bucks to the the price of the system (nearly a hundred, if you go for the top-end ones), but the payoff in much quieter operation and better cooling is enormous. For all I know, there's something else as good out there, but if so, I haven't come across it.

Motherboards

ASUS [http://www.asus.com]

I use ASUS simply because I'm used to them. Their talking BIOS is kinda nice too; it has helped me diagnose problems on two occasions. I've never had any major problems with any of their mobos that weren't caused by me. For all I know, though, they're no better than anyone else since I haven't actually built boxes on boards from anyone else. So take this as an endorsement rather than a review.

Hard disks

Samsung [http://www.samsung.com/Products/HardDiskDrive/]

Currently the "default choice" -- they're reliable, quiet, and reasonably priced. If I have no particular reason to do otherwise, I go with a Samsung hard disk.

Seagate [http://www.seagate.com/]

My second choice. Seagates are also reliable, quiet, and reasonably priced. If the store is out of stock with Samsung, I buy a Seagate instead.

Maxtor

I don't like Maxtors -- I've had two crap out on me, and they're also way noisier than Seagates or Samsungs. Could be I've just been unlucky, but in any case I'm not buying them anymore.

Western Digital [http://www.westerndigital.com/en/index.asp?Language=en]

Their Caviars are nothing special, but if you want near-SCSI access times on IDE or SATA, the Raptor is the only game in town. Reasonably quiet, too. I have two in my current computer.

Optical

Plextor [http://www.plextor.com/]

The Rolls Royce of optical drives. Plextors are twice as expensive as the competition, and they both look, feel, sound, and perform that way. If money is a concern, I go for something cheaper, but if I have an extra 50 in my budget, or I'm building for someone who wants something that feels classy, I use a Plextor.

LG [http://www.lge.com/]

LG's are reasonably quiet, nicely finished, and perform well. I've used a couple, built a couple more into other people's computers, and none of them ever gave me or them any trouble.