

Navigating within the Hardware Guide

Using Acrobat Reader couldn't be easier, but if you haven't already done so please examine the accompanying Getting Started and Help files on the CD.

Within this interactive hardware guide, there are several options available. Whenever you see text that *looks like this* clicking on it will take you to the appropriate part of the guide. You can return to your place by clicking on the Go Back tool in the Reader icon bar at the top of the screen.

On most pages you'll see an arrow icon in a red box at the lower-right corner; clicking there will take you to the appropriate part of the products and pricing Directory at the end of the guide. Again, the Go Back tool will return you to your position.

Finally, on the Contents screen clicking on any of the red-and-white section headings will take you to that section of the guide.

Enjoy.



Macworld

Macintosh Hardware Guide 1994

What to buy

Where to buy

How to buy smarter



Welcome to Macworld Interactive

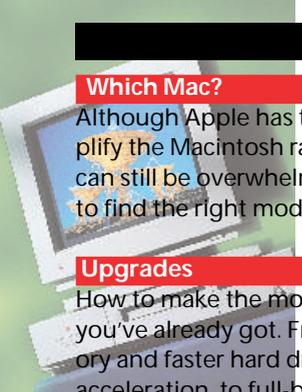
One day, perhaps, all magazines and newspapers may look, and arrive, a little like this. Surely not on CD, and certainly the delivery software will be far in advance of what is possible today. What you are reading now might be considered the electronic equivalent of a medieval manuscript – little more than an indication of what is to come. But electronic publishing and distribution is undoubtedly the future of publishing.

This project is one that I've wanted Macworld to undertake for a long time, but the technology simply wasn't available. Without a product like Adobe Acrobat, there was no universal way of delivering the printed word in

electronic format other than ASCII text – which is no alternative at all. The same but more so for graphics.

Although Acrobat is not ideal, it is a good “first technology”. At least it overcomes the ASCII limitation, allows the presentation of colour graphics, and lets you search for relevant text.

Already we know some of the future directions for Acrobat, which will include multimedia abilities like QuickTime video and audio. At some time in the future, another version of this Hardware Guide may include audio-video interviews with industry leaders, video tutorials on how to install memory upgrades, and interactive shopping. For now, though, I hope you find this an enjoyable and useful experiment. – Peter Worlock



Which Mac?

Although Apple has taken steps to simplify the Macintosh range, the choice can still be overwhelming. Here's how to find the right model for you.

Upgrades

How to make the most of the Mac you've already got. From adding memory and faster hard drives, plug-in acceleration, to full-blown motherboard swaps. Plus when to cut your losses and move to a new machine.

Where to Buy

Often as important as which products you buy is the question of where you buy it. Mail order companies can save you money, official dealers should have all the answers... here's how to weigh up the pros and cons.

Black & White Printers

From inkjets that combine low-cost with good quality print, to the best in superfast, networkable lasers the printer market has something for everyone.

Colour Printers

Once the preserve of cheap and cheerful business charts, or pre-press proofing at astronomical prices, colour

printers are on the verge of mainstream acceptance. But there are competing technologies to choose among...

Audio/Video

Whether you want to be a contender for next year's Oscars, or just get your corporate training tools on video, the solutions are here.

Input

Unhappy with your mouse? Worried about RSI from your keyboard? Change to something better...

Storage

In these days of mammoth image files and multimedia, you don't just need storage, you need a storage strategy. Here's your guide to the myriad technologies from floppy to floptical, and magnetic media to magneto-optical.

Connectivity

If you're ready to move from one Mac and a printer to a real network, here's a route map to take you through the maze of hubs, bridges and routers.

Modems

CCITT, v.42, hardware handshaking, MNP – what does it all mean?

Imagesetters

Granted, they're a long way from mainstream output devices – but imagesetters are cheaper, easier to manage and easier to install than ever before.

Scanners

No longer the exclusive preserve of desktop publishers, scanners are so flexible and so affordable you almost need a reason not to buy.

Display Systems

The right monitor can make your life easier – or the wrong one can cramp your style and ruin your eyes. Buy right with this comprehensive guide.

Slide Recorders

Like imagesetters, they're not for everyone, but for professional presenters they can save you time and money.

CD Drives

The time is right – there's no reason to delay buying into the brave new world of multimedia any longer.

Directory

A comprehensive guide to more than 1,100 Macintosh hardware products, with pricing and UK distributors.

Which Mac?

Despite Apple's efforts to simplify the Macintosh family, there is still a wide variety of machines, many with confusingly-similar specifications. And the introduction of Power Macs, with a new family of processors, makes matters still more complicated.

Buying a Mac has never been easier – from traditional Apple dealers, to High Street stores like Dixons and Wilding, to the computer superstores springing up across the country, there are now more places to buy from than ever before. You can even buy one on a Saturday. Buying a Mac has never been cheaper – despite the recession, prices continue to plunge and will fall further still with every new model Apple introduces. Where the sub-£1,000 Mac was once a dream, it is now commonplace.

But choosing the Mac you buy has never been more difficult. Originally there was but one model: the Macintosh 128K. Eventually, there were two kinds of Mac: the “affordable” ones, and the powerful ones. And sometime later, the range divided again: “compact” Macs like the Plus, SE and SE/30; expandable Macs like the IIfx, IIfx and IIfx; and the unloved Mac Portable. Several different models, perhaps, but a range that was easily understood. Then for a long time the Mac family was all-but

impossible to understand without making a full-time study. There were non-expandable compact Macs galore, and expandable desktop systems. Somehow Apple managed to squeeze between them hardly-expandable desktop systems like the original LC and the IIsi. At least you knew where you were with the compacts – they were black-&-white... at least until Apple launched the Colour Classic.

As of this writing in early 1994, things are once again a little simpler. The compact Mac has all-but disappeared in the UK. And the 68030 processor – not long ago the king of Mac hardware – is now nearly as scarce, confined to the Performas, and the portables.

But there remains ample scope for confusion. If you're not a computer expert, the closer you look the more confusing things can get. For example, you might know that faster processors are better, but why is a 25MHz 68040 more powerful than a 33MHz 68030? What, if any, is the difference between an LC475 and a Quadra 610?

You'll find all the answers here: explanations of key issues like processor power, memory expansion, and the ins and outs of video displays; direct

comparisons of every machine in the current range (and a few recent departures); and Macworld's quick-and-easy recommendations on which models are suitable for which tasks.

Cutting through the jargon

Computer novices often complain about the bewildering jargon of computing. But every subject has its own jargon – most car buyers need to understand, even if only vaguely, the difference in engine sizes and power, and few balk at the use of terms like mpg, mph, coupe, estate, 1600cc and 2.6 litre.

Computing might have more jargon than most subjects, but the essentials aren't difficult to grasp. The power of a computer is a function of the processor, and how fast it operates; and the flexibility of a computer is a function of memory, data storage and expansion, and (to a lesser extent) its video display.

Processor

The processor (sometimes called the CPU, or central processing unit) is the 'brain' of the computer. Until the launch of Power Macintoshes in early 1994 (see [Power Mac: Time to Move Up](#)), all Macs used one of a family of proces-

sors made by Motorola, and the family is usually designated the 680x0, where x indicates another number. For example, the original Macs used a 68000, the IIs used a 68020, for a long time the 68030 was the mainstay, while the most powerful machines, the Quadras, use the 68040. Higher numbers denote greater power.

The speed of the processor is measured in megaHertz, or MHz, and again higher numbers denote greater speed and power. So a processor running at 33MHz is faster than the same processor at 25MHz. But the overall power of a system comes from the combination of processor and clock speed: because a 68040 is much more powerful than the 68030, an 040 at 25MHz is far more powerful than an 030 running at 33MHz or even 40MHz.

Actually, there's a third factor governing the power of a system, and that's the speed at which the processor can exchange data with other parts of the computer. The route that data takes as it moves around the system (from memory to processor to storage device) is called the data bus. The 'width' of the bus is measured in 'bits' and determines how much data can be carried at a time. All of the Mac proces-

Mac Essentials: Entry-level & Mid-range

	Classic	Classic II (Performa 200)	Colour Classic	LC	LC II (Performa 400)	LCIII	LC475	IIci	IIsi	IIvx (Performa 600)	IIfx
Overall speed	1.0	1.9	2.1	1.8	1.7	4.0	10.3	4.9	3.3	5.0	7.0
Price	na	na	na	na	na	£525	£599	na	na	na	na

Processor

Type	68000	68030	68030	68020	68030	68030	68040	68030	68030	68030	68030
Speed	8	16	16	16	16	25	25	25	20	32	40
FPU	No	option	option	option	option	option	no	yes	option	yes	yes

Memory

Base RAM	1MB	2MB	4MB	2MB	4MB	4MB	4MB	4MB	1MB	4MB	none
Max. RAM	4MB	10MB	10MB	10MB	10MB	36MB	36MB	128MB	65MB	68MB	128MB
SIMM type	30-pin	30-pin	30-pin	30-pin	30-pin	72-pin	72-pin	30-pin	30-pin	30-pin	64-pin
SIMM speed	120ns	100ns	100ns	100ns	100ns	80ns	80ns	80ns	100ns	80ns	80ns

Built-in video

Included	monitor inc.	monitor inc.	monitor inc.	yes	no						
Standard VRAM	none	none	256K	256K	256K	512K	512K	none	none	512K	na
Max. VRAM	none	none	512K	512K	512K	768K	1MB	none	none	1MB	na
Standard colours	2	2	256	16	16	256	256	256	256	256	na
Max. colours	2	2	32,768	256	256	32,768	32,768	256	256	32,768	na
Max. monitor (8-bit)	na	na	na	14-inch	14-inch	16-inch	16-inch	14-inch	14-inch	14-inch	na
Max monitor (16-bit)	na	na	na	na	na	14-inch	14-inch	na	na	14-inch	na

Slots & Ports

NuBus slots	none	3	none	2	6						
PDS slots	none	none	1	1	1	1	1	1	1	none	1
Cache	no	yes	no	yes	no						
Sound-in	no	yes	yes	yes	yes	yes	yes	no	yes	yes	no

Storage

Max SCSI transfer rate	680KBps	11KBps	1100KBps	1100KBps	1400KBps	3000KBps	3400KBps	1800KBps	1800KBps	1400KBps	1400KBps
Internal HDs	1	1	1	1	1	1	1	1	1	2	0

sors can work with 32 bits of data at a time, but some models of the Mac (the LC II/Performa 200, for example) have a data bus that is only 16 bits wide. This means that when the processor wants a piece of information from memory, it needs two trips to get it on a 16-bit bus, and only one trip on a 32-bit bus. A narrow data bus creates exactly the same kind of bottleneck that you get when roadworks close two lanes of a motorway – everything slows down.

Not every Mac comes with a maths coprocessor (also called a Floating Point Unit, or FPU). A maths coprocessor is very useful if your main applications involve spreadsheets, CAD, 3D rendering, and some kinds of image manipulation. If that sounds like you, you want one; if it doesn't, you don't.

Memory

There are two kinds of computer memory: RAM and ROM. The latter (which stands for Read Only Memory) can safely be ignored since, although it's essential to the working of the Mac, you can't do anything to it. When everyone talks about computer memory, RAM is what they mean.

Don't worry about what RAM stands for (the acronym is meaningless and

confusing); the important thing to know is that this kind of memory is your computer's workspace. It is where programs are held so the Mac can run them, and where the Mac works with the information you give it; whether that information is words in a word processor, numbers in a spreadsheet, or lines and colours in a graphics program.

Memory is measured in multiples of bytes. A single byte is equivalent to a single character, so 1,000 bytes would hold 1,000 characters, or about 160 words. The jargon word for 1,000 bytes is a kilobyte, usually written as 1K (more accurately, 1,024 bytes but who's counting?); the term for 1,000 kilobytes is a megabyte, written 1MB; and 1,000 megabytes is a gigabyte, or 1GB.

Generally speaking, the more memory you have, the better. Apple sells most models of the Mac with 4MB of memory, and that's just about enough for a basic working system. If you can afford it, 8MB is better, while for graphics work 16MB, 32MB, or more should be considered essential.

What does the memory get used for? The operating system (the software that let's the Mac keep track of your data files, manage the flow of informa-

tion around the system, read input from the mouse and keyboard, and send images to the monitor) occupies around 1.5MB. If you add lots of fonts, and software extensions, that can rise to 3MB or more. Second, every program you run occupies another chunk of memory; simple applications like word processors may take up between 500K and 1MB, while complex applications like page-layout software might need as much as 2MB or more. Finally, the information you work with also occupies memory – a simple letter or report may need only 10K or 20K, but a large spreadsheet might take up several hundred kilobytes, while graphics files can run to tens of megabytes.

More memory lets you work with more advanced software and larger files, but it also has two other advantages that can speed up your work. First, you can have the Mac running two or more programs while you switch between them at will, saving time in quitting from one, starting the other, then repeating the process to go back. Second, most software will work with files that are larger than available memory, but only by accessing the file on disk. Since even the fastest drives are slower than memory, this slows

things down considerably. The more data that can be held in memory, the faster you and the Mac can get things done.

Storage

When you switch off the Mac, the contents of memory are erased. To avoid starting every job from scratch every time you work with the Mac, you need a method of saving your data files. There are many forms of computer storage, but the largest group relies on magnetic recording and includes floppy and hard disks, and tape drives.

Floppy disks, so called because the disk inside the plastic shell is flexible, usually hold around 1.4MB of information (older Macs used disks that could only hold around 800K). Although by Mac standards, floppy disk capacity is tiny, they are still essential since software companies have standardized on floppies for distributing their applications (although other methods are becoming increasingly common).

While most users store some information on floppies, the mainstay of Mac storage is the hard disk – so called because the disk itself is a rigid piece of metal.

A newer form of storage is the CD-

ROM drive. Using similar technology to the audio compact disc, these drives use lasers to read pits etched into the surface of the disk. CD-ROMs can store large quantities of information on a single disk (up to 600MB) which makes them useful in a number of applications. For example, many font suppliers make their entire type libraries available on CD; a growing number of publishers use CD for distributing large quantities of information, such as encyclopaedias and other reference works; and software publishers are slowly moving towards putting their increasingly-large products on CD – Microsoft, for instance, makes its Office collection, which would otherwise need 20 or more floppies, available on CD.

Although there are now some systems that can write information to compact discs, CD should generally be considered a read-only medium – in other words, your Mac can read the information, but you won't be able to save your own data on CDs.

Display

The kind of display you get with your Mac is a function of two devices: the video hardware the Mac uses to create the signal, and the monitor used to dis-

play the image. Confusingly, Apple uses these two items in many different combinations.

The monitor is the easiest to understand: you can have either greyscale or colour – there's no such thing as a black-&-white monitor, nor a 24-bit colour monitor. Those variations are the province of the video controller. (Where portable Macs using LCDs are concerned, you can have black-&-white displays, as well as greyscale and colour.)

The key considerations for video controllers are bit-depth and memory. When perusing the adverts for display systems, you'll find phrases like "256-colour" and "8-bit", or "24-bit" and "16 million colours" used interchangeably. "Bits" refers to the amount of memory allocated to each dot or pixel on the screen. A 1-bit controller, for example, gives you two colours – black-&-white – while an 8-bit controller gives you 256 colours or shades of grey.

(Technically, the number of colours or shades is two to the power of the number of bits: 1-bit gives two colours, 2-bit gives four colours, 4-bit gives 16 colours, 8-bit gives 256 colours, 16-bit gives 65,000 colours, and 24-bit gives 16 million colours.)

Mac Essentials: Quadras

	Quadra 700	Quadra 800	Quadra 900	Quadra 950	Quadra 610 (Centris 610)	Quadra 650 (Centris 650)	Quadra 660AV	Quadra 840AV
Overall speed	11.9	16.4	10.5	14.7	12.1/8.8	14.6/12.8	12.4	16.5
Price	na	£2,050	na	£2,699	£990	£1,320	£1,825	£3,025

Processor

Type	68040	68040	68040	68040	68040	68040	68040	68040
Speed	25	33	25	33	25/20	25/33	33	40
FPU	yes	yes	yes	yes	yes/no	yes/yes	yes	yes

Memory

Base RAM	4MB	8MB	none	none	8MB/4MB	8MB	8	8
Max. RAM	64MB	136MB	256MB	256MB	68MB	132MB	68MB	128MB
SIMM type	30-pin	72-pin	30-pin	30-pin	72-pin	72-pin	72-pin	72-pin
SIMM speed	80ns	70ns	80ns	80ns	80ns	80ns	80ns	70ns

Built-in video

Included	yes	yes	yes	yes	yes	yes	yes	yes
Standard VRAM	512K	512K	1MB	1MB	512K	512K	1MB	1MB
Max. VRAM	2MB	1MB	2MB	2MB	1MB	1MB	2MB	2MB
Standard colours	256	256	256	256	256	256	256	256
Max. colours	16.7 million	32,768	16.7 million	16.7 million	32,768	32,768	16.7 million	16.7 million
Max. monitor (8-bit)	21-inch	21-inch	21-inch	21-inch	21-inch	21-inch	21-inch	21-inch
Max monitor (16-bit)	na	16-inch	na	19-inch	16-inch	16-inch	16-inch	16-inch

Slots & Ports

NuBus slots	2	3	5	5	none	3	0	3
PDS slots	1	1	1	1	1	1	1	1
Cache	no	no	no	no	no	no	no	no
Sound-in	yes	yes	yes	yes	yes	yes	yes	yes

Storage

Max SCSI transfer rate	3400KBps	3800KBps	3400KBps	3800KBps	3800KBps	3800KBps	3800KBps	3800KBps
Internal HDs	2	4	4	4	1	2	2	3

Memory comes into play because eight bits equals one byte. You can see that, depending on whether you are using a black-&-white or 256-colour display, the video controller needs one byte of memory to display either 8 dots or a single dot, respectively.

For more information on display systems, see the relevant section in this Hardware Guide

Expansion

“Expandability” is a catch-all phrase covering all of the above. It means the ability of your Mac to have more – more memory, more storage, more add-on devices, and bigger and better displays.

Expansion is important for the simple reason that change is a fact of computing life, for you and the Mac. As you become proficient in the use of your computer, you'll

probably want to do more with it – designers who bought Macs for graphics and DTP begin to use spreadsheets and accounting software; business users who start by running spreadsheets begin exploring graphics and desktop publishing.

But even if you're forever content to run your one and only application and therefore think that expansion is academic for you, you'll find that the software publisher has other ideas. New versions of software never get smaller – usually they need more memory to run, and occupy more disk space. And the files you create will ultimately fill your hard disk.

Expanding the system can be done in three ways. First, you can add more memory – one of the most effective, and certainly the most cost-effective, routes to take. Second, you can add more or different storage devices. Although it's possible to replace your Mac's standard hard disk with a bigger drive, most users opt for an external drive to supplement the built-in unit. Similarly, other forms of storage are most convenient in external form – perhaps a SyQuest cartridge drive, or an optical drive for larger requirements, or a tape drive for backup.

Power Mac: Time to move up?

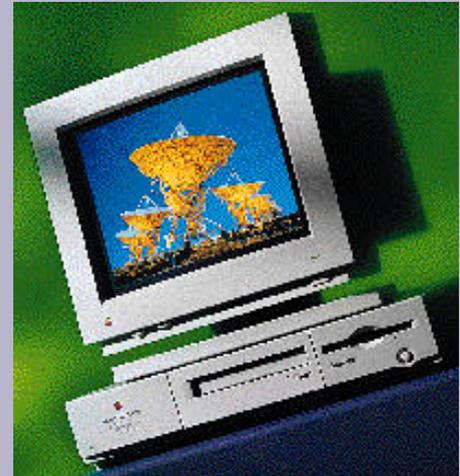
There are three models of the Power Macintosh: the 6100, 7100, and 8100. To a casual observer, they look pretty much like a Quadra 610, 650, and 800, respectively. Although it's the PowerPC 601 inside that largely sets them apart, there are some other notable differences.

As the names suggest, the Power Mac 6100/60 uses a 60MHz PowerPC 601 CPU, while the 7100/66 and 8100/80 use 66MHz and 80MHz CPUs, respectively.

Inside the Power Macs

From the outside, the Power Macs look almost identical to their Quadra counterparts. Look closely and you'll notice the word PowerPC on the case, as well as the Quadra 605-like styling for the floppy drive panel. Internally, too, there are more similarities than differences.

SYSTEM MEMORY The Power Macs all have 8MB of RAM soldered on the



motherboard. You can expand the memory with the same type of 72-pin SIMMs as used on Centris and Quadra models introduced last year. But unlike with the Quadoras and Centrises, you need to add SIMMs two at a time.

The 6100 has a maximum memory capacity of 72MB using hard-to-find 32MB SIMMs in both of its SIMM slots. The 7100 has four SIMM slots, for a maximum memory capacity of



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Such external devices connect to the Mac through a system called SCSI – the Small Computer Systems Interface. SCSI lets you add up to six external devices. Not all of these need to be storage products: many companies also use the SCSI interface for scanners, and some printers.

The third route to expansion is via add-in cards, small printed circuit boards that give the Mac extra abilities. Apple currently uses several variants on two basic themes: NuBus cards, and PDS cards. NuBus is a standard for add-in cards. It is commonly used for adding better video capabilities – say, to take your Mac from 8-bit to 24-bit video, or to add video acceleration (because the Mac is a graphical computer, it spends a lot of time drawing objects on screen – even if its only a page of scrolling text – and video acceleration can provide a big performance boost). NuBus is also used for adding extra networking abilities beyond the LocalTalk networking built in to every Mac.

PDS stands for Processor Direct Slot, and as the name suggests it is a way of plugging in extra features so that the main processor can control them directly. Generally, you'll find the same sorts of features on PDS and NuBus

136MB with 32MB SIMMs. Filling an 8100's eight SIMM slots with 32MB SIMMs gives it 264MB. If you don't need that much RAM, the Power Macs also work with 2MB, 4MB, 8MB, and 16MB SIMMs.

The 601's internal 32K primary RAM cache lets Apple use relatively slow 80ns RAM for the Power Macs' main system memory. Faster 70ns and 60ns SIMMs, which some Quadra and Centris models require, also work on the Power Macs but do not improve performance.

CACHE For better memory subsystem performance, the Power Mac 8100 comes with a 256K secondary RAM cache on a 160-pin SIMM. On the 7100 and 6100, users can add a secondary cache by plugging in a 160-pin, 256K SIMM (not a standard RAM SIMM). On the 8100, you can replace the 256K SIMM with a 512K cache SIMM. The secondary cache does not approach the blistering transfer rates of the CPU's internal 32K primary cache (640MB per second for data and 2.5GB per second for instructions), but at 200MB per second, the secondary cache more

than doubles the transfer rate between CPU and RAM or ROM. On a prototype Power Mac 7100/66, Macworld Lab saw a 14 percent difference with the optional cache installed for typical processing, and we saw 44 percent for floating-point operations, both with 680x0 programs. The additional throughput benefits the emulator and emulated 680X0 software more than native PowerPC software.

DISPLAY Apple made major changes to the Power Mac's video-display support. The two most significant changes are the inclusion of two video ports in all models but the non-AV 6100, and the adoption of multisyncing support – even on-the-fly resolution switching – in the Power Macs' ROMs. The Power Macs (except the standard 6100) are also the first Macs ever to support two monitors without extra hardware.

One video port is on the Macs' back panel. The second video port is on a card that plugs into the PDS (Processor Direct Slot). All AV Power Macs have an AV card in the PDS, and that card includes the video

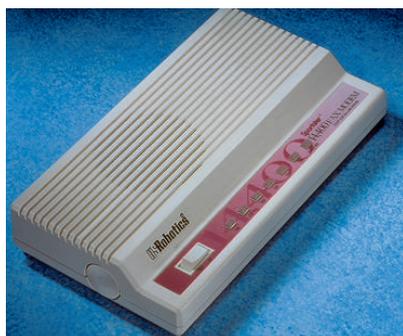


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Error Correction and Data Compression;
V.42, V.42bis
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cards. The difference is one of compatibility. For many years, NuBus was a standard across the Mac range – a NuBus card you bought for a IIcx could be used in any NuBus-equipped Mac subsequently. However, with the introduction of the Centris 610, Apple created a non-standard NuBus design because the 610's box could accept cards just seven inches long (versus the 10- or 12-inch cards that had been standard). The seven-inch form factor is also used in the Quadra 660AV and in the Power Mac 6100.

There have been several different versions of the PDS. While Apple may provide PDS slots in future Macs, there's no guarantee that your current PDS cards will work in those machines.

In summary, what this means is that the ability to expand your Mac is important, and sometimes critical. With that in mind, PDS expansion is better than no expansion at all, but NuBus expansion is best of all.

Putting it all together

So how does this crash course in computer technology help you choose a Macintosh? How do you decide which model to buy?

Before getting down to technology

port and 2MB of video RAM, plus the TV-signal input and output connectors. The PDS in the non-AV 7100s and 8100s has a video card in place of the AV card. (The non-AV 6100 has no second video port, and there is no option to add one; you'd have to buy a 7-inch NuBus video card from another company.

The port on the Power Macs' back panel is an AV-style video port, which has pins for the video, ADB (Apple Desktop Bus), and sound signals that an Apple AudioVision 14 or compatible monitor accepts. If you want to plug a standard Apple monitor or a VGA monitor with an adapter cable into this port, you'll need an AV-to-standard-Mac video adapter. Fortunately, the second video port is standard.

The AV cards and the 7100's and 8100's bundled video cards all support up to 24-bit colour on monitors up to 14 inches, and 8-bit greyscale on a 15-inch portrait monitor. Beyond that, colour depth depends on the amount of VRAM available. A 16-inch monitor can display 16-bit colour with 1MB of VRAM or 24-bit

colour with 2MB or more. A 19- or 21-inch monitor can display 8-bit colour with 1MB, 16-bit with 2MB, or 24-bit with 4MB of VRAM.

SCSI The SCSI port is compatible with the SCSI-2 protocol (but not the Fast or Wide protocols), and theoretically transfers data at 5MB per second. Under optimal conditions with Apple's internal drives, Macworld Lab measured transfer rates of 2.3MB to 2.6MB per second to and from the prototype Power Macs. The 8100 has a second SCSI channel with an internal connector; this channel is compatible with the SCSI-2 Fast protocol and transfers data at up to 10MB per second. Actual throughput depends on the speed of your SCSI devices.

DIRECT MEMORY ACCESS In the Power Macs, data passes through the SCSI, serial, ethernet, and sound ports directly to and from memory at high rates because a direct memory access (DMA) controller supervises the data transfer, relieving the CPU of this chore. The same controller chip provides DMA for the internal floppy drive port. DMA leaves the

issues, there are two more basic questions to answer first. Of these, the critical one is, how much you can afford. The second is, what do you want to do with your Mac.

Budget is more complex than a simple sum. Of course, if you only have £800 then your options are strictly limited, but larger budgets shouldn't automatically mean a bigger, better Mac. For one thing, any Mac is more useful and more generally productive if you have a printer. Second, you'll need at least some software and while the Performas come with enough to get you started, you'll probably still want more, and other Macs don't have any.

What you want to do with your Mac is a more complicated question and sometimes the answers are counter-intuitive. You might, for example, think that a business user needs a more powerful Mac than someone buying for home use. But in fact, the business user (doing a lot of word processing and average spreadsheet work, for example) may well be satisfied with a comparatively low-end Mac with a greyscale display, spending more of the budget on a laser printer and extra storage. But home users should strive to afford a colour Mac since nobody's

CPU free to perform other tasks uninterrupted, resulting in faster data transfer through the ports and faster processing of other tasks. NuBus Apple says that the Power Macs' NuBus slots – there are three

NuBus card and the CPU, and 80MB between NuBus cards. Apple says it has measured data transfers at 35MB per second from the CPU to a NuBus card, 20MB per second the other direction, and 80MB per sec-

Power Macintosh Pricing

Model	Memory/ Hard disk	Base model	Full system	System with SoftWindows
6100/60	8/160	£1,299	£1,499	£1,919
6100/60	8/250/CD	£1,599	£1,799	£2,219
7100/66	8/250	£2,099	£2,299	£2,719
7100/66	8/250/CD	£2,299	£2,499	£2,919
7100/66/AV	8/500/CD	£2,899	£3,099	£3,519
8100/80	16/500/CD	£3,977	£4,177	£4,321
8100/80	16/1000/CD	£4,477	£4,677	£4,821
8100/80/AV	16/500/CD	£4,077	£4,277	£4,421

Full system price includes 14-inch RGB monitor and extended keyboard.

in the 7100 and 8100 and an optional 7-inch slot in the non-AV 6100 – can transfer data two to four times as fast as other Macs except the 660AV and 840AV, thanks to a NuBus controller chip that Apple designed for the Power Macs. Theoretically, data-transfer rates can reach 40MB per second between a

ond between NuBus cards. SOUND The back-panel ports have more in common with an AV Mac than any other model. The sound-in and sound-out ports handle 16-bit stereo sound for speech recognition and CD audio fidelity. None of the Power Macs include a microphone. COMMUNICATIONS Both the modem

going to be thronging to experience entertainment and education software in black-&-white.

Similarly, it's easy to overestimate the value of some aspects of the system. Most users will be perfectly well served by 256-colour displays. If you place a great emphasis on desktop video, or something like Kodak's Photo CD, you'll find that 16-bit displays are adequate. Only professional designers and publishers need 24-bit colour. For screen size, again designers, publishers and CAD users should buy the biggest display they can afford; the rest of us can get by happily with a 14" monitor – although 16" and 17" displays are better if you can afford them.

Everyone should buy a Mac equipped with 8MB of memory, and for business use more is better. Designers and publishers should consider 8MB the absolute minimum, and 20MB or 32MB is a better target to aim for.

When choosing storage, always buy more than you think you need – or if you have to buy a 80MB machine now, plan on adding an external drive later. And while CD drives are not yet essential, there are increasingly compelling reasons for investing in one, particularly in the home.

port and the printer port are high-speed GeoPorts, like the modem port in the 660AV and 840AV Macs. You can also connect a LocalTalk network or any serial device (like a fax modem) to either GeoPort.

STORAGE Internal storage space is the same on the Power Macs as on the equivalent Centris and Quadra Macs. The 6100 and 7100 have room for a floppy drive, a 3.5-inch third-height hard drive, and a 5.25-inch half-height device with removable media, such as a CD-ROM or SyQuest drive. The 8100 has space for the same plus one full-height or two half-height 3.5-inch drives (not accessible for removable media).

A CD-ROM bundle is also available, and it includes a new type of CD-ROM drive that does not use bothersome CD caddies. Instead, there's a built-in tray to hold the CD, as in a stereo CD player. With the CD-ROM configurations, you get a CD that works as a start-up disk.

PowerPC in Your Future

Apple plans to move all Mac lines to PowerPC CPUs over the next couple

of years. When you move to a Power Mac depends on you and on the software you use.

Certainly you can rule out a Power Mac if you need a portable. The PowerPC 603 CPUs that will be in future PowerBooks won't be available until the end of 1994.

The first Power Macs are mid-range and high-end-business computers. Whether to buy a Power Mac hinges on two issues. For graphic designers, publishers and pre-press operations, the Power Macs will be compelling when native software arrives (throughout the course of 1994). When your key applications are available in native mode, then you can make the move.

For one group of Mac owners, however, a Power Mac purchase is an obvious choice. If you have an older Mac – a II, IIcx, LC or a compact Mac – and have been pondering a move to new hardware, you should go straight to Power Macintosh. Even under emulation, your software will run considerably faster, and native applications will really burn rubber.

Upgrades

Feeling underpowered?

Photoshop speeds getting

you down? Jealous of the

Power Macintosh pio-

neers? Upgrades will help

you boost your Mac's per-

formance, whether it's a

lowly Plus, a racy Quadra,

or a punchy Power Mac.

No matter which Mac you use, sooner or later you'll want something faster, bigger, better. More colours, more storage, more memory, and above all, faster speed. With nearly two dozen models of desktop Macs in use today, the upgrade possibilities seem endless – and bewildering. You can upgrade to Quadra speeds, to Power Macintosh performance, to blistering Photoshop velocities... you can do something to even the lowliest Macintosh and you'd be amazed by how much you can do to the top-of-the-range Macs.

The first thing you've got to get yourself is a strategy – built around what you need now, what you might need in the future, how much you want to spend now and later, and what your present Mac can handle. But before you get down to examining manufacturer's specification sheets, dreaming of all the things you'll accomplish when the upgrade's installed, and wondering how you'll pay for it all, there are a number of

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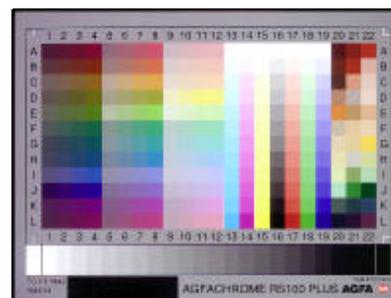
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MacWorld CD-ROM

questions you should ask yourself:

1 Do I need to upgrade? If you're now retouching scanned images or working with QuickTime movies when you used to use just a word processor and electronic mail, the answer is yes. If your system performance has slowed to a crawl because you've installed System 7 and newer, memory-hungry versions of your favourite programs, the answer is yes. But if you've realized that there are faster Macs out there and you feel left out, the answer is most likely no.

However you answer this question, make sure you assess what you do on your Mac and what you're likely to do in the near future, then evaluate those tasks against the processing power your Mac has right now.

2 Will basic enhancements solve my problem? Often, you need only a system enhancement (more memory, a larger monitor, greater colour support, etc) to get rid of a bottleneck that makes your Mac seem underpowered. For example, if your only problem is sluggish file opening and saving, you probably need a faster hard drive. But if practically everything you do seems to

be taking forever, it's time to upgrade your Mac.

3 Do I need an accelerator or a logic-board replacement? Accelerators speed up a Mac's processing and sometimes add support for additional monitors. But an accelerator doesn't update or replace the ROMs or other special Apple features on the logic board. Logic-board replacements (available from Apple for just some Mac models) let you exchange your Mac's logic board for a newer version. But this option can be very expensive, and the performance gains you get may be very small (see [Replacing your logic board](#)). However, if the difference in price between an accelerator and a logic-board upgrade is minimal, go for the logic board; it's a better long-term strategy.

4 Do I upgrade or buy a new Mac? If you expect to run sophisticated programs and peripherals that take advantage of the latest Mac offerings, like QuickTime and the forthcoming Open Collaboration Environment, go with a new Mac – high-end peripherals and programs tend to use the functions in newer Macs that an accelerator

board doesn't offer. Otherwise, an upgrade will probably suffice – for now.

Pick the right products

Once you've determined an upgrade strategy, it's important to evaluate the products available based on their performance; features relevant to your work; price; and customer support. What follows are some guidelines for seekers of better performance.

MEMORY The first upgrade for almost any Mac is RAM. If you want to run System 7 and hefty applications such as Microsoft Word 5.1 and Excel 4.0, you should have at least 8MB. You can get by with 4MB of memory only if you stick to running one major program at a time and keep the number of system extensions to a minimum.

ACCELERATOR BOARDS Accelerator boards tend to stretch the Mac's inner workings in ways Apple never intended, so incompatibilities with both very new and very old programs and peripherals are likely to occur. In addition, not all companies test their accelerator boards thoroughly on all supported Macs.

All vendors provide software fixes to customers who report problems; some companies automatically give the fixes



to all customers who might be affected. Some accelerator board incompatibilities are caused by the board's processor. The 68040 in particular has several compatibility issues that might affect you.

68040 CACHE If a piece of software is incompatible with the 040, your system will crash when you try to use that application. The reason is that some applications can't recognize the 040's internal cache. Most software vendors have updated their programs to work with the 040, so make sure you have the latest version. For software that hasn't been updated, many accelerator vendors provide a control panel that lets you switch the 040's cache mode on or off.

PROCESSOR VARIANTS Some vendors, such as Fusion Data Systems, Radius, and Total Systems, use 040 variants, which can cause incompatibilities. These processors cost less and use less power.

An 040 can have three variants: LC, EC, and ELC. (An 030 can also have the EC variant.) LC indicates that there is no built-in maths coprocessor. EC means that the built-in Paged Memory Management Unit (PMMU) is missing (a PMMU lets a Mac use virtual memory

Replacing your logic board

Sometimes, the best way to upgrade your Mac is to replace its main logic board. But this can also be the least cost-effective approach, so how do you know when a logic-board upgrade makes sense? Follow these three guidelines.

1. Consider what you're getting for the money. Most Apple logic-board upgrade kits cost too much for what they deliver. A notable exception used to be the £450 LC III upgrade for LC and LC II owners. But Mac prices have dipped since then – you can pick up a brand-new LC 475 from only £599, with new floppy and hard drives.
2. Be sure a logic board (and not an accelerator board) is what you need. To be worth the money, a logic-board replacement must offer sufficient new capabilities. Look for expanded video support, higher-capacity system buses, more storage capacity, faster SCSI ports, higher memory capacity, and built-in extras like ethernet. If a logic board doesn't offer at least several of these features, an accelerator may be a better-performing, less-expensive alternative.
3. Avoid investing in a dead-end Mac. Apple has clearly decided that the LC series, Centris/Quadra 610, Ilvx/Centris/Quadra 650, and Quadra 800 are the platforms for the long term, so you are likely to get good support (and more upgrade options) for these machines for years. Most important now – possible upgrades to PowerPC technology (see later).

under System 7). ELC indicates that both the maths coprocessor and PMMU are missing. Another code, RC, is not a variant but simply denotes that all processor functions are built in.

VIRTUAL MEMORY Many 040-based accelerators are incompatible with virtual memory (which is why many vendors use the cheaper EC040 variant). Check before buying if VM is important.





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CACHE CARDS Cache cards, which store common instructions and data in a special type of memory that the Mac's processor can access quickly, are another form of acceleration. The IICI, IIx, and Quadras are the only Macs that support cache cards.

If your Mac supports a cache card but doesn't have one, strongly consider adding one. You can increase performance by 10 to 20 per cent for between £125 and £350 – enough, perhaps, to keep you from buying more acceleration than you really need.

MATHS COPROCESSORS Beware the ads that promise spreadsheet-speed improvement if you buy a maths coprocessor (also called an FPU, for floating-point unit). The truth is that only a specialized set of mathematical operations (trigonometric and transcendental) take advantage of the maths routines imprinted in a maths coprocessor. So follow this easy rule: if you don't know what these calculations are, you don't need a maths coprocessor.

VIDEO DISPLAY Since the autumn of 1990, Apple has included built-in colour monitor support for new Mac models, letting you hook up standard colour monitor sizes (12" and 14", even

16") without adding a video-display board. But you need a display board if you have an older Mac.

A sluggish display board or built-in video can make a system seem to run slowly when in fact the bottleneck is getting the image to the monitor. In addition, a small monitor can require extra scrolling, which slows your performance. Speedy video-display boards and larger monitors solve those problems.

Because many Macs have only a few expansion slots, vendors are increasingly turning to multi-function display boards. These include accelerator boards with a video port, video-display boards with ethernet, and video-display boards with video-capture and video-presentation capability. If you have few slots available – whether NuBus or Processor Direct Slot (PDS) – the multi-function approach merits strong consideration.

For Macs with built-in video, the most cost-effective way to upgrade may be to add video RAM (VRAM). More VRAM will not speed up your display, but it will let your monitor show a wider range of colours.

STORAGE The constant improvements in hard-drive technology mean that

yesterday's fast drive is today's slowpoke. The solution is to buy a faster hard drive, but don't worry about getting the fastest. Unless you own a Centris or Quadra, your Mac has its own limit on how fast it can communicate with a hard drive. Drive speed is measured in milliseconds (ms) and referred to as access time; speeds of 15ms to 23ms are fine for most Macs.

If you have a Quadra or other fast Mac, consider getting a SCSI accelerator, especially if you're using the Mac as a database server or you're working with large image files.

OTHER OPTIONS There are several upgrade options that might apply to your Macintosh: slot extenders that add NuBus or PDS slots; ROM upgrades for older Macs that wouldn't otherwise be able to support a SuperDrive; and power-supply replacements that let you add even more devices to your Macintosh or use more power-hungry ones.

Plan for the long term

Because upgrades often involve spending hundreds (perhaps thousands) of pounds, try to foresee your needs over the next several years. It's easy to buy more performance than you need in

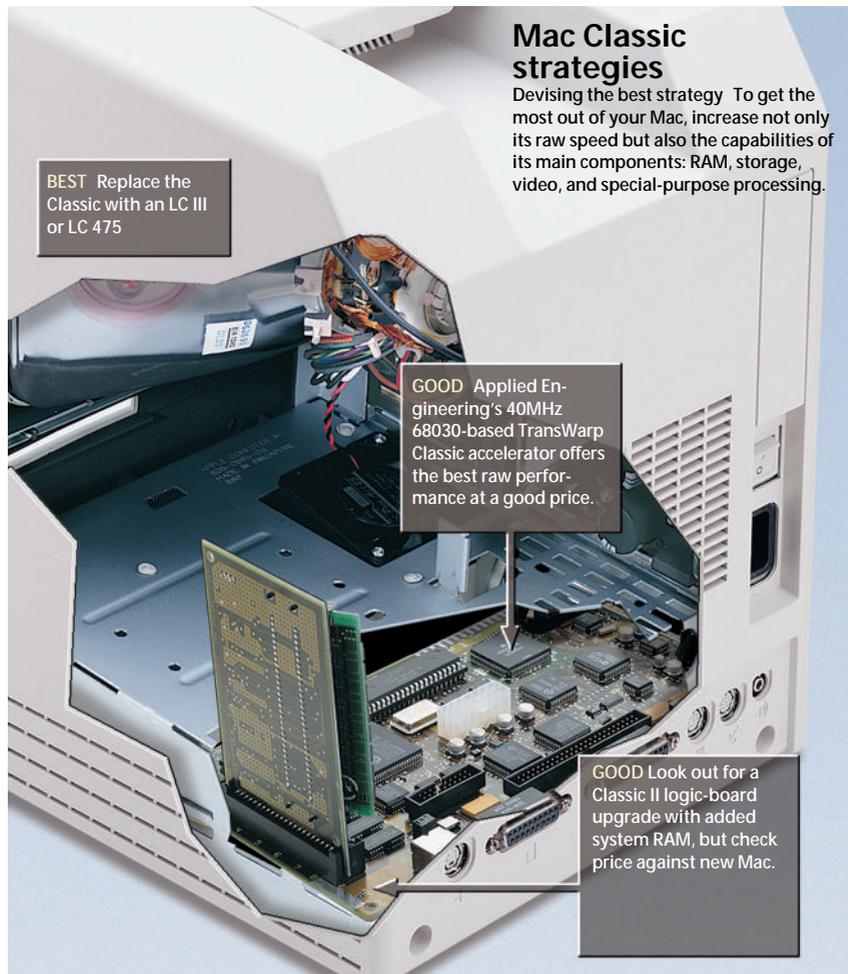


the quest for having the latest and greatest. But it's also easy to buy lots of marginal upgrades that, over time, add up to more money than what you would have spent on a major upgrade to begin with.

There will always be a faster, more capable Mac just around the corner – this is probably the one immutable law of computing. But you can keep up with the Joneses without going broke by thinking ahead and choosing your upgrade strategy wisely.

Compact Macs

Hand-me-downs. Outdated curiosities. It's easy to dismiss older compact Macs as little more than antiquated appliances. Unless, of course, you need to use one. A Plus or even an SE/30 might lack the power and suavity of Apple's newer offerings, but many thousands of them get the job done each day. I know. Back in the dawn of desktop publishing, I helped edit the first magazine put out on the only Macintosh around – a 128K with a single floppy drive and no hard drive. Memories of those days made several years of publishing a 16-page newsletter on an unaccelerated 1MB Plus seem like a cinch. (OK, scrolling TIFF files in Page-



Mac Classic strategies

Devising the best strategy To get the most out of your Mac, increase not only its raw speed but also the capabilities of its main components: RAM, storage, video, and special-purpose processing.

BEST Replace the Classic with an LC III or LC 475

GOOD Applied Engineering's 40MHz 68030-based TransWarp Classic accelerator offers the best raw performance at a good price.

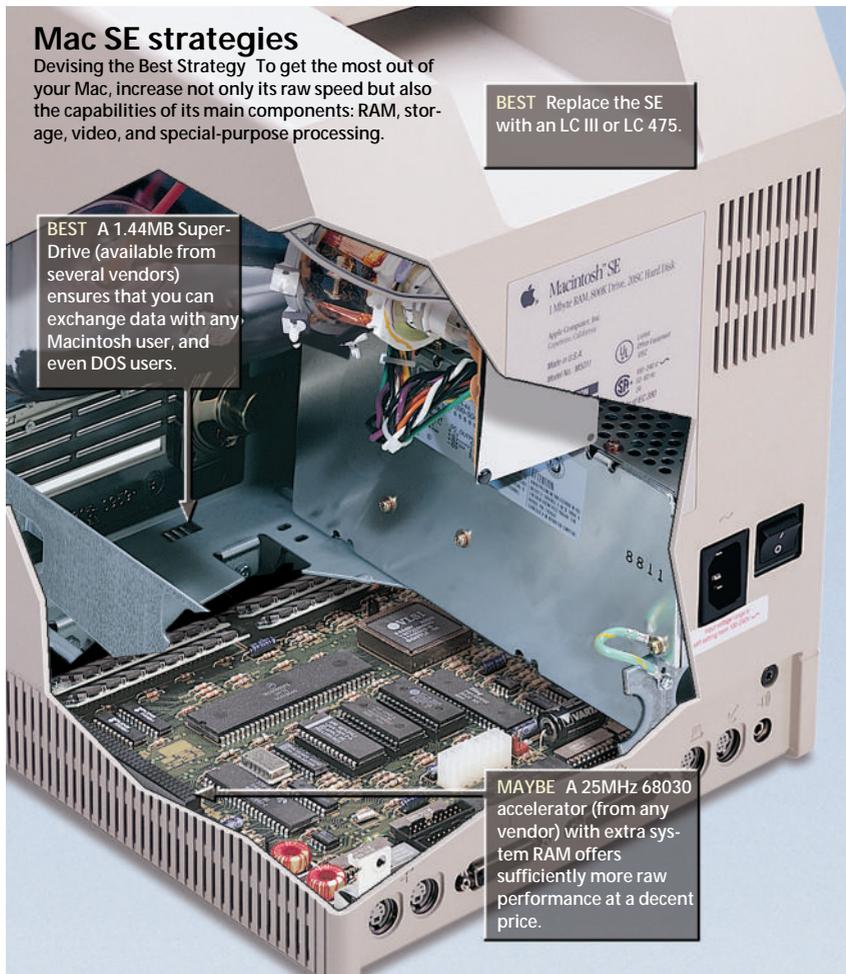
GOOD Look out for a Classic II logic-board upgrade with added system RAM, but check price against new Mac.

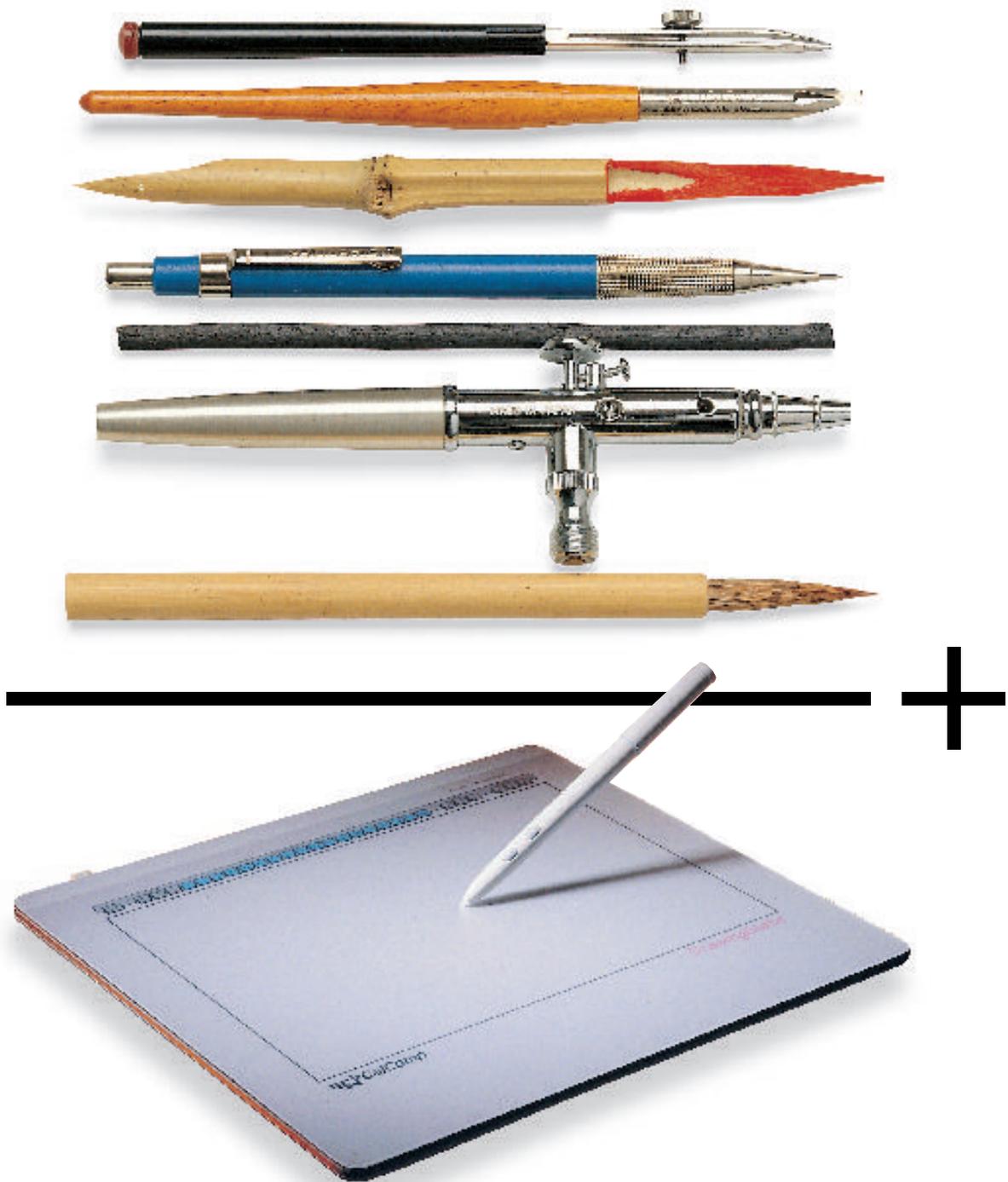
Maker was a tiny bit aggravating.)

I know scientists and educators who keep large flat-file databases on SEs. One researcher I've interviewed runs sophisticated statistical analyses on an SE/30. But there's always room for improvement.

Still, upgrading a compact Mac involves some painful choices. These Macs were not designed, for the most part, to be upgraded. Sure, you can add memory and maybe an expansion board. But that's about it. If you're seriously constrained by your compact Mac's limitations, you should graduate to an LC III or 475 or midrange Mac that offers wider video and expansion options, plus an upgrade path for the long term. Mac prices are getting low enough, even for those on a budget. If you decide that your compact Mac is basically all right, but you'd like to see improvements in one or two areas, then selective upgrading makes sense if the price is right. If you've outgrown your Mac and your budget is very tight, an upgrade may be your only option.

Plus The Plus has very few upgrade options and is, fundamentally, hardly worth upgrading. Use it as is, sell it, or give it to charity. Consider buying an LC III to replace it.





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SE Buy an accelerator if you need improved performance, but don't go for the top of the line, because a new Mac would be cheaper.

SE/30 The best improvement is to get access to more RAM, which means making sure you've installed Mode32 or, if you're running System 7.1, Apple's 32-Bit System Enabler Extension.

CLASSIC If all you want is more speed, buy an inexpensive accelerator. Otherwise, replace the Classic with an LC III.

CLASSIC II (PERFORMA 200) Live with it, sell it, or replace it with an LC III.

Compact Macs (despite their appliance-like design) do allow incremental changes. The performance of the Plus, SE, SE/30, Classic, Classic II, and Colour Classic can all be enhanced. Deciding which upgrade path best suits your budget and suite of tasks is the trick. But if your needs are bigger, you might need a new Mac.

LC Macs

The best-selling Macs ever, the LC series (the LC, LC II/Performa 400, LC III/Performa 450, and LC 475/Performa 475) offer good performance at hard-to-beat prices, making them the perfect Macs for word processing, home-office computing, electronic-mail access, un-

Mac LC strategies

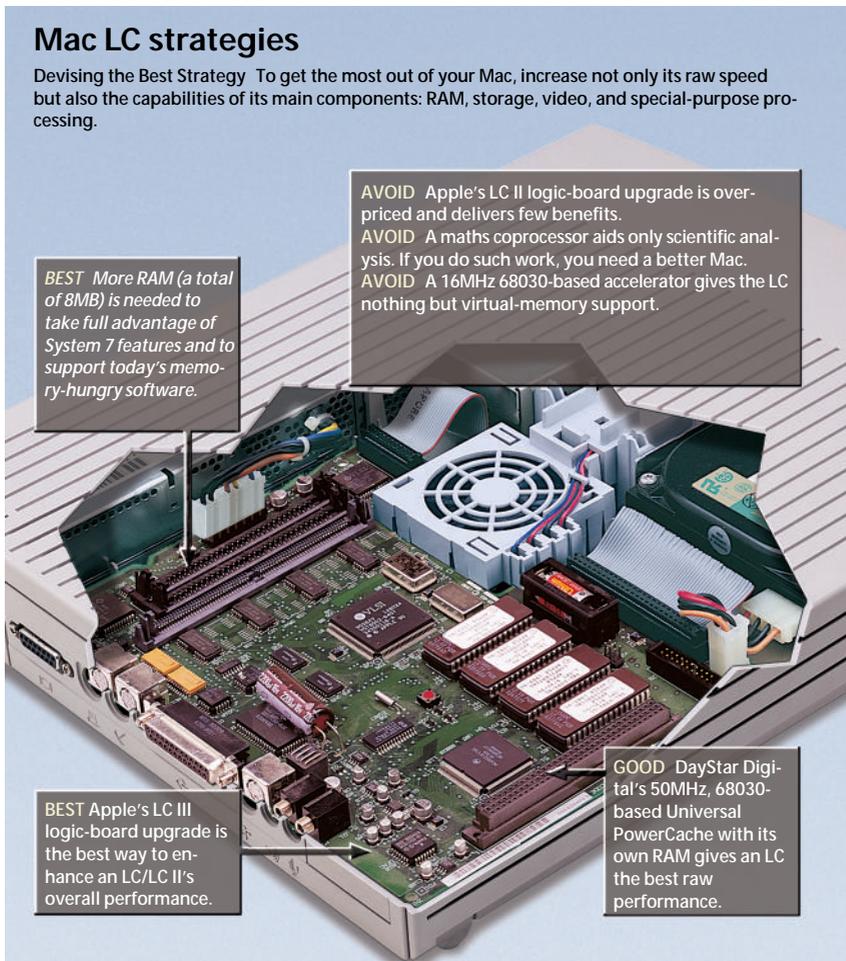
Devising the Best Strategy To get the most out of your Mac, increase not only its raw speed but also the capabilities of its main components: RAM, storage, video, and special-purpose processing.

BEST More RAM (a total of 8MB) is needed to take full advantage of System 7 features and to support today's memory-hungry software.

AVOID Apple's LC II logic-board upgrade is overpriced and delivers few benefits.
AVOID A maths coprocessor aids only scientific analysis. If you do such work, you need a better Mac.
AVOID A 16MHz 68030-based accelerator gives the LC nothing but virtual-memory support.

BEST Apple's LC III logic-board upgrade is the best way to enhance an LC/LC II's overall performance.

GOOD DayStar Digital's 50MHz, 68030-based Universal PowerCache with its own RAM gives an LC the best raw performance.



complicated spreadsheet work, and other basic business applications.

Although their small, pizza-box size makes the LCs appear to be impossibly constrained in terms of performance, there are several worthwhile upgrades that will give your LC a long, useful life.

LC AND LC II (PERFORMA 400) The LC and LC II are still fairly new machines, so you don't have to worry about upgrading outdated components. Instead, focus on removing any unnecessary bottlenecks, such as insufficient memory or slow hard drives – or the logic board itself. Here are some

The first upgrade any LC/LC II owner should consider is memory (the LC has 2MB standard; the LC II, LC III, and LC 475 have 4MB). Insufficient memory (less than 8MB if you're using System 7, and under 4MB with System 6) prevents you from running several applications and INITs concurrently.

Upgrading an LC or LC II to an LC III is the best way to overcome generally sluggish performance, since Apple's £450 logic-board replacement will almost double your system's speed. The upgrade betters the earlier LC II upgrade board by adding 16-bit colour depth (32,768 colours) for 14" monitors and 8-bit colour for 16" monitors, as

well as support for 15" monochrome portrait monitors. An Apple logic-board upgrade to the LC 475 should soon be available (check with dealers).

There's one considerable drawback to this upgrade, though. The LC III and 475's RAM SIMMs differ from those used in an LC or LC II. As a result, any memory you've already added to your LC or LC II won't work with the LC III or forthcoming 475 upgrade. If you recently bought this memory, you might be able to return it in exchange for the new SIMMs, but it depends entirely on your dealer's refund and exchange policy.

While the LC III/475 upgrade makes the best sense overall, anyone interested in the best possible raw performance will want an accelerator board.

The LC and LC II have decent (but not speedy) built-in video RAM (VRAM) that's fine for word processing, presentation design, and spreadsheet use. But if you intend to work with colour images, paint programs, or QuickTime, look to enhancing your video performance. Similarly, if you need monitors larger than 14 inches, you'll have to upgrade your video.

You have two choices: replace the LC or LC II with an LC III/475 logic board

or add a speedy video-display board.

LC III Many of the strategies for the LC and LC II apply to the LC III as well. Although the LC III can theoretically support 36MB, most owners will probably have to settle for less. The LC III has only one RAM slot, so buy the largest-capacity SIMM you can find, since adding more memory later means throwing away the additional RAM you installed earlier.

Unlike the LC and LC II, the LC III uses 72-pin DOS SIMMs, which are readily available in the 4MB capacity but not in larger sizes. If you look around you should be able to find 8MB and 16MB SIMMs – and doing so will ensure that you have memory to spare for the days when even 8MB isn't enough.

To get the LC III's 36MB maximum memory, you'd have to buy one 32MB SIMM board (the LC III comes standard with 4MB), but SIMMs in that capacity aren't always easy to find.

Keep your eyes open for the logic-board upgrade that'll make your LC III into an LC 475. Until then, several companies offer accelerator boards that work in the LC III, boosting clock speeds and upping the chip to an 040.

The LC III is the first LC with a slot for an optional maths coprocessor. Shop

around (at local dealers and mail-order vendors) for a good deal on a Motorola 68882 maths coprocessor: just make sure it runs at least as fast as the LC III's 030 processor (25MHz).

The Mac II family

The Macintosh II family is more receptive to upgrades than most Macs are. All Mac II's, except the IIs, contain at least three NuBus expansion slots, which open the door to, among other things, accelerator boards that boost processing speed; video-display boards that provide more colours, faster display speed, or both; and network boards that provide faster alternatives to the built-in LocalTalk ports that all Macintosh computers have.

II AND IIX The oldest and largest members of the Mac II family, the II and IIX are also the least prone to obsolescence. Six expansion slots (more than even the Quadra 950 provides) and a heavy-duty power supply combine to make the II and IIX (as well as the IIfx) the most expandable Macs. But the II and IIX do not have built-in video, which means you must fill one slot with a video-display board.

If you have the computer's original hard drive, it's probably slow by today's

Mac II strategies

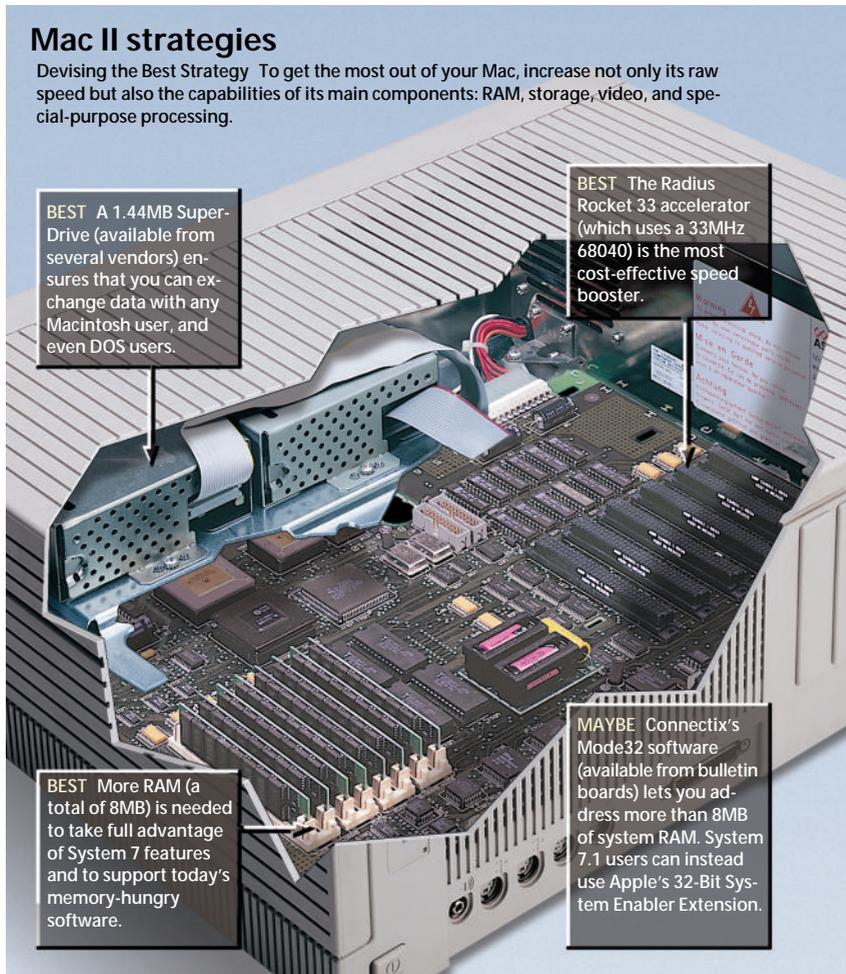
Devising the Best Strategy To get the most out of your Mac, increase not only its raw speed but also the capabilities of its main components: RAM, storage, video, and special-purpose processing.

BEST A 1.44MB Super-Drive (available from several vendors) ensures that you can exchange data with any Macintosh user, and even DOS users.

BEST The Radius Rocket 33 accelerator (which uses a 33MHz 68040) is the most cost-effective speed booster.

BEST More RAM (a total of 8MB) is needed to take full advantage of System 7 features and to support today's memory-hungry software.

MAYBE Connectix's Mode32 software (available from bulletin boards) lets you address more than 8MB of system RAM. System 7.1 users can instead use Apple's 32-Bit System Enabler Extension.



standards – the 20MB, 40MB, and 80MB drives that Apple used in the Mac II had access times in the region of 30 to 60 milliseconds; today, access times of under 20ms are common.

The Mac II and IIx ROMs aren't 32-bit clean and were designed to support only up to 8MB of system memory. You can work around these limitations, though – with the Connectix Mode 32 control panel or Apple's new 32-Bit System Enabler, an extension to System 7.1. You can install more than 8MB on the logic board, but you need special RAM SIMMs containing a programmable-array logic (PAL) chip or its equivalent. The Mac II has some additional weaknesses. It lacks a SuperDrive; third-party 3 1/2-inch drives are available, as are floptical drives that take 1.4MB disks as well as the 21MB flopticals.

Even if you pick up a IIx logic board, remember that you also need to buy memory – the IIx can't use the existing SIMMs on your Mac II or IIx. And if you have a Mac II, you'll probably want the SuperDrive upgrade, too. When you're finished, you'll have a machine that's still quite a bit slower than today's faster Macs.

An accelerator board is a better upgrade for a Mac II or IIx. For ease of

Mac IIci strategies

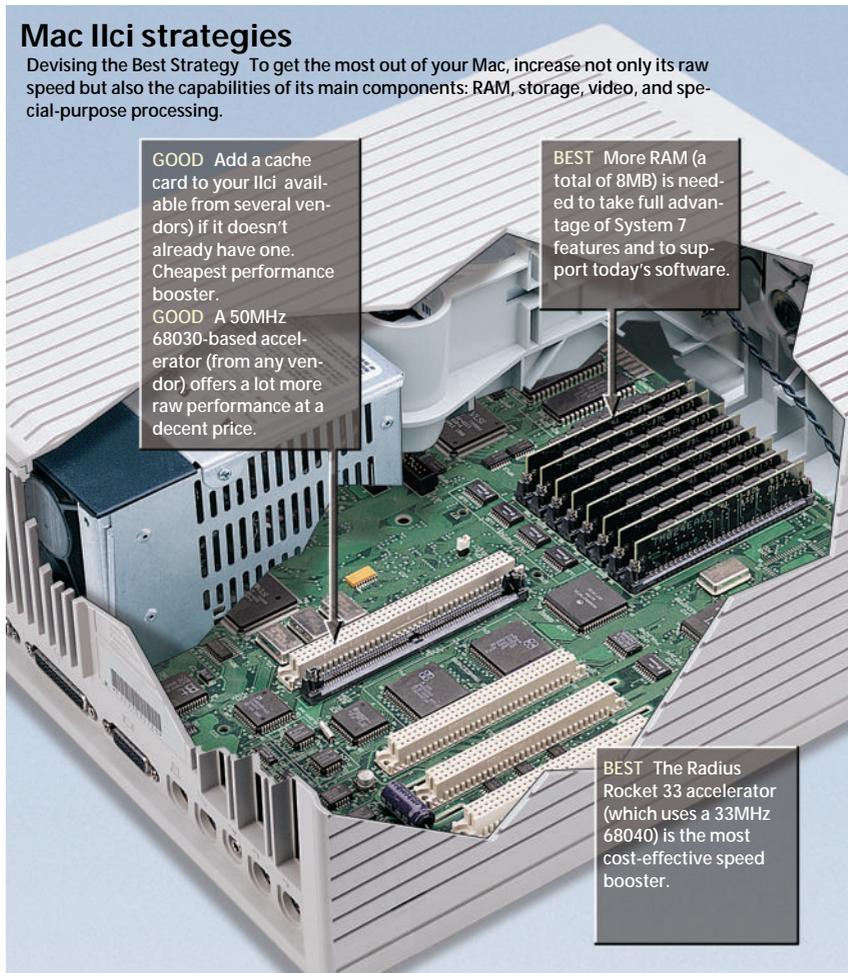
Devising the Best Strategy To get the most out of your Mac, increase not only its raw speed but also the capabilities of its main components: RAM, storage, video, and special-purpose processing.

GOOD Add a cache card to your IIci available from several vendors) if it doesn't already have one. Cheapest performance booster.

GOOD A 50MHz 68030-based accelerator (from any vendor) offers a lot more raw performance at a decent price.

BEST More RAM (a total of 8MB) is needed to take full advantage of System 7 features and to support today's software.

BEST The Radius Rocket 33 accelerator (which uses a 33MHz 68040) is the most cost-effective speed booster.



installation, the Radius Rocket boards are best: they install in a NuBus slot and don't require any delicate chip-pulling surgery. The Rockets' ability to accommodate up to 128MB of memory (using standard SIMMs) is another plus.

Ilcx While not as expandable as the Ilci, the Ilcx, with the right upgrades and add-ons, is still a worthy mid-range Macintosh. The Ilcx has three NuBus expansion slots and accommodates up to 128MB of memory (using eight 16MB SIMMs). A SuperDrive is built-in, and there is room for a second floppy-disk drive if the internal hard drive is removed. The Ilcx has no built-in video, and is not 32-bit clean.

Note that after adding an accelerator, some weak spots remain, including a relatively slow SCSI port and no ethernet networking.

Ilci A still-viable midrange Mac, the Ilci accommodates a larger selection of performance enhancements than does any other Mac II. The Ilci has three NuBus slots and a cache card slot. The cache card speeds performance by providing a small amount (usually 32K to 64K) of fast memory, which holds the most recently used program instructions or data in the likely event the processor needs them again.

The built-in video is capable of displaying 256 colours, which is adequate for basic business tasks and spot-colour publishing. The Ilci accommodates up to 128MB of memory; its ROM is 32-bit clean. However, the built-in video uses up to 300K of the Ilci's memory, thereby slightly reducing the amount of memory available for applications. More significant, this slows the machine when the SIMMs in Bank A are of a larger capacity than those installed in Bank B. The 3 1/2-inch hard drive bay limits internal hard drive selection.

Most Ilci models contain Apple's 32K cache card (the card was an extra-cost option for early models). If yours is an older Ilci and you want a modest performance gain, consider a cache card.

For a bigger boost, consider an accelerator board.

Ilci With just one expansion slot, the Ilci is the least-expandable Mac II. Its expansion slot is flexible, accepting either one PDS board or one NuBus board (both require an adaptor board for installation). Large expansion boards, however, can tax the small power supply.

The Ilci has just four SIMM slots, limiting maximum memory capacity to 65MB. The ROM is 32-bit clean, and the

Ilci includes built-in 8-bit (256-colour) video. Built-in video, like that of the Ilci, can slow overall performance. There's no built-in maths chip (one is built into most 68030 PDS or NuBus adaptor boards as well as many accelerators).

Fewer accelerators are available for the Ilci than for other Mac II's, thanks largely to the Ilci's featherweight power supply.

Ilvx AND PERFORMA 600 Plenty of upgrade options (including a PowerPC upgrade) and a generous array of built-in features give the Ilvx a long life expectancy. To display thousands of colours (on most monitors) instead of 256, add a VRAM SIMM to bring video memory up to 1MB.

If you crave speed, go for Apple's Centris 650 logic-board upgrade (£825). In addition to a roughly 150 per cent improvement in overall performance, you get a faster SCSI port and built-in ethernet. The Centris 650 can't use any 1MB SIMMs you might have (its minimum SIMM size is 4MB), but this isn't a significant drawback, since the upgrade includes 8MB of memory.

CENTRIS/QUADRA 610 AND 650 Both of Apple's briefly named Centris midrange Macs do provide room to grow. If you're buying one of these second-



hand, check the technical specs carefully. There are significant differences between early base Centris models and later Quadras.

These Macs accept a VRAM upgrade that lets them display thousands of colours on most monitors. They provide NuBus expandability, with the Centris/Quadra 610 supporting one 7-inch NuBus slot and the Centris/Quadra 650 providing three full-size NuBus slots. Because the 610's slot size is a new standard for Apple, few boards on the current market will fit it. In addition, you must buy a £70 adaptor to add a NuBus board to the 610. The same is true of the Centris/Quadra 660AV, which has the same short case as the 610.

The Centris/Quadra 650 also has a PDS slot that accepts PDS boards designed for Quadras. Most models of the 610 and 650 come with built-in ethernet ports. If you bought a model that doesn't include an ethernet port, you can add one via third-party adaptor board or SCSI-based box.

If you own a Centris 610 without a maths coprocessor and find yourself getting into 3D graphics, you might consider upgrading the processor from a 68LC040 (a version of the 68040 with

no maths coprocessor) to a full-fledged 68040, which has a built-in maths coprocessor that speeds up 3D rendering programs.

All high-end Macs

Although "high-end" tends towards specialized applications, there are general guidelines for all of them to follow.

Anyone doing serious desktop publishing work should consider 20MB of memory the minimum, while Photo-shop users working with large files need at least three times as much RAM as the largest file they work with.

Because a math coprocessor resides on the logic board of the Mac IIx and is built into the processor of the Quadras, there is nothing to upgrade.

A hard drive's performance contributes significantly to the Macintosh's overall performance. On low-end and mid-range Macs, the hard drive is less important because other system components are slower. But an adequate drive for, say, a IIci, can become a bottleneck between applications and the processor when used on, say, a Quadra 950.

When shopping for a fast hard drive, don't rely solely on average access times or raw theoretical transfer rates –

they don't accurately predict real-world results. Pay less attention to small differences in access time (like 2 milliseconds) and instead look for read-ahead buffers and write-ahead buffers, which can make a significant difference in actual performance. Only a few companies manufacture the mechanisms used in high-speed, high-capacity hard drives, so you can focus more on the vendor's price and the mechanism's performance than on the label on the case.

The latest hard drives offer gigabyte or better capacity, high data-transfer rates, and first-rate reliability.

Unless they use two SCSI ports simultaneously, drive arrays (also called Level 0 RAID, or Redundant Array of Independent Drives, systems) offer little or no performance advantage over regular high-capacity drives, despite a theoretical advantage. They also offer another disadvantage: increased chance of data loss. Data is written partly on one drive and partly on another, so if one drive has a problem, you might lose all the data stored on both drives.

A related performance bottleneck is the SCSI port built into every Mac since the Plus. No Mac SCSI port can transfer

Quadra 900 strategies

BEST More RAM is needed to take full advantage of System 7 features and to support publishing and graphics.

MAYBE Increasing video RAM lets you display as many as 16.7 million colours on a 16-inch monitor. If you need this on a larger monitor, get a video-display board.

BEST A cache card (available from several vendors) is the cheapest performance booster.

MAYBE Applied Engineering's Quadra-Link DMA lets you attach four serial devices to one serial port, which is great if you use the Quadra as a server or as a manufacturing-control system.

AVOID Apple's Quadra 950 logic-board upgrade offers little but a faster processor, whose performance you can get much more cheaply with a cache card.

data faster than about 3.5MB per second (MBps). That's why many vendors support the new SCSI-2 standard, which adds new software and two new data bus types: SCSI-2 Fast and SCSI-2 Wide. See page 78 for more on SCSI-2.

Publishers, product designers, and CAD users will want large screens (and probably photo-realistic 24-bit colour) so accelerated, large-screen video is a must. See page 122 for more on 24-bit video cards. Other users should consider adding VRAM.

IIfx The IIfx's performance is comparable to that of the Centris Macs and, for some tasks, to the old Quadra 700.

With six NuBus slots, the IIfx is one of the most expandable Macs ever made, and its 128MB maximum memory will meet most high-end users' needs. Its 40MHz 68030 processor and accompanying 68882 maths coprocessor are fast enough for many computation-intensive tasks.

The IIfx does not use a 68040, which is the de facto high-end Mac processor. (Among the 68040's advantages is a built-in maths coprocessor that works faster than the IIfx's 68030/68882 combination – an important consideration for rendering and CAD users.) Since it's a discontinued product, long-term sup-



port and compatibility remain in doubt. The IIfx uses a special type of RAM (a 64-pin SIMM also used in the Laser-Writer IINTX) that no other Mac (or other popular computer) uses, and this RAM is likely to be harder to get as fewer IIfx's remain in use and the incentive to provide it decreases.

If you have already invested a lot in your IIfx, such as adding a lot of memory and accelerated video, it's probably worthwhile to stick with the system you already have. But keep in mind that a fully loaded Quadra 650 or Quadra 800 offers a platform that will let you improve your processing power over the long term.

By selling your IIfx and buying new (keeping the IIfx's NuBus boards for that new Mac), you may spend only a little more than you would to upgrade, but you would get a better, long-term configuration.

QUADRA 700 The Quadra 700 is a dead-end Mac, with little room for expansion. If you seek a powerful Mac for the long term, sell your Quadra 700 and replace it with a Quadra 650 (which is more powerful, much more expandable and which seems designed for a long PowerPC-based future). If you decide these options cost too much, consider the

following upgrades to make the most of your Quadra 700.

QUADRA 900 AND 950 If you have a Quadra 900, use a cache card to bump its speed up to that of a Quadra 950. Apple's £975 upgrade that makes a Quadra 900 into a Quadra 950 is overpriced. Bypass it in favour of system acceleration. Just as with a Quadra 700, your only option is a cache card.

QUADRA 800 The Quadra 800 is similar to the 700 in that it has a single SCSI port, so you can't use a dual-port drive array as in the 900 series. Your best bet is to start with a fast hard drive and add a SCSI board if you need more speed.

Upgrading your high-end Mac means tailoring it to your needs. Speed is just one factor in creating an optimal system. By balancing all the system components, you will get a turbo-charged Mac for the long term. Think of it as holistic computing for the power-hungry.

Adding it all up

Whether you buy a new Mac or upgrade an older one, keep in mind that faster, less expensive, more powerful machines will always be on the horizon. The Macintosh world is a moving target, and your system is a snapshot –

an image of the intersection between your budget and Apple's product line at the time of your purchase. If you can't afford to change that image by buying a new machine, it's comforting to know that you can at least spruce it up with accelerators and other upgrades.

PowerPC upgrade strategies

Longing to cash in on Power Macintosh speed, but find yourself a little short on the green stuff to make it a reality?

Three hardware upgrade options that should be available at the same time as the new Power Macs will enable many older Macs with 68040 CPUs (as well as the 030-based Ilvi and Ilvx) to use PowerPC 601 CPUs and run Power Mac software.

A replacement motherboard from Apple works in all older Macs that have the same cases as the new Power Macs. The other two upgrade options, one from Apple and one from DayStar Digital, will work in Macs that have a 68040 CPU and an 040 PDS slot; the DayStar upgrade also requires a NuBus slot. Other upgrades are in the works.

Power Mac motherboard An older Mac whose case is similar to one of the Power Mac models (the Quadra and



Centris 610, 650, 660AV, 800, and 840AV models, as well as the Ilvi, Ilvx, and Performa 600) can become a true Power Mac for about half the cost of the new computer – from about £900 to £1,700, depending on the Power Mac model. Any of those older Macs can acquire a Power Mac AV motherboard with the audio and video capabilities of a Quadra 840AV. An Apple dealer replaces the Mac's motherboard and back panel.

This motherboard upgrade makes economic sense if you need a full-featured Power Mac but want to protect your investment in a high-quality hard drive, and you need a CD-ROM drive and keyboard. The Power Mac motherboard has 8MB of RAM soldered to it, a 4MB bonus for 610 and 660AV upgrades. Also, all the RAM SIMMs from a Centris or Quadra (but not a Ilvi, Ilvx, or Performa 600) can be moved to a Power Mac motherboard.

Apple estimates that street prices will be about £900 to £1,700 for motherboard upgrades, with the 6100/60 at the low end of the range, the 7100/66 in the middle, and the 8100/80 at the highest end.

POWER MACINTOSH UPGRADE CARD If you're looking to save even more

money, consider Apple's user-installed Power Macintosh Upgrade Card, which should sell for about £600. Such cards will work in all Quadra and Centris models with a PDS slot (except the Quadra 605, which uses an LC III-style PDS slot). Working in conjunction with the host Mac's motherboard, the upgrade card makes it possible to run PowerPC native software on the older Macs.

While Apple's Power Mac upgrade card appeals to people on a tight budget, it also suits those who need a reversible upgrade, ensuring full 68040 performance and compatibility with 680X0 software (including the driver and ROM software of NuBus cards). While the upgrade card can run 680X0 applications in emulation, this can cause a significant slowdown in performance. Alternately, many users will take advantage of the option of shutting off the upgrade card (without removing it), restarting the Mac, and enjoying true – and faster – 68040 on the motherboard for running 680X0 applications.

The upgrade card comes with its costs, however: you lose the option of Power Mac AV features, including 16-bit sound, speech recognition, and

GeoPort – critical elements of future Mac computing.

The PowerPC 601 CPU on the Power Macintosh Upgrade Card runs at twice the speed of the 68040 on the motherboard using a technique called clock doubling. Thus the PowerPC 601 runs at 50MHz on a Centris 650 or a Quadra 610, 700, or 900; and at 66MHz on a Quadra 650, 800, or 950. The card runs at 40MHz on a Centris 610, which calls into question the value of the Centris 610 card upgrade; the 610 requires a PDS adaptor to install the card, raising the price to about £700. For only £900, you could buy a motherboard with all Power Mac AV features included.

The upgrade card has no RAM of its own; it uses the RAM on the motherboard (8MB minimum). Although the PowerPC 601 can access RAM across a 64-bit data path, the motherboard has only a 32-bit data path to RAM. The mismatch creates a performance bottleneck for the 601, which Apple has diminished with a whopping 1MB secondary RAM cache on the card.

The Apple upgrade card has no slots or ports, nor does it have circuitry to support them. It works with the NuBus slots, the back-panel ports, the built-in video, and the I/O circuitry on the

motherboard. One NuBus slot is not usable because the upgrade card sits behind it in the PDS slot. (A Centris or Quadra 610 has no NuBus slot available when the upgrade card occupies the one expansion slot.)

DAYSTAR POWERPRO 601 Another upgrade option, is DayStar's PowerPro 601 for the Centris 650 and the Quadra 650, 700, 800, 900, and 950. This card should come in two versions (66MHz and 80MHz) and at DayStar's estimated prices of £1,215 to £1,620, would not be cost-effective for most users.

It would appeal, primarily, to a fairly narrow band of users who rely on two kinds of programs simultaneously: native PowerPC versions of high-end graphics and publishing programs which are starting to become available now that the Power Macs have shipped, and specialized, high-performance 680X0 programs (say, custom statistical, engineering, or scientific programs) that are unlikely to go native soon.

DayStar anticipates that its PowerPro card will be speedier than Apple's upgrade card because PowerPro cards will run at 66MHz or 80MHz, independent of the host Mac's speed, and can use Quadra-style SIMMs, increasing the

PowerPC recommendations

- Centris and Quadra 610 owners can choose Apple's motherboard upgrade or a Power Mac Upgrade Card. At £900, a 6100/60 motherboard costs only £300 more than the upgrade card, and its greater performance and functionality are worth it unless you need to run 680X0 software on a real 68040 CPU.
- Quadra 700, 900, and 950 owners can choose either upgrade card. If top performance when running native PowerPC applications and the ability to run 040 applications in native mode are both vital, and price is no object, consider DayStar's PowerPro 601; but check the most current reviews to make sure they verify DayStar's expectations. If moderate performance is acceptable, save £500 to £1,100 and get Apple's upgrade card.
- Centris 650, Quadra 650, and Quadra 800 owners can choose a motherboard upgrade or either upgrade card based on the advice in the preceding paragraphs.
- Ilvx, Ilvi, Performa 600, Quadra 660AV, and Quadra 840AV owners have only one choice, an Apple motherboard upgrade. An Apple motherboard upgrade turns your old Mac into a full-fledged Power Mac, while Apple's Power Mac Upgrade Card and DayStar's expected PowerPro 601 let you hedge your bets by running PowerPC software on the upgrade card and 680X0 software on your Centris or Quadra motherboard. Either way you get Power Mac performance without buying a new computer.

total RAM available. The PowerPro will have faster access to its own RAM than it has to RAM on the host motherboard. The PowerPro also has a slot for an extra RAM cache.

OTHER POWERPC OPTIONS Other upgrade options should be out later this year. Applied Engineering is nego-

tiating a licence for the Power Mac ROM from Apple and plans to make upgrade cards for Macs that have a 68040 CPU and a PDS slot. Apple plans an upgrade for the Performa 475 and 476, and the LC 475. DayStar plans to migrate the PowerPro upgrade cards to other colour Macs.



Photoshop acceleration

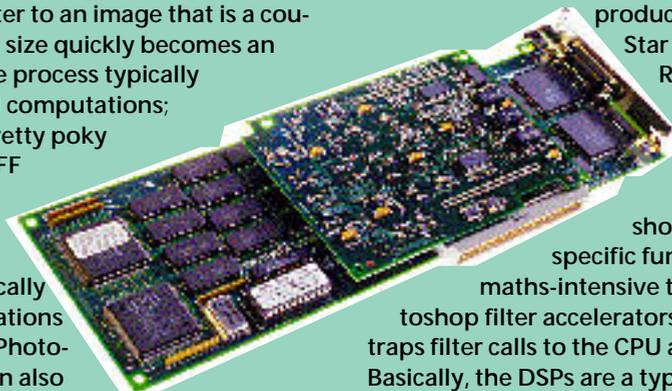
If you frequently need to retouch large image files in Adobe Photoshop using such filters as Gaussian Blur, Sharpen, and Emboss, then you need either the patience of Mother Teresa or a digital signal processor (DSP) board.

Applying a Photoshop filter to an image that is a couple of megabytes or more in size quickly becomes an exercise in endurance, as the process typically involves large mathematical computations; even a Quadra 800 seems pretty poky when sharpening a 40MB TIFF file. To the rescue come DSP boards – special-purpose hardware with micro-processors designed specifically to accelerate the math operations that lie at the heart of most Photoshop filters (some boards can also accelerate filters in other programs, such as Fractal Design's Painter).

DSP technology received a lot of attention with the release last year of Apple's AV Macs, which include AT&T's DSP3210 chip as a dedicated processor for telephony and video processing, among other tasks. If you already own a Quadra 660AV or 840AV, you can use the AV Macs' DSP to accelerate Photoshop filter operations using Adobe Systems' AV DSP Power Plug-In for Photoshop. The plug-in sends 18 filter operations to the 3210 DSP, is included in Adobe Photoshop 2.5.1, and is available free from online

services or for a small fee from Adobe (081 547 1900).

After a year or two of false starts, DSP boards began appearing on store shelves in late 1993. Among companies now selling or planning to sell DSP products are Radius, SuperMac, Day-Star Digital, E-Machines, and RasterOps, at prices ranging from just under £599 up to nearly £3,600.



How DSPs Work Photo-shop filter acceleration is a highly specific function that's usually more

maths-intensive than QuickDraw calls are. Photoshop filter accelerators depend on software that traps filter calls to the CPU and passes them to DSP chips. Basically, the DSPs are a type of specialized math coprocessor designed to perform multiplications rapidly in parallel (most products use two DSP chips and split up computations between them).

Many filters accomplish their tasks by taking sums and differences of transformed versions of the original image. The exact number of computations needed to alter an image using a filter depends on the size of the image. A filter applied to a 5MB image, for instance, can result in more than 100 million arithmetic operations, a large fraction of which will be multiplications.

A computer image is, in essence, a configuration of



numbers, coded in colours by the Mac so it's easier to manipulate. Applying a Photoshop filter to that 5MB image is the equivalent of recalculating a ridiculously large spreadsheet (an 81/2-by-11-inch image at 300dpi is a 2,550 by 3,300 array of numbers) in which the recalc operates on every cell. That's why Photoshop filters in native mode on a Mac without a DSP board are so slow.

WHAT ABOUT POWERPC? Now that the first PowerPC Macs have arrived, many Photoshop users may wonder whether DSP boards are still a worthwhile investment. While the first PowerPC Macs to appear have standard PDS and/or NuBus slots, the next generation is expected to use a new bus format, the PCI – meaning the DSP boards you buy today aren't designed to work in the PowerPC models to be released a year or two from now. Even if that becomes the

case, however, DSP boards in PowerPC Macs will be largely superfluous; Apple claims that the PowerPC Macs' multitasking RISC processor will be all you need for image-editing acceleration.

Nonetheless, DSP boards should remain a cost-effective upgrade to existing Macs for at least the next year or two. The first 60MHz PowerPC Macs have about three to five times the processing power of the Quadra 800 (with its 33MHz 68040 micro-processor). But if most of your computing time is spent using Photoshop, you can get an equivalent speed increase for much less than the price of a new PowerPC Mac. For example, a PowerPC Mac with the 60MHz 601 chip costs from £1,299. By comparison, the overall fastest DSP

board we tested, the Radius PhotoBooster, costs £999.

TIME TO BUY No matter which DSP board seems most appropriate for you, you should have a game plan for PowerPC Macs and factor that into your buying decision.

On the one hand, with a PowerPC Mac all your applications will eventually run faster – an attractive reason to head straight for a Power Mac. On the other hand, the fastest DSP boards are a match for the PowerPC, and several of the boards cost considerably less than a new computer.

Also, a DSP board buys you some time; you get an immediate performance boost while you watch how the first wave of PowerPC Macs shakes out. Bottom line: If you're

working on an older Mac and spend hours every day in Photoshop, you need a DSP board, and this is a good time to buy. – Charles Seiter

Macworld Recommended...

PHOTOBOOSTER In most of our tests the PhotoBooster came out ahead of the pack. Its AT&T DSP3210 chip makes it a good choice for graphic artists who'd like to add some AV Mac functionality to their computer. Company: Radius. List price: £999.



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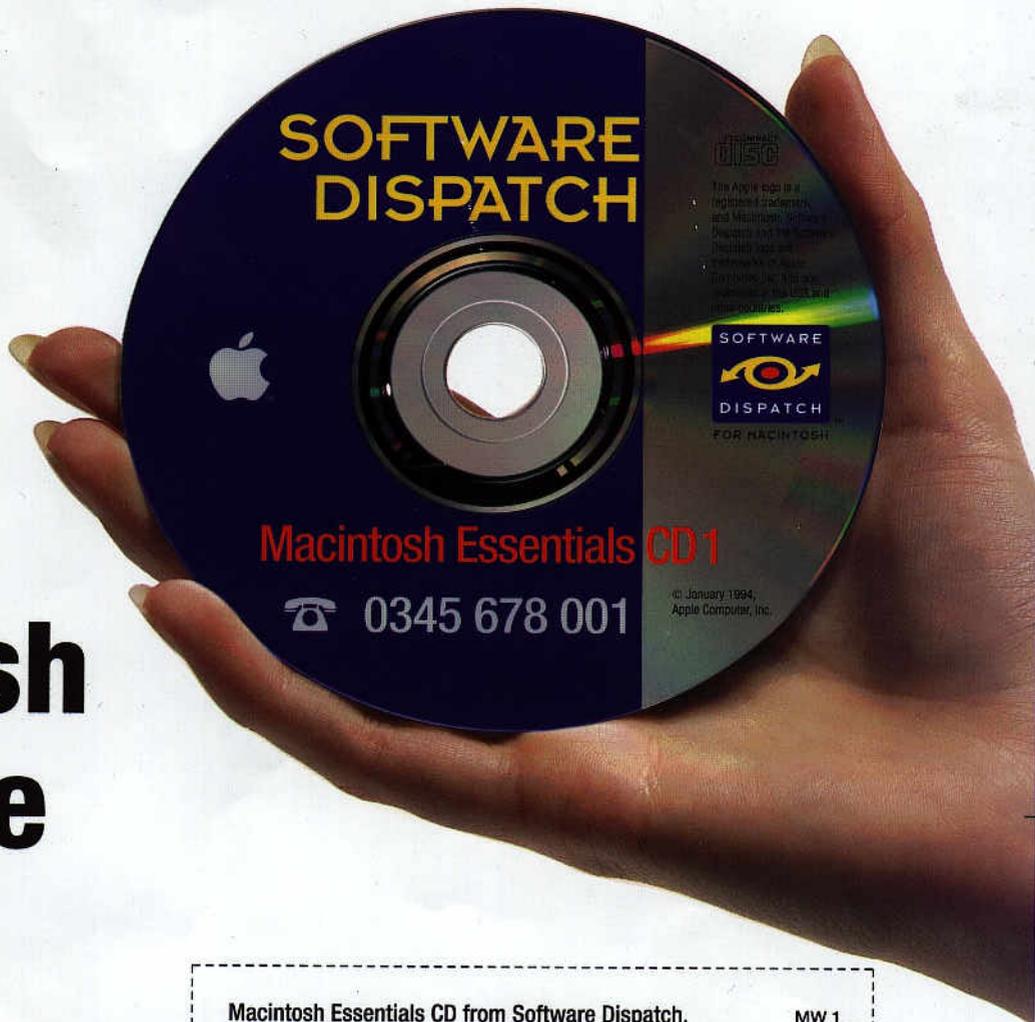
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Where to buy

Choosing which Mac to buy causes enough headaches – but choosing where to buy it from offers far more possibilities, advantages, disadvantages, trade-offs, compromises, bargains, rip-offs, legal wrangles, satisfaction, and nagging doubts. It's not that hairy really...

An old Ukrainian proverb suggests that when you are skinning your customers, you should leave some skin on to grow so that you can skin them again. While a few PC dealers probably still haven't heeded that advice, a lot more have and today's Mac consumers are getting a much better deal now than they were a few years ago. Apple has made a concerted effort to simplify the choices available. Currently, if you want to buy a Mac you can either have a Performa, an LC, or a Quadra. You could also choose a PowerBooks. Or, if you like to be on the cutting edge of technology, you could opt for a new Power Mac. Unfortunately, while clearer marketing and cheaper prices have made buying a Mac and related bits easier, deciding where to buy is not quite as straight forward.

According to Apple's Richard Bradley, the number of various authorized companies selling Apple products has grown from 200 to 500. However, unlike many general consumer retailers that belong to trade associations, most of these outlets where

where you can buy Macintosh kit do not have standard codes of practice drawn up with the advice of the Office of Fair Trading. Every dealer, regardless of their size, status or market focus, will swear blind that they 'guarantee' the best level of pricing, service, and support on offer. However, all too often these glowing promises can be about as honest and reliable as a Serbian cease-fire agreement.

Broadening the channel

In 1991, there were around 50 AppleCentres in Apple's 187-strong dealer network. Today, there are around 60 AppleCentres plus an expanding array of other outlets such as authorized dealers, high-street retailers, dealer chains, PC stores, superstores, and even mail-order houses. "We've broadened the channel to reflect the way people want to buy," said Bradley. "Customers will choose to buy from outlets where they feel comfortable to buy from and we've tried to establish a presence in all of these sort of places."

Today, customers have more choice as to where they can buy Macintosh systems and this trend is reflected in the growing number of users who now buy through various PC and super-

store-style resellers and the ever increasing number of customers buying by post through mail order houses or directly from catalogues from the US.

A few years ago when Apple began to realize that it needed to change its distribution structure to reflect a more accessible high-street approach for low-end machines, it launched a number of ApplePoint shops in conjunction with a number of authorized dealers. The idea was to provide a less intimidating environment where consumers could browse around, try out various Mac systems, and perhaps play a game or buy software as quickly and as easily as walking into a branch of Dixons.

On the street

While these ApplePoint shops did achieve a degree of success, Apple finally decided that if it was really going to provide the convenience of a high-street shop, why not simply use a high-street shop. So, with the launch of lower-cost Macs and the introduction of the Performa range, Apple struck a deal with established retailers such as Dixons, Ryman, Wildings, Argos, and John Lewis. This means that the Macintosh Performa range is now distributed in some 1,000 consumer retail outlets

across Europe and every Macintosh Performa comes complete with enhanced system software, pre-loaded applications and hot-line support for start-up assistance.

Buying a Performa from a high-street retailer is no more difficult than buying a GameBoy or a VCR. The sales staff may not be quite as knowledgeable about Apple kit as, say, staff in an Apple Centre, but for most non-specialist buyers, these outlets are as good as any.

If you're buying for business, education, or any other high-end specialist application, expertise and after-sales support are likely to be more important so the AppleCentre or authorized dealer network is probably the best place to start if you're looking for anything in the LC, PowerBook, or Quadra range. AppleCentres used to have a distinct advantage over other outlets in that most of their staff were trained and supported by Apple itself. However, as Apple has co-operated in the broadening of the whole retail channel, service and support can now be equally as good from superstores and traditional PC resellers.

"Traditionally, AppleCentres have offered superior knowledge and service," said Bradley, "primarily because

they concentrate on one single product line. They have an Apple-only approach which means that they can offer more choice, and they're more familiar with the entire product line including peripherals and software so they can cater for niche and vertical market specialisms. Nowadays, AppleCentres are more independent and each one operates differently depending on the personalities involved."

While customers can now choose between AppleCentres, authorized dealers, and a plethora of PC dealers and superstores, the fastest growing outlet for Macintosh kit is mail order. Until very recently, Apple UK did not officially permit the sale of Macintosh hardware by mail. That doesn't mean it didn't happen, it simply means that it wasn't officially sanctioned. Before Apple saw the light and began to cut prices and market low-cost systems, a number of often unscrupulous individuals made quite a nice living out of what was quaintly called 'grey importing'. Macintosh systems, sourced overseas in a way that took advantage of price and currency fluctuations and discrepancies, were marketed in the UK, often by mail, at prices considerably less than the SRPs offered by autho-

rized Apple dealers and AppleCentres. Today, with more international pricing controls, there's very little incentive for ventures into the grey market and a new generation of mail order supplier is beginning to emerge offering a real alternative to customers who want to shop in the convenience of their own home.

According to Apple's David Bradley, mail order now accounts for around 30 per cent of the UK Mac market. And even out of the 60 per cent which is sold through traditional PC resellers ranging from VARs to out-bound sales forces, over 12 per cent now behave in a 'mail order fashion'.

Joining the already established line of mail order suppliers such as MacWarehouse and MacLine, Apple launched its own version of catalogue consuming called Apple Direct. The catalogue includes sample configurations for business, entry level, and mobile users plus a full range of monitors, printers consumables, and software. Ordering from Apple Direct is quick and easy and you can place your order via a toll-free number from 8am to 8pm Monday to Friday as well as 9am to 6pm on Saturdays. In line with new views on Sunday trading, Apple

Direct even allows you to purchase kit from 9am to 6pm on Sundays and bank holidays if you so desire. If you don't want to tie up your telephone, you also have the option of completing an order form included in the centre of the catalogue and posting or faxing it back to Apple Direct. Apple is keen to emphasise that Apple Direct ensures the very best in quality, value, and service – so, for example, orders of £500 or more are delivered next day at no extra cost. You also get a 'no-quibble' 30-day returns policy and all prices in the catalogue include 1 year's on-site support.

Dial a program

While there are currently several ways to buy Macintosh technology, you can now even use Macintosh technology to buy software. Around a year ago, a new company called InstantAccess launched a service allowing users to sample various software applications from a compact disc and if they liked them, they could ring up, pay for them, and receive a code to unlock the full version from the disc.

Last November, Apple UK announced a similar scheme for customers to explore and purchase software for Macintosh and Windows

personal computers. Like InstantAccess, Software Dispatch provides a CD-ROM delivery system that lets customers try, compare, and buy popular software in the comfort and convenience of their home or office. When customers call the Software Dispatch number to order, they receive an unlocking key upon telephone purchase that lets them immediately install and use their software. Software Dispatch CDs are distributed by mail for a nominal charge of £5.95.

"We're committed to providing superior software solutions to both Macintosh and Windows customers," said Annette Bono, business manager of Software Dispatch at Apple UK. "Software Dispatch is more than a new business for Apple – it's a whole new way for the industry to bring solutions to a broad reach of target customers."

When you begin to explore the Software Dispatch CD, a QuickTime movie tutorial is available to explain the trial and purchase process. You can then interactively discover the features and benefits of specific software via guided tours, limited trial versions, and product information sheets. Once a selection has been made, you simply click an order button which automatically adds

the software to an electronic order form and when you're ready to buy, simply dial the Software Dispatch number to receive a key that unlocks the software allowing you to immediately install the application directly onto your hard disk.

The unlocking mechanism also provides access to on-line product documentation that is identical in content to the print version traditionally delivered in a software box. "CD-ROM-based software distribution is rapidly gaining momentum in the marketplace," said David Pratt, senior vice-president and general manager for Adobe's Application Products Division. "What distinguishes Software Dispatch as a software shopper's resource is not only its array of available applications, but advanced electronic documentation readers such as Acrobat, that make the customer's experience easier and more consistent."

If you're simply buying an LC or Performa and StyleWriter for home use, you can probably afford to shop around for the best price. Buying from a mail-order house or unauthorized dealer is probably no riskier than buying from any other high street shop such as Dixons. Macintoshes, on the

whole, are incredibly well-made and reliable pieces of equipment and you probably won't need much after-sales support and service. If, however, you are buying for a medium to large company, you're probably better off sticking to the authorized or specialist channels where you will get better pre and post-sales advice and service as well as the option of extended maintenance agreements, specialist training, etc. For everyone else in between, there's no single solution for every situation apart from getting as much information and advice as you can.

If something goes wrong after you've purchased your system, always take your complaint to the seller, not the manufacturer since in law, it is the seller who is responsible for the goods.

No matter what you are told, you have the same rights in law when you buy through mail-order as when you buy from a dealer. When you buy by mail, it's always a good idea to use a credit card since this provides added protection if there's a problem with your purchased goods. Some large companies are members of MOTA (Mail Order Traders Association), which provides a code for prompt delivery dates, return of unwanted goods, servicing

arrangements, complaints, and so on. MOPS, or the Mail Order Protection Scheme, provides some protection if you send off money for goods to an advertiser who goes into liquidation or bankruptcy before dispatching your goods. Provided you apply to the Advertising Manager of the publication which carried the advert within the time specified, you should get your money back. These schemes do not cover classified ads or traders who advertise catalogues from which you have to order goods.

If any dealer displays or advertises a lower price on something than they actually charge for it, they are committing an offence under the Trade Description Act 1968. If you see an advert that is seriously misleading, contact your local Trading Standards Officer. It's also worth noting that your rights are not affected when any guarantee runs out since any guarantee offered is always in addition to your legal rights under the Sale of Goods Act.

Just in case there's any doubt, the Sale of Goods Act 1979 states that once a dealer has accepted your offer to buy, a legally enforceable contract has been made giving both parties certain rights

and obligations. Any 'seller' has three main obligations:

- to ensure that goods are of merchantable quality
- to ensure that the goods are fit for any purpose made known and will perform in the way the seller assures
- to ensure that the goods are as described, ie in any display, sign or advert

The Consumer Protection Act

If a dealer agrees to deliver goods within an agreed period or by a given date, it is legally bound to have the goods ready for you by that date. If they fail to deliver, you have the right to cancel the order and ask for your money back. You may also sue for compensation if you were forced to spend more as a result of not receiving the goods on time.

While there are plenty of suppliers to choose from when buying a Mac or peripherals, you should be aware that companies do sometimes go into liquidation. Romtech estimates that 50 outlets a month will close in 1994 compared with 58 per month in 1993 although the overall rate of failure last year among resellers slowed by around 16 per cent.

Earlier this year, the flagship Apple

dealer, AppleCentre Waterloo became insolvent and is now being liquidated by KPMG Peat Marwick. The Companies Act 1985, as amended by the Insolvency Act 1986 currently governs companies' conduct and administration and the principal purpose of the legislation is to protect third parties – creditors, customers, and employees, as well as shareholders and investors.

Unfortunately, there is no precise legal definition of insolvency. Usually, a company is legally insolvent if it is unable to pay its debts and discharge its liabilities as and when they fall due. Different definitions apply when considering disqualification and wrongful trading, but essentially, a company becomes insolvent if it goes into liquidation at a time when its assets are insufficient for the payment of its debts and other liabilities and if a receiver, or 'insolvency practitioner' as they like to be called, is appointed.

If your favourite Mac supplier or dealer goes into liquidation while you're still waiting for some goods or services, what can you do? If you've paid by credit card, you may be able to recover what you've spent. If you've paid by cheque or hard cash, you're probably out of luck.

APPLECENTRE/AUTHORIZED DEALER

FOR:

- Official authorized channel
- Full support, service, and backing assured by Apple
- One-year worldwide warranty on all Apple hardware
- Professional advice and training
- Niche and vertical market specialists available
- Some advantages for corporate or bulk purchases

AGAINST:

- Not particularly interested in individual consumer or one-off purchases
- Probably the most expensive prices
- Few official discounts
- Variable standard of service despite Apple requirements

Unfortunately, in cases of liquidation, large corporate creditors are usually first in the queue when assets are carved up leaving little or nothing at all for customers. If you can prove wrongful trading or even fraudulent or negligent misrepresentation which is covered under section 2(1) of the Misrepresentation Act of 1967, you may be awarded compensation if you're prepared to go to court. However, going to

OTHER AUTHORIZED DEALER

FOR:

- Official authorized channel
- Full support, service, and backing assured by Apple
- One-year worldwide warranty on all Apple hardware
- Can be less formal than AppleCentres
- Prices occasionally cheaper than AppleCentres

AGAINST:

- Not geared up for specialist applications
- Not always 'Apple-only' in approach
- Staff not always au fait with Macintosh and peripherals
- Not always that interested in individual or one-off purchases

law can be expensive and settlements are never as simple or straight forward as one might think. According to the Office of Fair Trading, while there is little you can do after a company goes into liquidation, you can avoid problems by following these few simple rules:

- Never hand over money to a company or trader you know nothing about. Only pay if you're satisfied that the firm

is reputable and an established business

- Don't pay any money in advance unless you absolutely have to
- If you pay in advance, pay by credit card. If you have any problem or the company disappears, you may be able to claim your money back from the credit card company
- Insist on a receipt when paying cash showing the company's full name and address and only buy from companies belonging to trade associations that offer protection against lost deposits

Second-hand Macs

One way of getting a higher spec Mac relatively cheaply used to be to buy second hand through auctions, classified, ex-rental, or ex-demo or even reconditioned machines from dealers. However, Apple's more aggressive pricing and the added power of new machines means that this is no longer quite as attractive as it used to be.

If you are interested in 'second-user' kit, start with the obvious classified ads in various popular computer magazines. There are even bespoke 'shopper' magazines now which look a bit like computer versions of Exchange & Mart. These should give you a fairly

clearview of what individual users think they can get for secondhand kit although be aware that personal owners usually have an inflated view of its value. You should also remember you won't receive a warranty.

Owing to the current economic climate, a number of companies have emerged to deal exclusively with bankruptcy and liquidation stock. Often, Mac equipment obtained from these sources is new or hardly used and can be bought much more cheaply than from individual vendors. Another particularly good place to look for secondhand kit is from the various computer rental companies. Make sure you deal with a reputable firm.

While second-hand or recycled Macs can be excellent bargains for certain applications, the whole market does have its risk. Fortunately, Macintoshes are well-made and fairly reliable so if they haven't been physically abused, there's no reason why you can't buy a good, reliable system secondhand.

Before you buy second-hand, always:

- Shop around and make sure you have a feel for the current pricing/performance ratios of various machine ranges compared to newer models

MAIL ORDER/CD CATALOGUES

For:

- Lower overheads and high volume providing very competitive prices
- Wide selection of hardware and software
- Will handle smaller-market and low-cost software
- Can order by post or phone

Against:

- Can offer less individual consultation and after-sales support
- Not always a long-established firm – often unreliable
- Little protection available if company goes into receivership unless large and reputable

- Question closely about the age, usage, and origin of the equipment
- Check external casing for signs of neglect or outright hostility & beware of any excess dirt, nicks or scratches
- Check screen for signs of phosphor burn or negative imprint of the desktop
- Check out internal disk drive, keyboard and mouse
- On Mac IIs, examine SIMMs for damage to clips or poor installation
- Choose a Mac with NuBus expand-

HIGH STREET & OTHER RETAIL

For:

- Convenient and familiar
- Range of equipment sold like plug-&-play appliances
- Suitable for most home, SoHo, and some educational uses
- Competitive pricing

Against:

- Staff not always au fait with full range of Macs, peripherals, and software
- Limited range of Mac software and add-ons
- Not really interested in business/high-end purchases
- Bundled software not always most recent version (eg ClarisWorks 1.0)

ability so you'll be able to upgrade speed and power and also have more flexibility in display options

- Confirm your understanding of what you're buying in writing
- Get a receipt with the vendor's name, address, phone number, and, if applicable, VAT number
- If possible pay by credit card; cheque or postal order is next best... never part with cash before you receive the equipment – **Michael Prochak**

You can save your files and fonts to disk, copy them onto a cartridge, call a bureau, deliver the cartridge or pay for a courier, wait for two hours, collect the cartridge and an A3 bromide, get charged up to £20, and then realise that you've made a typo.



OR You can use the GCC SelectPress™

You know what it's like. Bureau outputting is fine - but it's slow, expensive and the control is out of your hands.

Until now..

Output up to 12" x 19" at true 1200 x 1200 dpi

GCC's SelectPress range of A3 plain paper typesetters offer true 600 and 1200 dpi printing, giving you the kind of quality output that was previously only available from equipment costing tens of thousands of pounds more. And they can handle paper sizes up to 12" x 19" and that means full A3 output with crop marks.

Proofing in minutes not hours

For fast data transfer, all the SelectPress printers come with Ethernet as standard.

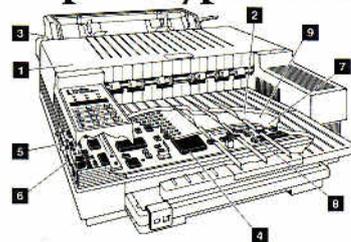
This combined with the latest generation RISC processor means high quality output in record time, even on your most complex pages.

Talk to everyone!

Mac or PC? LocalTalk or Ethernalk? - No problem! SelectPress is

GCC SelectPress Plain Paper Typesetters

1. 1200, 600 or 300 dpi resolutions for camera-ready artwork or fast draft proofing.
2. PostScript Level 2, PCL 5 or HP-GL/2 emulations for true cross platform solution.
3. Printable area of 11.61 by 19 inches giving full A3 with crop marks, and the option of printing direct to plate via the Multi-Purpose Feeder.
4. 25MHz AMD RISC processor with instruction cache for fast imaging of complex text and graphics.
5. Ethernet, serial, parallel, LocalTalk and SCSI interfaces to meet all your connection needs.
6. EtherTalk as standard (with TCP/IP optional) making network printing fast and flexible.
7. 135 PostScript fonts pre-installed on hard disk (SP600 35).
8. 8, 16 or 24Mb memory (upgradeable to 40Mb with



industry standard SIMMs) so even the most complex documents will print easily.
9. 160Mb internal hard drive (SP600 40Mb) as standard making future operating system enhancements and extensive font downloading easy.

a true multi-platform printer offering intelligent Mac and Windows switching via AppleTalk, serial, parallel & ethernet ports.

Internal hard drives for faster printing and easy upgrades

Every SelectPress features an internal hard disk drive (up to 160Mb) to store fonts and operating software, making printing faster and future software upgrades quick and easy.

Cut your bureau bill by up to 99%

A GCC SelectPress can cut your bureau bill by up to 99%* with costs per page less

than 4p it will start to pay for itself from day one. It will also save you time, and give you more control over the typesetting process. And unlike your bureau, the SelectPress can print on heavy bond paper, envelopes and transparencies too!

SelectPress can't eliminate your typos, but can however considerably reduce the time and cost of correcting them!

SelectPress 600	£394
SelectPress 600 Pro.....	£499
SelectPress 1200	£669
SelectPress 1200 with 40Mb RAM.....	£769

For **FREE** sample output & details of your local dealer fill in the form or

Call 081 569 4030



Yes! Send me my free sample output.
Fax to 081 577 5072, or post to GCC Technologies
Name _____ Title _____
Company _____

Black & White Print

Macintosh printer choices used to be limited: you could have a clunky ImageWriter for several hundred pounds, or a laser printer for several thousand. Now, though, the choice is huge – from low-cost inkjets, to a networkable powerhouse

A printer is likely to be the first add-on hardware you buy for your Mac. Unlike a monitor and hard drive, a printer may not actually be essential, but it will extend the range of uses of your computer. And like the Macintosh itself, printers have never been so capable, and so affordable, as they are now. Just a few years ago your choice of printers for the Mac was limited. In terms of affordability, your only choice for a personal printer was Apple's noisy and slow ImageWriter. And the price of even "low-cost" laser printers was such that only company workgroups could justify the expense – even those printers were not particularly network-friendly.

Today, however, there are dozens of models to choose from, from truly low-cost inkjets at the personal level, to fast and powerful, networkable lasers at the workgroup level. And such has been the rapid development of performance, and falling prices, that new categories are emerging: for example, you can now buy a PostScript laser printer for personal use at prices

that just four or five years ago would have bought only a slow inkjet (see [Choosing a Personal Printer](#)).

PERSONAL PRINTERS

Inkjet bargains

Inkjet technology has redefined what you can expect from a low-cost personal printer. Where “personal” and “affordable” once meant slow and very noisy dot-matrix impact printers that produced poor quality output, inkjet has ushered in models that work in near silence and produce excellent print.

Prices start at under £300 but that affordability still means some compromises. Inkjets are still slow, they can be finicky about paper, and produce splotchy copy that smears when it gets wet. On the other hand, new versions of their driver software produce better results with greyscale scanned images.

Take the Apple StyleWriter II (£270), which uses a compact and lightweight (just 6.6 pounds) Canon-built mechanism that prints 360 dots per inch (dpi). The StyleWriter II's driver lets the printer render scanned images better than some laser printers.

The driver also lets you share the

printer on a LocalTalk network – just click on the Setup button in the Chooser and then check the Share This Printer box. (Apple calls this combination and improved greyscale technology GrayShare.) You can even give the printer a password that other users must type before they are able to access it. (One catch is that your Mac slows down when it processes other users' jobs.)

The Hewlett-Packard DeskWriter 510 (£329) can be shared on a network without slowing down the Mac it's attached to. The bulky, 300dpi DeskWriter is aging but still spry. Overall, the DeskWriter is faster than the StyleWriter II, although the latter prints text documents faster. The latest DeskWriter driver improves the printer's greyscale output. HP has added options for dithering – the process of combining dots in patterns that simulate grey shades. The DeskWriter's results aren't as good as the StyleWriter II's, however. For good greys on a bad budget, the StyleWriter II is the inkjet printer to buy.

Printers for portables

In the personal printer department PowerBook owners haven't been for-

gotten. Several companies now offer dedicated printers for output away from the office and desk.

The GCC Technologies WriteMove II (£399) weighs just 2.5 pounds. It isn't an inkjet – it uses a 360dpi thermal-wax transfer mechanism built by Citizen. The thermal-wax output doesn't smear when wet, and large black areas don't mottle as they do with liquid ink. The printer supports a multistrike ribbon that you can use until it's threadbare, or a single-strike film ribbon that produces dark, crisp output. Do stock up, though – the WriteMove II gets only 20 pages from the single-strike ribbon. A pack of five ribbons costs £18.

The Apple Portable StyleWriter (£299), a slightly repackaged version of a battery-powered Canon inkjet, the BJC-10sx. At an almost portly 4.5 pounds, the Portable StyleWriter is nearly twice as heavy as the WriteMove II, but it gets a few hundred pages from a single ink cartridge.

In Macworld Lab tests, the Portable StyleWriter did poorly, turning in about half the speed of the StyleWriter II. The Portable StyleWriter nicely matches the look-and-feel of a PowerBook, but if you can do without battery operation, you'll get much better performance



Take a closer look

Before buying your next printer, you should take a close look to make certain it has Adobe™ PostScript™.

Adobe PostScript gives you consistent, high quality printing of the documents you create, no matter how simple or complex, in black and white or full colour. And it's supported by more than 5000 applications programs, running on DOS, Windows®, OS/2®, Macintosh® and UNIX® computers.

With well over 100 models from leading printer manufacturers to choose from, there's an Adobe PostScript printer to meet every printing requirement and budget, from personal printers to networked print servers.

Only genuine Adobe PostScript offers this combination of quality, compatibility and choice, so ask for it by name.



Adobe PostScript

It's not just printing, it's Adobe PostScript printing

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and greyscale output from the StyleWriter II.

A printer of note in the inkjet category is the GCC Technologies WideWriter 360 (£1,599) – a 360dpi, Canon-based inkjet with the unusual attribute of printing sheets up to 17 by 22 inches. The WideWriter doesn't use PostScript, but includes a driver and outline-font package similar to those of GCC's WriteMove II and PLP II. It also works with ColorAge's PostScript emulator, Freedom of Press Classic. The WideWriter is a low-cost alternative to a large-format laser printer, ideal for proofing tabloid-size publications, and for design applications. It's also a perfect choice for those working with large spreadsheets.

Lasers for less

Although you may think your budget limits you to an inkjet printer, it's worth examining many of the new personal laser printers. Laser prices have gone from five figures in the seventies, to four figures in the eighties, to three figures in the nineties. And they're not just cheaper – most offer more features and better performance than their multi-thousand pound predecessors.

The Apple LaserWriter Select 300

Macworld Recommended...

STYLEWRITER II The StyleWriter II is slower than the HP DeskWriter and not as easy to share, but offers superior output especially when printing greyscale images. It's also small enough to be considered portable, although it doesn't run on batteries.

Company: Apple Computer. List price: £270.

LASERWRITER SELECT 300 Again, Apple's offering is slower than the competition (in this case, the GCC PLP II), but its support for FinePrint and PhotoGrade yields superior output.

Company: Apple Computer. List price: £700.

MICROLASER SERIES The microLaser Plus models are good (and affordable) performers that can be upgraded to the lightning-fast microLaser Turbo.

Company: Texas Instruments. List price: from £1,440.

(£700) is a prime example of this new breed. It uses Apple's FinePrint resolution-enhancement technology to create razor-sharp text, and if you upgrade its memory to 5MB, it supports Apple's PhotoGrade technology to produce the best greyscale output for less than £1,000. There isn't a better non-PostScript printer for producing newsletters and other publications containing scanned images.

The Select 300 connects to the Mac's modem or printer port but can also be shared on a network through the

GrayShare scheme described earlier. The LaserWriter Select line uses a 5ppm Fuji-Xerox engine that uses a Canon-like slide-in toner and drum cartridge. The Select 300 includes a 250-sheet paper tray and accepts a wider variety of paper-handling options than most printers in its price range.

A second 250-sheet feeder costs £105, a 500-sheet feeder is £215, and a 30-envelope feeder is £65. Street prices for the Select 300 may be as little as £500.

Then there's the Apple Personal

Choosing a personal printer

When you're shopping for a printer, it helps to clarify what you expect from your purchase, and what you can expect for the money. Here are some guidelines...

INKJET OR A LASER? With prices starting at £250, inkjet printers sell for about half the cost of a cut-rate laser, and they take up less space. The latest machines (especially Apple's StyleWriter II) produce results that are difficult to distinguish from laser output. (Tip: You can make the output look even better – and eliminate the risk of smearing – by photocopying it.) On the downside, inkjets are slow and lack the paper-handling features most lasers provide. And no PostScript monochrome inkjets are available.

DO YOU NEED POSTSCRIPT? PostScript, a language designed to describe the appearance of pages, is essential if you'll be creating artwork in Adobe Illustrator or Aldus FreeHand, or creating publications that will be printed

by a service bureau. You can also use a PostScript printer with non-Mac PCs, and nearly all PostScript printers include built-in network connectors.

DO YOU WANT POSTSCRIPT LEVEL 2?

PostScript Level 2 is a newer version of the language and provides numerous enhancements, many of which have to do with colour printing. Still, a few Level 2 improvements (the ability to store, or cache, elements that repeat on each page and the ability to accept images in compressed form) have the potential to improve any PostScript printer's performance. If price and other features are equal, choose a Level 2 printer.

INTERESTED IN A CLONE? PostScript-clone printers contain interpreters created by firms other than Adobe Systems. Early clones were plagued with problems, and while today's clones are generally reliable, bugs still surface now and then. *Macworld* recommends you buy a printer with genuine Adobe PostScript, particular-

ly if you rely on PostScript-driven applications like Adobe Illustrator, Aldus Freehand and PageMaker, and QuarkXPress.

WHAT ABOUT TRUETYPE? If you're buying a QuickDraw printer, this question isn't relevant, since all QuickDraw printers support (if not require) TrueType fonts. But if you're buying PostScript and you want to print TrueType fonts look for a printer that contains the TrueType rasterizer. You can print TrueType fonts on a printer that lacks the rasterizer, but they'll take longer to print.

DO YOU WANT HIGH-RES OUTPUT? Several printers incorporate resolution-enhancement technologies that result in smoother text and, in some cases, better-looking scanned images. Other companies use print engines that provide higher resolution – say, 600dpi instead of 300. A printer that produces more dots per inch is likely to cost more, since it requires more internal memory.

LaserWriter 300. Tipping the scales at only 15 pounds, this may be the lightest laser around – it weighs less than Apple's original Mac Portable.

But it isn't a lightweight performer. The Personal LaserWriter 300 supports GrayShare. It uses a new 4ppm Canon engine that sports an energy-saving power-down feature. The printer is always on (there is no power switch) but until the Mac tells the LaserWriter 300 to print a job, it keeps itself in an idle state that uses less than five watts of power. (Several other printers, including GCC's PLP II and Lexmark's LaserPrinter 4039 family, offer similar energy-saving modes.)

The Personal LaserWriter 300 is faster than the LaserWriter Select 300 for text documents, and the two printers performed similarly for graphics and mixed text-and-graphics pages. The Personal LaserWriter 300's paper-handling options don't measure up to the LaserWriter Select 300's (no second tray is offered) but this probably isn't a drawback for the home and small-office market for which this printer is designed. If you disagree, consider the LaserWriter Select 300 instead.

Then there's the venerable GCC Technologies PLP II (£599), the latest

version of the first personal laser printer – GCC's Personal LaserPrinter, which debuted in 1987. The PLP II uses a compact 4ppm engine whose paper tray holds 250 sheets of paper. Changing toner cassettes for this Okidata-built engine is potentially messier than for the Apple printers, which use a disposable toner cartridge-and-drum assembly. But the PLP II's toner cassettes cost only £99 for four. After 15,000 pages, you'll have to snap in an imaging drum at a cost of £239.

Still, the PLP II is one of the least expensive personal laser printers to operate.

The PLP II is the only currently shipping personal laser that connects via the Mac's SCSI port, which can transfer data more quickly than the serial or LocalTalk connectors other printers use. This helps make the PLP II faster than its competitors, but there are drawbacks. Setting up a chain of SCSI devices can be tricky, especially when one of the devices (the PLP II) has just one SCSI port, not the usual two.

Still, the PLP II has a lot going for it. If you use System 7, you can share the PLP II on a network. Unlike almost any other laser, it can print to the left and right edges of the page (output quality

deteriorates a bit at the edges). For £699, you can upgrade the PLP II to a PostScript-based BLP Elite. The PLP II uses GCC's time-tested driver, the latest version of which includes improved dithering routines that produce better results with scanned images.

And GCC was conserving energy long before it became fashionable – the PLP II has always had a standby mode that kicks in automatically after a few minutes of rest. And it has a power switch.

PostScript for Peanuts

Moving further up the scale, you may be surprised to find that you can afford not only a laser printer, but one that supports the industry standard output language, Adobe PostScript.

However, beware if you spy a printer that looks just like a LaserWriter Select 300. This is the Select 300's evil twin, the LaserWriter Select 310 (£945). The Select 310 provides PostScript, but with too many compromises. It cannot be shared on a Mac network (DOS PC users can attach a third-party printer-sharing box to its parallel port), it includes only 13 fonts (the Select 300 comes with 39), and it can't print a complex page (one containing graph-



Using PC printers with the Macintosh

There are hundreds of dot matrix, ink-jet, and laser printers on the market – but comparatively few are Mac compatible. Several vendors bridge this gap between the Mac and PC worlds with adaptor-cable-&-printer-driver packages that allow a Mac to print to nearly every PC printer now available. Those packages include GDT Softworks' PowerPrint, Insight Development's MacPrint, and Orange Micro's Grappler IIsp

All of the packages are hardware-software combinations. Each provides a cable outfitted at one end with a converter that plugs into the parallel or serial port of a PC printer. The packages also include printer drivers for a broad range of PC printers. Some include extra software, such as networking utilities or a built-in spooler – a feature that allows background printing and lets you cancel or reorder jobs you have queued for printing.

The best of the packages, PowerPrint, is available in two versions –

one for individual users and another, PowerPrint/LT, that lets you share the PC printer with other Macs over an AppleTalk network. The PowerPrint adaptor plugs into the Centronics (parallel) port of the printer. The network version of PowerPrint is nearly identical, but includes a bulky external power supply that must be plugged into the adaptor.

PowerPrint comes with printer drivers for numerous types of PCs. The drivers for laser printers contain most of the standard LaserWriter driver options, such as the ability to flip images horizontally or vertically on the page and to make photo reductions at any percentage.

The Grappler IIsp package also supports network use. The driver options aren't as plentiful as those offered by PowerPrint: you can print at three levels of quality but can only reduce documents to 33 per cent and 66 per cent.. MacPrint is the most bare-bones of the Mac-to-PC printer packages. It connects to the printer's

serial port and offers no spooling or networking features.

Of the cable-driver packages tested, PowerPrint was the best performer followed by MacPrint. PowerPrint printed substantially faster than its competitors on complex Word and PageMaker documents containing a variety of fonts. And PowerPrint provided the best quality output on complex graphics and scanned images.

Are converters worth the money? If you already have a PC printer, buying one of these cables gets you a Mac printer for just over £100. If you're shopping for a printer, just think of the wide variety of low-cost PC printers you can choose from if you also invest in a PowerPrint or MacPrint converter. Of course, with Mac printer prices dropping, you still might be better off with a Mac-specific printer; but if your work calls for printing from both Macs and PCs, a conversion package can save the cost of a second printer. – Joseph Schoor

ics and a variety of fonts) without a memory upgrade.

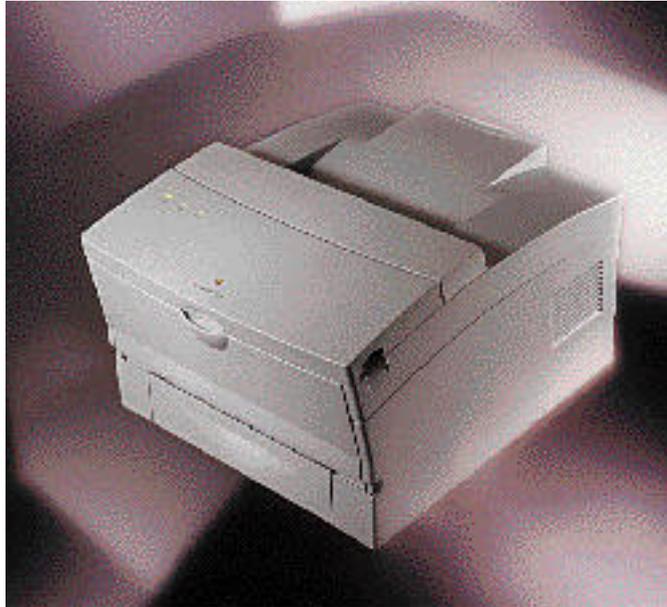
The 310 is probably the slowest PostScript printer available, and it supports neither FinePrint nor PhotoGrade, Apple's output enhancement technologies.

For cheap PostScript, a much better choice is the Texas Instruments microWriter PS23 (£699). This 5ppm printer includes just 23 fonts (a 35-font model costs £1,020), but TI throws in much of what Apple threw out: a LocalTalk network port, enough memory to print a complex page, even HP LaserJet emulation with automatic emulation switching.

Its overall performance is much better than the Select 310's, and the microWriter offers a similar array of paper-handling options.

The 4ppm, 17-font DEClaser 1152 (£979) broke new ground by becoming the first under £1,000 to support PostScript Level 2, the latest and greatest

version of the PostScript language. (Street prices take it below £900.)



Unfortunately it's also very slow, performing just ahead of the slug-like Select 310.

Even better, however, is yet another offering from Apple: the Personal LaserWriter 320 – not the fastest with its 4ppm engine, but with PostScript Level

2 and street prices under £700 it is an excellent choice for those who demand high-quality output.

Going upscale

If you're one of the blessed for whom money is no object, you can afford to look still further down the price lists, at machines that top £1,000.

Many of the printers here outperform machines that cost thousands more a couple of years ago. One fast machine is the NewGen Systems TurboPS/400p, which uses a 400dpi Canon engine, and is also a good deal at £999. The extra resolution not only helps text, but results in better greyscale output, too.

Then there's the NEC SilentWriter Model S62P. This printer has some fine attributes, starting with Post-Script Level 2 and resolution enhancement. Unfortunately, the S62P finished near the bottom of the pack in Macworld speed tests, and it is overshadowed by many newer models from other manufacturers.

Among them is Lexmark's Laser-

Printer 4039-10R (£1,445; a £600 option supports duplex printing – the ability to print on both sides of a page.) The 4039-10R produces 600dpi output and offers text and greyscale resolution enhancement. It also provides energy-saving automatic power-down features.

WORKGROUP PRINTERS

Workgroups today demand a lot more from printers than mere device sharing. Besides providing faster throughput, network printers must distinguish between different jobs and sort them accordingly, notify network users when a job is done, and indicate when the printer is out of paper or low on toner. These devices must even remember where they left off on a job if they run out of paper while printing it. Printers such as the Dataproducts LZR2080 and the Compaq Pagemarq 20 come with multiple paper trays both to handle the extra load that workgroups create and to give users the option of reserving a tray or two for special paper like letterhead or legal-size paper and envelopes. Additionally, printers such as the New-Gen Turbo PS/660B and the GCC SelectPress 600 accept ledger or tabloid (11-by-17-inch) paper.

With multiple users, some of whom may have a computer other than a Macintosh, the printer needs to manage several jobs at once – and it may need to speak HP's PCL page-description language along with the standard Adobe PostScript or third-party PostScript emulation. Software innovations such as QMS's Crown Architecture and HP's autoswitching scheme help printers change between these page-description languages with relative ease. Apple has also joined the fray with its LaserWriter Pro 630 and 810, both of which have PCL emulation on their controller boards. Multiple ports adorn the back panels of these output devices, with LocalTalk, Centronics parallel (for DOS and Windows PCs), and RS-232 serial being the most common. Most also come with ethernet either as an option or built in.

A new wrinkle in the multiuser, multiprotocol saga this year is Dataproducts' *Virtual Printer Technology* (VPT), which lets a network manager create several profiles for a single printer, each offering different capabilities; for example, one might print on letterhead only (see "Virtual printer technology").

Another big story in network printing has been the migration to higher

resolutions. Almost all the printers reviewed here produce at least 600-dots-per-inch (dpi) output, thanks largely to the proliferation of 600dpi engines. Apple's LaserWriter Pro 810, Compaq's Pagemarq 20, Dataproducts' LZR2080, and LaserMaster's Unity 1200XL-O, sport even higher resolution. Although the output from these devices is good, our test results show that higher resolution doesn't always translate into superior printing quality.

Finally, workgroup printers have become easy to afford. The 12 Level 2 PostScript printers Macworld Lab tested cost from £1,300 to £3,500 on average, with the least expensive being the MicroLaser Pro 600 at £1,149.

The best of both worlds

Multiplatform networks used to give end users and network managers headaches. Switching between PCL and PostScript presented a problem: a Macintosh user would send jobs to a printer after a PC user had printed a job, and the Mac job wouldn't print. Or the Chooser wouldn't show the desired printer because you or one of your coworkers had failed to flip the correct DIP switch on the printer.

Today emulation switching isn't so

Virtual printer technology

In a Macintosh-only network, printing is straightforward and uneventful thanks to an excellent printer driver from Adobe and Apple. Unfortunately, it is a different story on an enterprise-wide network of systems that communicate in various protocols over one or more network architectures. Since few standards are available, printer sharing is usually less than efficient.

A primary concern of network printer users is that they don't know which emulation is active at a given time. Automatic switching between PostScript and PCL 5, while mostly reliable thanks to emulation-sensing technology, can occasionally fail to switch to the appropriate format.

Virtual Printer Technology (VPT), Dataproducts' proprietary technology for printer management is the most intelligent solution to date for solving problems associated with printing on a multiplatform network.

VPT allows a network manager to create up to 64 profiles for a single

printer. These profiles are treated by the network as though they were real printers, and users can see and select them from the Chooser.

VPT is convenient for network managers because they can configure VPT-equipped printers (including the new Apple LaserWriter Pro 810) from a remote terminal. The 64 virtual personalities also help managers alleviate many small printing problems users face.

One printer selection might be Virtual Printer Letterhead, which prints in portrait mode at 600dpi in Apple EtherTalk protocol in PostScript format using paper from the letterhead tray. By selecting the appropriate virtual printer, the user can safely assume that the output will be in the expected format.

Another problem associated with network printing is the inadequacy of some application drivers. For example, some older DOS applications support only a single paper tray, a 300dpi laser printer, or even a lowly

dot matrix printer. With VPT, different configurations are preset to take advantage of different printing scenarios; all you need to do is select the virtual printer of choice in the network.

A future version of VPT will feature configuration authorization. Network managers can specifically authorize access to a certain group of users and exclude others. A manager can also set print-queue priorities so that, for example, the boss never has to wait in line to print.

VPT will eventually include resource accounting. This will give a network manager information on the total resource consumption for each user. The network manager can then decide whether to charge departments or users for paper, toner, and general printer use.

Even for users of a Mac-only network, VPT can eliminate many problems. For anyone managing or using an enterprise-wide network, VPT represents a huge step. – Mark Hurlow



bothersome, particularly if the PC users work in Microsoft Windows. Many of the printers here, such as the Compaq Pagemarq 20 and the Dataproducts LZR2080, ship with Windows printer drivers. Many Windows applications speak PostScript, too, so Mac and Windows users mostly work in the same page-description language. For networks whose PC users work only in DOS, however, automatic emulation switching has made switching between PCL and PostScript easier.

With automatic emulation switching, the printer determines whether a file is PostScript or PCL and then switches to that emulation to print the document. The HP LaserJet 4M and 4Si MX, the LZR2080, and the Pagemarq 20 are among the printers offering this capability.

While most cope with simultaneous LocalTalk and parallel connections accepting the jobs on a first-come-first-served basis, Apple's LaserWriter Pro 630 offers a different scheme. The printer's ports are all simultaneously active, so the 630 can, for instance, accept input through its EtherTalk and RS-232 ports. Also, each port is configured for a specific emulation – the EtherTalk and LocalTalk ports accept PostScript docu-

ments only, while a network manager can configure the RS-232 or Centronics ports to accept PCL input.

You can change this configuration at the rear of the printer using two push buttons, or you can use the Mac version of the printer utility software.

The ethernet connection

If you have a large network or print a steady stream of documents, consider a printer that offers ethernet connections. It's a good investment, particularly if many of your users print large documents or documents with multiple fonts or graphics. Of course, if you don't have a Mac Centris or Quadra, which have ethernet as a standard feature, you may have to buy an ethernet card for all the Macs on your network.

Ethernet is much faster than LocalTalk. Its data-transfer rate is 10 megabits per second, while LocalTalk's is 0.234 Mbps. Some companies might use LocalTalk to connect users to a printer with the idea of saving money; however, the time spent waiting for documents to print will probably offset any cost savings.

On a large network, ethernet has a data-transfer rate that is about 400 per cent faster than that of LocalTalk. In

printing, the speed advantage is much lower since print speed is determined by the processors on the controller board inside the printer as well as the print engine.

But when traffic is heavy (as it would be on a large network) ethernet gives you more bandwidth to play with than LocalTalk.

PostScript's stamp

Another boon to cross-platform printing is PostScript, a platform-independent page-description language. Adobe began shipping Level 2 PostScript in 1991, though Apple and Adobe didn't ship the printer driver for another two years. The new PostScript improves most aspects of document processing, especially on printers designed to take advantage of Level 2.

The biggest change you'll see with Level 2 is the use of custom PPD (printer page description) files, which let you customize the driver to the requirements of your printer. For example, you can turn image-enhancement features on and off, switch printer-resolution settings, and switch paper trays. In most applications, these changes can be made from the Print dialog box.

Level 2 boosts background printing



speed between 10 and 30 per cent. Also, PostScript's memory-management techniques now allow the printer's CPU to tap memory from a single memory pool (rather than divide it for separate chores, as is done with Level 1); this should reduce out-of-memory messages when you print documents.

The current Level 2 drivers do have a few drawbacks. There are some compatibility problems with older applications that are documented in the Read Me files from Adobe and Apple. Also, printing is a two-pass process, which doesn't help speed up document processing if you prefer to work with background printing inactive.

Some of the promised Level 2 enhancements didn't make it into the first releases of the software; for example, there is no forms-and-pattern-caching, which would allow data describing a form or pattern to be stored in the printer's memory for rapid reuse. Other features, such as on-the-fly compression and decompression of documents, require updates to the application from which you print.

Macworld Lab tests on the Apple LaserWriter Pro 630 and HP 4Si MX with Level 1 and Level 2 drivers revealed improvements of 12 to more than 30

per cent on complex documents.

We experienced no problems resulting from PostScript emulators like Truelmage or PhoenixPage, but these clones offer no price advantage over true Adobe PostScript and as Adobe refines PostScript software, the clones may need hardware updates – QMS issued a ROM revision to address problems printing from with Illustrator 5.0.

Engine or the controller?

Workgroup printers commonly advertise engine speeds of 8 to 20ppm. If you are printing simple documents with one or two resident fonts, or multiple copies of the same document, you might actually achieve those speeds. But when it includes multiple downloadable fonts, complex art, and halftones, you need to look at how efficiently the controller crunches data to build a page.

Fortunately, printers with high-speed engines tend to have high-powered RISC processors.

Workgroup printers may offer other features to speed-up performance, too. For instance, using QMS's Crown Architecture, the QMS 860 and 1725 Print System printers employ a multitasking scheme that divides the information on

the page into compressed blocks of data instead of dealing with the entire page in a single step. According to QMS, this method allows the printer to compile the elements of the page, rasterize it, and hold the data in memory until the printer is ready to output the document. This processing can continue even as another page is being printed. And if the paper runs out or jams, you can print the missing pages without resending the entire job.

HP's 4Si MX printer uses a PostScript job-overlap feature that begins processing a second document while the first is printing. Multiple frame buffers allow the printer to process a PostScript job while a PCL job prints or vice versa. For larger, more complex network setups, this scheme will automatically switch between multiple network operating systems.

How does it look?

Above all most new workgroup printers make your documents look good. Devices like NewGen Systems' Turbo PS/660B can output true 600dpi documents that look great to the naked eye.

The phrase "true 600dpi output" means the engine itself is capable of printing 600 dots per inch horizontally

and vertically. Many manufacturers are making 600dpi engines these days – Canon, Fuji/Xerox, Lexmark, Sharp, and Toshiba among them. Some printers are capable of more than 600dpi, but this isn't always accomplished by the engine. Software instructions incorporated into a printer's firmware help interpolate the output, in effect making a 600dpi printer simulate the higher output.

Such a scheme is used by LaserMaster as part of its TurboRes technology. But despite its claim of being a 1,200-by-1,200dpi printer, the Unity 1200XL-O turns out to produce 1,200-by-600dpi output, according to our inquiry of the printer's PostScript specifications.

Halftone performance was another story. Many of the printers, even those using image-enhancement techniques, such as the Hewlett-Packard LaserJet 4M, showed noticeable banding on greyscale images. This effect was especially visible in blends, images showing a gradual increase in shade. The true 600dpi models cope best with these kinds of images.

Getting up and running

Set-up for most of these printers is relatively easy and straightforward, but

should you need a hand, some manufacturers, such as HP, include a card containing printer setup shortcuts and information about status displays.

Other printers include on-board displays and switches, the LaserWriter Pro 630 is limited to four side-mounted status lights that indicate processing status, when toner is low, when the printer is out of paper, and whether there's a paper jam. Several printers,

such as the Pagemarq 20, have a control panel on the front with a digital display and buttons you can use to configure and set-up the printer.

Others, like the LaserWriter Pro 630, can be configured with utility software. Apple's printer accessory kits deserve special praise because they include installation disks for Mac and Windows along with a single manual that makes set-up easier.

Macworld Recommended...

LASERJET 4Si MX The 4Si MX combines high speed, efficient operation, and very good output quality. The best all-around performer in Macworld Lab tests among the high-speed devices.

Company: Hewlett-Packard. List price: £4,449.

LASERWRITER PRO 630 Part of a 600dpi tandem we selected as the best buys, the LaserWriter Pro 630 has good-quality output and decent speed. It also provides better graphics performance than the LaserJet 4M.

Company: Apple Computer. List price: £1,603.

LASERJET 4M The other half of the tandem, the LaserJet 4M also offers high-quality output and good performance. But it gets the nod over the LaserWriter Pro 630 in the area of type quality. HP's Resolution Enhancement Technology provides slightly sharper text output at 600dpi. Either printer is a good choice, however.

Company: Hewlett-Packard. List price: £1,849.



Like most colour printers, ours works best if you use the right paper.

Most colour printers limit you to printing on an A4-sized piece of special paper. Only Tektronix offers you choices. The Phaser™ 300 lets you print on any kind of paper, up to A3 size. From vellum to card stock, from newsprint to acetate. The Phaser 300 prints on almost anything. So you can do your comps on the same paper you'll use for the job. After all, what you print on is just as important as what you print.

If photorealistic output is more important to you than the ability to print on any paper, then the Phaser 480 is for you. With it you'll be able to print A3-sized "photographs" on your desktop in minutes.

Both the Phaser 300 and the Phaser 480 feature genuine Adobe® PostScript™ Level 2, 300 dpi, PANTONE®-approved colour simulations, and a 24 MHz RISC processor to keep your work humming.

They also connect nicely to Macs, PCs or workstations. Or all three at once. Above all, each gives you up to 16.7 million of the brightest, most saturated colours ever printed on a desktop. No wonder our printers have won more awards for excellence than any others.

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Colour Printers

Today's colour printers are a different breed than their predecessors. No longer confined to bureaus and design shops, colour printers can offer quality output at reasonable prices for every Mac user.

P *People rely on monochrome printers for day-to-day work, but more and more are buying colour machines – to proof publications, create package mock-ups, print scanned or video-captured images, and produce overhead transparencies, as well as just punch up documents. The increasing interest in colour isn't all that surprising. Colour printer prices have never been lower, and print quality has never been better.*

Perhaps as significant, the complex hardware and software required to accurately mix and apply pigments continue to mature – colour consumers need no longer feel like pioneers chasing rainbows.

Colour printers fall into three dominant categories: ink-jet, thermal-wax transfer, and dye-sublimation. These categories form a good-better-best hierarchy, and as you might expect, prices range from cheap to steep.

The low end of the colour-printer market is represented by

ink-jet printers, from the £459 Hewlett-Packard HP DeskWriter C to the £9,995 Tektronix Phaser III PXI Color Printer.

In the mid-range sit thermal-wax transfer machines. Prices vary significantly, beginning at £3,000 for Seiko Instruments' Personal ColorPoint PSE (the lowest-priced thermal-wax transfer machine to date) and ending at £6,495 for the NEC Colormate PS Model 80.

At the high end are dye-sublimation machines, whose prints look downright photographic. That quality goes for just under £10,000 – steep, but far less than the average price 12 months earlier.

Grouping printers into the ink-jet, thermal-wax, and dye-sublimation categories is convenient for price and basic comparisons, but your shopping list needs to address other things, too. Here's an overview of the key issues.

Media flexibility

Do you want to print on plain paper? If so, forget dye-sub printers. They require special (and expensive) paper designed to absorb the printer's dyes. The latest liquid ink-jets print on plain paper, but the results can look splotchy – a little like using a fountain pen to write on a paper towel. A few thermal-wax printers (such as units from Tek-

tronix, QMS, NEC, and Seiko) can print on plain paper, and even these printers require premium laser stock.

Most thermal-wax printers use a lightweight, coated paper that feels flimsy. If you want the wide-ranging plain-paper support that monochrome laser printers provide, you need to consider a solid ink-jet colour printer such as the Tektronix Phaser III PXI.

For many people, printing business letters in colour isn't nearly as important as printing colour overhead transparencies for presentations. All colour printers can print on transparency film, but in general, thermal-wax machines produce the best results.

The finish and durability of output varies from one technology to another. Liquid ink-jet output smears when wet. Solid ink-jet output has a textured, matte finish that can crack after repeated folding. Thermal-wax gives printed areas of the page an appealing gloss. Pages from a dye-sub printer are glossy in all areas, including white space, but text on dye-sub machines looks a little out of focus.

PostScript versus QuickDraw

In the Macintosh world, buying any kind of printer means choosing

between one that uses PostScript, the page-description language of desktop publishing, or buying one that relies on QuickDraw, the Mac's built-in software for creating text and graphics. A PostScript printer contains its own computer, or controller, that interprets PostScript-language commands coming from the Mac and translates them into the dots that form the printed image.

A QuickDraw printer, on the other hand, relies on the Macintosh to perform the calculations required to print a page. As a result, QuickDraw printers cost less but tie up the Mac.

A PostScript printer is a better choice for printing desktop publications and illustrations created with PostScript drawing programs such as Aldus FreeHand and Adobe Illustrator. Most PostScript colour printers include or accept an optional SCSI hard drive that can store fonts and provide other performance-boosting benefits.

For presentation materials and scanned images, a QuickDraw printer suffices. It is also possible to coerce QuickDraw printers into supporting PostScript by using emulation software such as Freedom of Press Professional.

If you opt for PostScript, you need to

choose between the real thing and a clone. Some printers use true Adobe Systems PostScript interpreters, but many use clone interpreters – they understand PostScript but were created by other firms. In the past, true Adobe PostScript produced much smoother text quality when printing Type 1 downloadable fonts – the most popular format for fonts that you buy to supplement a printer's built-in fonts. Improvements in clone interpreters have virtually erased this quality gap.

Compatibility is the larger issue, and the most difficult to quantify. No PostScript clone tested by Macworld Lab had compatibility problems – each successfully printed our test documents. But problems could surface in the future – as they did when numerous PostScript clones choked on Adobe's newly released Multiple Master fonts. The clone developers responded with updates, but until the updates became available, clone owners were barred from a significant new font technology.

To complicate matters, Adobe interpreters come in two flavours: Level 1 and Level 2. In theory, Level 2 PostScript offers additional benefits for colour printing, including image decompression and device-indepen-



Inkjet quality

Compared against the original image (top), the inexpensive HP DeskWriter 550C (middle) shows good colour fidelity, except for a slight overall lightening. Its effective dithering scheme holds sharp details, as seen in the scientific diagram at the left of the image. In contrast, fine print was illegible as rendered by the Apple Colour Printer (bottom).



dent colour capabilities. With the latter feature, the time-consuming translation of colours in an image into colours that a given printer can render is handled by the Level 2 interpreter.

Colour accuracy

One of the thorniest issues facing the industry today is colour matching. For pie graphs and bullet charts, you may not care if output doesn't exactly match the colours on screen. But colour accuracy is critical for publication proofs and scanned images. Monitors create colour by combining red, green, and blue light; printers create colour by combining cyan, yellow, magenta, and black pigments. This means that what you see on screen is rarely what appears on paper.

If Adobe can deliver on its promises, Level 2 could solve this problem. But some pieces are missing. In the mean-

Calibration counts

To get the most out of dye-sublimation, consider using a colour-management system. Compared with the original image (right), standard output from the Kodak XLT 7720 (below left) shows an overabundance of yellow, particularly in the building's thatched roof. After the printer was calibrated using Kodak ColorSense, the new output (below right) closely duplicates the original, except for the blue cast added to the circular shape at the right side of the image.



time, numerous firms, including Kodak and Electronics for Imaging (EFI), have developed colour-management systems that offer greater colour fidelity.

Networking features

When buying a colour printer for the office, you probably want each Mac (and perhaps also your DOS PCs) to be



able to access the printer. PostScript and networking go hand in hand: all PostScript printers provide a LocalTalk port for connecting Macs and LocalTalk-equipped DOS PCs. A growing number of printers also include ethernet ports – or offer them as options.

If you print from DOS PCs as well as Macs and don't want to buy LocalTalk boards for the PCs, look for a printer that offers an all-ports-active feature: all the ports are always listening for data. When a print job arrives at one port, other ports are temporarily disabled. The benefit, here, is that you need not flick switches to tell the printer which port to use.

Speed

Colour printer performance is often measured in minutes per page, not the pages per minute of monochrome laser printers. Colour output requires more processing time than does black-&-white output, as the controller (whether built-in or Mac-based) has to figure out how much cyan, yellow, magenta, and black ink to apply in order to create various hues. For QuickDraw printers, this means that the faster your Mac, the faster the printer. Beyond processing time, the actual

printing process takes longer for colour than for black-&-white laser printers, too.

INKJET

Choosing a colour ink-jet printer used to mean living with limitations: muddy output, special paper, no PostScript, and slow performance. Today's colour ink-jets are not going to break any speed limits, but they are faster and more flexible than ever. Most of last year's models produced between 180 and 300 dots per inch and required special coated paper. This time around, most have resolutions of 300 dpi or 360 dpi and can print on plain paper.

Macworld Labs tests show these machines produce surprisingly good results, considering their cost. Hewlett-Packard's HP DeskWriter 550C comes at under £669 and often sells for much less. More-expensive ink-jets, such as the HP PaintJet XL300 can handle paper as large as 11 by 17 inches (tabloid) – a capability that costs thousands of pounds in thermal-wax printer.

The software that drives the printers has also evolved. Printer drivers for QuickDraw printers have improved significantly for printing scanned images and colour blends. Today's QuickDraw

drivers are better at dithering, the process of applying dots in patterns to simulate hues other than cyan, magenta, yellow, and black (CMYK); red, green, and blue (RGB); and white.

PostScript has become more prevalent, too. You'll find PostScript support in Tektronix's Phaser III PXi Color Printer, Lexmark International's IBM 4079 Color Jetprinter PS, and Dataproducts Corporation's Jolt PS. Hewlett-Packard offers a PostScript option for its PaintJet XL300. All of these PostScript machines offer enhanced dithering options that produce much sharper output of scanned images than did early PostScript colour printers.

Liquid ink versus solid ink

Most inkjets spray fine streams of liquid ink through minute nozzles located in disposable ink cartridges. The ink itself consists of dyes dissolved in a water-based medium. Canon and Hewlett-Packard have worked hardest on this liquid-ink technology; indeed, every liquid ink-jet reviewed here uses either an HP or Canon print mechanism.

Two companies – Tektronix and Dataproducts – have printers that use solid inks, which are melted before being applied to the page. The Phaser



III PXi and Jolt are phase-change ink-jet printers, so named because the ink changes phases from a solid to a liquid and back again when applied to paper.

Phase-change ink-jet printers use ink sticks that look like mutants from the Crayola factory – fat, colourful wedges of wax containing adhesives and dyes. The dyes are not water-soluble, so output doesn't smear if it gets wet.

Because very little ink soaks into the paper, solid inks tend to deliver more brilliant colours than liquid ink. Solid-ink printers generally have larger colour gamuts – they can reproduce a wider range of colours. Solid ink-jets aren't as finicky about paper quality, either, delivering better results than liquid ink-jets on inexpensive photocopier paper stock.

Solid ink's real weakness is with transparencies. The solidified beads of ink scatter light that's transmitted through them, giving projected transparencies a washed-out, almost black-and-white appearance. Both Tektronix and Dataproducts sell desktop laminating machines that fix the problem by adding a layer of material that has the same optical density as the beads. But this adds to the printer's cost and adds a manual step to the printing process. If

you plan to print transparencies extensively, try a liquid-ink or a thermal-wax machine.

Another inkjet printer of note is the Canon CJ-10 Colour Bubble-Jet Copier with IPU. The Canon CLC-10 is a colour copier that combines Canon's digital colour-copier technology with a 400dpi ink-jet print mechanism. Add a SCSI-based computer interface unit, and it becomes a colour scanner and printer, too.

The CLC-10 is an impressive colour copier. You can reduce to 50 per cent or enlarge to 200 per cent as well as adjust colour balance, brightness, and contrast. The CLC-10's computer interface unit includes a QuickDraw driver as well as a utility that lets you scan images directly into Adobe Photoshop.

THERMAL WAX

For thermal-wax colour printers, the hot news is all about paper and price. While print quality has held fairly steady, several machines now print on plain paper – not the wide range of exotic papers and card stocks that monochrome laser printers can handle, but photocopier or laser-printer stock. Besides providing alternatives to the flimsy-feeling special paper to which

some thermal-wax printers are still limited, plain-paper support eliminates the need to stock yet another category of office supply.

Meanwhile, prices are dropping into the office-laser-printer range, with one high-end machine, the Tektronix Phaser 200e, retailing for less than £3,500, and one low-end newcomer, the Laser-Master Crayon-FX, announced at a cost of less than £1,500. Thermal-wax inks give printed areas of the page an appealing gloss that ink-jet printers can't match.

How thermal-wax works

Thermal-wax printers produce output through a combination of heat and pigmented wax. Inside the printer is a roll of plastic film coated with wax-based pigments of each process colour (cyan, magenta, yellow, and often, black – or CMYK). Each ink panel is the size of a full page, and a set of three or four panels is used in the course of printing a page. As a result, you always know how many pages to expect from an ink roll. With ink-jet and monochrome laser printers, the number of pages per cartridge depends on the amount of ink or toner that is applied to each page.

The print head in a thermal-wax

Thermal quality

Output quality among thermal-wax printers does not vary as widely as with other printer technologies, though these samples show visible differences in colour fidelity and image texture. Comparing output against the original image (top), the Seiko Personal ColorPoint PSE (middle) shows excellent colour fidelity, particularly in the hard-to-match green of the leaves in the centre of the image, and in the aqua swirls at the far left.

However, thermal-wax devices use dot patterns to create different colours. This can cause severe banding when moving from one shade to the next or in subtle fills, as seen at the lower right of the bird, as rendered by the Panasonic EPL-8543 (bottom).



printer contains thousands of heating elements that turn on and off to print individual dots, melt the wax, and thereby transfer ink to the paper. Nearly all thermal-wax printers can apply up to 300 dots per inch.

A page makes several trips past the print head. After the dots for the first process colour are applied, the page briefly appears in the output tray as the ink ribbon advances to the next panel. Then the printer draws the paper back in and applies the next process colour. The printer's mechanism must position the paper accurately for each pass or registration and colour quality suffer.

Most thermal-wax printers accept either a three-colour (CMY) or four-colour (CMYK) ink ribbon. (Some machines also accept a black-only ribbon and produce colour separations by printing one page for each process colour.) Printing with a three-colour ribbon is the fastest, since it requires one less pass. Without the black-ink panels, however, the colour printer must print black areas as composites of cyan, magenta, and yellow ink, which sometimes produces muddy-looking blacks.

The ink ribbon is attached to a take-up spool around which spent ink panels are wound. This presents a potential



security problem: someone can unwind the used ribbon and read documents that have been printed. When security is important, be sure to destroy spent ink rolls.

With three (or four) entire ink panels used for every printed page, you may think that thermal-wax printers cost more to operate than ink-jets. That can be true for documents containing only small areas of colour, but if you print overhead transparencies or other colourful pages, thermal-wax output often costs less. Put another way, the cost per page of ink-jet output varies depending on the amount of ink used, but the cost per page of thermal-wax output is the same regardless of how much colour you use. (The lesson is to beware of the cost-per-page figures used by ink-jet vendors. Such estimates are meaningless unless they specify the colours used and the amount of coverage.)

Thermal-wax transparencies aren't just more economical, they're also more vivid than ink-jet transparencies. The wax-based inks adhere well to transparency film and don't diffuse projected light to the extent that liquid and solid inks do. Given these quality, speed, and potential economic advan-

tages, thermal-wax represents the best technology for printing overheads and other presentation materials.

The media elite

Many ink-jet printers can't use plain paper effectively because ink sinks into the paper before drying, blurring the image. Plain paper presents different challenges to a thermal-wax printer. The surface of a sheet of plain paper is not smooth, but a bumpy mélange of crisscrossing fibres. Adhering a smooth, wax-based ink to such a surface is like wallpapering a textured plaster wall – you can do it, but it isn't easy.

All thermal-wax printers used to require special paper with an ultra-smooth surface designed to accept the melting wax. This paper was roll-fed, and a blade within the printer cut the paper to size at the end of the print job. Some printers still rely on such rolls, but a far greater number of units use cut-sheet plain paper.

QMS, Seiko, and NEC met the plain-paper challenge by redesigning their print heads to apply more heat to the ink ribbon, thereby transferring more wax to the paper. Tektronix takes a different approach with its Phaser 200i and 200e printers.

Tektronix sacrificed the black-ink panel in favour of a special primer medium that the printer applies to all areas of the paper that will hold ink. This primer coat covers the peaks and fills in the valleys of the paper, providing a smoother surface for the inks. It also means all blacks must be printed as composites of cyan, magenta, and yellow, however.

Tektronix claims that this approach allows for a wider range of paper surfaces and finishes. But Macworld tests show that only high-quality paper yields acceptable results.

The trend toward using plain paper is accompanied by the same kinds of paper-handling features as those found on laser printers or photocopiers. Many thermal-wax machines now use slide-in paper trays that hold 50 to 200 sheets. The Tektronix Phaser 200i and 200e also accept an optional second paper tray – put paper in one and transparency film in the other.

The £4,595 CalComp ColourMaster Plus series are the only colour printers available that can print on both sides of a sheet of paper. The ColorMaster Plus doesn't support plain paper, but the special paper it does require is heavier than most thermal-wax papers.

Printers from Seiko, QMS, Panasonic, General Parametrics, and CalComp can print on a special material that lets you create transfer sheets for fabric and ceramic. Some of these printers also print on offbeat media such as silver peel-and-stick paper (for plaques and nameplates) and static-cling plastic (for signs that stick on windows, with no adhesive). For ad agencies and design studios, the ability to do small, in-house runs of T-shirts and other promotional trinkets could be more significant than being able to print on plain paper.

Another plus for graphic artists is the ability to print colour documents with bleeds (printed areas that extend to the edge of the page). To print tabloid-size documents with bleeds, look at Océ Graphics' G5242-PS, Seiko's ColorPoint PSX Model 14, or QMS's ColorScript 230. As for colour matching, support for EFI's EfiColor colour-management system is available for the Tektronix, QMS, Seiko, and CalComp thermal-wax machines.

Many vendors are also creating profiles for Apple's ColorSync colour manager. Profiles are data files that describe a printer's colour capabilities, such as its colour gamut, ink characteristics, and halftone screen frequencies.

Together with the colour-management software (such as EfiColor or Color-Sync), these profiles form an intermediary between application program and printer. When you print a document, the colour-management system checks the printer profile to translate the colours in the document into ones that can be rendered by your printer.

Speed and networking

The majority of thermal-wax printers use PostScript-clone interpreters rather than true Adobe interpreters. Exceptions include the Tektronix, NEC, and Océ Graphics machines. All the clones passed Macworld Labs' compatibility tests. Most PostScript printers (whether clones or not) provide additional emulation such as HPGL, a popular language for plotters.

Thermal-wax printers aren't fast, but a notable exception is the Tektronix Phaser 200i and 200e, which boast an innovation that puts them in front. Both wind the sheet of paper around a circular drum that eliminates the time wasted by partially ejecting a page and then drawing it back into the print engine to print the second and third process colours.

Tektronix claims a maximum print

speed of two pages per minute – still glacial compared with a monochrome office printer's 10 to 20ppm, but still faster than any current thermal-wax printer.

Output quality

Any thermal-wax output looks better than that of a liquid ink-jet printer (except the liquid ink-jets from Iris Graphics, which start at over £30,000). But within the thermal-wax world, output quality doesn't vary dramatically.

DYE-SUBLIMATION

For photo-realistic results, you want a dye-sublimation printer. Unlike ink-jet and thermal-wax machines, dye-sub printers mix cyan, magenta, yellow, and black pigments to create any of 16.7 million hues without dithering. Dye-sub images are free of dot patterns that obscure details and destroy realism.

Photo-realistic results make dye-sub the preferred printers for proofing colour publications. Dye-sub is also the natural output choice for the growing field of electronic photography. The special paper that dye-sublimation machines use has a glossy finish that closely resembles photographic paper. Dye-sub printers' dither-free output is



September 1963.
Susan plays with colour



Thirty years later
her business depends on it



The first desktop laser for both colour and monochrome printing The new QMS ColorScript Laser 1000

The new QMS ColorScript® Laser 1000 is the first and only desktop laser printer in the world to produce brilliant, rich and vibrant colour and combine it with high-quality monochrome laser output, all on the same plain piece of office paper.

It features the full advanced paper handling and multi-tasking features that are only available through QMS® Crown™ technology, and works seamlessly in any type of office environment or networking configuration.



Colour laser printing is so versatile that it can produce forms, manuals, certificates, spreadsheets, newsletters, statistics, book covers, anything,

without changing paper or printer. It has PostScript™ Level 1 and 2 emulation, HP® PCL® 5c with HP-GL®/2 plus a unique intelligence that switches between any of its emulations automatically.

The new QMS ColorScript Laser 1000.

Don't be bold, be colourful!

For more information on the QMS ColorScript Laser 1000 please complete the coupon below and return it to:
QMS (UK) Ltd., QMS House, 49 High Street, Egham, Surrey TW20 9EW. Alternatively, give us a call on 0784-430900.

- tick here if you would like a demonstration
 tick here if you would like more information

Name: _____

Position: _____

Company: _____

Address: _____

Telephone: _____



MBG5/94

also well suited to scientific and medical imaging, where every detail counts.

Dye-sub printers also work with transparency film and do a beautiful job with the flashy graduated backgrounds that Aldus Persuasion and Microsoft PowerPoint provide. Ink-jet and thermal-wax printers must use dither patterns to simulate graduated fills (areas where one colour blends into another), but dye-sub printers produce the continuous colour blends that appear on the Mac's screen.

But the very qualities that make dye-sub machines so adept at printing continuous-tone images impair their ability to print sharp text. Text from a dye-sub machine sometimes looks fuzzy – like a slightly misfocused photograph. Large type, such as the 18- or 24-point text you might use in an overhead transparency, doesn't look bad, but small sizes can be difficult to read. If you work more with small text sizes and spot colours than with scanned images and graduated fills, you probably want a thermal-wax machine. Besides being able to print on plain paper, you'll pay less.

A lot less. Prices have dropped but dye-sub printers remain among the most expensive colour printers. Prices



Dye-sub quality

Unlike ink-jet and thermal-wax printers, which use dot patterns to represent different shades, dye-sublimation printers mix colours. This yields smooth, continuous-tone images. While both samples (from the Tektronix Phaser IISD, middle, and the 3M Rainbow, bottom) vary noticeably from the original (top), colour calibration would virtually eliminate the differences (see [Calibration Counts](#))

range from £5,500 for Nikon's CP-3000D Full Color Printer to £17,565 for Kodak's XLT 7720 Digital Continuous with most retailing for around £10,000.

Dye-sub printers also cost more to operate. A page from an ink-jet or thermal-wax machine generally costs a few pence; most dye-sub prints cost several pounds each. But against photographs – a closer comparison from the quality standpoint – dye sublimation looks almost reasonable in cost, especially considering that chemicals and dark-room work are not needed.

How dye-sub printers work

Dye-sublimation (also called dye-diffusion) printers closely resemble thermal-wax machines. Both types of printers use ribbons containing successive panels of cyan, magenta, yellow, and, optionally, black pigment. In both, a print head transfers pigment from the ribbon to the page. The paper shuttles into and out of the print engine once for every process colour – cyan, magenta, yellow, and black.

The key differences between thermal-wax and dye-sub printers are the type of paper, the composition of the colour pigments, and the way the print head applies the pigments. As the tech-

nology's name implies, dye-sub pigments are not inks. Inks rest on top of the print medium; dyes permeate the surface.

When a heated element in the dye-sub machine's print head contacts the dye ribbon, the dye sublimates – turns from a solid into a gas, with no liquid phase in between. The gaseous dyes are absorbed by the polyester coating on the paper. Regular inks are opaque and must be printed in various dither patterns to fool the eye into seeing various colours.

Dyes are transparent, so a dye-sub printer creates a given colour by applying dots of the process colours directly on top of one another. And a dye-sub print head varies the temperature of its heating elements to apply pigments in unequal amounts – say, a lot of yellow and just a little cyan. There are none of the dot patterns, or rosettes, that are the building blocks of colour halftones. This lack of dot patterns is one of the factors that make dye-sub output look like a photographic print. This extra sophistication also contributes to dye-sub's higher cost.

As the paper absorbs the dyes, they diffuse, so rather than having a sharply defined edge, each dot is slightly fuzzy.

This diffusion helps the dots blend and contributes to the printer's ability to produce continuous-tone images.

Quality concerns

But soft-edged dots can cause small text and line art to look blurred. Under magnification it's apparent that the dyes diffuse to a greater extent along the axis of paper movement – just as a raindrop hitting a moving car's windshield spreads more in one direction than in others.

One printer, Tektronix's Phaser IISD, compensates for this by adjusting the amount of dye applied using the Tektronix Photofine technology. The technique helps: the Phaser IISD produced some of the best-looking text of the printers tested.

Some printers turn their soft-edged dots into weapons against the stair-stepped jagged edges that are common artifacts in line art and large text. Several models provide a text anti-aliasing option that fills jaggies with subtle shades of intermediate colour values.

As you consider dye-sub specifications you may notice that output resolution varies in this category – from 163 dots per inch for the Sony UP-D7000 to 300dpi for most other printers. For

printing text or line art, the standard resolution rule applies – the more dots per inch, the better. For scanned or video-captured images, however, images printed by the 163dpi Sony UP-D7000 looked as sharp as those produced by the 300dpi printers.

For pre-press proofing, the dye-sub's colours must closely match colours from the printing press. Therefore, most vendors support a variety of colour-management schemes. The Efi-Color system from Electronics for Imaging is popular for pre-press colour matching, and is supported by RasterOps, SuperMac, GCC, Kodak, Tektronix, and Sony.

GCC provides its printers with profiles (descriptions of the printers' colour-rendering abilities) for Apple's ColorSync matching system, while Tektronix printers use the proprietary technology.

One printer, the 3M Rainbow, uses colour-matching technology similar to that of 3M's Matchprint system, a film-based colour proofing system. Supporting a paper size of 17.2 by 11.8 inches (super B size), the 3M Rainbow is one of only three dye-sub printers that can produce tabloid-size output with bleeds (SuperMac's ProofPositive Two-

Page Printer, and the Tektronix Phaser 480 are the others).

Controllers and connectors

In the thermal-wax world, the vast majority of printers provide network ports and built-in PostScript controllers. There's a greater variety of connector and controller schemes in the dye-sub field because of the need to move the vast amounts of data present in scanned images from the Mac to the printer as quickly as possible, and because some vendors want more-flexible alternatives to conventional PostScript interpreters.

A LocalTalk network is a bottleneck for printing scanned images; even ethernet can be inadequate for large files. Besides slowing printing, sending huge scanned images over a network slows down any file servers and electronic-mail systems on the same network. Therefore, printers from 3M, Seiko, Nikon, Sharp, Kodak, and Sony connect to the Mac's SCSI port, which provides the fastest data-transfer rates. These machines also provide print-server software that enables other Macintoshes on a LocalTalk or ethernet network to print, albeit with those networks' performance limitations.

As for controllers, GCC, Mitsubishi, Tektronix, RasterOps, and Sharp (in the JX-7000PS only) provide built-in PostScript-compatible controllers. The 3M Rainbow uses Adobe's software-based PostScript, called CPSI – configurable PostScript interpreter. Because CPSI runs on the Mac, this printer's performance depends on the speed of the Mac it's connected to – and the printer slows down the Mac while printing.

You can speed up CPSI-based units (and, for that matter, printers that use PostScript emulators or QuickDraw) by upgrading the host Mac's memory and processor – though this can be a costly option. A service bureau or publishing house should use a Quadra or accelerated Mac II-family machine.

In the ease-of-use department, GCC Technologies' ColorTone deserves special mention for its oversize front-panel liquid crystal display that displays status messages and options from a well-designed menu system. The ColorTone's controller also includes a built-in hard drive, a SCSI port for an external hard drive, and a built-in ethernet connector. The internal hard drive also contains the PhoenixPage interpreter, so you can upgrade the interpreter without swapping ROM chips –



just download the new software to the printer's hard drive.

Time to buy?

Falling prices, rising quality, and imminent availability of system-level colour management, have brought desktop colour printers closer than ever to the mainstream of personal-computer peripherals. Still, it's likely to be some time before colour printers become as common as colour monitors. One reason is cost: today's colour printers are slower, are more expensive, and cost more to operate than monochrome printers.

Another reason is common usage: many business documents are photocopied for distribution, and nearly all copiers are colour-blind. Adding colour charts or diagrams to a multipage report means printing the colour pages separately and then collating them into the final product – a labour-intensive job.

There may come a time when you won't think about buying a colour printer any more than you think about buying a colour television.

Until then, colour printers will remain specialized devices primarily for publishers and presenters.

Macworld Recommended...

Inket

HP Deskwriter 550C It's no pre-press proofing tool, but its output quality may surprise you. With a street prices some way below the list price, there isn't a better way to test the waters of liquid ink-jet colour printing.

Company: Hewlett-Packard. List price: £539

Phaser III PXi Color Printer **Phaser III PXi** The only printer in its price range that has the paper-handling flexibility that monochrome printers provide. The controller offers fast performance, PostScript Level 2, and sharp prints of scanned images.

Company: Tektronix. List price: £5,995.

Thermal-wax

Personal ColorPoint PSE This unit offers the lowest price of any 300dpi thermal-wax machine. Its enhanced screening delivers remarkably sharp prints of scanned images.

Company: Seiko Instruments. List price: £3,000.

ColorScript 210 Offering plain-paper support and the sophisticated Crown printer-architecture, this machine is a good choice for workgroup printing..

Company: QMS. List price: £2,695.

Dye-sublimation

Phaser IISD Color Printer Boasting Adobe Level 2 PostScript, Tektronix's Photofine text-enhancement technology, and TekColor image-enhancement technologies, the Phaser IISD is an excellent choice for presenter and publisher alike.

Company: Tektronix. List price: £7,995.

Audio & Video

Whether you want to be the next Steven Spielberg, a musical studio svengali – or simply add sound and motion to your next company presentation, there's a wide range of Mac hardware to help you get the job done.

For the longest time it looked as though multimedia on the Mac was a technology going nowhere – an all-round solution for which no real problem existed. Despite the best efforts of Apple and third-party companies to talk up the market, Mac users looked, listened and then went back to graphic design and desktop publishing and the mainstream personal computer applications.

But suddenly, the arrival of a new generation of third-party hardware, combined in part with Apple's launch of the AV-equipped Quadras, created a genuine application for the technology: desktop video. If you count yourself among the die-hard multimedia skeptics, consider the fast-growing market for low-cost video production: banks and building societies offering free videos explaining mortgages, pensions and insurance; travel agents offering free videos on holiday destinations; and a myriad other applications from corporate presentations to training. Macintosh hardware is now avail-

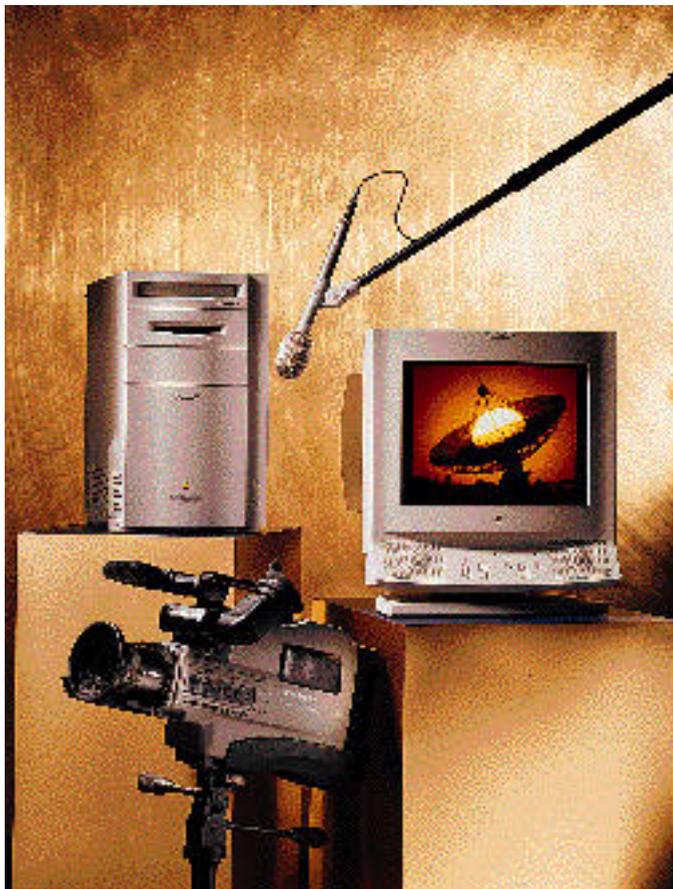
able to help in all areas of video production, from single-task applications like recording Mac graphics to video tape, to full-blown video editing systems.

The Digital Studio

At the high-end, and in the area that many of us probably consider synonymous with "desktop video" are the complete video production tools led by Radius VideoVision Studio, SuperMac's Digital Film, and Avid's Media Suite Pro.

These are all digital systems designed to do roughly the same thing: convert analogue video (from tape, or from video cameras) to digital information held on hard disk; allow you to edit and compose video sequences; allow you to add graphics, titles and other text created on the Mac; put all these elements together with special effects like dissolves, wipes and other special effects transitions; and finally re-record the finished sequence back to video tape.

As in so many areas, there is little to choose between the products from arch-rivals Radius and SuperMac. Both consist of a NuBus board to handle video digitizing, data compression, and the signal conversions, together with



an external hardware box for video and audio input and output. There's almost

no difference in price, and little difference in quality.

However, Radius has a slight advantage offering two video and audio inputs to SuperMac's one; and the final recorded output is slightly better from VideoVision Studio, especially on Mac-generated images.

But even with these £5,000 products you still need to spend a lot more. For example, to get the best output quality you need to generate huge amounts of data – as much

as a megabyte for each second of video and sound. That translates to large



amounts of memory in the Mac, and huge hard disk requirements. Count on nothing less than a Quadra with at least 32MB of memory and 2GB of hard disk space.

Moreover, the hard disk has to be lightning fast to handle digital video playback without annoying skipping and stuttering. Radius, for example, recommends a SCSI-2 Fast drive or RAID array (see "Supersonic Storage" in this guide's Storage section for more details).

While Digital Film and VideoVision Studio represent the best efforts of traditional Mac suppliers to enter the video market, Media Suite Pro from Avid is an example of the reverse approach – a video specialist exploiting the capabilities of the Mac to offer new solutions.

Avid is one of the world leader's in dedicated video editing systems. MPS uses the company's own proprietary software (Radius and SuperMac use Mac applications like Adobe Premiere), combined with no less than four NuBus boards. For this reason it demands a Quadra 950 – and also costs several thousand pounds more than the Radius and SuperMac rivals.

The extensive use of extra hardware

Sounding off

Mac owners can allow themselves a wry smile at the fuss the PC industry is currently making about sound. Such are the audio capabilities of even the humblest Mac that there is a positive dearth of add-on hardware in this area. Since all Macs have sound output built in, at stereo in the higher-end models, and most have the ability to digitize sound, again often in stereo and at CD-quality rates, there isn't a lot left for third-party manufacturers to offer.

For musicians, the key requirement is a MIDI interface that lets you control MIDI synthesizers and other keyboards, drum machines, hardware-based sequencers and other devices. Apple itself offers a basic model for around £60 providing a single input and single output port. This is sufficient for those beginning to explore the possibilities of MIDI music, but serious amateurs and professionals require a more sophisticated setup.

Turnkey (071 379 5148) offers several: one has a single MIDI in and three MIDI outs for £65; for professionals there are others offering multiple in/out ports for £699 and £899.

For those without an interest in music, a pair of external speakers is perhaps the only area for investment. Again Apple caters for basic tastes with the Apple Design Powered Speakers at £93, while for those seeking a "name" or more in the way of volume, Computers Unlimited distributes Bose speakers at £325 a pair. Between these two extremes, MacWarehouse offers the SRS range with prices starting at £70 and rising to over £200.

gives MPS some advantages over Digital Film and VideoVision Studio, not least faster performance and greater productivity. However, it also has one peculiar drawback: it provides no facility for what is called off-line editing and

creating editing decision lists (EDLs) – a kind of script that can be moved to a high-end editing suite which then executes transitions and other effects at full professional quality.

It can only be supposed that Avid



deliberately omitted this feature in order to avoid hurting sales of its high-end, dedicated systems.

A fourth contender in this area is from the third of the big three Mac video specialists, RasterOps. Its MoviePak system is based on a series of daughtercards that can be added to a variety of the company's Mac video adaptors. While it matches some of the basic functionality of Digital Film and VideoVision Studio, including in its latest version the ability to handle full PAL output at 30 frames/60 fields per second, it lacks the convenience and some of the extra features of its competitors.

Also of note is a hybrid approach developed by German manufacturer FAST Electronics. Unlike the all-digital systems already mentioned, FAST's VideoMachine uses a combination of digital and analogue technologies. It allows you to mix signals from two video sources, adding special effects, and recording to a third video deck.

This has the advantage that little of the video has to be digitized, doing away with the need for massive amounts of storage and also minimizing the problems of loss of image quality that arises from digitization. However, it is an expensive system

unless you already have three pro-quality video decks.

Video for the rest of us

Not all video applications require the complete range of features offered by systems like Digital Film and VideoVision Studio. Especially in the business world there is a greater need for the ability to record presentations and training materials for distribution on video. For others the Mac itself is the playback mechanism and the need is for video capture rather than video recording. In these and other instances, there is a range of products to suit ambitions – and budgets.

Your first consideration in these areas should perhaps be a new Mac, since Apple's AV models (the Quadra 660AV and 840AV, together with the new AV-equipped models of the Power Macs) can handle just about all of your requirements without the need for additional hardware. All AV Macs have the ability to digitize video and audio, and whether your resulting efforts will stay within the Mac or be recorded back to tape, all have the ability to accept signals from, and record to, S-Video and composite (TV encoded).

For those with existing Macs, third-

party manufacturers offer similar capabilities, but it should be noted that the cost of these boards often approaches or exceeds the cost of a Quadra 660AV.

For example, for video digitizing and frame-grabbing, British manufacturers Graphics Unlimited offer the Kingfisher board and Neotech has the Image Grabber, costing £995 and £1,250, respectively. Early US pioneer TrueVision (subsequently acquired by RasterOps) has the NuVista+, which matches and in some areas exceeds the abilities of the AV Macs – but at a price of £3,000 or more.

And bridging the gap between the low- and high ends of the market are two more products from SuperMac and Radius. The former offers VideoSpigot, available in a variety of configurations but costing £1,200 for the most capable, while Radius has VideoVision (upgradable to Studio) for £1,800.

Both can capture video and audio, although capture rates for video are limited to QuickTime standards giving a working maximum image size of half screen, 320x240 pixels. However, this is good enough for corporate training and presentations where the smaller video image can be embedded within a screen of text or graphics.



Input Devices

Input devices are your links to the Mac, letting you move around the screen in the direction of your choice. Most people are content using Apple's stock input devices – after all, one mouse or keyboard is the same as another, right?

There are a lot more input choices than those offered by Apple. You can choose from a large and varied selection of alternative input devices – trackballs don't require as much desktop space as mice; graphics tablets offer pen-like control for drawing and drafting applications; voice recognition stuff for AV Macs; keyboards that laugh at the mention of QWERTY absurdities – all of these exotic devices give you new options in controlling your Mac. And even if you are happy with the type of control Apple considers normal, you may want to investigate the market for third-party alternatives to Apple's keyboards and mice, which are – to put it charitably – priced at the top end of the market. Macs that came after the Plus are equipped with the Apple Desktop Bus (ADB), an expansion system for input devices – this is where the Macintosh learns of your input decisions. And since it is unique to Apple, it is also the reason why you can't simply use those ultra-cheap PC mice and keyboards.



Video Vision

STUDIO

Non-linear editing?

A revolution is taking place in the world of video. It's going digital. At the forefront of this new technology is a remarkable product called VideoVision Studio™ – a sophisticated new digital video system that lets you edit in a non-linear way, which saves time.



Besides this break-out panel, VideoVision Studio fits inside an Apple Macintosh.

VideoVision Studio digitally captures, re-plays and outputs full screen, full motion, 50 fields-per-second video with stereo audio.

You assemble clips or frames by moving visual representations on up to 99 frame-accurate tracks of video or audio. Then watch the result in jump-free, full screen colour immediately. And hear the audio. In stereo – at up to CD quality.

VideoVision Studio comes equipped with a host of digital video effects that you wouldn't expect to come free with an edit suite.

And features like full standards conversion between NTSC, PAL & SECAM. Digital adjustments to hue, saturation, brightness, contrast, sharpness, black & white and audio levels.

Oh, and a video grabber facility to produce perfect colour stills for story-boarding or desktop publishing.

Like many journalists and commentators, you are probably burning with enthusiasm to see VideoVision Studio in action. So come to one of our demonstration seminars and prepare to be amazed.



MacUser
Award '93

We've got it taped.



Or you can get hold of our free demonstration video by calling 0483 772 773, or writing to Radius (UK) Ltd, 13 Westminster Court, Hipley Street, Old Woking, Surrey, GU22 9LQ.

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The Mouse

Since its invention in 1964, the mouse has become the world's premier pointing device. Unlike a keyboard, it's conveniently included with each machine.

Although Apple's mice are among the best, they're mechanical beasts prone to wear and breakdown. The mouse mechanism uses a rubber ball that requires a smooth surface on which to roll, lest the pointer jerk across the screen. The ball and the rollers it touches accumulate dirt and require periodic cleaning – eventually you might need to replace your mouse.

Apple's current Desktop Bus Mouse II, has a comfortable, rounded shape. Its ball is located closer to the front of the mouse, a location that Apple says allows for more precision with less hard effort. And less hard effort means less strain on your hand, wrist, and arm muscles.

There are several third-party alternatives here. The most basic is Contour Design's Mouse Topper, which is a replacement top for your old Apple Desktop Mouse (which had a more

boxy, angular design). It is literally a snap to affix. Other mice come in all shapes and sizes. Some have more than one button – these let you program them to issue -key sequences or execute macros. People who use Apple's AU/X version of the Unix operating system should get one of these because Unix windowing systems often use a three-button mouse.

A mouse that doesn't suffer from the dust and wear problems of the rolling



ball variety is the Little Mouse. Designed for ADB-equipped Macs, the Little Mouse is an optical mouse. Rather than measuring the movement of a rubber ball, it measures the light reflected from a 7- by 8-inch pad covered with a grid of minute dots. Apart from its button, it has no moving parts to wear out – and it's smaller and lighter than Apple's mouse. But you are required to always use the supplied

pad, which can cause mobility problems.

You can get a cordless mouse, which uses an infra-red link instead of a wire. It runs on rechargeable batteries and provides a sleep mode that conserves juice when they aren't moving.

Trackballs

If you can't spare much desk space, consider a trackball – a plastic ball that sits on rollers housed within a small case that, like a keyboard, occupies a fixed location on your desk. To move the Mac's pointer, you roll your fingers across the trackball. A trackball's ability to fit and work in a small space is what makes it the pointing device on PowerBooks.

Most trackballs provide two buttons. One works just like a standard mouse button, while the other works like a mouse button that sticks. This second button lets you drag icons, windows, or other items without holding down a button: Click the button once to start dragging, and then click it again to stop. By giving your hand one less chore to perform, a locking-click button can help you make more precise point-

er movements, and it eliminates the finger fatigue that hours of delicate dragging can cause.

Keyboard options

Most alternative input devices are alternatives to the mouse. A pointing device is the cornerstone of the Mac's graphical interface, true – but the keyboard is essential too, especially for typing-intensive applications such as word processors and spreadsheets.

Apple offers several keyboards for the Mac. The Apple Keyboard comes with the LC III and most Performa models. It's also the keyboard you'd have got with your Classic Macs and early LCs. It has a standard typewriter layout supplemented by four arrow keys for moving the Mac's blinking insertion point, and a calculator-like numeric keypad for fast number entry. Many word processors also use the numeric keypad for scrolling.

The Apple Extended Keyboard II supplements the standard keyboard's typewriter, arrow, and numeric keypad keys with additional scrolling keys and a row of 15 function keys. Many programs use the function keys as keyboard shortcuts for often-used menu commands.

If you suffer from wrist pain caused by typing, you may want to consider the Apple Adjustable keyboard, which sports a "split keyboard" design that supposedly keeps your wrists in a healthier position. You can angle the left- and right-hand sections of the keyboard to up to 30 degrees to find the typing position that feels best. You get detachable palm rests; volume control; a separate extended keypad that includes function keys, a numeric keypad, and cursor-control keys; and adjustable feet that let you change the slope of keyboard and keypad.

Other weird-looking keyboards are included in the Maltron range. The latest Maltrons have a curved number pad section and a palm rest to reduce strain in finger minutes.

Different keyboard layouts

The conventional typewriter layout was created in an effort to slow down typists who were causing early typewriter mechanisms to jam. The Dvorak layout (as opposed to the QWERTY one) puts the most frequently used characters in more accessible positions. The maltron keyboards will operate in either QWERTY or an alternative called the Maltron mode.

Pens and tablets

For drawing and drafting it's hard to beat a graphics tablet, also called a digitizing tablet. Tablets provide a flat drawing area onto which you scrawl using a pen-like stylus whose tip contains a switch that mimics a mouse button.

Most tablets have a drawing area that's covered with a clear plastic sheet, or overlay, under which you can tuck artwork to be traced. A newspaper artist may use a graphics tablet and a drawing program such as Aldus Free-Hand or Adobe Illustrator to trace a map or diagram to accompany a story. Many tablet pens accept ink-filled cartridges, letting you place a sheet of paper on the tablet's surface to see on paper what you're drawing on screen.

Tablet work areas vary widely in size, and as the size increases, so does the price. One inexpensive tablet, Cal-Comp's DrawingPad (for ADB-equipped Macs) provides a small work area 7.5-inches square. Midrange tablets have work areas of about 8.5- by 11- by 18-inches. Large tablets can provide as much work area as a drafting table. Wacom offers a tablet with a 35- by 47-inch drawing surface.



Absolute vs relative motion

Their pen-on-paper operating style isn't all that makes tablets superior drawing tools. Equally important, tablets are absolute-motion pointing devices, while mice and trackballs are relative-motion pointing devices. Your blind mouse can't report its physical location: It doesn't know whether it's at the edge of the desk or in the middle. When you pick up the mouse and set it down elsewhere, the pointer doesn't suddenly jump to a different spot on the screen. Mice and trackballs simply report that they're moving a certain distance in a certain direction.

In contrast, each point on a graphics tablet corresponds to a point on the Mac's screen. Pick up a tablet's stylus and then touch it to a different part of the drawing area, and the Mac's pointer does suddenly jump to a different part of the screen.

It's this operating style that makes tablets ideal for tracing and drawing. Most tablets also provide a relative-motion mode that you can use when you want mouse-like operation.

Graphics tablets are also better able to discern small degrees of movement. Mice and trackballs can generally dis-

cern 200 to 300 units of movement per inch, but graphics tablets typically detect 1,000 units or more per inch. The higher a pointing device's resolution, the better suited it is to precise drawing, because it's able to register even minute movements.

Pressure-sensitive tablets

For artists, the most exciting graphics tablets are pressure sensitive. With tablets such as Wacom's SD series, pressing harder with the stylus gives you a darker or wider line. But there's a catch: You need a graphics program that responds to the pressure information the tablet sends.

Another desirable, if costly, trait in a tablet is the ability to work with a cordless pen. By eliminating the pen-to-tablet umbilical, tablets such as Wacom's SD series and Kurta's IS series take one more step toward providing a natural-feeling drawing surface. Most tablets, including Wacom's and Kurta's, also accept a mouse-like cursor containing a lens with cross-hairs that aid in precise positioning.

Talk to me

Apple's AV Macs and Plain Talk voice-recognition technology let you use

some hardware of your own (your mouth) as an input device. PlainTalk can aid users who have disabilities and it lets you rest your wrists now and then by choosing menu commands and activating palette tools with spoken commands.

Specialized input

Less common, but out there if you look hard enough are joysticks (great for games) and various devices for disabled users, including headsets and foot pedals. For a while it was thought that touch-sensitive screens would be ideal alternatives to desktop pointing devices. Hewlett-Packard even released a computer with a built-in touch screen. Unfortunately people's arms got tired. But they are often used for computerized directories (check out the National Gallery in London), and are useful in factory environments where there aren't many desktops.

Always test drive your input

Whether you go for an Apple keyboard, third-party equivalent, or ergonomic keyboard; whether you go for a trackball in preference to Apple's mouse; or whether you swallow the tablet sales talk – don't buy until you try.

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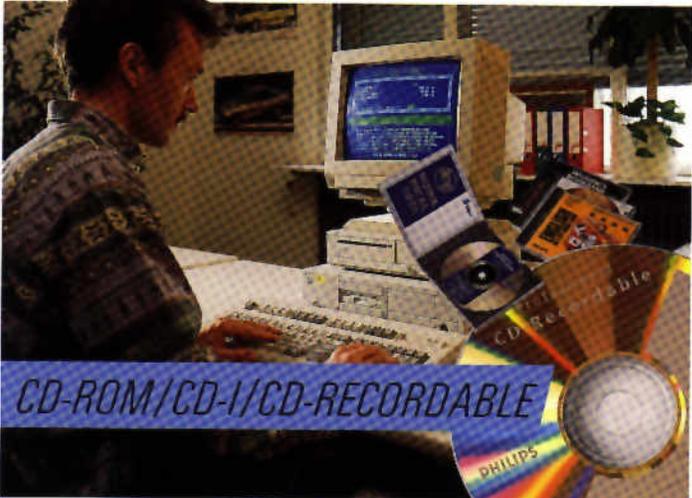


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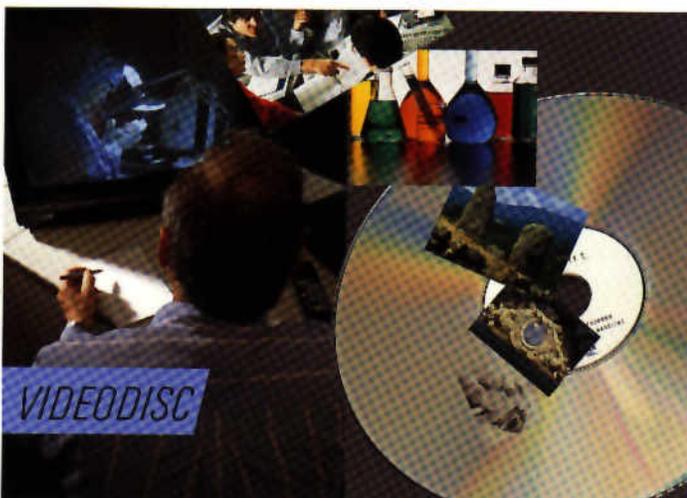


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Storage Solutions

A drive, is a drive, is a drive, as Will Shakespeare might have said. But that's because Will didn't have the QuickTime version of Hamlet cluttering up his hard disk, nor the multimedia guide to Elizabethan theatres. Today you need not just storage solutions but a storage strategy

Into the life of every Macintosh user there comes this day: you need more storage. The new hard drive that once seemed a vast frontier waiting to be filled is now jammed with files and applications, fonts and system extensions, scanned photographs and page layouts, maybe even a couple of QuickTime movies and stereo sound. A bigger hard drive with, say, a couple hundred more megabytes won't do. You want space, like galactic space – boundless, limitless, extending infinitely.

But it's more than just limitless space you need, it's portable space—space that fits in your pocket or briefcase on your way to the service bureau, your client's office, your job, or your home.

If you're only toting a few spreadsheets or text documents around, the humble floppy disk will serve you well. An 800K disk holds a good 750 pages of plain text or a 10,000-cell spreadsheet, fits in a pocket, and is compatible with virtually any Macintosh. But you won't be able to squeeze even one high-resolution scanned photograph onto an 800K floppy and

disk, and you'd need the patience of a saint and 120 or more of these disks to back up an almost-full 100MB hard drive. And long gone are the days when you could fit the Macintosh System software on a floppy. For all of these purposes you need an alternative form of storage.

You're in luck.. The Mac supports several alternate-storage technologies, each with rewritable removable-media cartridges or disks that effectively give you limitless storage to take anywhere.

To help you choose the right removable-storage solution – or solutions – Macworld has looked at the array of available options and evaluated them in terms of speed, device price, price per megabyte of storage, and appropriateness for different work settings.

At the low end of the market (from around £300) you'll find Floptical and very-high-density floppy (VHDF) drives. Both drives offer roughly 20MB of storage (remember, that used to be a hard drive's worth) on a single 3.5-inch disk. At the high end of the market, with street prices around £800 to £4,000 but falling, magneto-optical mechanisms provide archival storage on virtually indestructible disks holding up to a gigabyte of data each.

Somewhere in between these two markets, you'll find the original removable-storage kings – the Bernoullis and SyQuests, two institutions that still dominate the market, and for good reason. They've proven their worth as reliable, sturdy, and cost-effective. And finally, removable and external hard drives and tape-backup systems fill out the bill.

But before we get to these wonderful, exotic beasts remember that first and foremost your Mac needs a mainstream storage system as well: a reliable, workhorse hard drive.

MAINSTREAM DRIVES

Unless you routinely work with huge database or graphics files, don't waste your money buying a giant hard drive (if you need a bigger, faster drive for specialized applications, see *Supersonic Storage*). A drive no larger than 500MB offers plenty of space for your business and personal needs. The great challenge of buying a mainstream hard drive lies in stripping away drive vendors' claims about the added performance value of their software.

The key factors for speedy data delivery are the size of read and write caches (small amounts of memory that

increase the efficiency of data transfers); spindle speed (the speed with which the disks revolve); and, to a lesser extent, access time (the rate at which data is found on the disk). All of these are determined by the design of the mechanism that each hard drive is based on, not by the vendor that sells you the product.

Macworld Lab tests revealed that, in mainstream drives, regardless of the software supplied by the vendors, higher capacities mean faster drives. Where different vendors' drives use identical mechanisms, performance is nearly identical.

Although these drives sell for £250 to £1,400, you can pay £1 or less per megabyte of storage at any capacity. This makes your buying decision relatively straightforward: pick the biggest, fastest drive you can afford, from a vendor that offers reasonable technical support and service.

Buying smarter

Over several years of testing hard drives, Macworld has learned that the performance gains attributable to a reseller's driver software (the software the Mac uses to control the hard drive) don't amount to much, despite some

Driving too fast: When the Mac can't keep up

Before deciding that the drive mechanism is all-important, remember that your system is only as fast as its weakest link. Whenever you read or write data to a drive, the controller on the drive and the controller on your Mac's motherboard (or SCSI adaptor) have to communicate at the same rate. The controller hardware on older computers can't keep up with faster, higher-capacity drives. The drive effectively slows down to the computer's speed. For example, the SCSI chips on a Mac LC have a maximum bandwidth of 1,100 kilobytes per second; most drives in the mainstream of the Mac drive market can transfer data at 1.4 MBps. Thus the LC is the bottleneck.

The minimum computer you need to take full advantage of the full speed of any mid-range hard drive is an LC III or Centris 610. In other

words, if you own a less powerful Mac simply don't worry about drive performance because your Mac is the limiting factor. Conversely, a fast computer, such as the Quadra 840AV, will spend a good deal of its time waiting for a slow drive, bogging you down considerably.

All of the 68040-based Macs have fast SCSI hardware yielding transfer rates of about 3.4 MBps – more than fast enough for drives up to 540MB. Additionally, the Quadra 660AV and 840AV incorporate the new SCSI Manager that supports faster data transfers and background operation (see the feature "Drive faster,").

As computer speeds continue to improve and the practical limitations of SCSI disappear, drive manufacturers will have to dramatically improve on existing technologies (or invent new ones) just to keep up.

Unless you have a Quadra or Centris 650, you can't just buy a SCSI-2 Fast drive and expect to be up and flying. To allow a slower Mac to take full advantage of a fast drive, you need a SCSI-2 adaptor. These are sometimes called SCSI accelerators, but the term can be misleading, since most adaptors don't speed up the Mac's existing SCSI bus but instead add a SCSI-2 bus. SCSI-2 adaptors are available that install in a NuBus expansion slot or in the PDS of a Quadra or IIfx.

Looking ahead, expect to hear much of FireWire, a very high-speed serial data bus that could replace serial ports, ADB, and SCSI in future Macs and peripherals. It is being developed by Apple, Texas Instruments, and other key industry players. FireWire could go live with the second generation of PowerPC Macs.

vendors' claims. The fastest and slowest drives based on the same mechanism will always be within 10 per cent of each other's performance – and usually show less than 5 per cent difference.

Moreover, only about 30 per cent of the time spent on typical functions, such as opening or saving a file, involves the hard drive; system and program overhead accounts for the

other 70 per cent. Therefore, the real performance variation between like mechanisms from different vendors is less than 3 per cent. For example, saving a 400K Microsoft Excel file will differ



by as little as one or two seconds.

By the same token, some software vendors claim their formatters enhance drive performance, though they acknowledge that speed benefits are small. In 1994, for the second year in a row, the Maxtor MXT-540 mechanism was the speed leader. It can be bought in drives from Ambar Systems, PLI, and MicroNet Technology, with prices beginning at £495 from MicroNet.

Two other mechanisms (the Quantum LPS525S and the Seagate/Optima ST3610N) are only slightly smaller and slower than the MXT-540. With formatted capacities of 500MB and 509MB respectively, these drives perform only 10 per cent slower overall. If you save a 3.9MB Adobe Photoshop file, for example, this translates into a difference of only 4 seconds.

For those of us with more modest budgets, the Quantum LPS240S represents an attractive option. This mechanism is only 20 per cent slower than the MXT-540 in overall performance. Eleven vendors carry it, with prices ranging from £295 (Focus) to £1,099 (La Cie). If your wallet is thinner still, consider the 161MB Quantum ELS170S. This drive is slow but you can buy it for only £190 (from d2 électronique). And you'll get

Keep your hard drive healthy

Your hard drive stores all your valuable data, so you should learn to treat it with the respect it deserves. (And you should always remember to back up your data.) Follow these ten simple rules and your hard drive should live longer.

1. Turn on your drives first. Once they are up to speed, then turn on your Macintosh.
2. Turn off your Macintosh first, then turn off the drive. Always quit each application and perform a shutdown using the Special menu.
3. Do not turn the drive on and off many times in succession. Allow about one minute for the System to completely shut down before turning it back on.
4. Never move or jar the drive while it is operating.
5. When transporting the drive, prevent jostling it by using a padded container or the original packaging.
6. Allow adequate space around the system's cooling vents. Remove books, papers, or anything that might block airflow.
7. Do not place the drive on carpeting; the static electricity found in carpeting can cause data corruption.
8. Do not place the drive on top of or directly next to the monitor; electromagnetic radiation will interfere with the drive and may corrupt your data.
9. Attach and detach SCSI cables carefully – you can irrevocably damage the whole drive by wreckless cable-yanking that can harm connectors.
10. Avoid rapid temperature changes. Allow your drive to warm up to room temperature before operating it if the drive was previously in a very cold environment.

50MB more storage than with the cheapest and slowest mechanism we

reviewed, the Quantum ELS127S. Several drives of about 120MB are



available: Ambar Systems and Focus Enhancement have the Maxtor 7131S; MindFlight Technologies sells the Quantum Go 120S; Microtech International, Third Wave and Thame Systems offer the Quantum ELS127S; Computer Capability and MacAccessory Centre sell the Quantum LPS 120S. For the most part, all of these mechanisms are poor deals. Prices are relatively steep, starting at £199 (£1.65 per megabyte) and going up to £370 (£3.08 per megabyte).

Other mechanisms to avoid include the Toshiba MK2326 and the Maxtor 7345S. While both offer reasonably high capacity, they ranked, respectively, fourth and third to last in performance, and typically cost more than £1.15 per megabyte.

REMOVABLE STORAGE

If you're looking for simple, clear distinctions—price versus speed versus reliability, for example—be forewarned. The right solution depends as much on the state of the technology as on the type of files you create and kind of work you do, and the technology is constantly changing.

You may find – as many companies large and small have – that you need or

want several removable-storage devices. Artists and graphics firms, for example, may find it effective to use a removable hard drive for work in progress and a SyQuest drive for transporting files to service bureaus. An accounting firm might keep a stack of digital audiotapes for daily backups but archive client records to a magneto-optical drive. With that said, here's how to get unlimited and portable storage forever.

Bernoullis and SyQuests

Until recently, when referring to removable-storage devices, people usually meant SyQuest-based drives, Ricoh-based drives, or Bernoulli cartridge drives from Iomega, the first three removable-media mechanisms out the gate. (Ricoh recently exited this market.)

These highly versatile devices, which today support 44MB to 150MB media, gained rapid widespread popularity almost as soon as they hit the market in the mid-1980s, especially as mountable backup devices for hard drives and as convenient ways to transport large files. Because these drives use magnetic media, files stored on them are vulnerable to stray magnetic fields and to

eventual weakening, but their superior speed and wide acceptance among Macintosh users make them an excellent choice where long-term durability is not essential.

Whether you opt for an internal or external drive, you can find a Bernoulli or SyQuest drive for roughly £250 to £700, list price; street prices start around £200 with SyQuest cartridges ranging from about £30 to about £65, depending on capacity. Bernoullis are a bit more expensive, with prices of £50 for the 35MB disk to £85 for the 150MB.

SyQuest cartridges are available in the 5.25-inch format in either 44MB or 88MB capacity; newer 88MB drives can both read and write to, but not format, 44MB cartridges, although at irritatingly slow speeds, according to Macworld Lab tests. SyQuest now also offers a 3.5-inch mechanism with cartridges at capacities of 100MB and 256MB. A new 5.25-inch drive pushes capacities up towards 200MB.

The original Bernoulli drives worked with 5.25-inch, 44MB cartridges and were succeeded by 90MB drives that could read but not write to the 44MB cartridges. The MultiDisk 150 works with a new range of cartridges—35MB, 65MB, 105MB, and 150MB—and can

both read and write to the 44MB and the 90MB cartridges. The MultiDisk 150 gives consistently good speed on all of the new cartridges but there's a substantial speed deficit when writing to the 90MB and 44MB cartridges.

In Macworld Lab's tests, the Bernoulli MultiDisk 150 was somewhat slower than both SyQuest's new 3.5-inch 105MB drive and the 5.25-inch 88MB drive.

On average, the Bernoulli MultiDisk 150 took about 23 percent longer than the SyQuest 105MB mechanism and about 22 percent longer than the SyQuest 88MB mechanism to open, copy, and save files.

Which One When?

In the Macintosh world, SyQuest drives, manufactured by SyQuest but packaged and retailed by an assortment of resellers, hold a sizable dominance over Bernoullis. In the DOS and Windows marketplace, the reverse is true. Service bureau clients, however, can safely choose either system; all but the smallest bureaus and prepress houses accommodate both SyQuests and Bernoullis.

Unlike the rigid disk inside a SyQuest, a Bernoulli uses a flexible

medium, something like that inside a floppy disk. The read-write head floats slightly above the disk on a cushion of air that also whisks away any dust that makes it through the disk's protective case. If the air current ceases (due to a loss of power, for example), the disk falls out of the way of the head, eliminating the threat of head crashes. While out-and-out head crashes are relatively rare in SyQuest drives, the drives are susceptible to dust, which can make individual files unreadable.

But while Bernoulli technology has enjoyed a reputation as being more reliable than SyQuest's, the problems with early SyQuests have been fixed and the technology's reliability is no longer an issue.

Mighty Mo

MO, as it's often referred to, has plenty to recommend it. Though the initial cost for a magneto-optical system can be up to six times as much as a Bernoulli or Iomega drive, the price gets you access to superlow media costs. Each megabyte of MO storage will cost about 10p, compared with close to £1 per megabyte for a typical SyQuest system. For those who need storage in truckloads, paying between

£750 for a 3.5-inch 128MB MO drive and £3,750 for a high-end 5.25-inch gigabyte drive is a worthy investment.

If archival durability is your foremost concern, a system based on a magneto-optical drive is your best choice, period. The infrared laser beam in the mechanism's read-write head records information on a layer of medium that is safely sandwiched between two protective layers; even if you manage through exceptional malice or neglect to damage the coating, the focal depth of the laser reading the data is long enough (sometimes over an inch) to access data reliably.

Further, optical cartridges are several hundred times more resistant to magnetic-field corruption than are conventional magnetic media, making for a far longer shelf life, up to 30 years, for optical disks.

Not surprisingly, government agencies and insurance companies use opticals to store scanned-in collections of forms and to archive data on write-protected disks. Artists and graphics houses working with high-resolution scanned photographs use opticals to save multiple versions of images for reuse virtually indefinitely.

And many service bureaus maintain

optical archives on behalf of their clients.

Due to the low cost of media, many users back up to opticals as well. Opticals may be more expensive than tape-backup drives, but like Bernoullis and SyQuests, opticals have two aces in the hole. You can boot up your system from an MO drive, and you can search data backed up to MO far more quickly than you could ever hope to with tape.

In the past, MO drives have been faulted for both their lack of industry-wide standards and their slow speed (compared with hard drives). In response to the former, the optical vendor community is nearing consensus on a whole range of media specifications, affecting everything from track density and disk height to the size of the spindle hole.

As for overall speed, in Macworld Lab's tests the 3.5-inch optical drives performed notably more slowly than SyQuests and Bernoullis. However, 5.25-inch opticals compare very favorably with SyQuests and slightly outperform Bernoullis.

But don't make a buying decision based on speed tests. While superfast access times are critical for a primary storage device, like a hard drive, they're

not imperative for devices used for secondary storage. Few users run applications from MOs. Instead, most MOs are used as backup devices or as secondary storage for large files and images.

Meanwhile, prices for the MO's laser mechanism – the heart and soul of the device – have nearly halved since introduction. What's more, a new, split-head design for the read head, available in a few models, dramatically reduces the weight of the traveling portion of the head, enabling far greater access speeds.

Even so, data-transfer rates are still about twice that of hard drives because, although the head can find data faster, the data itself goes through the logic board at the same rate once it's been found.

For users with astronomical storage needs, optical-drive makers have developed a mechanism known as the optical jukebox. Like its audio forebear, the optical jukebox holds multiple disks and places them into operation one at a time at the user's bidding. For example, the PMO 10GB from Pinnacle Micro holds 16 5.25-inch 650MB cartridges.

Floppies on Steroids

If your backup and archiving require-

ments are modest, and you are not too concerned about transporting files from Mac to Mac to Mac, two direct descendants of the venerable floppy drive can offer you a convenient and economical option. Around £300 to £500, Floptical drives and VHDF drives let you cram about 20MB of data onto one 3.5-inch disk that looks – and unfortunately performs – like its ancestors.

Of the two technologies, Flopticals have the clear edge. Drives such as the Floptical from Iomega are backward-compatible, so they can read and write to 1.44MB floppy disks. VHDF drives, manufactured by Brier Technologies and available on the Mac only as the QuadFlextra from Quadram, cannot read or write to regular floppies.

If you work with a small number of files, the 20MB ceiling might not trouble you. An inability to share files with other Macintosh users might, however; these drives have yet to penetrate deeply into the Mac market, which diminishes your chances of being able to use them to share files with colleagues, bureaus and others.

In Macworld Lab's speed tests, the Floptical drives trailed the other removable media by a long shot, roughly tak-

ing twice as long as the 3.5-inch optical drives and about four times as long as the 88MB SyQuests.

However, Floptical speeds are respectable in comparison to the speed of a standard floppy disk. Both Floptical units tested performed overall about 57 percent faster than the Mac IIfx's internal SuperDrive.

A few years back, these two super-floppy technologies might have turned some heads, maybe as a replacement for one of the Mac's internal floppies, but for most people today, they offer too little too late. On the other hand, if you work mainly with small files, you may find super floppies an excellent low-cost and practical choice.=

Movable Hard Drives

Before succumbing to the siren song of the new storage technologies, don't overlook the obvious: for all the hoopla over alternate-storage technology, the only storage medium that offers the performance of a hard drive is a hard drive. Removable hard drives and portable hard drives make it easy to carry away hundreds of megabytes, whether you're taking your work on the road or securing it in a locked cabinet.

So if your hard drive runneth over

but it's not a chronic situation, the solution may be simply to purchase an additional portable or removable hard drive. For example, a £350 investment in a portable drive can easily net you 100MB or so of fast, flexible, reliable storage, and the pound-to-megabyte ratio drops quickly as you reach the higher-capacity ranges.

Given adequate space on the second drive, you can devote separate partitions to seldom-used applications, password-protected data, and routine backups.

On the other hand, portable drives are not infinitely extensible. They come in a variety up to 200MB or more. But once you fill a portable drive, that's it. Just as with any hard drive, you have to clear files off the disk to make room for new ones.

Removable drives, which pop in and out of stationary docking stations, or chassis, operate very much like portable hard drives, with one added bonus: you can extend their capacity by purchasing additional storage units. La Cie's Passport Removable Hard Drive, for example, has a chassis into which you can plug storage units from 50MB to 240MB.

The price is high, but if you have a

chassis at home and one at work, a removable hard drive can be a convenient choice—with its protective carrying case it's slightly smaller than a portable drive and you don't need to connect the SCSI cable each time you use it. Nevertheless, expect to see these relatively rare devices become even rarer as removable-cartridge systems and MOs dominate the market.

Tape Drives

Finally, some old news: if it's back-up storage you seek—and just backup—magnetic tape drives are still by far the cheapest way to go. You can set up your backup system to operate automatically and then virtually forget about it until you need to restore.

Individual users and others with reasonably modest storage needs can pick up a good-quality drive with backup software for around £600. With 150MB tape cartridges that gives you running costs of a few pence per megabyte.

Companies looking for network backup and those working with very large files can find gigabyte-plus drives using either helical-scan (8mm) or digital-audiotape (DAT) technology. The drives themselves range widely in price, from around £1,300 to several thou-



sand for a 5GB 8mm tape drive from companies like MacinStor or Storage Dimensions, but high-capacity tape cartridges bring the DAT's media price down below a penny per megabyte.

Although cheap and reliable, tapes are not sufficiently stable to provide long-term archiving. For routine backup you can confidently reuse cartridges many times. After a while, though, tapes stretch and wear out, just as audiotapes do, but with potentially disastrous effect. That's why many users maintain a stash of tape cartridges and cycle through them for weeks or months, replacing them periodically with fresh tapes.

Even if you use tapes only once and then put them away, the magnetic charge weakens with time. Files stored on magnetic tape – as on any magnetic medium – can become corrupted and unrecoverable after a couple of years.

The great advantage to tape is its low price. Its great disadvantage, and the one that sets it apart from all the other storage media discussed here, is that data access is sequential and not random. That means to restore data saved to tape, you've first got to find it by rolling forward or backward on the tape.

New software, such as Optima Technology's DeskTape, can index tape contents and place a directory folder on the desktop. With these applications, selectively restoring files and folders becomes a familiar—if still painfully slow—copy operation.

Which Storage Universe?

All removable systems provide virtually limitless storage. The question, then, is which standard is best for you.

If your main concerns are compatibility, versatility, device price, and speed, then the most flexible all-around choice remains, at least for now, SyQuest drives. With performance just slightly behind that of a hard drive, and with widespread use among Macintosh users, 88MB SyQuests make good sense for people who routinely carry large files around.

For a slightly higher investment, you can purchase a Bernoulli MultiDisk 150 and get the same flexibility and a little sturdier cartridge for your data. Either type of drive makes for a convenient, if not necessarily economical, backup device – although fewer bureaus use Bernoulli drives.

If you're more concerned about long-term data integrity or random

access to gigabytes' worth of data, make the move to magneto-optical. Though the technology is still maturing, it's stable enough to justify the investment, and the low media cost is surpassed only by tape. The optical industry is sure to respond in kind to SyQuest's aggressive competition, which means prices will continue to fall as performance rises.

If cost is an issue, here is the rule of thumb. If you work with small files or a modest number of files, the cost of the device is more important than the cost of the media. If you routinely work with colour, video, scanned images, and other through-the-limit file sizes, you will save money in the long run by buying a device that offers low media cost, even if it means a higher investment in the device itself.

It's always tempting to hold out until the next innovation ships – to wait for the high-capacity SyQuests or the next faster optical. Yes, whatever you buy today will be supplanted tomorrow by something better.

But if your hard drive is bulging at the seams right now, there's no way to avoid it; take the plunge immediately – but start saving for your next hardware investment.



Supersonic storage: faster, bigger, cheaper

Although high-capacity hard drives may seem expensive, prices have plummeted. And they look likely to continue doing so. If you can count on one thing, it's that hard drive capacities go up, and prices come down – often at the same time. Physical sizes are also diminishing: many high-capacity drives still use 5.25-inch disk platters, but a growing number use smaller, 3.5-inch mechanisms. If you prefer an internal drive – for the extra security it provides or simply to control desktop clutter – the downsizing trend means you're more likely to find a high-capacity drive that will fit inside your Mac. Only the Mac II, IIX, IIVx, IIfx, Centris 610 and 650, Quadra 800, 900, and 950 can accommodate an internal 5.25-inch drive; the other members of the desktop family require 3.5-inch drives.

FASTER AND FASTER For color publishers, a hard drive can't be too fast. Pre-press professionals lose money every time they drum their fingers waiting

for Adobe Photoshop images to open or save. Fast, high-capacity hard drives are also essential for professional-quality video work. And they're the mainstays of network file servers that supply programs and documents to an office full of computers. A fast hard drive enables a server to keep up with the data demands of the users connected to it.

The latest drives meet these challenges. One reason the drives with these mechanisms are faster is that their internal platters spin faster. A fast spindle speed allows for a faster data-transfer rate, since the drive's heads cover more information each second.

But this extra speed is wasted if the Mac can't keep up. The fastest hard drives can send and receive data faster than any Mac except a Quadra. On a slower Mac, an ultrafast drive twiddles its thumbs as it waits for the SCSI bus (see *Driving too Fast*).

SCSI GOES FAST – AND WIDE The fact that a fast drive demands a fast

input/output bus has helped spur development of an updated version of the SCSI specification, called SCSI-2. Understanding what SCSI-2 does and does not provide is an important first step in creating a performance-tuned storage system.

The most basic aspect of SCSI-2 involves an updated set of the commands that SCSI devices use when conversing. This aspect of SCSI-2 does not address performance; rather, it simply defines a new vocabulary for devices to use when communicating.

The aspects of SCSI-2 that do address performance are two data-transfer techniques called Fast and Wide. SCSI-2 Fast is just that—it describes new timing and data-packing methods that boost the speed at which data can travel over a SCSI bus. SCSI-2 Fast allows for maximum sustained transfer rates of 10MB per second – twice the rate of standard SCSI.

SCSI-2 Wide doubles the number of data pathways from 8 to 16. The



combination of SCSI-2 Fast and Wide allow for maximum data-transfer rates of 20MB per second. When 32-bit Wide devices appear in the future, that theoretical rate will double to 40MB per second. (And SCSI isn't stopping there – the industry is already starting to talk about SCSI-3, which will support fiber-optic connections that promise gigabyte-per-second transfer rates.)

Encouraging as this sounds, SCSI-2 and its Fast and Wide variants have created fertile ground for confusion and advertising hype. The problem is that most current hard drive mechanisms are advertised as supporting SCSI-2, when many merely understand the SCSI-2 command set and don't incorporate Fast or Wide features.

BIGGER MAY NOT BE FASTER Until recently, larger-capacity drives were almost always faster than their more-cramped cousins. That isn't always the case now. In Macworld Lab tests, drives in the 2.7GB–2.9GB range performed faster as a group than the 2GB machines but were slower than

the speediest 1GB drives.

For tasks that involve transferring hundreds of megabytes at a time, you'll get the best performance from a disk array, which combines two or more drive mechanisms with specialized controller circuitry and driver software that fools the Mac into thinking that it's communicating with a single drive.

Disk arrays come in several flavors, with each described according to a framework called a RAID—redundant array of inexpensive disks. RAID Level 0 is the simplest and least expensive; it uses a technique called data striping to split data evenly across two drives, boosting data-transfer rates by allowing disk reads and writes to occur simultaneously. The drawback is that the array is only half as reliable as a single mechanism – if one mechanism fails, you lose the contents of both.

The redundancy aspects of RAID surface in Levels 1 through 5. By using complex data-recording techniques, a Level 3 or Level 5 array can reconstruct the contents of any mechanism that fails. With most Level

3 or 5 arrays (RAID Levels 2 and 4 aren't used on the Mac), you can even replace a faulty mechanism without shutting down the system. The drawback of such systems is that the extra overhead required to keep track of each mechanism's contents slows overall performance, particularly with small files.

A Level 1 array provides a better balance between performance and reliability using a technique called mirroring, which writes the same information to two mechanisms simultaneously. Disk reads from a Level 1 array are about as fast as from a Level 0 array, but writes take longer, since the data must be written twice – once for each disk in the pair.

Most SCSI-2 adapter boards include software for setting up a mirroring array. Most arrays can be configured as either Level 0 or Level 1.

You can buy an array as a complete package that includes drive mechanisms, driver software, and in some cases, a controller board; or you can assemble an array yourself by combining two or more drive

mechanisms with a SCSI-2 board that includes striping or mirroring software.

OUTFITTING A MAC FOR FAST SCSI Unless you have a Quadra you can't just buy a SCSI-2 Fast drive and expect to be up and flying. To allow a slower Mac to take full advantage of a fast drive, you need a SCSI-2 adapter. SCSI-2 adapters are available that install in a NuBus expansion slot or in the Processor Direct Slot (PDS) of a Quadra or Mac IIx. A PDS-based SCSI-2 adapter will be faster. If you want to speed up your Mac's overall performance as well as its SCSI transfer rate, you might consider pairing a Radius Rocket accelerator with SCSI-2 Booster.

In the RocketShare environment, the SCSI-2 Booster has some appeal. Thanks to RocketShare's multiprocessing capabilities, you can start transferring megabytes of data across the SCSI-2 Booster's bus, and

Macworld Recommended...

MINIPAK 1000 A gigabyte to go: this Maxtor-based drive delivers fast performance in a portable package.

Company: Optima Technology. List price: from £599.

Nova XL 2700 Rugged construction, solid performance, and a five-year warranty make this drive a standout.

Company: Microtech International. List price: £5,071.

QuickSCSI This reasonably priced, NuBus-based SCSI-2 adapter for the Quadoras provided a bigger performance boost than the competition—as it did last year. Its documentation needs work, however.

Company: PLI. List price: £469.

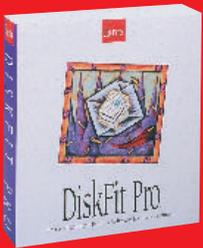
then switch back to the Mac's logic board (or to yet another Rocket) to work in a different program.

This could save time for people who use a scanner or SCSI-based printer extensively. Without RocketShare, however, you can't use a drive connected to the SCSI-2 Booster as a start-up drive.



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Connectivity

Networking may be easy on the Mac, but there comes a point where you have to move into the next level of complexity. Bridges and routers lurk in wait for the unsuspecting – but it doesn't have to be that daunting...

Thanks to the Macintosh's famed ease-of-use, an ease that extends even into the normally arcane reaches of connectivity, networking the Mac is something many users do without thinking. Hook up your Mac to a laser printer via LocalTalk and you've created the simplest kind of network; add another Mac and you have a network that contains all of the requisite elements – multiple computers sharing files, information and print resources.

In most Macintosh workgroups, you can grow this sort of network without too many worries, since most Macs are concentrated in small groups. But in all likelihood there will come a day when you stretch the network to breaking point, or you need to connect two networks, or add your little Mac enclave to the corporate system.

At this point, you need to consider adding one or more of the stranger devices in Mac-dom: repeaters, bridges and routers. These devices let you connect cables together to form

larger networks. Routers require the most detailed consideration since they are more complex devices with the most complex tasks.

Repeaters

A repeater is simply a signal amplifier that lets you push the network information along a length of cable beyond its normal limits. It is a dumb device (it can't differentiate between different kinds of signals, for example) so it is only useful for connecting similar networking cables: LocalTalk to LocalTalk, or ethernet to ethernet.

A repeater such as Farallon's PhoneNet StarController also provides some management tools that can, for example, automatically remove a malfunctioning machine from the network and track network traffic. You place repeaters where all network lines terminate, in the wiring closet. Doing so turns the network into an active star, in which a repeater actively amplifies the signals to ensure that they reach every machine on the network.

Repeaters have two limitations: first, you can only pass a signal through two repeaters; second, they do nothing about collisions if you have too many nodes on the network segment.

In either of these cases you need to move to the next level of complexity, a bridge.

Bridges

Think of a bridge as a smarter repeater. It does all the things the repeater does, but it also adds some traffic-handling abilities.

For example, a bridge keeps a list of which nodes are located on each side of it; it checks each packet of information passing through and sends it in the appropriate direction. In this way, local traffic is kept within the relevant areas of the LAN, and network traffic is reduced overall.

However, bridges also have two limitations: first, a bridge can do nothing about "broadcast" packets, which go to everyone on the network, and as your network grows such broadcasts will ultimately overwhelm the network; second, like repeaters bridges can only connect similar cables, LocalTalk to LocalTalk or ethernet to ethernet.

In both cases you need to move up to a router.

Routers

A router is a smart traffic manager for linking two networks together. Obvi-

ously this is just what you want if you need to attach your Mac-only LocalTalk network to a corporate ethernet LAN. But if you introduce a router into a LocalTalk-only network you create two distinct networks, one on each side of the router.

This latter point has some clear advantages. For example, if you place a router as a link between the network in marketing and that in accounts, you can look at any data packet and identify its source and destination departments. With a bridge there would be no network address, and you couldn't tell whether it came from marketing or accounts.

Routers direct traffic flow between the different physical segments of a network. While bridges, repeaters, and hubs blindly pass network traffic down the wire without being aware of where it is destined, routers are aware of the existence of the rest of the network and control traffic accordingly.

Gateways, which often run in tandem with routers, translate network packets from one protocol to another but also don't consider the traffic's destination. Routers are responsible for knowing where network data is headed, making sure it's addressed correctly,

and directing that data on the most efficient path available.

Choosing and installing the staple Macintosh router – the kind that connects LocalTalk and Ethernet networks—can be frighteningly complex, mysterious, and expensive. What starts out as a seemingly simple process (the LocalTalk-bone connected to the Ethernet-bone) can escalate into major surgery on alien anatomy.

But with increasing competition, routers have grown easier to install, configure, and manage. Today's routers keep their cool when the power goes out. They can be managed more easily, with software that reaches out over the network, automatically configures the router, and keeps security tight. But best of all, they are getting cheaper.

Here are the things to consider:

SPEED While it's true that a slow router affects a network's performance, Macworld Lab found that most routers today perform quite comparably.

INSTALLATION/CONFIGURATION Even for experienced networkers, setting up a router can be frustrating. Since there's little room for competition on speed, many router companies have tried to

Top Tips for router zoning

TIP You create zones when you divide a network into different segments, usually through the use of a LocalTalk-to-ethernet router. The names of the zones should reflect this segmentation – typically by including the building names, locations, or departments that are attached to that network segment. Users are usually most comfortable with geographical or department names that provide them with some indication of how the network is divided.

TIP Because servers are usually located in one central area, geographic clues are not needed, so their names can be more friendly. Some companies name them after cartoon characters or personalities from popular fiction. You can have fun with server names, but make sure they bear some relation to the services they provide.

TIP Changing zone names is easy, but doing so can cause users difficulties: automatic log-ons, mail programs, and printer selections, for example, might be disabled when a zone or server name changes.

TIP Plan your naming structure to accommodate network growth and minimize renaming later. When names do change, make sure that users are informed of how to recover and reset the services they use, like electronic-mail and file-server connections. Although this doesn't usually require reinstalling the products, the setup of both hardware and software often must be altered to point to the newly renamed servers or zones.

simplify the installation and configuration. Their solutions range from better documentation to simpler (or sometimes automatic) configuration to more-intuitive interfaces.

Kudos go to Cayman for the thoroughness of the GatorBox CS's canoni-

cal documentation, especially for its careful explanation of the intricacies of TCP/IP. For simplicity, user-friendliness, good organization, and just the right amount of information, however, Farallon's InterRoute/5 documentation is tops. It leads you through unspectacu-

lar but straightforward installation and configuration.

MANAGEMENT SOFTWARE The software initially used to configure a network is also often used to manage the router, keeping track of its traffic load and error rates for troubleshooting or reconfiguring the router. Look for software that works from any Mac connected to the network, letting you look at more than one router at a time. And look for support of the Simple Network Management Protocol (SNMP).

SECURITY Every router except the stripped-down Dayna PathFinder offers some password security or ability to hide parts of the network. Hardware routers have the upper hand in providing password security.

FOOTPRINT While footprint isn't a huge consideration for someone with one or two routers, it can be crucial if you have 20 or 30 competing for space in wiring closets. Software routers aren't very space-effective because they have to be installed on a Mac (or a PC in the case of Novell), which takes up a lot of space and can't be wall- or rack-mounted. While hardware routers vary in

shape, they can usually be stacked or mounted on a wall.

If you already have a concentrator or rack-mount system and want to add a router, several vendors, including Cayman, offer versions of their routers that plug into these.

TCP/IP OPTIONS Want to use a big TCP/IP network like Internet to hook up two networks on different sides of the nation? Do you need to communicate with Unix machines or other types of computers typically found on TCP/IP networks, or will you in the future? Then consider your TCP/IP options. Routers offer TCP/IP options in two basic flavors: gateways and wide-area connections.

Gateways let Macs equipped with the proper terminal-emulation software and TCP/IP protocol stack pretend to be dumb terminals and log on to Unix workstations, minicomputers, and mainframes on TCP/IP networks. Routers facilitate this charade by making it appear as if AppleTalk nodes have TCP/IP addresses.

For wide-area connections, tunneling is used to connect two AppleTalk networks through a TCP/IP network. Tunneling sends native AppleTalk traf-

fic disguised as TCP/IP packets so that they can travel across the foreign network unmolested. The router on the receiving end strips off the TCP/IP wrapper, making the packet recognizable to the remote AppleTalk network.

PRICE You'll find that some bargain-price routers are comparable to more expensive rivals. Their interfaces may not be as slick, and their implementations not as polished in one area or another, but if you are willing to put up with this and to settle for often skimpy documentation, bargain routers may be the thing for you.

Be sure you aren't paying for things you don't want, and be willing to pay for the things you need or will need soon. Although Apple and Compatible Systems sell TCP/IP options separately from their routers, many routers, like the GatorBox CS, come with built-in support. If you need TCP/IP support, make sure that you factor in the cost of add-ons.

If you need room for future expansion (and remember that most networks do grow), consider paying for a multiport router. In fact, generally allow for future expansion in all areas of your network.



Apple's Workgroup Servers: The easy choice

Finding and installing the right server for your network can be an arduous and daunting task. Fortunately, Apple has taken some of the fear out of server-buying by bundling preconfigured hardware and new software that make old Apple servers look like antiques.

The Apple Workgroup Server 60, 80, and 95 bundles combine specially tuned versions of AppleShare with the most appropriate Macintosh CPU configurations. The bundles (and the company's recommendations for using them) are a bit limiting at times.

But they are well thought out, and good value, particularly for system administrators who insist on the convenience and relative ease of use of AppleShare-based products.

AWS 60 The AWS 60 is the entry-level server based on a Quadra 610, running AppleShare 4.0 under System 7.1. This straightforward server is a smart choice for relatively small workgroups and for administrators who don't want the headaches of complex server management.



It's meant for simple file-and-print service, and possibly light-duty database applications.

AWS 80 The AWS 80 is a good communications and general-purpose file server based on a Quadra 800, running AppleShare 4.0 under System 7.1. Apple recommends the AWS 80 for use as a communications server. With NuBus Ethernet or Token Ring adapters and the Apple Internet Router Basic Connectivity Package, the AWS 80 can route network traffic between Ethernet, Token Ring, LocalTalk, and remote network segments. Add a NuBus serial card and the AppleTalk/X.25 Wide Area Extension, and the AWS 80 can double as a gateway to X.25 packet-switched networks. With Apple's SNA ps gateway software, the AWS 80 can serve IBM 3270 terminal sessions from a coax/twinax card, Token Ring, or serial connection.

Alternatively, by using Apple Remote Access (ARA) MultiPort Server software, the AWS 80 can support 4 AppleTalk remote network connections through the dial-in software's

bundled NuBus serial card. (Two more serial cards each supporting 4 modems can be added for a total of 12 dial-in ports.) Just don't try all of this at once! Not only will you run out of slots, you'll slow your system to a crawl.

The AWS 80 offers a 4mm DAT tape option that includes Dantz Development's Retrospect Remote backup server software, which makes the server an ideal, cost-effective tool for automated network backup.

And the AWS 95 represents the high-end of the product line, based on a Quadra 950 with a PDS (Processor Direct Slot)-based card providing additional processor caching and SCSI acceleration – it runs AppleShare Pro under A/UX, Apple's implementation of the Unix operating system.

AWS 90 With four available NuBus slots, the AWS 95 with 32MB of RAM, a 1GB hard drive, AppleShare Pro, and a tape-backup unit) might seem the best choice for communications services. But most of the communications and AppleTalk

networking software Apple sells for AWS-based communications servers is based on the Mac Operating System, so it can't run under Unix on the AWS 95.

In any case, the SCSI acceleration that distinguishes the AWS 95 would not be put to effective use in something like a router, which depends much more on fast access to memory. (The AWS 80's faster, interleaved memory would make it a better router than the AWS 95.) On the bright side, A/UX lets administrators provide a wide range of TCP/IP services.

Apple provides three basic configurations of the AWS 95: two are for file-and-print service, the other one is for database service.

The AWS 95 PDS Card distinguishes the AWS 95 from a Quadra 950. The card adds two accelerated SCSI buses to the two already provided by the AWS 95 motherboard and comes equipped with an expandable processor cache (up to 512K). One of the SCSI buses is for internal devices only, while the other has both internal and external connectors. Both

buses offer SCSI DMA and Disconnect/Reconnect, features that transfer data more efficiently between disk, memory, and the network. They provide the greatest benefit when multiple users are simultaneously accessing large files on different parts of the served disk, as in a multi-user database.

Although the AWS 95's four SCSI buses can theoretically support up to 20 devices, Apple recommends you use only the AWS 95 PDS Card's two higher-performance buses (which allow a total of 14 devices, seven per SCSI chain). In some cases you may be limited to seven, since not all software distinguishes between devices at the same address but on different buses.

The AWS 95's large case offers easy access to the SIMM, PDS, and NuBus slots, and all the drives conveniently slide out together on a tray at the top of the machine. But the AWS 95 has only two removable-drive bays (occupied by the SuperDrive and tape drive) – the single drawback to the hardware. Since both A/UX and AppleShare Pro software ship

exclusively on CD-ROM, that option is conspicuously absent.

You'll need to add either an Apple AUI Ethernet transceiver or a Local-Talk connector, to link the server to a network; and you must add server software for all but one AWS 95 configuration. Optionally, you can add a keyboard and monitor.

POWERPC SERVERS Apple already announced that it will release PowerPC-based versions of its servers during the first half of this year (as well as PowerPC PDS-based upgrades. Initially, PowerPC server applications will probably run emulated 680x0 code, rather than native PowerPC code, however. Consequently, their initial performance should be close to that of current servers, if not a little slower. Eventually, as applications and operating systems go native, the PowerPC-based servers should operate much faster than 040-based units.

THE AWS 80 STANDS OUT Despite the increased complexity of network administration, the Apple Workgroup Servers using AppleShare 4.0 or Pro

are a big step forward. The AWS 60, at the low end of the spectrum, is a superb deal; it should perform basic server functions in one-third the time (or less) than the fastest AppleShare 3.0 servers for far less money than a 3.0 system.

For the most demanding networks, the AWS 95 is an entirely justifiable purchase. It supports far more disk storage and RAM than any other Macintosh-based server and adds caches that speed operations such as multiuser database service. But it appears most sensible to purchase the server in its high-end configuration or not at all.

But the best value in Apple's server line is the Apple Workgroup Server 80, offering speed and versatility as a communications or file-and-print server.

For typical server functions, the AWS 80's RAM expandability is adequate for most networks, and its three NuBus slots and System 7-based operation give you the flexibility of using the AWS 80 as a communications server – all for a fair price.

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Modems

Data communications continues to be a struggle, but the world of modems is changing. prices have fallen and speeds have increased. So cut through the telecommunications jargon and learn some numbers.

The benefits of using modems for data transfer usually outweigh the sometimes considerable disadvantages. Modems can be difficult to set up and use, and it can take time to learn how to use them productively. But it's usually much quicker to transfer a file over a dial-up link than it is to use couriers, overnight delivery services, and faxes (with a fax much of the data may need to be re-entered in a computer at the other end).

Beyond the simple exchange of data, you can use modems for many additional purposes. Third-party, dial-up services like AppleLink, CompuServe, and Cix give you access to electronic mail; you can get free or low-cost shareware applications and utilities, fonts, and clip-art; you can access technical support services offered by leading hardware and software companies; or you can get hints, tips, and advice from thousands of users from around the country and across the world. Mastering the myths associated with computer communications begins with

the CCITT numbers used to describe modem performance. The CCITT is part of the United Nations, and as part of its work it gives reference numbers that correlate to the technical ability of a modem. The current fastest CCITT standard for transmission speeds is V32 bis (a faster implementation of V32 called V32 'Terbo' is available on a few advanced models, but this is not CCITT ratified, despite the V prefix).

V.FAST modems offer a transmission speed of 28,800bps (bits per second) plus data compression to give a theoretical 115,200bps throughput. V.FAST techniques will also be applied to fax machines, and V.FAST fax is the next logical progression. It should appear in mid-1994.

There are a number of modems that offer non-CCITT modes. Courier modems from US Robotics have 'HST' (High Speed Transfer) modes built in, and some Hayes Smartmodems feature Hayes 'Express 9600' mode. Neither of these modes are CCITT ratified, and are therefore non-standard, so you need a similarly-equipped modem at the other end to make these modes work.

If you are tempted into buying a modem with non-ratified modes, make sure that it also has a full complement

of CCITT modes. This applies equally to the newer V32 Terbo modems.

Modem types

Modems that provide V21, V22, V23, and V22 bis are often called quad (four-speed) modems. A quad modem with V32 is sometimes quoted as having quin-standard capability. Generally it's worth paying a little extra for quad modes in addition to fax or V32 bis standards because one day you will need to connect to an older service or want to broaden your communications horizons. While V32 bis is the business as far as contemporary comms is concerned, many of the services run by PTOs (Public Telephone Operators) are still limping along at V22 bis speeds. Most V32 bis modems have all or most of the quad modes built-in.

Hayes compatibility

The first intelligent (smart) modems were designed by Dennis Hayes and Dale Heatherington back in the early 1980s and Hayes have been key players in the modem and dial-up data-comms field ever since. Modems from other manufacturers are often touted as being 'Hayes Compatible' but the truly Hayes Compatible modem is a rare

beast. The term is used to show that the modem in question uses part of the 'Hayes AT Command' set, but you should be aware that all manufacturers tend to use different sub-sets. This causes confusion when trying to set a modem up from scratch as a command that works with one modem is not guaranteed to work with another.

All modern modems are now fitted with V42 error-correction. This monitors data throughput and as line conditions deteriorate packets of data are re-transmitted if found to be faulty. This results in clean data transfer, at the price of lower throughput.

A V32 bis modem has a maximum transmission speed of 14,400 bits per second but the actual throughput of the modem is increased by the use of data compression. V42 bis compression automatically compresses the data within the modem at the transmit end, and decompresses it at the receive end. This increases the actual data throughput by a factor of four in ideal circumstances, and a V32 bis modem armed with V42 bis can manage throughputs of up to 57,600bps in some cases.

Older modems use MNP5 compression, which manages compression by a factor of around two. These figures rep-



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Mac Modem cables

Not all Macs are equipped with the same serial ports. This isn't a problem until you start to use modems or other devices which need to see special signals at the serial ports. The Mac serial port offers the following pins to modems:

Mac function	RS232 function	Mac pin	DB25 pin
RxD (receive)	Receive Data	5	3
TxD (transmit)	Transmit Data	3	2
Ground	Ground	4 & 8	7
HSKo	DTR	1	20

HSKo is the handshake out line. This cable only works with XON/XOFF (soft) handshaking.

For fast modems you need a hard handshake cable:

Mac function	RS232 function	Mac pin	DB25 pin
RxD (receive)	Receive Data	5	3
TxD (transmit)	Transmit Data	3	2
Ground	Ground	4 & 8	7
HSKi	CTS	1	5
HSKo	RTS & DTR	2	4 & 20
GPI	CD	7	8

HSKi is the handshake-in line. GPI is a general purpose pin not present on all Macs. It is supported on SE, SE/30, II, IIx, IIcx, IIci, Quadra 700, 800, 900, 950, and LC III models. It may be supported on some IIsi models. It isn't supported on models like the Plus, Classic, Classic II, Colour Classic, or LC.

If your Mac cannot support GPI you can use the hard-handshake cable above but your Mac won't be able to see CARRIER DETECT (CD) from the modem unless the modem sends a text message to that effect. Some BBS and remote access software needs to physically sense this pin, so take this into account when setting up ARA servers, or Bulletin Board Systems.

resent theoretical maximums – in practice V42 bis compression results in an increase of around two to three times, depending on line noise, the compressibility of the data, and the ability of the

transmitting computer and modem to keep up.

Most text and graphics files are highly compressible, but archived data such as that found in SEA and SIT files tends

to be already compressed and cannot be further compressed by the modem. This is why you'll see lower transfer rates with compressed files; typically they travel at around 1,600 characters

per second (cps) through V32 bis modems.

Mac to modem speeds

This increase in throughput means that the speed of the connection between the Mac and the modem has to be higher than the transmission speed of the modem by a factor of two to three. Most V32 bis users set a speed of 38,400 to 57,600bps at the Mac to gain the benefit of data compression, but in practice there is little to be gained by going above 38,400bps. In fact there can be significant data loss on slower Macs at 57,600bps.

It's unlikely that a Mac fitted with a 68000 or 68020 processor will be able to reach the maximum throughput of a V32 bis modem. A 16 MHz 68030 Mac should be able to process incoming data at up to 3,500cps but if you are running any background processes such as AppleTalk or fax-receive software then rates will drop dramatically.

Nightmare on Cable Street

Cables for use with fast modems need to be selected with care. Fast modems interface with the computer via a process called hard-handshaking, and the cable needs to have the handshake

wires connected so the Mac can sense flow control signals to and from the modem. You can't therefore use any old Mac cable with a fast modem, nor can you generally use cables designed for use with earlier modems unless they have those extra handshake lines.

The wrong sort of handshaking can cause real problems for Mac modem users: you can lose data, or your modem might not give you the full throughput it's capable of. Slow data transfer rates over Mac links are often caused by cable problems, so if you cannot reach the fast speeds quoted you should check that you have the correct cable (see [Mac Modem Cables](#)). If you have come across a modem that needs a particular cable then specialists like Ex-Micro (0602 455077) will make one up for you.

Fax modems

Fax modems are useful in areas where there are no standalone fax machines, and they lend themselves to mobile applications away from the office or home, if you can find a phone socket. Fax modems have their own set of CCITT standards, but the one to look out for is Group III compatibility at V17, V29, & V27 ter speeds. This is the mode

used by the several million standalone fax machines in the world.

Fax modems are more useful for sending faxes than they are for receiving them. To receive a fax the attached computer has generally to be left switched on with the comms software loaded. Many of the cheaper fax modems will transmit faxes at the 9,600bps but receive them at only 4800 bps. This isn't really a problem as most fax modems are used only in transmit mode, but if you are going to use a fax modem in receive mode for any length of time then you should check its receive capability.

For fax generation and transmission you need special fax-compatible software. Some modems come with fax software, others don't, and Mac fax software is often of varying quality. Some of the Mac fax software takes over a megabyte of system software at boot time. This can be a problem on smaller Macs such as Plus's and Classics.

Fax and OCR

Faxes don't arrive in Macs as readable ASCII text so you can't load a fax into your word processor and edit it for re-transmission. Optical Character Recognition (OCR) software can sometimes

translate the images but fax has a resolution of only 200dpi so results tend to be variable. And converting incoming faxes to editable or printable documents is time and processor intensive. All of this makes modem-based fax reception something of a compromise. It's occasionally useful, but cumbersome in the long term.

Approval

In the UK you cannot legally attach unapproved telephony equipment to services run by BT, Mercury, the Kingston-upon-Hull telephone system, Vodaphone, and Cellphone networks. It used to be the case that you could spot unapproved equipment a mile off because it wore a label bearing a red triangle. However this labelling requirement applies only to equipment up to V23 capability. Newer and faster equipment is exempt from such labelling, although not from the approvals procedure. Approved modems carry an approvals notice, usually on the underside.

The approvals issue is a major consideration in the UK and Europe. What you should get in an approved modem is the ability to work with the European speech-coding methods which are

interposed on some trans-national links. Some unapproved American modems are not always able to connect easily over these Euro-links, and fail to negotiate connections or drop lines on long file transfers.

The Hayes Optima range is a prime example of modems produced for the European market. These modems are entirely different from the Optima range sold in the USA, and are designed to be compliant with all European approvals procedures.

V.FAST for fast

V.FAST modems offer V32 bis modes too, so you can use existing modems with them. Manufacturers will offer V.FAST as an addition to their product ranges, leaving V32 bis as a mid-price option. It looks as though you will have to fit a NuBus card to your Mac to get the best out of V.FAST since ordinary Mac serial ports may not be able to cope with the full throughput, especially if other processes are running. So if you have limited expansion on your current Mac you may find that V32 bis is as fast as you can go and you should buy now. On the other hand if you don't want to go down the ISDN route but need fast comms then V.FAST may

be just what you need. But you will need a fast Mac to get the throughput. If you are contemplating buying V32 Turbo then don't – unless you get a written warranty form the supplier that the modem will be upgraded to V.FAST at a reasonable cost. This is because you are unlikely to see an easy upgrade path to V.FAST as current approvals procedures mitigate against this in the UK.

Portable or desktop?

The choice between buying a portable or a desktop modem can be difficult. If you have a peripatetic PowerBook then the choice is fairly clear-cut as you'll probably want a portable or internal modem. Office-bound Macintosh users often choose a portable too, it can be used with other computers or locked away in a drawer when not in use. The internal modems used in PowerBooks are a mixed blessing. On the one hand there's nothing else to carry around once the modem is fitted, on the other you cannot easily use a PowerBook modem with another Mac. So if you have more than one Mac then an external portable modem is a good all-round tool.

Desktop modems tend to be able to

survive general office life a little better than their portable counterparts, and are marginally more immune to coffee spills and the exotic aerosol sprays used by office cleaners. But in either case if you send or receive more than half-a dozen faxes a day then buy a standalone fax machine. It will be more productive than using existing fax modem technology.

The average 'intelligent' modem is about as user friendly as a starving rat. Getting one up and running involves fighting with incomprehensible Hayes configuration commands and the complexities of hostile comms software. The best you can hope for is that your new modem comes with comms software that will isolate you from the worst.

Software solutions

Comms software supplied with Mac modems is often of the light-weight 'get-you-going' variety. Few approved Mac modems come with the ZModem file transfer software needed to exploit the full throughput of the modem so you will almost always have to buy extra software to get the best out of it. Modems that do come with faster comms software are often bundled

with shareware or general purpose comms programs which take little account of a particular modem's abilities; this often shows up as a difficulty in negotiating an error free link or connecting to distant modems via satellite or other echo-infested link.

It's worth buying a decent comms software package for your modem. It will often pay for itself in the first few months of operation and many of the commercial packages such as Hayes Smartcom II or Vicom give faster throughputs than some shareware products.

Some configuration of the modem

and comms software is almost always needed to get it to talk to the outside world. The better modems will work out of the box with no need to fight with command strings. The more obscure (mainly imported) modems often need individual set-up strings for the country in which they are to be used. This makes them more difficult to set-up.

Buying a modem from one source, a cable from another, and software from a third is the easiest way to make life difficult for yourself. So go buy a complete Macintosh package and then invest in some decent comms software.

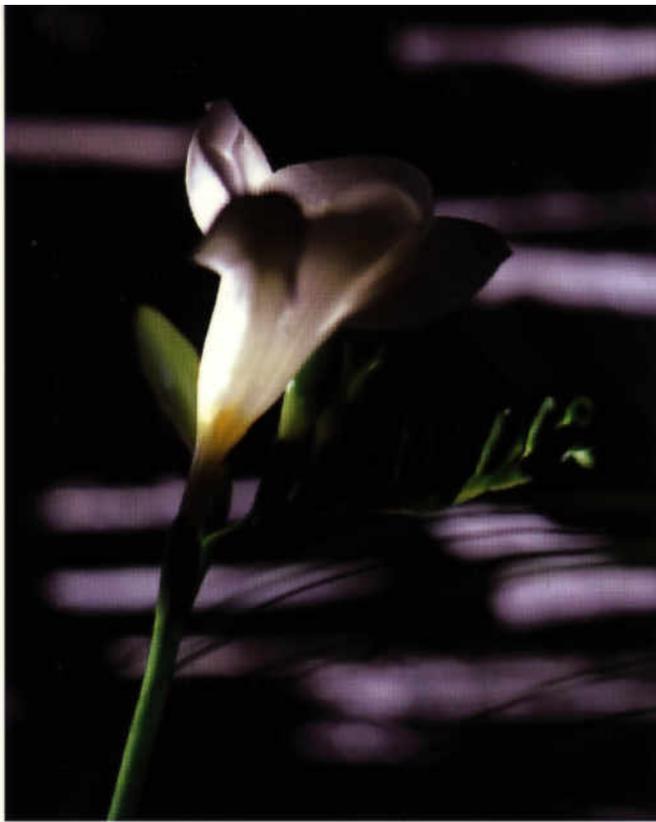
Macworld Recommended...

MULTITECH MT1432MK-MAC This portable wins on pure performance basis. It will give you great results if you treat it to some decent comms software. It also comes with a two-year warranty and fine documentation.

Company: Multitech List price: £749

PACE MICROLIN FX The 2,400bps FX model is a fine low-cost portable modem if you need occasional dial-up comms. Good performance, great value, and a five-year warranty. Like its faster brother (the FX32 Plus), the FX is small and neat enough to be used with a PowerBook, yet is fully featured enough to prove useful in the office.

Company: Pace List price: £249



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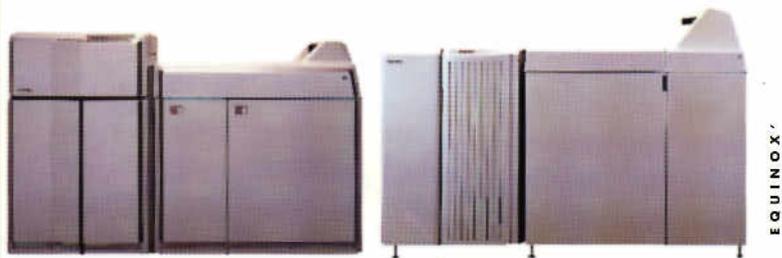
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DT-R2035

DT-R1065

Imagesetters

Once the exclusive preserve of dedicated pre-press and typesetting businesses, imagesetters have improved in quality, ease-of-use and cost to the point where they are now a viable purchase for advertising and design agencies, and other commercial users

There was a time when buying an imagesetter was like investing in a mainframe computer. Not only was it a hugely expensive piece of equipment, it also needed to be sited in a special room with controlled temperature and humidity, surrounded by trained staff who waited on it round the clock.

The purchase price was just the start. Staff and support costs often added up to the point where few companies outside the professional printing industry could afford their own image-setting equipment. But as the technology matured, imagesetters became more affordable and more reliable – a process continuing today. Five years ago the cheapest imagesetter would have cost at least £30,000; today you can buy a desktop unit for half that.

The low cost of the equipment has encouraged many new output bureaus to start up in business, and reduced support costs have meant that many publishing companies are now

doing their own imagesetting. But it isn't just traditional magazine and newspaper publishers – some of the biggest publishers of printed information are mainstream businesses in areas like finance, property and construction, and engineering, and these companies are also moving towards in-house imagesetting.

The bulk of the imagesetting market lies in mid-range systems, balancing the needs for good performance and quality output without investing close to £100,000 for systems that a better suited to very high-quality repro.

Key considerations

The three most important factors in considering any imagesetter are speed, accuracy and quality. While issues such as networking and hardware design do affect overall output speeds, the engines used by most models are quite capable of accepting data as quickly as it can be sent by the accompanying raster image processor (RIP).

It's the need for reproducible accuracy that has brought about the most important recent development in imagesetter design – the adoption of rotating drum mechanisms compared to the earlier standard capstan devices.

The first imagesetters were based on traditional typesetting machines produced by companies like Linotype and Compugraphic, and were fitted with a RIP that let them accept PostScript files from a desktop computer. These typesetting devices worked by feeding bromide paper (light-sensitive, chemically-coated paper) through a series of rollers.

The first dedicated imagesetters were based on the same type of design and simply replaced the photographic mechanisms of the typesetter with a laser-optical system. But, as the name implies, these devices were able to create graphic images as well as text, and that demanded greater accuracy.

Moiré is less

Accuracy, in imagesetter terms, means the ability to reproduce the same image time after time with great precision.

Simple black-&-white output requires just a single pass of the bromide or film to capture the image. But colour printing requires the same image to be exposed onto four or more sheets of film that are overlaid to produce the final image. Even tiny misalignments between the four film

images can create distinct moiré patterns or other aberrations.

To overcome this, most manufacturers made effort to improve the precision of capstan mechanisms, but others took an altogether different approach using a revolving drum instead. Scangraphic currently holds the major share of the drum imagesetter market, but most manufacturers now offer drum-based designs at the higher end of their product ranges.

Where capstan devices are adapted from traditional typesetting technology, drum imagesetters are based on high-end scanning systems from companies like Crosfield and Hell-Xenotron. In these devices the film is wrapped around the surface of a the drum while a laser scans the surface.

There are two variations on drum design: internal and external. An internal drum remains fixed while a rotating prism or mirror in the centre of the drum moves along the length, deflecting the laser onto the film. Since this has only a single moving part (the prism itself) it is extremely accurate.

In the external drum design, the drum rotates while the laser is moved along the length of the cylinder.

Drum designs have not eliminated



Which RIP?

One of the key decisions to be made when looking at imagesetting systems is the choice of RIP; and, more critically, the decision between a hardware or software RIP.

A software RIP is simply a program that can be loaded onto a Mac (or to run on a co-processor board, or often on a different hardware system such as a Pentium-based PC or Sun SparcStation). The choice is a complex one because there are various factors vying for attention:

- Software RIPs are cheap – around £5,000 compared with the £20,000 to £30,000 for a hardware RIP. However, you usually need to add in the cost of the computer to run it on.
- Software RIPs are easier to upgrade – you simply install new software rather expensive hardware.
- Software RIPs often give you unexpected performance boosts – anyone running a RIP on a IIfx automatically gets a faster RIP if they upgrade to a Quadra 840AV.
- Hardware RIPs give you the best performance – no generic computer

like a Mac or PC can match the performance of dedicated hardware with the RIP software in ROM.

● Software RIPs can be supplemented by additional hardware – Adobe now offers an add-in board called PixelBurst to handle screening calculations, the most complex portion of the RIP's workload. Such combinations blur the differences between hardware and software solutions.

Even with faster computers like the PowerPC Macs, many in the publishing industry feel that the Mac still lacks the power to match dedicated hardware RIPs. That belief is reflected by the number of Sun SparcStations to be found in otherwise Mac-only operations.

PowerPC does have the potential to make software RIPs the route of choice, but only when manufacturers offer native PowerPC versions of their RIP software. As of early 1994, none had made such an announcement although Adobe has promised a native PowerPC version of its own software RIP, the CPSI.

capstan systems, however. Both are finding their place in the market with capstan designs increasingly used for lower-cost imagesetters for black-&-white and spot colour work. They are, however, capable of high resolutions, up to 2,400dpi – only the lack of reproducible accuracy prevents them from quality colour work.

The more affordable systems usually also include a RIP. Prices at this end of the market usually run around £15,000 to £20,000, although some manufacturers produce faster, more expensive versions for high-volume output. For example, Linotype-Hell's model 70 and 90 were speed-doubled and dubbed the 170 and 190. Agfa ProSet was delivered in similar dual-role formats.

Capstan imagesetters with more sophisticated feed mechanisms are also used in many entry-level and mid-range colour imagesetters that begin at around £25,000. Above this level it becomes difficult to quote prices because the choice of RIP and film recorder combinations becomes so wide. Drum-based imagesetters, though, usually start at around £50,000.

The modular design of most RIP/recorders means that it is possible

to configure systems with a wide degree of flexibility and most manufacturers will discuss your individual needs before recommending a system and quoting a price. But as a rough guide you can assume that “mid-range” means prices between £30,000 and £50,000 for systems capable of producing all but the very highest quality work. Beyond this point lie jobs like the cover of *Vogue*, or fine art books – colour work that accounts for the top 20 per cent of colour output.

Quality not quantity

Speed and accuracy are relatively easy to quantify, and manufacturers will often be quick to quote figures for resolution, repeat accuracy, and recorder speed. But quality is harder to specify.

Two of the most important factors are sharpness and screening, and both are determined by the way in which the imager creates the dots that make up a halftone image.

Traditional printing techniques worked by creating halftone dots in a grid of intersecting lines. A different glass screen is used for each of the four printing colours, and the number of lines per inch gives the screening frequency. The four screens are also creat-

ed at different angles in order to create the best finished colour.

Imagersetters work in a slightly different way, and it's the attempt to mimic the traditional print screening that causes a number of problems.

Although imager resolution is measured in dots per inch (dpi), an imager dot is not the same as a halftone dot. To avoid confusion manufacturers often refer to the latter as a “spot” instead. Every halftone dot is made up of several spots – the exact number depends on the imager's resolution and screen frequency options.

The lower the resolution, the larger the halftone dot, resulting in “soft” or slightly blurred colours. Higher resolution gives sharper colour focus.

Screen angles are a greater problem. Imagers are designed to print on a regular horizontal and vertical grid, but screen angles between these 90- and 180-degree angles are necessary. When four colour film separations are overlaid for printing, the combined irregularities can cause patterning effects called moirés.

Like device-independent colour, the elimination of moiré and other artifacts has been one of the most troublesome

for imager manufacturers and others involved in pre-press.

The algorithm from Hell

The shape and positioning of halftone dots is controlled by complex algorithms within PostScript. Adobe's solution is called Accurate Screening – but for some jobs these are not accurate enough and many manufacturers have developed their own.

Linotype-Hell is perhaps the leading contender with HQS – High Quality Screening. This is based on algorithms that were developed and jealously guarded by Hell-Xenotron before its merger with Linotype.

Other contenders in the screening technology stakes include Agfa with its Balanced Screening, and Varityper's ESCOR. When considering systems, it's important to remember that some manufacturers put their screening technology in the imager, while others build it into the RIP.

If you're buying a combined RIP/film recorder from a single manufacturer this doesn't matter, but can cause problems if you want to mix-and-match components from different manufacturers.

The most recent entrant in the battle

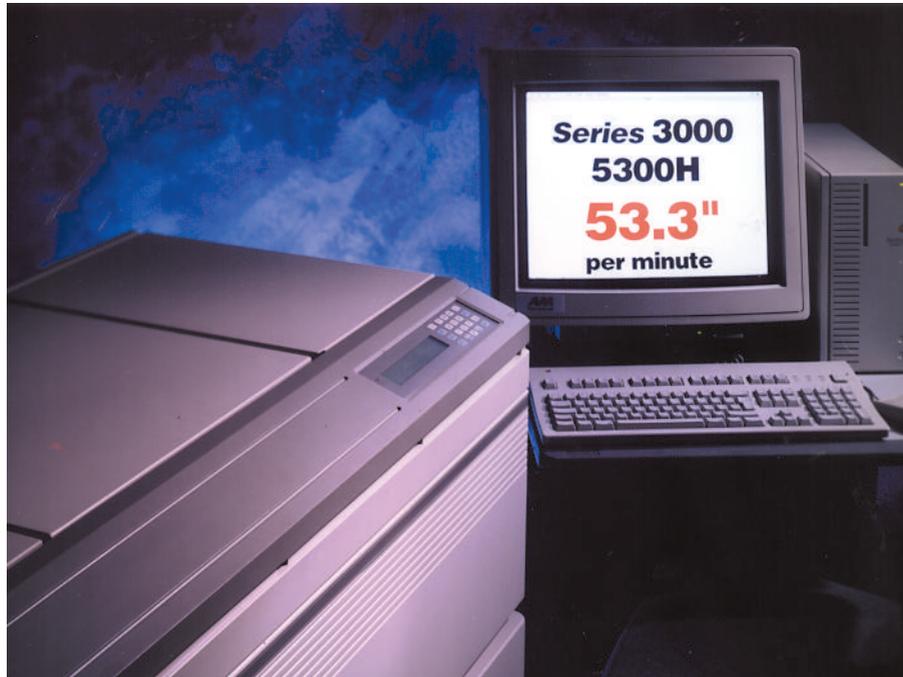


is Frequency-Modulated (FM) screening (sometimes called stochastic screening). FM screening uses halftone dots of variable size and position, which allows imagesetters to generate dots away from the 90-degree grid that causes so many problems. Even at lower resolutions, FM screening provides moiré-free colour and can even replicate continuous-tone, photographic-quality print. Both Agfa and Linotype-Hell offer FM screening as options with their imagesetters.

Final considerations

There are a number of other factors to be considered when weighing up an investment in an imagesetting system. Essentially, as technology improves one area, the result is a shifting of bottlenecks. For example, if you want the fastest possible system you can't simply consider the speed of the marking engine in isolation. In the early days of PostScript-based imagesetters, it was the speed of the PostScript RIP that often proved the limiting factor on performance.

Recent RIP improvements (see [Which RIP?](#) for more) pushed the emphasis back on the marking engine. But a faster marking engine often shunts the



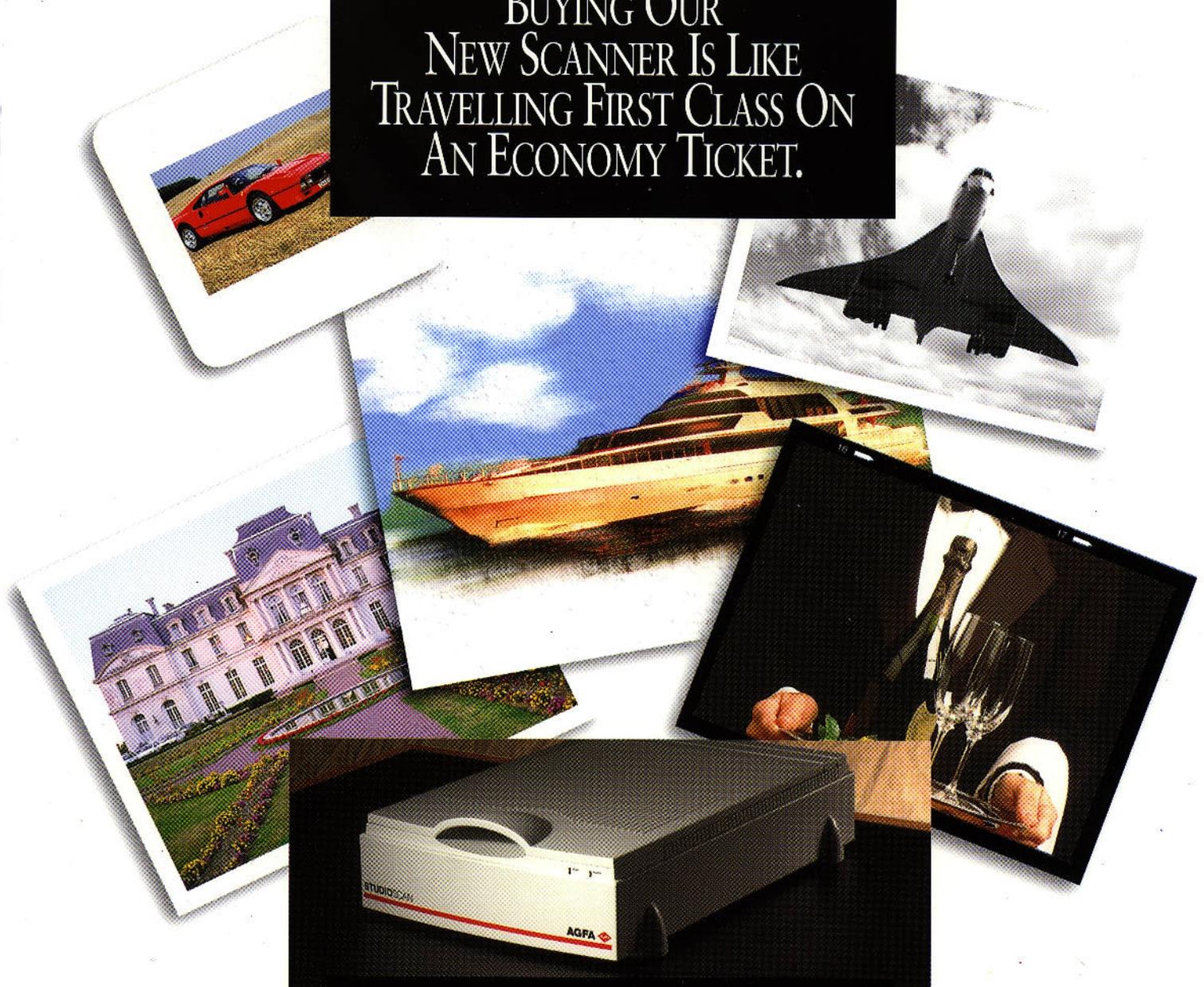
real bottleneck back to the network connection – the RIP can only image as much data as is arriving from the controlling Macintosh.

Network system, local storage, RIP, film recorder – all combine to create the imagesetting system, and all must be considered before you arrive at the right choice.

For the non-expert the choice in imagesetters is bewildering – not just in technical terms, but in suitability for different tasks. From high-end, colour-capable systems to mono systems that fit on a desktop. In between are some of the toughest choices covering image quality, speed and the option of a hardware RIP or (like the Vari-typer 3000) a software RIP.



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It used to be that unless you had a lot of money to spend, a scanner was simply out of the picture. But now there's Agfa StudioScan, the feature-rich scanner that's wonderfully affordable.

StudioScan offers the speed and efficiency of one-pass scanning with an optical resolution of 300 x 600 dpi enhanced to 2400 dpi for both black-and-white and colour images. Its flatbed design accommodates sizes up to 8.5" x 14", and an optional transparency module scans 35mm slides up to 8" x 10".

What's more, StudioScan comes with a complete software package, including Agfa's proven labour-saving FotoLook, FotoTune LE, FotoSnap programs, and Adobe PhotoShop LE. Compatible with both Macintosh and PC systems, StudioScan actually guides an entry-level user through the entire scanning process.

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Scanners

Whether you need print-quality photographs and artwork, laser-quality graphics for business documents, optical character recognition – or just the ability to grab a few pictures and bits of text, a scanner is the tool for the job.

Colour flatbed scanners, once found exclusively in design shops and graphic arts departments, are on their way to becoming mainstream Mac accessories. Prices have dropped to such an extent that you can find 24-bit colour scanners for under £1,000, often bundled with professional and entry-level software. This fact should guide you in your approach to considering a scanner for purchase: unless you have a compelling reason otherwise, a colour flatbed model should be at the top of your list of candidates. There are other reasons why flatbeds dominate apart from price, including higher resolution for your money, the flexibility to handle reflective art up to A3 sizes, and the ability to add transparency modules to many leading models. Of course, there are other possibilities providing a range of capabilities and at a range of prices – from a couple of hundred pounds for handheld devices, to more than £50,000 for professional pre-press drum scanners.

Overall, scanners break down into a number of technologies:

- Handheld scanners resemble paint rollers and operate in much the same way. You position the scanner over the object to be scanned and wipe the scanner down or across. Because no motors are required to move the scanning head, handhelds are the cheapest scanning option (see [A Scan in the Hand](#)).
- Overhead scanners, the scanning head and CCD array are mounted over the platen to capture the image from above. With this method you can capture images of 3D objects as well as flat artwork. High-quality scans are difficult to obtain because of focussing and lighting problems.
- Flatbed scanners are the most common. Very similar to photocopiers, they move the scanning head under a glass platen that holds the artwork. Although transparency attachments are available for many flatbeds, like photocopiers they are best suited to flat, reflective artwork like line drawings or photographic prints.
- Slide scanners are designed to capture images from photographic transparencies. The slide is placed in a slot inside the scanner, and a light is direct-

ed through it onto the CCD array. The results are highly saturated colours and a greater level of detail than you'd get with a typical flatbed scanner. Dedicated slide scanners are frequently used for colour pre-press and other high-end photographic applications. They usually provide much higher resolutions than flatbeds, in order to allow enlargement of small slides.

- Drum scanners are the most expensive, and advanced, scanners for the Mac. In the drum process the transparency or reflective art is mounted on a drum, which is rotated at high speed. Meanwhile, the scanning head is moved along the length of the drum, capturing a fine line of the image with each revolution. The result is a very-high quality, and high-resolution, image. But the precision engineering required makes these devices very expensive – low-cost models may cost more than £15,000 and prices are more typically in the £25,000-plus range.

Some of these technical distinctions automatically make certain technologies more suitable for certain applications. For example, high-end publishing and pre-press work demand quality colour, limiting choices to the high-end of the colour flatbed market, slide scan-

ners and drum scanners.

If money is strictly limited, a handheld scanner may be your only choice – but these low-cost devices can still provide good results for optical character recognition (OCR), and for laser-printed DTP documents.

Slide scanners can provide publication-quality images without going to the expense of a drum scanner. The real limitation is in resolution – most models provide sufficient resolution to allow a 35mm slide to be reproduced at small enlargements, but for big blow-ups (to magazine covers, for example) you require the ultra-high resolution that only drum scanners provide.

Where your main application is heavy-duty OCR, you are limited to flatbed scanners and preferably the limited few that offer sheet-feeders – even a fast flatbed scans so slowly as to make it intolerable to scan more than a few pages at a time, whereas OCR often requires the scanning of documents up to 50 or 100 pages.

With these limitations in mind, Macworld recommends a colour flatbed for the vast majority of users. This is the area where most manufacturers concentrate their research, leading to greater functionality; and fierce compe-



How much resolution is enough?

Scanner resolution ratings tell you how many image measurements, or samples, a scanner makes per inch. A higher-resolution scanner typically can produce bigger, shapre images. But scanner makers charge high prices for high resolution. So, how much resolution is “enough”?

The answer depends entirely on how you’re going to use your scans. Producing film separations for print is a resolution-hungry application. 600dpi resolution is the bare minimum for 35mm slides intended for print.

Printing to a film (slide) recorder also requires lots of data. If you use a 35mm recorder look for a scanner that has resolution at least equal to the resolution you use for film recorder output. Image sharpness

increases progressively as scan resolution approaches twice the output resolution; beyond that you get diminishing returns.

People who make scans for on-screen display don’t have to worry much about resolution unless they typically crop images severely. The smaller the image scanned, the higher the scanning resolution required to enlarge the image.

When comparing scan resolution ratings, be sure the number you’re looking at is the optical resolution. Scanner makers and sales people have a bad habit of quoting figures for interpolated or non-proportional resolutions instead. Interpolation is an image processing technique by which a program simulates a higher resolution than the scanner actually

captures by guessing at pixel colours-between known pixels. This can be helpful for avoiding the jaggies when you blow up a scan, but like most synthesized commodities, interpolated data is a poor substitute for the real thing.

Nonproportional scanners collect more data in the vertical direction than in the horizontal one, then use interpolation to build up the resolution on the weak side. Nonproportional files offer about the same amount of image detail as scans with a resolution midway between the nonproportional rates. So having a 300x600dpi machine is almost as good as having a true 450dpi scanner. The disadvantage is that the files you create will take up as much space as 600dpi files.

tition has driven prices down to levels that were unthinkable just a few years ago.

In contrast, we don’t recommend greyscale flatbeds – most greyscale models are stuck at 300dpi resolutions, while their colour cousins have moved

to 400dpi, 600dpi and beyond; and greyscale prices are unattractively high compared with colour models.

How scanners work

Colour flatbed scanners use a combination of lenses, lights, an analogue-to-

digital converter, and charge-coupled device (CCD) arrays to digitize artwork. CCDs contain a number of photo sensors, which convert the light reflected from (or through) a piece of illuminated art (an 8-by-10-inch colour photograph, for example) into electrical charges. An



UMAX Scanners set the world alight



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Colour Scanner with
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You may not be familiar with the UMAX name, let alone its comprehensive range of colour scanners. But around the world UMAX has been stacking up the accolades. UMAX scanners are now so popular that the company is one of the world's biggest scanner manufacturers.

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† Document Feeders & Transparency Adaptors
available on all models.

* MacUser- US edition October 1992

INFOLINE No. 133

A scan in the hand... is not worth much

If you occasionally need to grab small extracts of text for future reference, or small graphics like company logos or maps, or if you need to scan bits of thick textbooks that don't sit easily on a flatbed, or if your desktop is already crowded with monitors, disks and printers – a handheld scanner could be the answer.

These little devices work well enough for draft-quality halftones or line drawings, and one – the Caere OmniScan – is accurate enough for optical character recognition (from fairly clean originals).

But even allowing for their inherent limitations, hand scanners still require some practice to master. As you scan you must hold down the scan button, move the scanner at a suitable pace (sometimes excruciatingly slow) and keep the scanner moving in a straight line. Even when you get it right, the results leave a lot to be desired. All can capture graphics at sufficient quality for use in laser printed business documents. Even the best will struggle to capture a wide range of greys, and fine lines are difficult to scan properly.

For OCR, the OmniScan is the only model worth considering – only it could come close to the accuracy results from even a low-cost flatbed scanner.

You should also check compatibility before you buy. The OmniScan only works on Macs with a 68020 processor or better (which rules out a Plus, Classic or SE), and needs 8MB of memory. The Thunderware Lightning Scan does not use the SCSI interface; instead it connects to the UperDrive floppy disk connector on older Macs.

Of the devices that do use SCSI, all use 25-pin connectors rather than 50-pin plugs, which makes them difficult to daisy-chain.

Macworld does not recommend any of these units – you'll be much better off in terms of end results and convenience (and not much worse off financially) buying a low-cost flatbed scanner.

If you must buy a handheld, then consider the OmniScan for OCR, the Lightning Scan Pro 256 (hard to find in Britain) for greyscale graphics, or the Logitech ScanMan for black-&-white graphics.

analogue-to-digital converter then translates the electrical charges into digital information.

During the scanning process, the scanner interprets white-to-saturate-red, white-to-dark-green, and white to-dark blue as separate 0-to-255

greyscales. Thus, a 24-bit colour flatbed scanner interprets up to 256 shades for each of the three primary colours: red, green, and blue. That translates to image files that contain 24 bits of colour information per pixel.

There are two kinds of colour flatbed

scanners: one-pass and three-pass. One-pass scanners typically use three separate lights (one each for red, green, and blue) that flash on and off while scanning. Using this method, the scanner head (which contains the CCDs) passes over an image only once to cap-



ture the RGB data. Three-pass scanners typically employ one lamp and three colour filters; the scanner head moves across an image three times, once while the red filter is over the lamp, again while the green filter is in place, and again while the blue is in place.

Manufacturers of one-pass scanners often claim that their products scan faster than three-pass models, while three-pass scanner vendors have been known to assert that their devices capture sharper images than their one-pass counterparts. In general, however, our speed tests and scanning results don't support those claims.

Most flatbed scanners have optical horizontal resolutions ranging from 300dpi to 600dpi. Optical resolution is determined by a scanner's hardware, while interpolated resolution is generated through hardware and software. With interpolation, the scanner software creates additional pixels from the pixels generated by the hardware.

Horizontal resolution is ordinarily listed first. For example, a 400-by-800dpi scanner has a horizontal, optical resolution of 400dpi; the 800dpi is the vertical resolution and is interpolated. In some cases, interpolated resolution is four times greater than the scanner's

true optical resolution. Keep in mind that interpolated resolution can smooth the jaggies in line art or in scanned photos when enlarged, but it can't add a higher level of pictorial information to an image.

Flatbed Scanners

Any of these scanners can produce accurate 8-bit scans for each colour, resulting in a 24-bit RGB colour image. Their resolution is fine for screen presentations; low-resolution for position-only images that are used as placeholders in page-layout spreads; and images used in brochures, newsletters, newspapers, and for office reports and other documents destined for output on a 300dpi colour printer.

There are several reasons, however, why you wouldn't want to print glossy, dress-to-impress museum catalogues, or coffee-table tomes with graphics scanned on these flatbeds. First, many images have a wide dynamic range, or depth of colour, that can't be fully captured by a 24-bit flatbed. You need a high-resolution slide or drum scanner if you plan to output a transparency on a dye-sublimation printer or other device capable of rendering photo-realistic colour. Second, many flatbeds are

restricted to images no larger than 8.5 by 14 inches (most can't scan images larger than 8.5 by 11.75). Thus you're better off with a drum scanner if you need to scan various format sizes (if you can afford one, that is – drum scanners cost £8,000 and a long way up).

Details, details

The colours in a scanned image can seem out of sync with the colours in the original artwork (see [Comparing colour output](#)). When that occurs, you can usually adjust the colour to your satisfaction with an image editing program such as Adobe Photoshop.

But when a scanner doesn't capture the fine details of an image, it's not so easy to fix. Most likely, the Sharpen command offered by many scanning software utilities and programs (used to improve focus and clarity) won't fill in the details of an image that weren't captured by the scanner hardware, and using the command can create contrast problems with other parts of the image. In fact, you may end up fussing around so much (sharpening some areas at the expense of others) that you drive yourself quietly dotty.

As a result, a scanner's effective resolution (the amount of image detail it





Original



Apple Colour OneScanner



Hewlett-Packard ScanJet IIc



Epson GT-8000



Microtek ScanMaker IIx



La Cie Silverscanner II



Mirror 800 Plus

Comparing colour output

An intriguing test of scanners involved scanning the same image on different units, then printing the resulting image to a dye-sub printer (results shown here). The subjective results of the test were revealing: The prints of the Epson GT-8000 and the La Cie Silverscanner II were among the judges favourites, even though those scanners were among the poorest performers in Macworld Lab colour accuracy tests.

None of the flatbeds were capable of producing highly accurate colours – note the marked variations in yellows, and the overstated reds and other values (such as the hat in the Microtek image).

captures) is one of the most important factors to consider before buying. Resolution is determined by the number of CCDs built into the scanner head, but the quality of a scanner's mechanics can vary among vendors. Thus, a scanner's claimed optical resolution doesn't always tell the whole story.

In the Macworld Lab resolution tests, using both black-&-white and colour images, we found little, if any, demonstrable relationship between a scanner's optical resolution and the level of detail in the scanned images it generates. Some images scanned with flatbeds that claim an optical resolution of 400dpi looked muddy when printed, for instance. Meanwhile, some scanners, including the Epson GT-6500, which modestly claim 300dpi resolution, generated images that printed to the full resolution capabilities of a 300dpi printer.

Images scanned on the Hewlett-Packard Scan Jet IIc, the Tamarack ArtiScan models, Microtek's ScanMaker IIXE, Mirror Technologies' Mirror 800 Plus Colour Scanner, and XRS Corporation's 12c OmniMedia Scanner displayed effective resolutions of 240dpi to 280dpi (based on the number of lines resolved from the target image).

The images generated by the Umax scanners, Apple's Colour OneScanner, and Focus Enhancements' FocusScan 800C revealed the least amount of image detail in printed output.

The bottom line: When buying a scanner (particularly if you plan to pay a bit more for a flatbed that claims optical resolution higher than 300dpi) insist that the dealer run a resolution-target scan for you. Even though you're shopping for a colour scanner, consider scanning black-&-white line art for this test, as resolution problems are much easier to spot in black-&-white than in complex continuous-tone colour. Then print the image for evaluation; simply viewing it on a monitor isn't sufficient.

Keeping the noise down

In addition to resolution testing, we also measured the amount of noise (or visible speckling within an image) these scanners generated. Essentially, our noise measurements were designed to test scanner consistency. For our tests, we scanned one colour and one black-&-white image at the same settings three times each, and then compared the scanned images for noise.

As it turned out, all the scanners we tested produced some level of noise.

This means you can expect to do some despeckling in an image-editing program on a scanned graphic with any of the scanners reviewed. Exactly which areas need despeckling, and by how much, will vary from scan to scan – even of the same image.

A rose is a rose – sometimes

To determine how accurately scanners reproduce the colours of an original image, we looked on screen at raw, unedited scans of a calibrated Kodak Q60 colour-swatch test image with defined colour values. We also devised a mathematical definition of distance in colour space, essentially a measure of accuracy. The smaller the distance between the known colour values on the swatch and the values we measured on the scans, the greater the accuracy; a bigger distance on this scale means more deviation from true colour accuracy. The practical implications of the test have to do with calibrating and adjusting colour gamma curves after an image is scanned.

HP's ScanJet IIc placed first in the colour accuracy test. The scan's RGB values, on their measured scales of 0 to 255, are correct to within about 5 units of the expected values. Several scan-





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HITACHI



ners, such as those from Tamarack, UMax, Apple, and Mirror, came close to HP's in colour accuracy, showing RGB differences of 5 to 15 units.

But the measured values from scans generated by the Epson and La Cie scanners were significantly farther from the defined values. Both scanners were generally accurate on green and blue but overstated red by 20 units or more.

The implication is that, when scanning images with strong red values, you lose significant resolution in the red channel with the Epson and La Cie scanners. This can't be completely corrected after a scan, because information from the image is actually lost during the scan just as if you had acquired a greyscale image with the scanner set for black-&-white..

Eye of the beholder

If the La Cie and Epson scanners generate too much red, the images they generate must look pretty bad when printed, right? Wrong. As we know all too well, life is never that simple.

The subjective ratings of scanner output provide plenty of lessons in perception. In a blind test of scanners, judges from Macworld's editorial, art, and production departments evaluated

the quality of scanned images that were output on three different devices: a monochrome laser printer (the Apple LaserWriter IIg); a colour thermal-wax transfer printer (the QMS ColorScript 100 model 30si); and a dye-sublimation printer (3M Rainbow).

In this test, the scanner that scored the highest in colour accuracy, the ScanJet IIc, was also the subjective favourite for producing the best greyscale output. In fact, there's a rough correlation between colour accuracy and high ranking in the subjective greyscale output tests. Inspecting the details of the accuracy ratings, we can formulate a fairly simple principle: If the scanner exaggerates red values, the resulting output on a mono laser printer will be too dark.

That principle reverses when you evaluate printed colour output, though. Strangely enough, the subjective favourites in colour output were technically the least accurate scanners – specifically, the scanners that overstated the red content of images.

So does intrinsic colour accuracy matter when choosing a scanner? In truth, not much. Most scanners offer some calibration method that adjusts the scanner's settings to match your

colour printer's output capabilities. And if you're resigned to touching up colours after the scan in an image-editing program such as Photoshop, then colour accuracy is not the most important criterion. More important, as noted before, is the scanner's ability to capture details, which can't be easily added after a scan.

If you like to take lots of previews before acquiring a final scan, you'll find the ScanJet IIc, the La Cie SilverScanner II, and the Epson models to be the most convenient. The ScanJet IIc can preview a 5-by-7-inch colour image at 300dpi in 13 seconds. The scanners that are the fastest at previews, however, slow down considerably for final scans. The fastest flatbeds at making final scans of the 5-by-7-inch image were the Apple Colour OneScanner, Tamarack's Artiscan 6000C, and Umax's UC630 MaxVision. The Epson GT-6500 was the slowest in this test.

Keep in mind that scanning time can significantly expand when you use software interpolation to boost resolution. For example, Apple's Colour OneScanner, which has an optical resolution of 300dpi but can interpolate 1,200dpi, took 46.1 seconds to make a final scan of a colour 5-by-7-inch image at 300dpi.



When scanning the same image at 600dpi via interpolation, the speed slowed to a whopping 445 seconds.

Slide Scanners

35mm slide scanners are straightforward to use: open a door, slip the slide into metal clips, close the door and scan. These scanners do only one thing – scan 35mm slides and negatives – but they generally do it better than all but the most expensive flatbeds.

With a flatbed the normal cover is usually replaced with a panel that opens on a hinge and illuminates the slide from above. The first transparency attachments were obviously afterthoughts, not at all easy to use, but today's models are far superior. The majority of flatbeds, though, still have resolutions that are comparatively low for slide scanning.

Flatbed scanners for desktop use with the Macintosh do have one advantage, however. The Mac's dedicated slide scanners are limited to 35mm transparencies and negatives. If you want to scan pro-size transparencies you need either a drum scanner or a flatbed; many of the flatbed transparency adaptors let you scan up to 6x9-inches or larger.

Macworld Recommended...

FLATBED SCANNERS

SCANJET IIcx Colour accuracy and simple-but-rugged design combine with 400dpi resolution and a good price to make this a winner.

Company: Hewlett-Packard. List Price: £930

MIRROR 800 PLUS With good (600dpi) resolution, colour accuracy and a competitive price, this is a bargain despite its slow final scan speeds.

Company: Mirror. List Price: £1,199

ARCUS PLUS For those requiring higher quality, with capable transparency options, the Arcus Plus with its 1,200x600dpi resolution fits the bill.

Company: Agfa. List Price: £3,745.

SLIDE SCANNERS

LS-3510AF Autofocus design offers maximum sharpness with minimum fuss. Even the 8-bit machine provides good dynamic range.

Company: Nikon. List Price: £6,995 (8-bit); £8,395 (12-bit).

LEAFSCAN 35 Fixed-focus design and resulting sharpness problems are offset by superior tonal control and dynamic range.

Company: Leaf Systems. List Price: £7,000.

Generally, the factors you need to consider with slide scanners are exactly the same as those for flatbeds: resolution, colour accuracy and speed.

But one difference is how the device connects to the Macintosh. Almost all flatbeds attach to the Mac's SCSI port,

so connections are relatively straightforward. On the other hand, many slide scanners use the General Peripheral Interface Board (GPIB), which requires an add-in card that uses a NuBus slot, ruling out their use with Macs like the Quadra 610 and 650, and the LC series.

Slide Into sharper scanning



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Display Systems

In these ergonomically-conscious days, few Macintosh peripherals have a greater effect on your health than your monitor. After all, you'll be staring at it for years to come, so it's worth spending the time to make the right choice.

It may seem odd that Mac users spend a lot of time considering, debating or just musing about monitors. After all, the Mac is still famed as the all-in-one box with its tiny 9-inch screen. But maybe it's not so odd: that 9-inch window on the world inside the Mac was a prime factor in driving the external monitor market. And the all-in-one design is now a rarity (at least in the UK). Moreover, as in so many areas, the Mac has led an industry trend towards larger display systems, prompted by the widespread use of Macs in desktop publishing and graphic design.

The choice of monitors and systems (the monitor and a board to drive it) is now so large that making the right choice can require a good deal of research and careful consideration. You can opt for black-&-white or greyscale, 8-bit or 24-bit colour, and from small 14- and 15-inch screens, through the fast-growing mid-range sector at 16- and 17-inches, up to the wide-open spaces of 20- and 21-inch mammoths costing more than your Mac. In the last two years, a major change has

complicated the marriage of monitor and video-display board: most Macs since the IIsi now contain built-in video circuitry (on-board video) that can handle 15-inch and larger monitors. With these Macs, you can attach compatible monitors directly to the video port. You don't have to buy and install a separate video board (although you can if you want). With the built-in video, you get 16 or more colours (or shades of grey), depending on the configuration ([see Working with Built-in Video](#)).

But there are trade-offs between using built-in video and installing a separate video-display board. You paid for built-in video when you bought the Mac and there's no need to open the system unit and install a board. But built-in video is slower than a separate video board (more so with graphics than with text), especially in the PowerBooks, the IIsi, and Ilic, so it may be a false economy.

MONO MONITORS

Why consider a monochrome monitor when everyone seems to be so enamored of colour displays? Colour is expensive – considerably more expensive than the cost of a comparable monochrome system. Also, images dis-

Does 72 dpi Matter?

The built-in monitors of the original compact Macs displayed 72 dots per inch, and hardware manufacturers used to adhere to this standard to ensure that what you saw on the screen precisely matched the size of the printed version. But manufacturing realities – and the fact that few people need or expect the size of an object on screen to correspond exactly to the printed result – have changed all that. These days, the pixel densities of monitors (including Apple's) range from 72 dpi to 82 dpi; the higher the density, the more condensed the image. For most people, these pixel densities are not significantly different. When choosing a monitor, worry less about the dpi value itself and more about how the image looks when you view it.

played on monochrome monitors tend to be sharper – and thus the text clearer – than on colour monitors. If you work

mostly with words and numbers, the purchase of a colour monitor could well be something you come to regret.

As for black-&-white versus greyscale, the choice depends on the tasks to be performed. Consider a black-and-white display for letter-writing and number-crunching. Black-&-white displays are cheaper, their text is as good as it gets, and they are faster and more responsive than greyscale (or colour) displays.

Editing scanned photos, creating many kinds of PostScript art, and previewing colour art in monochrome all require a monitor that can display as many as 256 shades of grey. So, for publishers and designers its worth spending more to have a greyscale monitor. For anyone who spends most of the day working with large greyscale images, I'd also consider the purchase of a video-display board that includes acceleration. Although most such boards are designed for use with colour monitors, they work well with greyscale monitors, too.

For 256 shades of grey, an 8-bit board is sufficient (don't buy a 24-bit board thinking you'll get even more levels of grey – greyscale doesn't get any better than 256 shades).

Understanding display screen sizes

This may seem like a silly question, but is a 15-inch display bigger than a 14-inch one? Is a 17-inch really bigger than a 16-inch? How about 19- versus 20- versus 21-inch?

14 INCHES VS 15 INCHES Although a 15-inch monitor has a larger viewing area, it still displays images at the same resolution as a 14-inch monitor; what you see are bigger pixels spread across a larger area and not more pixels. If viewers prefer the bigger viewing area, vendors may try upping the resolution and pushing 15-inch monitors as smaller, cheaper versions of 16-inch displays. But 15-inch monitors really have too little room to adequately display the 832 by 624 pixels that 16- and 17-inch monitors do.

16 INCHES VERSUS 17 INCHES Monitor screens – like televisions – are measured diagonally from corner to opposite corner, a measurement called the screen diameter. But what you may not know is that all so-called 16- and 17-inch monitors are either

identical in size or very close to it. For example, based on their names, you might expect Mitsubishi's Diamond Pro 17 to be larger than Apple's Macintosh 16-Inch Colour Display. In fact, they both offer an identical Trinitron picture tube manufactured by Sony. The difference is that while Mitsubishi and most other vendors measure the picture tube diagonally from corner to opposite corner, Apple measures only the viewable area's diagonal (the portion that can display an image) of the tube (about 16.05 inches). Of course, not every vendor buys tubes from Sony. Some vendors, including NEC and Philips, develop their own varieties of picture-tube technology. But these, too, have similar diameters.

19 INCHES VS 20 INCHES VS 21 INCHES Once again, there is no real difference between the 19- and 20-inch models. However, the 21-inch screen size is genuinely bigger.

More important than the size of the picture tube is the active screen

dimension, which is the portion of the screen that contains the image. And within similar categories, these can vary enormously. For example, fresh out of their boxes, the 17 monitors evaluated by Macworld Lab have active screen dimensions ranging from a scant 13.9 inches diagonally to a generous 15.6 inches.

This represents a difference in vendor philosophy. The perimeter of the screen is where you're most likely to see colour shadows and screen distortions. Some makers hope to protect you from these abnormalities by presetting the active screen area to not reach the perimeter; others figure you'll be concentrating most of your efforts nearer the center of the screen, so you might as well enlarge the pixels as much as possible.

To summarize: 14- and 15-inch monitors are physically different but display exactly the same image. 16- and 17-inch monitors are the same. 19- and 20-inch monitors are the same, but 21-inch monitors are genuinely bigger.



Monochrome display systems fall into four groups. The first cut separates black-and-white from greyscale. Each of these two groups can then be divided according to the size of the monitor: portrait displays and two-page displays.

Small Display

The one exception to this size scheme is Apple's Macintosh 12" Monochrome Display, a low-cost landscape monitor with the same 640-by-480-pixel resolution as that of a standard 14-inch colour monitor. It produces a very sharp display, but has a strong blue cast that makes it appear especially dim, and displays about half the area of a portrait monitor. Thus we don't recommend the Apple 12-inch monitor to anyone intending to work long hours at the computer. But its rock-bottom price makes it appropriate on a server whose monitor is viewed only rarely.

Portrait Displays

Virtually all portrait displays show 640 by 870 pixels, just big enough for a standard, letter-size page. The only exception is Sigma Designs' SilverView Portrait. It displays 870 by 1152 pixels, which is about the size of a tabloid page (11 inches by 17 inches). Portrait

Macworld Recommended...

BLACK-AND-WHITE PORTRAIT

15-INCH GREYSCALE PORTRAIT DISPLAY This greyscale display system's paper-white phosphor, sharp focus, and low price add up to excellent value.

Company: Mirror Technologies. List price: £399 (£499 with display board).

GREYSCALE PORTRAIT

PIVOT DISPLAY Its quality imaging, particularly for greyscale clarity and text sharpness, plus its pivoting feature make this display system an excellent choice.

Company: Radius. List price: £699

GREYSCALE TWO-PAGE

MULTIMODE 120; SILVERVIEW PRO The MultiMode 120 offers six pixel densities for a relatively high price; the SilverView Pro's much lower price makes it an excellent value.

Company: Sigma Designs. List price: MultiMode £1,299; SilverView Pro £499.

monitors are ideal for wordsmiths who want to see as much text as possible at one time, yet don't want the inconvenience or expense of a big screen. But portrait monitors should be avoided by those whose visual domain tends to be horizontal (landscape-oriented graphics or two-page spreads, for example).

A marked contrast to most monitors' fixed orientations is the Radius Pivot Display, which can be run either as a

portrait monitor or as a small landscape monitor.

Two-Page Displays

Despite their name, most two-page monitors cannot display two full pages side by side. A 19-inch monitor usually displays an area of 1024 by 768 pixels (which crops about an inch off the top and bottom and two inches on each side of a full two pages); a 21-inch mon-

itor usually displays 1152 by 870 pixels (which crops about an inch right and left). Despite the misnomer, two-page displays are prized by spreadsheet artists (who tend to accumulate columns faster than rows) and graphic designers (especially those who work with double spreads or large graphics).

What to consider

One of the first factors in mono monitor evaluation is the colour of the screen phosphor. Although many manufacturers describe their mono displays as “paper white”, truly white screens are a rarity. The majority have a pronounced blue-ish hue and where this is particularly accented the screen can appear dim.

There's also an element of personal preference – some users prefer the brighter, white displays; others find the blue tinge attractive, especially on greyscale displays. Whichever you prefer, examine monitors for a good range of brightness and contrast. Many monitors have limited ranges, and you'll often find that the controls have to be set near maximum to get a good picture. That's too bad, because as time goes by, the screen phosphor ages and brightness tends to decline. If the

It's all in the tube

The picture tube determines how rich the colours appear on screen as well as the level of glare (which you may or may not experience). Of the colour monitors Macworld has tested over the years, monitors built around Sony's trademark Trinitron CRT technology produce richer-looking colour than does conventional tridot technology.

Trinitrons also use tridot technology – three phosphors (red, green, blue). However, where a conventional tridot arranges these phosphors in three-dot clusters, Trinitrons arrange the phosphors in three stripes. A slotted aperture grill focuses the electron beams instead of a conventional shadow mask composed of holes. This arrangement produces colours that are richer looking and more accurate.

One sharpness-related quality factor is pitch. Generally, the smaller the number, the better the dot pitch. A large dot pitch can make fine work difficult. Previously, Trinitrons could not achieve a dot pitch under

0.30mm because of the engineering of the screen grill. The trade-off was the Trinitron's brighter, more accurate colour. Now a newer Trinitron screen allows a dot pitch as low as 0.25mm.

Several other monitors offer flat-square picture tubes, a form of tridot technology that, though neither truly flat nor square, looks much flatter than the standard spherical-section tubes. These cheaper standard tubes definitely bulge out at the centre, making them harder to look at, and they typically lack sharpness in the corners when you're looking at text. In addition, monitors with standard tubes are more prone to glare.

Generally, a flatter screen is the best antiglare feature available. With a flatter screen, slightly shifting the monitor's viewing angle usually redirects the source of glare out of your line of vision. A more spherical screen reflects light in all directions. No matter how you face a monitor with that type of screen, you still get hit with the glare.



brightness control can be turned up higher than the current optimal setting, you can compensate for the monitor's natural aging. If the monitor must be set at optimum brightness from day one, you can't compensate later on.

The next area to consider is sharpness and focus. The human eye is one of the best and most reliable instruments for measuring these attributes, so there's no substitute for getting out and looking your prospective purchases squarely in the eye. While almost all monitors are acceptably sharp at the centre of the screen, you'll often find that fine lines (especially on small text) can get fuzzy towards the edges. These problem areas also highlight another failing, with supposedly straight lines developing curves and wobbles, particularly at top and bottom corners.

Flat screens are a big plus, and especially so in monitors with larger tubes (the portrait and two-page displays). Cheaper tubes tend to have pronounced curves and the effect can be likened to looking inside a goldfish bowl. It can also make it difficult to judge whether a line at the edges is truly straight or just apparently so.

In these ergonomically-conscious days it may be surprising to raise the

issue, but check the positioning of all controls. While most manufacturers are standardizing by putting all oft-used controls on the front, some still force you to stretch around the sides, or even to fumble at the back for brightness, contrast and power switches.

COLOUR MONITORS

Even though there are good reasons for choosing a monochrome display system for your Mac, the majority of users will demand, prefer or simply lust after a colour system. If you make that choice, many of the same considerations apply here as to monochrome monitors. Issues like brightness and contrast, focus and lack of distortion, placement of controls, and more are the same whatever kind of monitor you're considering.

Obviously, though, there are additional considerations with a colour display. But before turning to those specific issues consider an excellent, affordable but surprisingly underused possibility that is available to all Mac users: a two-monitor set-up.

Every Mac, from the SE to the II series, and PowerBooks as well, has the ability to use two (or more monitors). This gives Mac owners the unique abili-

ty to create a custom system that best matches their requirements without spending more than necessary. For example, consider the spreadsheet power user who spends most time looking at large worksheets, but requires the ability to create colour charts. Or the page layout artist whose main requirement is the ability to view an A4 pages, but also wants to preview colour illustrations and scanned images. In both cases, a 19-inch colour monitor looks like the obvious choice. But it will be much cheaper (particularly with a Mac with built-in video) to drive a monochrome two-page display, and use a small 14-inch monitor for colour work. If the designer requires better than 8-bit (256-colour) displays, then the built in video will provide 16- or 24-bit colour on the small monitor, while a cheap mono board will drive the larger display.

Small is beautiful

Within the colour sector, the key choice is size – and therefore the price – of the display (see [Understanding Display Screen Sizes](#)). Low-cost Macs like the LC III, Performa, and Centris are whetting users' appetites for similarly inexpensive colour displays. But price isn't the

Working with built-in video

Ever since Apple introduced the IIfx over four years ago, every desktop Mac except the IIfx, Classic, and Classic II has offered a built-in video port, letting you hook up a monitor without first buying a separate video card. But the capabilities of built-in video vary considerably from Mac to Mac, based on the amount of video RAM (VRAM) available to your system. (The discontinued IIfx and IIsi – do not support VRAM, instead stealing from system memory.) More VRAM means better colour on larger monitors.

Each Mac comes with at

least 256K of VRAM; you can add SIMMs to upgrade the VRAM to as much as 2MB, depending on the motherboard. VRAM delivers colour in inverse proportion to the resolution of your monitor (see the table): the higher the resolution, the fewer colours. Generally speaking, you need to have enough VRAM to hold the entire screen image at once. To accommodate 256 colours on a 640-by-480-pixel screen, this means that you must have at least 307K of VRAM (1 byte x 640 pixels x 480 pixels = 307K). As you increase the screen resolution, you must increase the VRAM or suffer fewer colours.

Calculating the VRAM requirements for 24-bit display gets a little trickier. No Mac lets you display 16.7 million colours at resolutions higher than 832 by 624 pixels (the standard for 16-inch displays). But you might think that 1MB of VRAM would accommodate 24-bit color on a 13-inch monitor, since 921K (3 bytes x 640 x 480 = 921K) is significantly less than 1MB. After all, NuBus cards with

1MB of VRAM can display 24-bit colour on 14-inch monitors, so why not internal video?

Most NuBus cards rely on what's called the chunky pla-

nar storage mode to use just 1MB to achieve 24-bit colour depth. This mode fully uses its 1MB of VRAM by loading a 24-bit screen image in three separate passes, one for each RGB channel. The system is inefficient, but the speed loss goes largely unnoticed, thanks to NuBus's inherently slow access speed. But built-in video can't hide behind a slow NuBus, so it has to sacrifice some colour depth. The result is that a 14-inch monitor's image consumes 1228K (4 bytes x 640 x 480). As a result, most Quadra users will need to buy a separate video card to access 24-bit colour. Either that or settle for a 512-by-384-pixel 12-inch monitor.

HOW MANY COLOURS DOES BUILT-IN VIDEO PROVIDE

	12-Inch	13-, 14-Inch	15-inch (portrait)	16-, 17-Inch	19-, 20-Inch	21-Inch
VRAM	(512 ∞ 384)	(640 ∞ 480)	(640 ∞ 870)	(832 ∞ 624)	(1024 ∞ 768)	(1152 ∞ 870)
256K	256	16	4	16	4	4
512K	32,768	256	16	256	16	16
768K	32,768	32,768	256	256	16	16
1MB	16,777,216	32,768	256	32,768	256	256
2MB	16,777,216	16,777,216	32,768	16,777,216	32,768	32,768

only reason to consider the wide range of 14- and 15-inch monitors available.

In addition to being affordable, these monitors produce a high-quality image. The richness of the colour as well as the sharp focus of many of these displays make them ideal for working with graphics and retouching photos, as well as for video-based projects. In addition, some of these monitors include audio jacks to enhance multimedia applications.

And consider these other issues:

- If you're on a tight home or office budget, these low-priced displays may be your only option. They are great entry-level displays, perfect for getting started with a basic, functioning Mac.
- If you are buying Macs in large, corporate quantities, these monitors will serve both Macs and PCs, simplifying your purchasing and support. Should you decide at a later date to get a larger display for one of your Macs, for example, the smaller display will find continued value hooked up to a PC.

Most of these monitors are the same multisync monitors sold in the DOS and Windows PC marketplace, but with the right cable adapter, they can also handle Mac video-display signals well. Although there are over 100 makes and

models of 14- and 15-inch monitors sold for PCs, Macworld recommends the few that sell as plug-and-play systems – VGA monitors with cable adapters bundled in or as an option.

Some monitors, such as the Apple AudioVision 14, Philips's 4CM4270 and Brilliance 1520 come with a built-in stereo amplifier and speakers. All provide a simple way to boost your Mac's internal audio, sound card, or CD-ROM audio without cluttering your desk with stand-alone speakers and wires. The AudioVision 14 is the best endowed in this area, with input jacks to support audio, video, and ADB devices, which are on either side of the monitor so you don't have to reach around the back to hook up a camcorder to the monitor. The AudioVision supports PlainTalk voice recognition as well as Apple-Phone and other third-party telephony applications. And the monitor comes with controls for volume, brightness, and contrast mounted on the front of the monitor.

You should note that low-priced Macs – the LC II and LC III, for example – offer only mono sound, as do PowerBooks and the Colour Classic and Classic II. Likewise, the IIvi and IIvx sport only monophonic sound unless you

add the optional CD-ROM stereo-audio upgrade. Centris, Quadra, IIci, and IIsi models ship with built-in stereo audio, however.

There's a price to paid for these extra features – the AudioVision 14 is £200 more than its non-audio sibling the Macintosh Colour Display – but they are good home and educational purchases.

The controls on these monitors are a varied lot – some, like those for the Macintosh Colour Display, are pretty vanilla, while others, like those for the NEC MultiSync 4FGe, have digital controls with more tools than you ever thought possible. The latter sports RGB colour-balance control through its AccuColor colour controls, letting you increase or decrease red, green, or blue video levels. You can store two sets of colour adjustments in addition to the factory defaults.

The Sony CPD-1430 offers the most control over the size, position, and shape of your display. This is good if your work requires unusually precise screen geometry. Digital controls include keystone distortion, to prevent uneven image width between the top and bottom of the screen, and a keystone-balance control to correct any



Quick road tests

You can't drag a test lab into a computer showroom or exhibition hall, but here are a few simple tests that will help you choose the monitor that is best for you.

- Fill the screen with 10- or 12-point type and then check whether the type looks crisp in all areas of the display. Better monitors stay sharp, even in the corners.
- On colour monitors, take a look at white text on a coloured background

to check colour convergence. On a problem monitor the white text appears fringed with colour.

- Draw a circle or square on screen. Then increase the monitor's horizontal and vertical screen area to see how large an active screen area you can get without distorting the image and bending the edges of the square.
- Glance at the screen out of the corner of your eye. This will usually show any flicker that may cause eyestrain.

- Look at the screen while chattering your teeth. Sounds strange, but that action interrupts any compensation your brain is making for a jittery display and helps you to determine which display is the steadiest.
- If you can, get the dealer to help you simulate the lighting of your work environment. The lighting at the dealer's will show you the monitor at its best – your work environment may reveal some glaring issues.

horizontal tilt. Side pincushion and pincushion-balance controls let you maintain straight vertical borders. In addition to nine default settings for different video signals (which you can modify), you can also store nine additional screen settings.

The middle ground

Mid-size colour monitors – those with a screen size of 16 and 17 inches – constitute one of the fastest-growing markets in computer hardware. When compared with their 14-inch cousins, 16-

inch monitors are 30 percent wider, 30 percent taller, providing a total of 69 percent more on-screen real estate.

Street prices typically range between £1,000 and £1,400, and you need no extra video-display board if you own a Centris, Quadra, LC III (Performa 450), or any of the second-generation PowerBooks (160, 165c, 180, and 180c).

Many types of users can benefit from the greater area of a midsize monitor:

- If you spend most of your time using a word processor, you'll have room for

another paragraph on screen – or two documents side by side.

- Number crunchers can expand the size of their spreadsheets by roughly 100 cells.
- A desktop publisher can view all but the extreme margins of a two-page spread at 75 percent magnification versus 50 percent on a 14-inch monitor.
- If you dabble in image editing, you can view every pixel of a standard 4-by-5-inch photograph scanned at 160 dpi.
- Database managers can see the bigger picture, online enthusiasts can jug-



gle more open windows, and presentation professionals can exploit larger screens.

- And absolutely anyone will have more room to position folders, icons and aliases on the Finder desktop.

After only a few days with a 16-inch display, you'll wonder how you ever managed to work on a smaller screen.

While using a 16-inch monitor has its pleasures, getting it running can be a pain. Not all Macs support 16-inch mode. First, 16-inch video technology is too new to be fully compatible with yesterday's Macs. Plugged into the factory-equipped video port of an LC, LC II, IIsi, IIfx, or any Performa but the 450, a 16-inch monitor runs in the 14-inch mode – 640 by 480 pixels. As a result, you see bigger dots – not better resolution – hardly worth paying the extra money.



If you want to boost the screen display to its proper 832-by-624-pixel splendour, you need to buy an additional video board.

The higher resolution can mean fewer colours. For example, an LC III

upgraded to 768K of VRAM can display 32,768 colours (16-bit colour) on a 14-inch screen, but only 256 colours (8-bit colour) on a 16-inch screen. Similarly, if your system uses Apple's 8·24 GC video board, get ready to say good-bye to the abundance of 16.7 million colours (24-bit colour) and hello to a parsimonious 256 colours. To regain the larger colour range, you again need to purchase a new video board or upgrade your current one.

If your work depends on 24-bit colour, the total £1,800-or-so price

may set you wondering whether a 19- or 21-inch monitor is a better solution. Well, only if you're made of money: a 19-inch monitor in 24-bit colour is likely to cost in the neighborhood of £3,000 or more.

Twin peaks

For most Mac users the choice of a 19- or 21-inch display revolves around two questions: Do I really need one? And, Can I afford one? The former question used to be somewhat easier to answer. If you were doing any kind of work that required a lot of detail, or the viewing of lots of information – like CAD, magazine layout, or large spreadsheets – the answer was obviously “yes”. But with the advent of the mid-range 16- and 17-inch displays things aren't so clear cut.

Many desktop publishers will find a 17-inch monitor adequate; professionals working in double-page spreads will still justify the bigger size. Spreadsheet users will also be able to justify a bigger monitor, although a colour two-page display may be overkill.

With the bigger monitors you really must be prepared to go out and evaluate units. It is foolish, and impossible, to try to buy from manufacturers' specifications.

For example, a monitor's sharpness is a function of the display's brightness but manufacturer's don't agree on how bright to set monitors when measuring sharpness. Also, most large monitors

using Sony's Trinitron tubes display moirés (fine, multicolour patterns made up of concentric ovals) when displaying large areas of light or medium grey.

Generally, the things you should look for are exactly the same as you need to consider in smaller monitors: brightness and contrast, colour purity,

Macworld Recommended...

SMALL COLOUR

CPD-1430 This 14-inch monitor performed the best in all of our subjective tests, providing excellent saturation and colour range. High-end graphics designers will like the richness of colour for working with scanned images. Company: Sony. List price: £649.

MIDSIZE COLOUR

PRECISIONCOLOUR PIVOT ERGO The colour version of this versatile monitor is an excellent all-round choice for those dealing with A4 pages, colour illustration and general applications.

Company: Radius. List Price: £1,095

MULTISYNC 5FG Not to be confused with the 5FGe – which offers fewer colour and resolution options – the 5FG is the control king, letting you edit on-screen colours and switch resolutions on the fly.

Company: NEC Technologies. List price: £1,195.

LARGE COLOUR

PRECISIONCOLOUR DISPLAY 20 The only monitor with top scores in all Macworld Lab image-quality tests. Also offers easy-to-use multi-resolution settings.

Company: Radius. List Price: £2,699.

SUPERMATCH 21 TWO-PAGE COLOUR DISPLAY A high-contrast monitor that performed well in most tests. Not cheap, though.

Company: SuperMac. List Price: £2,895



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Pay & Display: Choices for graphics acceleration

Historically, Macworld has paid little attention to the matter of add-in display boards for the Mac. The reasons for this are straightforward: in the early days, add-on systems were unusual and when you bought an external monitor it almost always came with a display board from the same company. In any case, most users preferred the convenience and cost-savings of such all-inclusive bundles.

More recently Apple has adopted a policy of including built-in video display support in all Macintoshes, and for most users this provides a low-cost solution with acceptable capability.

The exception to these rules of thumb has always been in the area of accelerated 24-bit colour. Such boards cater for the graphics professional who wants maximum speed – but unless you're ludicrously rich, you also want value for money from these boards that can cost more than the most expensive Mac.

But if you've been tempted to

hand over £3,000 or more for one of these gems we have some good news: Macworld Lab testing revealed that most artists and designers will derive as much benefit from inexpensive accelerated video cards as from expensive ones. This is because, while QuickDraw accelerators speed up common screen-display tasks, such as window drawing and scrolling, they do little to expedite the kinds of custom graphics routines commonly used in illustration and page-layout programs.

Although one video card may draw window elements faster than another – shaving off as much as, say, a full second – neither card will quicken the redraw of complex graphic elements inside your document, which is by far the more time-consuming task an artist or designer faces.

In fact, in blind tests and without the aid of stopwatches, we were rarely able to distinguish the performance of one accelerated video card from another.

So if money is no object, feel free to go for broke and buy the best card that technology has to offer, particularly if it also offers other features that you need, like accelerated CMYK work in Photoshop. But if money is scarce, you can save a few thousand pounds if you're willing to endure the occasional infinitesimal slowdown. (But don't go to the extreme and get an unaccelerated video card: they are noticeably slower than accelerated cards.

WHY DIFFERENCES ARE SMALL Many video cards provide separate chips designed to accelerate a handful of QuickDraw routines commonly called by the system software and other applications. This QuickDraw acceleration is not only the most publicized criterion in evaluating 24-bit video cards, it is also arguably one of the least compelling.

The result is bad news for artists. While manufacturers make extravagant claims for the performance of products – heralding speed increases

from 500 to 2000 percent – we were hard-pressed to find many subjective benefits to using accelerated video cards, particularly inside such graphics-intensive applications as Aldus PageMaker, QuarkXPress, Adobe Illustrator, Aldus FreeHand, and Adobe Photoshop.

For example, in tests where we pressed and held down the scroll arrow inside Microsoft Word and Excel, and other popular applications, the scroll speed improved by as much as 1000 percent when using QuickDraw acceleration. But this kind of scrolling is more commonly used inside word processors and spreadsheets than inside graphics programs.

Here's the impact acceleration had on the most popular graphics applications:

- In Photoshop, zooming was not perceptibly faster. Maneuvering around an image with the hand tool was smoother, but it took no less time to get from one point to another. Scroll speed improved only when we used the scroll arrows.
- In FreeHand, the only meaningful

acceleration occurred when magnifying the drawing area in the preview mode.

- In Illustrator, acceleration made next to no difference.
- In PageMaker, scroll speed improved, but not quite to the same extent as in Word or Excel. The magnification speed also improved.
- In QuarkXPress, scroll speed improved by an amount similar to PageMaker's level of improvement, but magnification speed did not improve noticeably.

For graphics professionals, the primary benefits of QuickDraw acceleration are smoother screen redraw and better performance on high-resolution 19- and 21-inch monitors.

THE COST OF ACCELERATION However you judge its benefits, QuickDraw acceleration is pervasive and generally inexpensive. Every NuBus video card that supports 24-bit display on 19-inch and 21-inch monitors provides some kind of acceleration. And while you can buy unaccelerated cards for 16-inch screens, the savings are marginal.

But while entry-level acceleration is a good value, enhanced acceleration is harder to justify, especially within a single product line. Consider, for example, the Spectrum/24 PDQ Plus and the Thunder/24, both from SuperMac. Although priced at £1,195 and £2,199, respectively, the only differences between the two cards are the Thunder/24's GWorld memory-expansion slots, improved QuickDraw acceleration, and dedicated Photoshop speed-up. Largely ignored these days, GWorld acceleration requires that you fork over more cash for SIMM chips, and even then it only works with GWorld-compatible programs, the number of which you can count on your fingertips. That leaves the improved QuickDraw acceleration, which according to our task-oriented tests makes the Thunder/24 only 8 percent faster on average than the Spectrum/24 PDQ Plus – hardly worth the difference in price if you're not a hardened Photoshop user.

Another kind of acceleration that is finding increasing acceptance on 24-bit video cards is digital-signal



processing (DSP). Currently dedicated to speeding up key Photoshop image-filter functions, DSP chips are optional extras on a wide range of 24-bit boards – a real boon to professional color publishers.

RESOLUTION AND CARD SIZE Another attribute that drives the prices of 24-bit graphics cards is screen resolution. If you own a 14- or 16-inch monitor and don't expect to be in the market for a larger screen any time soon, you can buy into 24-bit color for around £600. The PrecisionColor-Pro 24XP from Radius and the Futura II SX from SuperMac's E-Machines division are both ideal candidates. If your new 19-inch or 21-inch monitor just about emptied the petty-cash reserves, the Futura II LX and Mirror Tornado deliver 16.7 million colors

for just a little more.

If you own a Centris 610 or a Quadra 610, or if you want to avoid covering up the PDS slot on a Centris 650, 660AV, or one of several Quadra models, you'll need to purchase a 7-inch card. Among the shrunken few

are cards in the Radius PrecisionColorPro series and the Futura and ColorLink cards from E-Machines. All other NuBus graphics cards are roughly 12 inches long, but SuperMac said it would phase in 7-inch cards throughout 1994.

Macworld Recommended...

PRECISIONCOLORPRO 24XP Of the cards that Macworld tested, the 24XP represents the best value for people with 16-inch or smaller monitors. Company: Radius. List Price: £599

TORNADO For little more than the cost of the Radius board, Mirror gives you accelerated colour on large monitors at a resolution of 1,152x870. Company: Mirror. List Price: £699

THUNDER II GX•1360 Fast graphics acceleration, CMYK acceleration, and DSP options for Photoshop make this the powerhouse for heavy-duty Photoshop users. Company: Supermac. List Price: £3,595



Slide Recorders

While the line between presentation graphics and all-singing, all-dancing multimedia is increasingly blurred, the traditional slideshow remains the dominant method of delivery. And to create slides you need a slide recorder...

After word processing came the spreadsheet, and after the spreadsheet came desktop publishing. These computer-based activities were dubbed the “killer apps” by software firms – firms that desperately wanted to know what the next killer app was going to be. Believe it or not, the next killer app after desktop publishing was going to be... presentation graphics. Of course, with hindsight it's easy see the error, but presentations has developed into a sizeable market – as witnessed by continuing healthy sales of Microsoft Power-Point and Aldus Persuasion – and where there is dedicated software there is hardware. Which leads us to the slide recorder.

Today there are roughly a dozen film recorders available for the Macintosh; and while all of them promise to affordably, quickly and easily generate slides direct from the Mac, they don't always live up to their claims. Affordability, for example, is in the eye of the beholder: prices range from several thou-

sand pounds to nearly £20,000. Some are less than quick, some less than easy.

A film recorder is essentially a 35mm camera, a monochrome cathode-ray tube (CRT), and a colour-filter wheel wrapped up in a big box – an electronic darkroom on your desktop (or, sometimes, next to your desk).

Control and flexibility

Ideally, a film recorder should offer certain hardware controls to make using it easier – the ability to push a button and rewind the film, for example; or a liquid-crystal display (LCD) that lets you know what the film recorder is doing. Unfortunately, that isn't always the case.

Most recorders offer at least some level of hardware control and feedback. For example, models from LaserGraphics use the Ricoh/Lasergraphics Smart-Back 35mm camera, which I found to be the easiest to use. It incorporates an LCD that tells you, among other things, how many exposures have been made and how many are left on the film.

Agfa's PCR II is exemplary, however, for its hardware controls and feedback. Its LCD keeps you well informed as to what's going on inside the film recorder, giving you "intelligent" error messages if things go wrong, and

telling you what file is printing, how many images have been exposed, the output resolution, and more.

Some film recorders, particularly lower-end models like Lasergraphics' Personal LFR, come with a 35mm camera permanently mounted. That's fine if you plan to do nothing but generate 35mm slides, but other recorders let you use various types of device such as bulk film loaders, Polaroid instant film cameras, or 70mm cameras.

The waiting game

One thing you'll need if you buy a film recorder – apart from a wad of money – is patience. With most recorders, your Mac is tied up from the moment you select a slide to be printed, to the final click of the camera shutter – a process that in Macworld Lab tests took anywhere from 50 seconds for a simple MacDraw Pro PICT file, to 25 minutes for a 10MB scanned picture.

The slowest available option is the Spectra Star 450 – the result of the machine's unique design. Unlike other film recorders, the Spectra Star is not a dedicated machine; it is a 300dpi colour printer, with slide recording obviously tagged on as an extra feature. As such, its performance is optimized for 300dpi

pages, not the dense, 4096x2732 pixels required in a high-resolution transparency.

The Lasergraphics recorders (particularly the Personal LFR and LFR II) perform very well. When attached to Lasergraphics' RISC Rascol (an optional hardware-based PostScript rasterizer) they proved to be unbeatable in Macworld Lab tests. The RISC Rascol isn't cheap at around £9,000 but if you need to crank out slides in a hurry there's no better way to do it.

Image quality

Helpful hardware and good speed don't matter much if the images a film recorder generates aren't presentable. Most of the recorders available deliver slides suitable for a boardroom presentation, but none was perfect and you'll need to make some compromises somewhere in choosing the right model for your own slide designs.

Two key areas are the ability to display smooth colour gradients, and to display fine lines in fonts in graphics. The former is a function of colour resolution (the number of distinct colours the unit can generate and capture), and the latter is a function of image resolution (the larger the CRT, and the smaller

the dot-pitch on the tube, the higher the resolution).

The toughest test of a recorder's colour resolution is a black-to-white gradient, and the Mirus FilmPrinter Turbo II, the Lasergraphics LFR II, and the Agfa Forte fared best – all use 36-bits of data to represent each colour compared with the more common 24- and 33-bit colour handling.

In resolution tests, the LFR II, Agfa PCR II and Forte did best, thanks to large CRTs (with a 7-inch screen diagonal in the Agfa models, 6-inches in the LFR II) and small dot sizes (under 0.04mm in each case). The Mirus Film-Printer lost out here because it uses the smallest CRT at just 2.4-inches.

Making a choice

If there was one clear solution, generating superb slides at rapid speeds, for little money there'd be no problem – and no competition since the other manufacturers would be dead in the water. Obviously, there's no such paragon. Instead each has strengths and weaknesses and you get what you pay for.

- With the emphasis on internal use where image quality is not absolutely critical, consider the Agfa ProColor Premiere, the Lasergraphics Personal LFR,

or the Polaroid Digital Palette. Within this group, consider what kind of slides you want to produce: for text and line graphics, the Agfa has better resolution; for subtle colour and scanned images, the Polaroid has better colour resolution (33-bit versus 24-bit); and the Personal LFR is a good compromise.

- Further up the image-quality scale, the Agfa PCR II, and Lasergraphics LFR

deliver good slides at a reasonable performance for less than £10,000.

- If money is less of a consideration than top-notch slides, then consider the Agfa Forte, and the Lasergraphics LFR II at £19,000 and £13,000, respectively. And for the ultimate in performance as well as image quality, combine the LFR II with the RISC Rascol rasterizer

Macworld Recommended...

LASERGRAPHICS LFR MARK II When you combine this model with Lasergraphic's RISC Rascol RIP you've got an extremely fast and flexible film recorder with high-quality output.

Company: IMC List price: £11,995

AGFA FORTE The Rolls-Royce of film recorders, with 36-bit colour, 8,000-line resolution, and first-class controls – but with a price to match.

Company: Agfa List price: £19,990

AGFA PCR II If getting the sharpest slides possible at a reasonable price is your main concern, the PCR II is a good choice. The fact that it works with an optional PostScript RIP is a bonus for service bureaus.

Company: Agfa List price: £9,750

MIRUS FILMPRINTER TURBO II This is the best film recorder for those on a budget. It's fast and easy to use, doesn't take up much desk space, and offers reliable results.

Company: Reflex List price: £4,880

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Power Mac 7100/66 8/250	250	8	72 pin	1Mb	66	1867
Power Mac 7100/66 8/250CD	250	8	72 pin	1Mb	66	1949
Power Mac 7100/66 8/250 AV CD	250	8	72 pin	2Mb	66	2579
Power Mac 8100/80 16/500 AV CD & Soft Windows	500	16	72 pin	2Mb	80	3429
Power Mac 8100/80 16/1000/80 CD	1000	16	72 pin	2Mb	80	3895
Power Mac 8100/80 16/500/80 AV CD	500	16	72 pin	2Mb	80	3569

	HD	RAM	Mhz	£
Power Mac 6100/60 16/160 & Soft Windows	160	16	60	1445
Power Mac 6100/60 16/250 CD & Soft Windows	250	16	60	1765
Power Mac 7100/66 16/250 & Soft Windows	250	16	66	2215
Power Mac 7100/66 16/250CD & Soft Windows	250	16	66	2326
Power Mac 7100/66 16/500 AV CD & Soft Windows	500	16	66	2925
Power Mac 8100/80 16/500/80 CD & Soft Windows	500	16	80	3588
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Performa 450 4/160 Bu	160	4	with Colour Plus 14" monitor & keyboard			750
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LC 475 4/80 Bundle	80	4	with Colour Plus 14" monitor & keyboard			699
LC 475 8/160 Bundle	160	8	with Colour Plus 14" monitor & keyboard			860
LC 475 4/80 Bundle	80	4	with Colour Plus 14" monitor, StyleWriter II, fonts & keyboard			963
LC 475 4/160 Bundle	160	4	with Colour Plus 14" monitor, StyleWriter II, fonts & keyboard			1070
LC 475 4/80 Bundle	80	4	with Colour Plus 14" monitor, Personal LW300, fonts & keyboard			1177
LC 475 4/160 Bundle	160	4	with Colour Plus 14" monitor, Personal LW300, fonts & keyboard			1305

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LaserWriter Select 320 2Mb	598
LaserWriter Select 360 7Mb	1190
LaserWriter Pro 600 4Mb	1279
LaserWriter Pro 630 8Mb	1439
LaserWriter Pro 810	3499

DIGITAL

DECLaser 1152 A4 PS	505
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CALCOMP

CCL600 A3/A4 600dpi PS	2509
CCL600XS A3/A4 600dpi PS 16Mb	2799

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LaserJet 4ML A4 360dpi PS	742
LaserJet 4MP A4 600dpi 4ppm PS	968
LaserJet 4M+ A4 600dpi PS	1274
LaserJet 4SI Mx 600dpi PS duplex	3230

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MicroLaser Pro 600 A4 600dpi PS	909

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Primera Dye-Sublimation Upgrade	259

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DeskWriter 310	169
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DeskWriter 310 Colour Kit	28
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Colour Display 21"	1874
IntelliColour 20"	1899

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CPD 1430S 14"	396
CPD 1730S 17"	727
GDM 2036S 20"	1529
GDM 2038 20"	1635

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APPLE MACINTOSH HARDWARE

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Quadra 610 4/160	160	4	72 pin	512k	25MHz 040	no	867
Quadra 610 4/160 CD	160	4	72 pin	512k	25MHz 040	yes	1047
Quadra 610 8/230CD	230	8	72 pin	512k	25MHz 040	yes	1290
Quadra 650 4/160	160	4	72 pin	512k	33MHz 040	yes	1158
Quadra 650 4/160 CD	160	4	72 pin	512k	33MHz 040	yes	1264
Quadra 650 8/230 CD	230	8	72 pin	512k	33MHz 040	yes	1507
Quadra 660AV 8/230 CD	230	8	72 pin	512k	33MHz 040	yes	1199
Quadra 660AV 8/500 CD	500	8	72 pin	512k	33MHz 040	yes	1280
Quadra 840AV 8/500 CD	500	8	72 pin	1Mb	40MHz 040	yes	2680
Quadra 840AV 16/1Gb CD	1000	16	72 pin	1Mb	40MHz 040	yes	3215
Quadra 950 16/1Gb	1000	16	30 pin	1Mb	33MHz 040	yes	3150
Quadra 950 16/1Gb Multimedia	1000	16	30 pin	1Mb	33MHz 040	yes	3799

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Powerbook 145B 4/80 modem	80	4	Cards	33MHz 030	919
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Powerbook 180 4/120	120	4	Cards	33MHz 030	1522
Powerbook 180 4/120 modem	120	4	Cards	33MHz 030	1689
Powerbook 180C 4/160	160	4	Cards	33MHz 030	1605
Powerbook 180C 4/160 modem	160	4	Cards	33MHz 030	1863
Powerbook duo 230 4/120	120	4	Cards	33MHz 030	832
Powerbook duo 230 4/120 modem	120	4	Cards	33MHz 030	998
Powerbook duo 230 4/120 & DuoDock Plus	120	4	Cards	33MHz 030	1439
Powerbook duo 250 4/200	200	4	Cards	33MHz 030	1415
Powerbook duo 270c 4/240	240	4	Cards	33MHz 030	1730

Newton Message Pad 359
Newton Message Pad 110 420

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Aldus Persuasion 2.1	225
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Iron Helix - CD	Call
Lotus 1-2-3	272
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Retrospect Remote	242
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Ritz Meridian	169
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24xk - 24 bit 16" display & below	399
24xk - 24 bit 2 page display	625
24x - fast 24 bit 2 page display	1129

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Spectrum 24 Series IV Nubus - 24 bit	745
Thunder 24 - 24 bit, very fast	1930
Thunder II - 24 bit, the fastest!!	3120

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GTX 8000 Xtra+OCR 769	849
HEWLETT PACKARD	Price
Scanjet IIP	369
Scanjet IICX	688
MICROTEK	Price
Scanmaker II SP inc. Photoshop LE	629
Scanmaker II XE inc. Photoshop	920
Transparency unit for IXE	495

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DABS DIRECT - 22 WARWICK STREET, PRESTWICH, MANCHESTER M25 3HN
Leave the M62 J17, follow sign for Prestwich/Salford. Go south on the A56 through the pelican at the hospital, the main lights in the village and on to the next pelican crossing. Turn right immediately after this into Warwick Street. We are 100 yds further on the right.
DABS DIRECT - LANSBURY ESTATE, LOWER GUILDFORD ROAD, WOKING, SURREY GU21 7EW
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MEMORY

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8Mb 72 pin SIMM (Quadra 800/840)	280
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16Mb 72 pin SIMM (Quadra 840)	559
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Compact Disc

Compact discs were once the preserve of professional font libraries and a few obscure multimedia titles.

But as the medium increasingly moves into the mainstream there are more and more reasons to invest in the hardware.

There's no doubt about it: the computer compact disc is finally coming of age. Multimedia discs for the Mac are coming out at an ever-increasing rate; software buying from CD (from companies like Apple's Software Dispatch and Instant Access) is a valuable new way to try and buy applications and utilities; and Kodak's Photo CD format (offering inexpensive, high-quality scans of 35mm photography stored on disc) is giving hardened CD sceptics another reason to consider buying their first drive.

Drives with double-speed transfer rates are now the standard, designed to increase the playback rate for video and animation by sending more data per second, which results in smoother motion and clearer images. These new CD-ROM drives also offer multisession CD-ROM XA Mode 2 support (which is needed for full Photo CD capability). And even faster models, such as triple- and even quad-speed drives from companies like NEC are emerging.

With prices under £250 for double-speed drives, and many more available for less than £500, it seems to be the perfect time to buy.

Rating transfer rates

To achieve the double-speed transfer rate, drive manufacturers needed speedier spindle motors. In addition, the drive's controller software and error-correction logic had to be reprogrammed to accommodate the increased flow of data.

Most manufacturers agree that upgrading drive mechanisms to handle double speed is a fairly straightforward process. The biggest challenge is in building mechanisms capable of faster speeds while still maintaining the same half-height form factor that most single-speed drives had.

But not all mechanism makers followed this same-size goal. Pioneer, for example, designed its CD-changer mechanism (which can accommodate six CDs at a time), the DRM-604X, to offer a "QuadraSpin" transfer rate of 600KBps. To provide that speed, the mechanism is roughly twice the size of other CD-ROM mechanisms. That extra space is needed for the larger motor and other components.

One of the best real tests of transfer rates is to view QuickTime movies and watch for jerky motion and missing audio. The faster the transfer rate, the smoother the video. Why? Because to transfer the video and audio to the Mac's processor in sync with the movie's playback rate, QuickTime skips frames and drops audio when necessary. Among the mechanisms we tested, the Pioneer's data-transfer rate was by far the fastest, followed by the Sony and Toshiba mechanisms.

Such tests reveal some improvement in video playback on the double-speed mechanisms compared with single-speed drives; overall, QuickTime clips ran a bit more smoothly, with less audio dropout (see [Understanding Transfer Rates](#)).

But again, the improvement is not significant – there's certainly not a twofold increase in QuickTime performance with double-speed drives. In fact, a QuickTime movie played on the Pioneer 600KBps mechanism looks much the same as it does when played on drives with 300KBps mechanisms.

Current multimedia titles have QuickTime video that's optimized to play on 150KBps drives. Those drives, after all, have been the standard for

years and represent the lion's share of the installed base for CD players. Once CD developers create new titles, or revise existing ones, with video optimized to run on 300KBps drives, your investment in a double-speed drive for multimedia viewing will really pay off. The faster transfer rate, for example, will enable QuickTime developers to sustain more frames per second in their video, which will result in more fluid video motion.

But it's anyone's guess as to when such titles will be available. An informal query of CD developers and publishers (Warner New Media, The Voyager Company, Brøderbund, and others) found that none had any immediate plans to take advantage of double-speed drives. "We develop for the lowest common denominator," explained one developer, "and for a while, at least, 150KBps is still going to be that denominator".

Grabbing graphics files

Although double-speed drives can't really show their stuff yet with QuickTime, their faster speeds are quite noticeable with large graphics files.

In a test designed to measure transfer rate, we opened a 1.4MB Adobe Photoshop 2.0 file from the Apple



Understanding Transfer Rates

Transfer rate measures the speed at which a CD drive moves data from the disc into the Mac's processor.

WHY TRANSFER RATE MATTERS Because of the large size of graphics files, a fast sustained transfer rate is needed to send all that data from the drive through to the computer as efficiently as possible. The faster the transfer rate, in theory, the smoother the video/audio playback, and the less time waiting for an image to appear on screen.

FASTER IS STILL RELATIVELY SLOW When CD-ROM drives were first released in the mid-1980s, their transfer rates averaged about 150 kilobytes per second (KBps) – a speed that didn't change until NEC released its Intersect 74 CD-ROM for the Mac in early 1992 (now supplanted by the MultiSpin 74), with transfer rates averaging 300 KBps. (By comparison, most hard drives can transfer data at about 1MB to 2MB per second.) As for all types of drives, the actual transfer

rate depends on the type and amount of data.

ADVANTAGES OF BUFFERS To help increase transfer rates, most drive manufacturers offer a data buffer (or cache), an internal storage area that helps smooth the flow of data during the transfer process. The majority of single-speed drives have 64K data buffers, but several mechanism manufacturers (Sony, NEC, and Toshiba among them) have upped that to 256K with the double-speed drives.

How audio is different Transfer rates for audio, unlike those for video and graphics, remain at 150 KBps on double-speed drives, because increasing the audio-speed standard would result in Pinky-&-Perky voices. As a result, double-speed drives must perform at dual speeds – 150 KBps for audio and 300 KBps for video and graphics, constantly shifting back and forth between the two speeds.

THE BOTTLENECK In most cases, CD-

ROM transfer rates are not significantly affected by the processing power of your Macintosh. The SCSI bus on a 68000-based compact Mac like a Classic, for example, has a maximum sustained data-transfer rate of up to 1MB per second. When playing a CD title on a drive capable of only 300 KBps, a Classic is hardly going to create a bottleneck. However, it is possible that the Mac could be a bottleneck for two types of CD titles – occasionally for QuickTime movies and often for Photo CD images:

- QuickTime uses the Mac's processor to decompress a movie as it's transferred from the CD-ROM drive, so you might notice some difference between a Classic and a Quadra when playing a QuickTime movie.
- How quickly (or slowly) your CD drive can transfer Photo CD files to the processor varies, depending on your Mac's processing power. Photo CD uses a proprietary compression scheme for the two highest Photo CD resolutions. The Mac's processor is responsible for decompression.

BEFORE YOU BUY A CD-ROM DRIVE CHECK THE MAGAZINES.



If you want a CD-ROM drive that delivers what PC Magazine called *the luxury of having six discs loaded and ready at any time* - we recommend you check out our magazine. (The revolutionary six disc autochanger also found on the award winning DRM-604X.) You'll discover quick disc selection, dual spin, 307KB/s data transfer rate, 300ms average access time, Photo-CD multi-session support, SCSI interface, and MPC2 compliance. In fact, for just £549 r.r.p. excl. VAT, you'll find the DRM-602X a real scoop.



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Colour Graphics Sampler CD, which comes with Apple's drive. The Pioneer mechanism was the fastest again, taking just 5.8 seconds; the Sony CDU-8003 mechanism, used in Apple's AppleCD 300 drive, was second, followed by the NEC 38 mechanism.

Assessing access speeds

CD drive manufacturers have not focused their efforts entirely on speeding up transfer rates. Access speed (how long it takes the drive to find a piece of requested information) has also been improved in most mechanisms. Access speed is measured in milliseconds (ms) and is an important performance criterion for those who regularly search large CD-based databases (dictionaries, encyclopedias, and so on).

In our tests designed specifically to measure access speeds, we performed a keyword search on Quanta Press's World War II historical CD. The speediest mechanisms were also those that delivered the fastest transfer rates: the Pioneer DRM-604X was tops, performing the search in 13.8 seconds, followed by the Sony CDU-8003 mechanism in Apple's drive.

The slowest was, not surprisingly,

the Toshiba XM-330/TA single-speed mechanism we used for comparison. We picked the Toshiba mechanism because, of the mechanisms used by multiple vendors in their single-speed CD players, it is the fastest, according to Macworld Lab tests.

Consider other factors

Speed is certainly one of the most important factors to consider when choosing a CD drive. But there are others to weigh as well:

- **Multisession Photo CD support** If you have a roll of film scanned onto a Photo CD, you'll be able to view those files (provided you have the right software) on many different single-speed, single-session drives. But should you add another roll of film to that disc later, only a multisession drive will be able to read those added images.

In most cases, those multisession drives are also double-speed drives. There's no relationship between double-speed and multisession, however, other than the fact that most drive-mechanism manufacturers added multisession capability at the same time that they increased the drive's speed.

- **Bundles** Increasingly, CD drive vendors are including choice CD titles with

the deal; some vendors even include a pair of stereo speakers or other gifts.

- **Physical characteristics** CD-ROM drives, for the most part, look a lot like external hard drives: boxy and nondescript. There are some exceptions, though. The Sony-based CD drives are sleek and slender; the drives based on Pioneer's DRM-604X CD-changer mechanism are big and bulky; and NEC's MultiSpin 38 is lightweight and portable.

All the drives (except the portable MultiSpin 38) we looked at have a covering over the disc-insertion slot to keep out dust. NEC's MultiSpin 74 model gets top honours here, with its double dust-door covering. Also, the MultiSpin 74 comes with external attachments that let you stand it on its side, an advantage in cramped desktop situations.

- **Ease of use** Adding a CD-ROM drive to your Mac is pretty straightforward (or as straightforward as adding a SCSI device gets). Among the manuals Apple's was the most complete – the only one to explain Photo CD and how to access files in that format. Other vendors should follow suit.

Most vendors also know that SCSI termination should be external or



switchable so you can easily put your CD player anywhere on the SCSI chain you need to. Only NEC's MultiSpin 74 and drives based on Sony's CDU-561 mechanism still use hard-to-reach internal termination, forcing you to put the drive at the end of your SCSI chain.

Adding it all up

All of the drives we tested turned in respectable (by CD-ROM standards) performances; even though some drives were faster than others, not one was bad. So your buying decision comes down to how important speed is to the work you're doing now or will be doing within the next year.

Graphic designers, photographers, illustrators, and others who plan to be serious Photo CD users will need the fastest CD-ROM drive they can

afford. For them Macworld recommends the Pioneer-based CD-changer drives – but only if you don't mind paying the price. If money is a limitation, the AppleCD 300 (£239; street as low as £145) and NEC 38 (£349) offer solid performance at reasonable prices.

If multimedia is your thing, the question remains: Should you buy a double-speed CD-ROM drive now and wait for the software titles to catch up in speed with the hardware? Or should you put off your purchase until next year, when

CD-ROM drives with 600KBps transfer rates will be more affordable (even though the software will still just be in transition from 150KBps to 300KBps transfer rates)?

It's a difficult decision to make and in the final analysis only you can make it: if you must have access to multimedia titles now, then pick the fastest drive you can afford. If you can put off buying for a while, then do so.

If you're just curious about multimedia and Photo CD, chances are the

cheapest drive you can find will adequately suit your needs for now. Just remember that in a year or so, you'll probably want to trade up.

But given the fast pace at which CD software and hardware are developing these days, you'd probably want to do that anyway, no matter which drive you buy.

Macworld Recommended...

PIONEER DRM-604X With the fastest speed and the ability to hold six CD-ROMs at once, this is the drive for true CD junkies without budget constraints.

Company: Pioneer List price: £1,280

APPLECD 300 This one comes close to having it all: a fast Sony mechanism, good documentation, an attractive bundle of CD titles, a slim chassis, and Photo CD access software – and the price is right too.

Company: Apple Computer List price: £239

NEC MULTISPIN 38 It's not as fast as other double-speed drives, and the lack of any real dust protection might be a concern for some. But you can't argue with the price, and its portability should please the PowerBook crowd.

Company: NEC Technologies List price: £349

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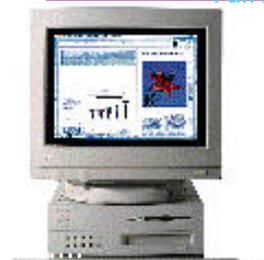
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*Manufacturers and distributors should send details of product announcements, price and specification changes, and corrections to:
Mary Cowan, Macworld, 99 Gray's Inn Road, London WC1X 8UT.*

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Powersafe Switch	Ecoman	Energy-saving switch	Ecoman	£59
SCSI Boy	APS	PowerBook SCSI connector	Mygate	£25
The Universal Notepac 4	Targus	Universal laptop case	Ingram Micro	£70
ThinPack	VST Power Systems	Powerbook external battery, with utilities	TeleAdapt	£230

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2-16GB DAT	Mirror Tech.		Mirror Tech.	£849
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3400DX	WangDAT	8-16GB DAT drive	Ambar	£1,277
DAT 4MM	Transitional Technologies	DAT tape drives from 1.4GB to 2.3GB	Principal	£2,995-£3,995
DAT d2	Électronique d2	800e-2GB DAT tape drive	Apple dealers	£1,065-£1,275
DeskTape	Optima	2GB DAT drive & unique mounting software	Principal	£2,295
hammerDAT	FWB	DAT tape drives from 1.3GB to 5GB	Midwich Thame	from £1,659
hammerTape	FWB	Tape drives 525MB	Midwich Thame	£1,249
HP DAT drive	Hewlett Packard	2GB Series 6400 DAT Ext Drive	Principal	£1,999
Irwin 5040/60/80/120	Irwin	Tape drives from 40MB to 120MB	Merisel	£605-£841
La Cie DAT drives	La Cie	DAT drives from 1.3GB to 8GB	Principal	from £1,999
La Cie Tape drives	La Cie	Tape drives from 155MB to 600MB	Principal	from £849
Logical	Logical Engineering	Tape drives from 60MB to 5GB	Profyle	from £895
Micro/DAT MD-1300/MD-5000	MicroNet	DAT tape drives	Cal-Abco/ Ideal Hardware	£2,155-£2,425
Micro/Tape	MicroNet	350MB tape drive	Cal-Abco/ Ideal Hardware	£1,155
Micro/Tape MicroPak	MicroNet	155MB tape drive	Cal-Abco/ Ideal Hardware	£669
Microtech T150/T2000/T20001	Microtech	Up to 2.0GB tape drives	Mygate	from £799
MiniPak	Optima	2GB DAT tape drive	Principal	£2,249
ProDAT	Formac	2/8GB DAT tape drives	Formac	£1,880
ProDAT	Formac	4/16GB DAT tape drives	Formac	£1,945
QT-250es/525es	Tecmar	250MB/525MB external SCSI tape drives	Frontline	£1,560-£2,795

QTMAC40/80	Tecmar	40MB/80MB external tape drives	Frontline	£1,125-£1,435
Strategy	APD	2/5/16GB DAT tape drive	MacEurope	£2,495
Tape Drives	OR Computers		DPL	from £338
CD Drives				
CD 150	Apple Computer	CD-ROM player	Apple	£199
CD 300	Apple Computer	Internal/external CD-ROM player	Apple	from £239
CDR-1850S	Hitachi	CD-ROM player	Hitachi	£625
CDR-6700	Hitachi	Double-speed CD-ROM drive	Hitachi	£580
CD-ROM	PLI	Internal/external drives	Key Exchange	from £440
CD-ROM Drive	Mirror Tech	Double-speed CD-ROM player	Mirror Tech	£499
CD Shuttle	Memory Technology	650MB read-only CD-ROM drive/dual-speed	Memory Technology	£499
CMA 532	Cumana	CD-ROM player	Cumana	£560
CMA 632	Cumana	Double-speed CD-ROM drive	Cumana	£454
DRM604X	Pioneer	Quadraspin six-disc autochanger	Pioneer	£1,280
DRM602X	Pioneer	Double-speed six-disc autochange	Pioneer	£549
DRM1804X	Pioneer	Quadraspin eighteen-disc autochanger	Pioneer	£1,995
DRM104X	Pioneer	Quadraspin Single-Disc Internal	Pioneer	£499
DRM5004X	Pioneer	Quadraspin five hundred-disc autochanger	Pioneer	£19,500
HammerCD	FWB	Double-speed CD-ROM drive	Midwich Thame	£749
Micro/CD-ROM	MicroNet Tech	Double-speed CD-ROM player	Ideal Hardware	£499
MultiSpin 2Xi	NEC	Dual-spin CD-ROM player (int)	NEC	£199
MultiSpin 3Xe/i	NEC	Triple-speed CD-ROM player (ext. or int))	NEC	£479/£379
MultiSpin 3Xp	NEC	Triple-speed CD-ROM player (portable)	NEC	£399
MultiSpin 4XPro	NEC	Quad-speed CD-ROM player (ext)	NEC	£849
Optistore CDR	Data Peripherals	Write-once recordable CD-ROM drive	Data Peripherals	£2,995
PCD Writer 200	Kodak	CD writer	FOS-CD;Midwich Thame	£3,995
Philips LMS	Philips	Read/write CD-ROM	Ambar	approx. £4,000
PowerCD	Apple	Portable CD-ROM drive	Apple	£329
RCD-202	Pinnacle Micro	CD-ROM player	UK Flex	£3,495
RF4000	Reflection Systems	Double-speed CD-recorder system	Reflection Systems	£3,995
COMMUNICATIONS				
24/96	Mass Micro	Internal PB fax modem	MacWarehouse	£199

4-Sight EmailFax Integration	4-Sight	Multi-user fax/telex system	4-Sight	£250
4-Sight Fax	4-Sight	Multi-user fax/telex system	4-Sight	from £1,249
4-SightFax (10 users)	4-Sight	Network fax system	4Sight	£1,499
4-Sight Fax 4-port card	4-Sight	Serial port card	4-Sight	£499
4-Sight ISDN Manager v.1.9.3	4-Sight	128kbps file transfer and serial tool	4-Sight	£1,999
4-Sight Linocomms	4-Sight	Multi-user ISDN	4-Sight	£5,000
4-Sight SOLO	4-Sight	Portable data/fax modem	4-Sight	from £249
4-Sight Telex	4-Sight	10-user telex system	4-Sight	£2,999
Annex Three	Xylogics	ARAP Communications server	Xylogics International	per port £62
COMstation	PSI	Fax Modems	Computers Unlimited	from £199
Courier V32 bis/fax	US Robotics	V42 modem	Ingram	£599
DoveFax Desktop/Plus	Dove Computer	Fax modem	Mygate	£99-£275
Ethernet-SC	TechWorks	Ethernet adaptors	TechWorks	£309
Ethernet-SC PB	TechWorks	Ethernet adaptors	TechWorks	£329
FaxExpress v2.4	Glenwarne	Fax Modem	Glenwarne	£69
Linnet 32 plus fx	Pace	V42 desktop modem	Pace	£349
LinoComms	4-Sight	Multi-user ISDN/modem file delivery	4-Sight; Linotype-Hell	£3,600
MaCNet	MaCNet	Ethernet adaptors	Principal	from £130
MaCNet 10BaseT	MaCNet	Starter Kits ethernet adaptors	Principal	from £799
Microlin FX/FX 32 Plus	Pace	V42 modem	Principal; Tekdata	£249/£499
NetModem	Shiva	shared over AppleTalk	Principal	from £1,199
Optima 144	Hayes	V42 modem	Merisel, Ingram Micro	£650
Optima SmartModem	Hayes	SmartModems	Merisel, Ingram Micro	from £358
PB Express	Apple	Modem for PB160/180/210/230	Apple	£350
PBI PowerModem	PSI	PowerBook Fax Modems	Computers Unlimited	from £200
PDM40F	Psion Dacom	Pocket fax and modem	Frontline	from £349
PDM60F	Psion Dacom	V42 modem	Frontline	£499
Planet II	SHLP	NuBus ISDN Card	Principal	£1,295
Pocket ISDN Adaptor	RedNet	38.5kbps/64,000bauds a/synchronous	RedNet	£649
PowerBook fax modem	Apple	Internal	Apple	£295
QuadFax	SmartLink	Fax modem	Comtek	from £349
Quin Fax Plus	Andest Comms	V42 autosynch modem	Andest Comms	£549

RediCard fax modem	Data Race	Fits into Newton messagePad's PCMCIA slot	PPCP	£449
RoadRunner QuinFax plus	Andest Comms	38.4Kbps modem	Andest Comms	£675
RoadRunner Rocket	Andest Comms	V42 pocket modem	Andest Comms	£399
Sapphire	Dataflex	38.4Kbps modem	Dataflex Design	£599
Sapphire Plus	Dataflex	V42 Pocket modem	Dataflex Design	£599
SmartLink	SmartLink Comms	Fax modems	Comtek	from £249
Sportster Mac'n'Fax	US Robotics	V42 modem	Ingram	£399
StarNet	StarNET	Range of ethernet connectivity products	Performance Direct	from £49
TeleDaptor	TeleAdapt	Adaptors for foreign 'phones	TeleAdapt	from £100
TelePort	Global Village	V42 modem	Frontline	£109-£399
Tornado 14/42	Tricom	V42 modem	Tricom	£899
Ultralink 32plus	Pace Micro Technology	57.6Kbps modem	Pace	£599
ULTRA Smartmodem	Hayes	V-series, 2400,9600 & 14400 bps	Merisel, Ingram Micro	from £385
V32 bis/fax	US Robotics	V42 modem	Ingram Micro	£795
V32 turbo Modems	Andest	Data throughput of 115,200bps	Andest	£249
VidiMac	Satelcom	Video-conferencing system	Satelcom	£4,495
Worldport 14400 fax	US Robotics	V42 modem	Ingram Micro	£499

CONNECTIVITY

4511A	Tektronix	Ethernet interface for Tek colour printers	Tektronix	£1,295
AsanteHub 1012	Asante Technologies	12-port, 10BaseT ethernet hub	Profyle	£549
DaynaPort Card	Dayna	Full range	Computers Unlimited	from £90
DaynaPort/SCSI Link	Dayna	Small external SCSI Ethernet adaptor	Computers Unlimited	£330
DaynaPort/SCSI Link-3/SCSI Link-T	Dayna	Ext SCSI ethernet adaptor, RJ45	Computers Unlimited	from £400
EA412/414/419	Cabletron Systems	SCSI to Ethernet adaptors	Cabletron Systems	£468/£554/£410
Ether+(Thick/10BaseT)	Compatible Systems	Attaches Mac to Ethernet via SCSI	RedNet	£349
Ether+(Thick/Thin)	Compatible Systems	Attaches Mac to Ethernet via SCSI	RedNet	£349
Ether 10-T Starlet	Farallon	Ethernet mini-hub	Gomark; Ingram Micro	£299
EtherLink/NB	3Com	Ethernet adaptor card for Mac II series	Merisel; Principal	£395
EtherLink/SE	3Com	Ethernet adaptor card for Mac SE	Merisel; Principal	£330
EtherMac Cards	Farallon	For LC, SE, IIsi	Gomark; Ingram Micro	from £225
Ethernet Boards	Asanté Technologies	For Classics & Quadras	Profyle	from £325
Ethernet DNI Cards	Cabletron Systems	Network interface cards	Cabletron Systems	from £370

Ethernet LC Card	Apple	Ethernet adaptor for LC	Apple	£112
Ethernet NB Card	Apple	NuBus ethernet network card	Apple	£227
EtherNODE	National Semiconductor	Ethernet adaptor	Ingram Micro	EPOA
Etherport SE	Kinetics	Ethernet adaptor for SE, SE/30	Principal	£485
EtherPrint/3/Plus	Dayna		Computers Unlimited	from £399
EtherRoute II	Compatible Systems	LocalTalk to ethernet route	RedNet	£999
EtherRoute/TCP	Compatible Systems	As above, with TCP/IP and DECnet	RedNet	from £1,299
EtherTalk Interface Card	Apple		Apple	£430
EtherWrite	Compatible Systems	Attaches LocalTalk printers to ethernet	RedNet	£529
EtherWrite/LPR	Compatible Systems	As above, for UNIX and Mac-users	RedNet	£749
FastPath 5	Shiva	LocalTalk/ethernet Gateway	Principal	£1,995
FDDI NuBus	MacEurope	60MB per minute file transfer	MacEurope	from £2,495
FibreEthernet	MacEurope	Transceiver converts copper to fibre	MacEurope	from £1,999
FibreConcentrator	MacEurope	Ethernet and FDDI fibre concentrators	MacEurope	from £1,195
GatorBox	Cayman	Ethernet-to-LocalTalk router	Gomark; Cabletron Sys.	£2,195
GatorCard E/II	Cayman		Gomark; Cabletron Sys.	£359
GatorLink	Cayman		Gomark; Cabletron Sys.	£1,597
GatorMIM CS	Cayman	LocalTalk/ethernet router	Gomark; Cabletron Sys.	£2,150
GatorStar GX-M	Cayman		Gomark; Cabletron Sys.	£2,795
Hub-24	Dayna Communications	24-port 10Base-T hub	Computers Unlimited	£999
Hurdler	Creative Solutions	NuBus serial port cards	AM Micro	from £235
Hurdler SCSI/Serial box	Creative Solutions	For non-NuBus Macs	AM Micro	£595
InterBridge	Hayes	Expands interconnection of networks	Merisel	£799
International Travel Kit	Impactron	Set of socket adaptors	Impactron	£95
LanRover/E	Shiva Corporation		Principal	£170
LanRover/L	Shiva Corporation	Dial-in server for PowerBook	Principal	£675
LocalSwitch	Tribe Computer Works	16-port packet-switching hub	Gomark	£2,495
MacIRMA	DCA	IBM 3278/3279 display station emulation	Principal; Ingram Micro	£205
MacIRMAtrac	DCA	Token-Ring adaptor card	Principal; Ingram Micro	£822
MacIRMALAN Servers	DCA	Gateway and workstation packages	Principal; Ingram Micro	from £2,399
MacMainFrame TokenRing	Avatar		Gomark	from £849
MacTwin	KMW Systems	Connection for Mac and IBM AS/400	Principal	£925

Micro-Router	Compatible Systems	Hardware router, ISDN compatible	RedNet	approx. £1,500
MIM	Cabletron Systems	Module for connecting different networks	Cabletron Systems	from £620
Mini EN/SC	Asante Technologies		Profyle	from £341
MR9T	Cabeltron Systems	10Base-T standalone multiport repeater	Cabletron Systems	£560
MultiGate Hubs	Network Resources	12-/24-port intelligent hubs	RedNet	from £1,595
NetAccess	KMW Systems	Network gateway card to access IBM host	Principal	£2,600
NetBlazer	Chernikeef	Dial-up router	Gomark	£2,500
NetBridge router	Shiva	Extends AppleTalk networks	Principal	£399
Netway 2000	DCA	S+A Gateway	Persona	£4,018
NuvoLink	Nuvotech	SCSI-based ethernet controller	Principal	£395
OrangePC	Orange Micro	Board enables Mac users to use a PC	Principal	£1,599
PhoneNet Card (Ethernet)	Farallon		Gomark;Principal; I. Micro	£320
PhoneNet StarConnector EN500	Farallon		Gomark;Principal; I. Micro	£115
Plus Drive	Applied Engineering	Read/write DOS for Plus, SE, II	A M Micro	£375
Planet ISDN	MacConnect	High-speed communications	MacConnect	£995
Planet ISDN	Planet	High-speed communications	Principal	£995
PowerKeyRemote	Sophisticated Circuits		MacWarehouse	£35
Rand E	Focus Enhancements		Focus Enhancements	from £939
Remote/WakeUp	Farallon		Gomark;Principal; I. Micro	£50
RISC-Router 3000E	Compatible Systems	High-performance router	Rednet	£2,599
SCSI Cable Terminator	Apple	To terminate any chain of SCSI devices	Apple	£25
SCSI Extender Cable	Apple	Extends system or peripheral cable	Apple	£35
SCSI HDI-30 System Cable	Apple	Connects PowerBks to SCSI peripherals	Apple	£40
SCSI Net	MacEurope	Networks SCSI disk drives	MacEurope	from £1,000
SCSI System Cable	Apple	Connects Macs (except PBs) to SCSIs	Apple	£49
SCSIVue Terminator	Granite	Active diagnostic terminator	MacEurope	from £49
SCSIVue Diagnostic Cables	Granite	Eliminates SCSI errors, improves performance	MacEurope	from £29
Super Floppy	PLI	Read/write 31/2 DOS and Mac floppies	Key Exchange	£252
T6015	Cabletron Systems	Token ring DNI card	Cabletron Systems	£790
TechWorks	TechWorks	Ethernet cards	TechWorks	from £149
TeleBridge router	Shiva	Remote bridge between networks	Principal	£399
TokenTalk NB Interface Card	Apple		Apple	£745

Turbo Floppy	PLI	Read/write 31/2 DOS floppies	Key Exchange	£219
TurboStar	Nuvotech		Principal	£1,095
TwinAccess	KMW Systems	NuBus card giving Mac access to IBM	Principal	£925
DISPLAY – b&w and greyscale cards				
Clearvue/GSXL	RasterOps	8-bit greyscale card for Mac II	Frontline	£495
Display Card 4-8	Apple	Greyscale card	Apple	£160
DisplayNet	Lapis	Monochrome cards for 19" and A4	Midwich Thame	£499
DisplayServer	Lapis	Monochrome cards	Midwich Thame	from £249
L-View adaptor	Sigma Designs	Greyscale card	Aptec	£350
Monochrome Card	SuperMac	NuBus card for large B&W monitors	Principal	£399
PageView adaptor	Sigma Designs	Greyscale adaptor	Aptec	£380
Prograph GS card	Formac	19" greyscale card	Formac	£1,275
Prograph Mono card	Formac	19" B&W card	Formac	£875
QuickView Z21 greyscale card	E-Machines		H.& Son;Frontline;D.Tek	£1,150
QuickView Z21 Mono card	E-Machines		H.& Son;Frontline;D.Tek	£395
SilverView Mono Card	Sigma Designs		Aptec	from £500
SilverView Pro	Sigma Designs	Mono/card systems	Aptec	£299
TPD Interface for SE/30	Radius	Monochrome card for two-page display	Computers Unlimited	£349
DISPLAY – b&w and greyscale systems				
15" Analog Portrait System	Mirror Tech.	Greyscale	Mirror Tech.	£349
15/19" Portrait + Mono Card	Mirror Tech.	Greyscale	Mirror Tech.	£449/£649
Lapis A3 Mono	Lapis	19" B&W	Midwich Thame	£899
Mobius One-Page/Two-Page	Mobius	A4 portrait/19"B&W	Principal	£595/£695
PageView GS	Sigma	15" greyscale	Aptec	£499
PowerPortrait	Sigma	15" mono, for compact Macs and PBs	Aptec	£695
SilverMac 8/21"	Hitachi	B&W	Hitachi	£2,250
SilverView Pro	Sigma	21" mono/greyscale	Aptec	£899
Strategy GM	MacEurope	21" Greyscale	MacEurope	£999
DISPLAY – colour cards				
24S	RasterOps	24-bit multisync video card	Frontline	£690
24MX, MXQ	RasterOps	24-bit multifunction boards	Frontline	from £695
24SX	RasterOps	24-bit accelerated for 13"	Frontline	£545

24XLI	RasterOps	24-bit accelerated video card	Frontline	£1,995
264/SE 30	RasterOps	24-bit for SE 30	Frontline	£595
8-24	Apple	24-bit	Apple	£240
8XL	RasterOps	8-bit video card	Frontline	£545
8XLI	RasterOps	8-bit accelerated video card	Frontline	£995
BookView Imperial	Simms Int'l	8-bit internal colour card for PowerBook	Simms Int'l	£895
ColorLink DC/T	E-Machines	8-bit accelerated with Ethernet	H. & Son;Frontline;D.Tek	£575
ColorLink SX/T	E-Machines	24-bit accelerated, with Ethernet	H. & Son;Frontline;D.Tek	£625
Chroma	miro graphics	24-bit NuBus card	Aptec	£1,395
DigitalFilm	SuperMac	24-bit multifunction board	Principal	£3,495
Display Card 8-24	Apple	8/24-bit colour card	Apple	£415
Display Card 8-24 GC	Apple	Accelerated colour card	Apple	£895
Dome Md/Max	Data Cell	Data display controller card	Data Cell	£4,700/£5,400
DoubleColor LC	E-Machines	8-bit, supports Mac LC and LC11	H. & Son;Frontline	£425
DoubleColor LX	E-Machines	8-bit accelerated card for 12-21" displays	H. & Son;Frontline	£675
DoubleColor SX	E-Machines	8-bit accelerated card for 12-16" displays	H. & Son;Frontline	£375
Futura II LX	E-Machines	24-bit	H. & Son;Frontline;D.Tek	£795
Futura II SX	E-Machines	8-bit accelerated; upgradable	H. & Son;Frontline;D.Tek	£425
Futura MX/SX	E-Machines	24-bit accelerated	H. & Son;Frontline;D.Tek	from £595
Imagician	MacEurope	Real-time image manipulation	MacEurope	from £2,595
L-TV	Lapis	Lets LC hook up to TV	CU;Midwich Thame	from £449
L-TV Pro LC	Lapis	16-bit colour PAL video interface card	CU;Midwich Thame	from £449
L-TV Pro NuBus	Lapis	16-bit colour PAL video interface card	CU;Midwich Thame	from £549
MediaTime	RasterOps	24-bit multifunction board	Frontline	£2,149
Paintboard 8Li	RasterOps	8-bit colour	Frontline	£395
Paintboard 24	RasterOps	24-bit for 12-21" displays	Frontline	£1,395
Paintboard LI	RasterOps	24-bit for 12-20" displays	Frontline	£845
Paintboard Lightning	RasterOps	24-bit accelerated display adaptor	Frontline	£945
Paintboard Turbo	RasterOps	24-bit accelerated display adaptor	Frontline	£1,295
Paintboard Turbo XL	RasterOps	24-bit accelerated display adaptor	Frontline	£1,695
Pivot ERGO	Radius		Computers Unlimited	£629
PowerBases	Lapis	8-bit, display adaptors for PowerBook	Midwich Thame	£549

PrecisionColor/24X	Radius	24-bit card	CU; DirekTek	£1,799
PrecisionColor/24XK	Radius	24-bit accelerated colour card	CU; DirekTek	£999
PrecisionColor/24XJ	Radius	8-bit accel. non-upgradeablecolour card	CU; DirekTek	£599
PrecisionColor/24Xp	Radius	24-bit, QuickDraw acceleration	CU; DirekTek	£599
PrecisionColor Pro 24x	Radius	6.5", 24-bit card	CU; DirekTek	£1,799
PrecisionColor Pro 24xp	Radius	6.5", 24-bit card	CU; DirekTek	£,599
Prisma GX	miro graphics	8/16-bit NuBus card	Aptec	£795
Prisma GX	miro graphics	16/24-bit NuBus card	Aptec	£995
Prisma II	miro graphics	8-bit NuBus card	Aptec	£695
Procolour	RasterOps	32-bit for 12-21" displays	Frontline	£2,795
Pro ColorServer	Lapis Technologies	8-bit colour cards	Midwich Thame	from £349
ProColourServer II 24	Lapis Technologies	24-bit	Midwich Thame	£479
ProColourServer 24x	Lapis Technologies	16-bit	Midwich Thame	£599
Pro Nitron 80.19 card	Formac	8-bit card for 19"	Formac	£645
Pro Nitron 80.21 card	Formac	8-bit card for 21"	Formac	£695
Pro Nitron GA/GA+card	Formac	Graphics accelerator for 19" and 21"	Formac	£1,795
Rainbow GX24	miro graphics	24-bit card	Aptec	£2,295
ScuzzyView	Aura Systems	SCSI adaptor for PBs	MacSolutions	£545
Serpico 8/24	MacEurope	Accelerated 8/24-bit colour card	MacEurope	from £395
Spectrum/8 Series III	SuperMac	8-bit colour card for 13" to 19" displays	Principal	£499
Spectrum/24 PDQ Plus	SuperMac	Accelerated 24-bit colour card	Principal	£2,295
Spectrum/24	SuperMac	24-bit colour NuBus card for 13" to 19"	Principal	£1,099
Thunder II	SuperMac	Accelerated 24-bit colour card	Principal	£4,999
Thunder/8	SuperMac	Accelerated 8-bit colour card, 12" to 21"	Principal	£1,299
Thunder/24	SuperMac	Accelerated 24-bit colour card, 12" to 21"	Principal	£2,595
ThunderLight	SuperMac	24-bit	Principal	£1,495

DISPLAY – colour monitors

14MVX Plus	Hitachi		Hitachi	£395
15" PanaSync Pro 3	Panasonic	15" colour monitor	Panasonic	£599
17" PanaSync Pro 5	Panasonic	17" colour monitor	Panasonic	£995
17" PanaSync Pro 6A	Panasonic		Panasonic	£2,199
19" Sony Trinitron	RasterOps		Frontline	£1,995

20T	RasterOps		Frontline	£3,464
20 Multimode	RasterOps		Frontline	£2,319
2075 DualScan	RasterOps		Frontline	£2,495
2168 21"	RasterOps		Frontline	£3,550
21" Accuvue 5421-5D	MacEurope	21" colour monitor	MacEurope	from £2,100
21" Hitachi Colour	RasterOps		Frontline	£2,295
4CM4270	Philips	14" autoscans high resolution	DirekTek	£300
4CM6088	Philips	17" with trinitron tube	DirekTek	£1,299
5300/5900	3M	Active-matrix data projection panels	Reflex	£5,245/£6,295
5150/5450	3M	Data projection panels+presentation soft.	Reflex	£4,995/£5,795
AudioVision 14	Apple	14" monitor	Apple	£465
Barco OCM 2846	Barco UK	33" monitor only	Barco UK	£2,350
Brilliance 1520	Philips	15 " colour monitor	DirekTek	£430
Brilliance 1720	Philips	17 " colour monitor with PrecisionColor 24X	DirekTek	£1,279
Brilliance 2010	Philips	20" autoscans monitor	DirekTek	£1,599
Brilliance 2120	Philips	21" autoscans monitor	DirekTek	£2,499
C2082DAS	Philips	20" with Trinitron tube	DirekTek	£2,399
CM21 Colour	Hitachi	21" monitor for Apple cards	Ideal Hardware	£2,425
CM2187-304	Hitachi	21" monitor,colour temp.adjustment	Ideal Hardware	£2,799
Colour Display	Apple	16 & 21" monitors only	Apple UK	from £264
Colour Display/21	Radius	21" monitor only	Computers Unlimited	£2,799
ColourMac 8 21" Colour	Hitachi		Ideal Hardware	£3,995
ColorMax	Sigma Designs	15-21", monitor only	Aptec	from £595
ColorPage E16 Colour	E-Machines		Heyden & Son; Frontline	£995
ColorPage T16 Colour MW	E-Machines		Heyden & Son; Frontline	from £1,395
ColorPage T16 11 Colour	E-Machines		Heyden & Son; Frontline	from £1,595
ColorPage T19 Colour	E-Machines		Heyden & Son; Frontline	from £2,495
Diamond Pro 17	Mitsubishi		Art Systems; Reflex	£1,315
Diamond Pro 20	Mitsubishi		Art Systems; Reflex	£1,985
DiamondScan 20	Mitsubishi		Art Systems; Reflex	£1,895
DiamondScan XC3715	Mitsubishi	37"	Art Systems; Reflex	£6,995
DiamondScan XC3725	Mitsubishi	37"high-resolution	Art Systems; Reflex	£8,395

DiamondScan XC2930	Mitsubishi	29"high-resolution	Art Systems; Reflex	£4,495
ErgoView	Sigma Designs		Aptec	£1,499
FlexScan T Series	Eizo	15, 17 & 20" colour monitor only	Eizo	from £650
FlexScan F Series	Eizo	15, 17 & 21" colour monitor only	Eizo	from £670
IntelliColor Display/20	Radius	20" Trinitron-based monitor	Computers Unlimited	£2,999
LitePro Projection Panels	In Focus	LCD projection panels	Reflex	from £6,995
Macintosh Colour Display	Apple	14"	Apple	£225
Macintosh 16" Colour Display	Apple	16"	Apple	£715
Mirror 15" Monitors	Mirror	Portrait, Multimedia +FST colour monitors	Mirror	from £299
Mirror 17" Monitors	Mirror	Trinitron +FST colour monitors	Mirror	£599
Mirror 20" Monitors	Mirror	Trinitron +colour monitors	Mirror	£1,049
Mirror 21" Monitor	Mirror	FST colour monitor	Mirror	£1,699
Mitsubishi XC-33	Mitsubishi	33" monitor only	Art Systems; Reflex	£4,095
MultiSync 3V	NEC	15"	NEC	£499
MultiSync 4FGeipm	NEC	15"	NEC	£699
MultiSync 5FGeipm	NEC	17"	NEC	£1,049
MultiSync 5FGp	NEC	17"	NEC	£1,299
MultiSync 6FGp	NEC	21"	NEC	£2,199
MXV 14" Colour	Hitachi		Hitachi	from £395
MXV 15" Colour	Hitachi		Ideal Hardware	£699
MXV 17" Colour	Hitachi		Ideal Hardware	£1,179
PanelBook 450; 525; 530; 550	In Focus	Portable LCD projection panels	Steljes; Principal; Reflex	from £3,511
PrecisionColor Display/20v	Radius	2-page colour display	Computers Unlimited	£2,199
PrecisionColor Pivot Ergo	Radius	15" portrait/ landscape monitor	Computers Unlimited	£999
PrecisionColor Display/17 ERGO	Radius	Trinitron	CU; DirekTek	£999
ProNitron 80.19	Formac	20" Sony Trinitron	Formac	£2,575
ProNitron 80.20	Formac	20" Sony Trinitron	Formac	£2,119
ProNitron 80.21	Formac	21" monitor	Formac	£2,575
ProofScreen 21	miro graphics	24" Trinitron display	Aptec	£2,995
QA-1150	Sharp	Active-matrix LCD projection panel	Principal; Reflex	£5,495
QA-1650	Sharp	Multimedia colour LCD projection panel	Principal; Reflex	£6,995
QA-75A	Sharp	Mono projection panel	Principal; Reflex	£1,395

Radius 21" Colour Display	Radius		Computers Unlimited	from £2,799
Ranger	Aydin Controls	15 & 17", multiple-resolution	Aydin Controls	from £890
Ranger 21" FST	Aydin Controls	21" colour monitor	Aydin Controls	£2,690
Ranger 20SI	Aydin Controls	20" autosync colour monitor	Aydin Controls	£1,554
SmartTouch 17"	SuperMac	17"	Principal	£2,595
Sony CPD1420S	Sony	14" Trinitron for Mac LC	Aptec; Principal	£399
Sony CPD1430	Sony	14" Trinitron for Mac II, LC, Quadra	Aptec; Principal	£649
Sony CPD1730	Sony	17" Trinitron for Mac II, LC, Quadra	Aptec; Principal	£1,195
Sony GDM2036S/2038	Sony	20" Trinitron for Mac II, LC, Quadra, HI	Aptec; Principal	£2,495/£2,695
Sony GDM17SE1	Sony	17" Trinitron	Aptec; Principal	£1,500
Strategy 2019 Sony	Sony	20" Trinitron upto 1280x1024	MacEurope	from £1,995
Strategy 2019 CM24	Sony	24-bit, 20" Trinitron	MacEurope	from £2,300
SuperMatch 17, & 20 MultiMode	SuperMac		Principal	from £995
SuperMatch 20" Trinitron	SuperMac		Principal	from £2,695
SuperMatch 21 MW	SuperMac		Principal	£2,895
Sweet 16	RasterOps		Frontline	£1,049
ViewSonic Range of Monitors	ViewSonic	14,15,17,20,21" colour monitor	Ambar	from £24
VisionMaster 17	Idek Iiyama	17" colour monitor	Idek Iiyama	£850

DISPLAY – colour systems

17 MVX-PC8	Hitachi	With display adaptor	Hitachi	£1,740
17"Trinitron	Mirror Technologies	With display adaptor	Mirror	£999
2087-PC8	Hitachi	With display adaptor	Hitachi	£2,490
2186-PC8	Hitachi	With display adaptor	Hitachi	£2,490
2187-301-PC8	Hitachi	With display adaptor	Hitachi	£3,090
2187-303-PC8	Hitachi	With display adaptor	Hitachi	£3,290
Aspect 17"	Logical Engineering	With display adaptor	Profyle	£983
Aspect 820"	Logical Engineering	With display adaptor	Profyle	£2,595
Aspect 821"	Logical Engineering	With display adaptor	Profyle	£2,695
ColourCard 228	RasterOps	19" 8-bit	Frontline	£4,669
ProNitron 80.19	Formac	20" with adaptor	Formac	£3,095
ProNitron 80.20	Formac	20" with adaptor	Formac	£2,575
ProNitron 80.21	Formac	21" with adaptor	Formac	£3,095

RasterOps	RasterOps	Range of 20" s, with adaptors	Frontline	from £1,590
SyncMaster	Samsung	14" with adaptor	Midwich Thame	£279
DISPLAY – miscellaneous				
PrecisionColor calibrator	Radius		Computers Unlimited	£299
SuperMatch display calibrator	SuperMac		Principal	£149
SuperMatch display calibrator pro	SuperMac		Principal	£795
Truepoint	Microtouch	Touchscreens for Apple monitors	Microtouch	from £1,395
DISPLAY – monochrome monitors				
15" PageView Greyscale	Sigma Designs		Aptec	£499
15" Power Portrait	Sigma Designs	For PowerBook/Compact Macs	Aptec	£599/£769
19" Mono/Grey	RasterOps		Frontline	£990
21" Mono/Grey	RasterOps		Frontline	£895
FullPage	Lapis	A4 monitor only	Midwich Thame	£479
Macintosh Portrait Display	Apple		Apple	£449
MM21	Hitachi	21" monitor for Apple cards	Hitachi	£915
PageView Portrait Mono	Sigma Designs	A4 monitor only	Aptec	£575
Pivot Ergo	Radius	15" mono display	Computers Unlimited	£629
Prograph Mono	Formac	19" monitor only	Formac	£665
QuickView Z21 Mono/Greyscale	E-Machines		H. & Son; Frontline	from £1,295
Radius TPD/20GS	Radius	21" monitor only	Computers Unlimited	£999
Radius TPD/21GS	Radius	21" monitor only	Computers Unlimited	£1,199
Radius Full Page Display	Radius		Computers Unlimited	£499
SilverView/SilverView Portrait	Sigma Designs	21" monitor only	Aptec	£1,295/£1,995
SilverView Pro	Sigma Designs	21" two page display	Aptec	£499
FILM RECORDERS				
CI-5000S	Polaroid	2,000lpi film recorder	Polaroid	£5,250
ColorFast Digital Film Recorder	GCC Technologies	Up to 4k resolution; 16.7m colours	GCC Technologies	£4,699
Digital Palette	Polaroid	Up to 4k resolution; 16.7m colours	Polaroid	£4,950
FilmPrinter Turbo II)	Mirus Industries	Up to 4k resolution; 16.7m colours	Reflex	£4,880
Forte	Agfa	Up to 8k resolution; 68.7m colours	Agfa	£19,990
ImageCorder	Ambitron		Ambitron	£13,000
LFR	Lasergraphics	Up to 4k resolution; 16.7m colours	IMC; Reflex	£8,000

LFR-MkIII	Lasergraphics	Up to 8k resolution; 2MB film recorder	IMC; Reflex	£18,750
LFR Mark II	Lasergraphics	Up to 4k resolution; 68.7m colours	IMC; Reflex	from £11,995
LFR Personal	Lasergraphics	Up to 4k resolution; 68.7m colours	IMC; Reflex	from £5,495
LFR-X	Lasergraphics	Mid-range 35mm slide/film recorder	IMC; Reflex	£8,500
PCR II	Agfa	Up to 4k resolution; 16.7m colours	Agfa	£9,750
Personal LFR	Lasergraphics	Up to 4k resolution; 16.7m colours	IMC	£5,495
ProColor Premier	Agfa	Up to 4k resolution; 16.7m colours	Agfa	£4,950
Sapphire	Management Graphics	Up to 4k resolutions; 32-bit colour	Photobition	£12,995
Spectra Star 450	General Parametrics	Up to 4k resolution; 16.7m colours	InterQuad	£11,635

IMAGESETTERS

APS-6 series	Autologic	1,016dpi	Autologic	POA
Accuset	Agfa	600-3,000dpi	Agfa	from £32,000
BirmySetter	Birmy Graphics	600-2,540dpi	Birmy Graphics	from £15,495
Chromagraph	Linotype-Hell	up to 4,876dpi	Linotype-Hell	from £136,000
ColorStar	Scangraphic	813-3,252dpi	Scangraphic	£33,950
Dolev	Scitex	1,524-3,556dpi	Scitex	from £69,000
DTR1035	Dainippon Screen	1,016-4,064dpi	Dainippon Screen	from £75,000
ExpressMaster	Monotype	1,260dpi	Monotype	£38,000
FTR1035	Dainippon Screen	1,500-3,000dpi	Dainippon Screen	from £65,000
ImageMaster	Monotype	600-3,048dpi	Monotype	from £15,000
ImageMaker 80/10	Purup PrePress	colour, up to 2,540dpi	Purup PrePress	£85,000
Janus PD	Scangraphic	up to 3,252dpi; up to A2	Scangraphic	from £46,700
Linotronic 70/170	Linotype-Hell	monochrome only; up to 2,540dpi	Linotype-Hell	from £13,700
Linotronic 260-830	Linotype-Hell	colour range, up to 3,251dpi	Linotype-Hell	£20,000-£91,000
MagnaSetter 750	Crosfield	High-end colour, up to 9,000dpi	Crosfield	£100,000
Prism PS Plus	Monotype	A3 up to 2,400dpi	Monotype	£29,900
Scantext	Scangraphic	Internal drum range, up to 3,252dpi	Scangraphic	from £43,000
ScriptSetter	ECRM		ECRM, Rapitech	from £15,400
SelectSet	Agfa	High-quality colour, up to 3,600dpi	Agfa	£94,209
SpectraSet	Hyphen	Full imagesetter family	Hyphen	£19,000-£65,000
Vari typer 600	AM Vary typer		AM Vary typer	£39,000

INPUT

ADB - Custom Keyboard	Axxon	Custom keyboard service	Axxon	from £500
ADB - Graphics Tablet	Wacom	A5 pressure-sensitive digitizing tablet	Computers Unlimited	£399
ADB - Mouse	Plusware	Low costs ADB mouse	Mygate	£29
Apple Adjustable Keyboard	Apple	Adjustable ergonomic design	Apple	£169
Apple Extended Keyboard II	Apple	102-key layout	Apple	£143
Apple Keyboard II	Apple		Apple	£82
Bit Pad Plus	Summagraphics	Digitizing tablet	Frontline	£375
Desktop Mouse II	Apple	Ergonomic mouse	Apple	£40
DrawingBoard II	CalComp	Digitizing tablet	DirekTek	from £595
DrawingPad	CalComp	Digitizing tablet	DirekTek	from £375
DrawingSlate A5	CalComp	Digitizing tablet	DirekTek	£295
DrawingSlate A4	CalComp	Digitizing tablet	DirekTek	£395
DrawingSlate A3	CalComp	Digitizing tablet	DirekTek	£695
Extended keyboard	Plusware	102 key layout	Mygate	£69
Kidz mouse	Logitech	Rodent-shaped mouse	Logitech	£37
Kurta XGT	Kurta	Digitizing tablet	Art Systems	£755
Little Mouse	Mouse Systems	Optical mouse, ADB	Mac Accessory Centre	£75
Little Mouse	Mouse Systems	Optical mouse, A3	Mac Accessory Centre	£99
Mac 101E	Datadesk	Extended keyboard	Merisel	£125
Mac-105	Cutting Edge	Extended keyboard	Gomark	£115
Maltron keyboard	PCD Maltron	Ergonomic keyboard	PCD Maltron	£375
MC Keypad	Moonstone	For interactive applications	Moonstone	POA
MouseMan	Logitech	3-button cord/cordless mouse	Logitech	£53/£99
MousePenPro	Appoint	Pen-shaped surrogate mouse	KSI	£99
MouseStick	Advanced Gravis	Programmable joystick	Mac Accessory Centre	£90
MouseTopper	Contour Designs	Ergonomic mouse top	Camargue Computing	£20
Océ G642x	Océ Graphics	Digitizing tablet	Océ Graphics	from £395
PCD - Keyboards	PCD Maltron	Keyboards to reduce RSI	PCD Maltron	£375
Personal Writer PW 10SL	Personal Writer	Digitizing tablet	Heyden & Son	from £595
PowerBook KeyPad	Kensington		Mac Accessory Centre	£90
PowerGlide 105	Mac Accessory Centre	Extended Keyboard	Mac Accessory Centre	£75
Quora Cordless Designer	TDS Cad-Graphics	Pressure pen (painting/drawing tool)	TDS Cad-Graphics	from £580

Sicos Colani mouse	Sicos Colani	Ergonomic mouse	Catalyst	from £69
Sign-Maker	Roland Digital Group	Produces signs/stickers	Roland Digital Group	£1,795
SummaSketch III	Summagraphics	Digitizing tablet	Frontline	from £532
TrackMan	Logitech	Trackball	Logitech	£99
Turbo Mouse v. 4.0	Kensington	Trackball	Mac Accessory Centre	£105
Wacom A0 Graphics Tablet	Wacom	Digitizing tablet with cordless stylus	Computers Unlimited	£4,499
Wacom A1 Graphics Tablet	Wacom	Digitizing tablet with cordless stylus	Computers Unlimited	£3,599
Wacom A2 Graphics Tablet	Wacom	Digitizing tablet with cordless stylus	Computers Unlimited	£2,899
Wacom A3 Graphics Tablet	Wacom	Digitizing tablet with cordless stylus	Computers Unlimited	£1,199
Wacom A4 Graphics Tablet	Wacom	Digitizing tablet with cordless stylus	Computers Unlimited	£699
Wacom UD-1212	Wacom	A4 Digitizing tablet with cordless stylus	Computers Unlimited	£599/£699
XLC	Kurta	Digitizing tablet	Art Systems	from £2,800
XGT1212	Kurta	Digitizing tablet with cordless stylus	Art Systems	£750
ZedPen Plus	Numonics	Pressure-sensitive digitizing tablet	TDS Numonics	from £795

PRINTERS – colour

3M Rainbow TM	3M	Dye-sublimation 300dpi A3,	3M; CU	£16,495
4700	Rank Xerox	7.5ppm, 300dpi laser printer	Rank Xerox	£31,000
68000GA	CalComp	400dpi, poster printer	CalComp	from £39,950
BJC-600	Canon	360dpi, bubblejet	Pisa Sys; DirekTek	from £2,195
BJC-820	Canon	360dpi, bubblejet	Pisa Systems	£1,995
Calcomp 5424 A1	Calcomp	A1 bubblejet plotter, 4MB, 360dpi	DirekTek	£2,795
Calcomp 5436 A0	Calcomp	A0 bubblejet plotter, 4MB, 360dpi	DirekTek	£3,595
Chameleon	Ambitron	A1, 30ft x 2ft, 160dpi	Ambitron	£16,000
CHC-445P	Shinko	A4/A3 300dpi, thermal transfer, PostScript	ColorGraph	from £3,995
CHC-S445P	Shinko	300dpi, Dye sublimation, PostScript	ColorGraph	£9,995
ColourPoint A4	DataProducts	Thermal wax, 300dpi, PostScript 1	Midwich Thame	£3,495
ColourPoint A3	DataProducts	Thermal wax, 300dpi, PostScript 1	Midwich Thame	£5,995
CHC-S4461	Shinko	300dpi, Dye sublimation	ColorGraph	£9,995
CHC-S745	Shinko	24-bit proofing printer	MacEurope	£16,995
ColourEase PS	Kodak	300dpi, PostScript 2 dye-sublimation	Midwich Thame	£6,795
ColorEdge 1525	Kodak	400dpi, A3, Colour, PostScript	IMC	from £28,100
ColorEdge 1525+	Kodak	A3, Colour copier, PostScript	IMC	£11,000

ColorEdge 1550+	Kodak	A3,Colour copier,PostScript	IMC	£22,000
ColorMaster Plus PS	CalComp	A4/A3, 300dpi, PostScript	DirekTek	£3,595/£6,995
ColorMaster Plus XF A3/A4	CalComp	A4/A3, 300dpi, thermal wax	DirekTek	£7,995/£4,995
Colormate PS Model 80	NEC	300dpi PostScript thermal wax	NEC	£4,899
ColorPoint PSN Model 4/Model 14	Seiko	A4/A3, thermal wax, PostScript L.2	Ambitron	£5,745/£8,745
Colour Printer	Apple	A3, 24-bit, 360dpi bubblejet	Apple	£614
Colorright	Prime Option	300dpi, PS dye-sublimation	Tekware	£9,795
ColorTone	GCC	Dye sublimation	GCC	£6,999
CorrectPrint 300i	RasterOps	300dpi dye-sub.	Frontline	£8,999
CP 3000D Full Page Printer	Nikon	A4, 200dpi dye-sublimation	Nikon	£5,500
Digital Photo Imager	Ilford	Print/transparency photo printer	Ilford	£39,000
EPL 8543	Panasonic	203dpi, thermal-transfer	Panasonic	£4,495
Fiery 200i	EFI	RIP for colour copiers	EFI; CU	£31,950
Fiery Controller 1.25i	EFI	PostScript controller	EFI; CU	£23,950
FieryLite Controller	EFI	PostScript controller	EFI; CU	£14,500
Fiery Print Calibrator 1.0	EFI	For use with Canon CLCs	EFI; CU	£795
G5241-PS	Océ Graphics	A4/A3 thermal wax, 300dpi, PostScript	Océ Graphics	from £4,295
G370-10	Mitsubishi	300dpi, thermal-wax	Aptec; Reflex	£1,395
G6710-10B	Mitsubishi	300dpi thermal wax	Aptec; Reflex	£4,995
G8062	Océ Graphics	8ppm, 600dpi, laser plotter	Océ Graphics	£4,495
G9000	Océ Graphics	Direct thermal plotter	Océ Graphics	from £8,995
HP DeskJet 1200C/PS	Hewlett-Packard	600dpi, PostScript inkjet	Principal	£2,199
HP DeskWriter 310	Hewlett-Packard	Portable, colour/black, 300dpi inkjet	Principal	£230
HP DeskWriter 550C	Hewlett-Packard	Dual cartridge colour/black inkjet	Principal	£509
HP DeskWriter C	Hewlett-Packard	Inkjet; mono/colour	Principal	£309
HP PaintJet XL300	Hewlett-Packard	300dpi inkjet	Principal	£2,249
HP PaintJet XL300-PS	Hewlett-Packard	300dpi inkjet, PostScript 2	Principal	£3,685
HP PaintWriter XL	Hewlett-Packard	A3, inkjet	Principal	£1,795
IBM Color Jetprinter PS 4079	Lexmark	360dpi, PostScript inkjet	Aptec	£2,775
ImagerPlus 12 printer	NewGen	1,200dpi, A3 laser printer	Aptec	£6,995
ImagePrinter	Focus Graphics	Dye-sublimation,300dpi,24MB	Ambitron	£14,000
Jolt PSE	Dataproducts	300dpi, PostScript 2, solid ink	Midwich Theme	£3,995

JX-7000	Sharp	300dpi, 8MB, SCSI-2 dye-sub.	Intact/Reflex	£6,495
JX-9460	Sharp	600dpi, 6ppm	Intact/Reflex	£1,080
JX-9660	Sharp	600dpi, 8ppm	Intact/Reflex	£1,280
KXP 5400	Panasonic	300dpi, 4ppm, LED printer	Panasonic	£799
NovaJET II	ENCAD	Colour inkjet plotter	Accent Computers	£7,990
NovaJET-PS	ENCAD&Pisa	A0, Colour inkjet plotter, 48MB, PostScript	Pisa Systems	£11,495
Oce 6430	Oce	300dpi, 50 sheet	Oce	£4,695
Oce 6450	Oce	600dpi, 8ppm	Oce	£4,695
Oce 6460	Oce	300dpi, 8ppm	Oce	£7,695
Oce 6625/6665	Oce	400dpi, 20/32ppm	Oce	£13,995/£19,995
Oce 6730	Oce	30ppm, 300dpi	Oce	£29,300
Oce 6845	Oce	45ppm, 300dpi	Oce	£41,000
Personal ColorPoint PS A4	Seiko	300dpi, thermal wax, PostScript	Ambitron	£2,995
Phaser II SDX	Tektronix	Dye sublimation, PostScript 2	Tektronix	£7,995
Phaser III PXi	Tektronix	300dpi, PostScript 2 ink-jet	Tektronix	£5,995
Phaser 200e	Tektronix	300dpi, PostScript 2 thermal wax	Tektronix	£2,495
Phaser 220i	Tektronix	600dpi, PostScript 2 thermal wax	Tektronix	£5,395
Phaser 220e	Tektronix	600dpi, PostScript 2 thermal wax	Tektronix	£3,595
Phaser 300i	Tektronix	300dpi, PostScript 2 thermal wax	Tektronix	£8,995
Phaser 480	Tektronix	Full-bleed A3 dye-sub, PostScript 2	Tektronix	£12,995
Photomaker	Seiko	300dpi, dye-sub., PS 2	Ambitron	£8,712
Pictography 3000	Fuji	400dpi, photographic quality A4 prints	Gammadata	£18,800
PosterJet	Copy Colour	A4-A0 poster printer	Copy Colour	approx. £15,000
PowerScript	Xerox	400dpi plotter system	Xerox	from £94,000
Premiere	Questar	Printer controller	Art Systems	£2,699
Primer	Fargo	203dpi, thermal-wax QuickDraw	Colorgraph	£895
Primer+Photorealistic Upgrade Kit	Fargo	As above + ability to switch to dye-sub.	Colorgraph	£1,389
PS 6450	Océ	A3, 600dpi, PostScript 2 laser	Océ Graphics	£3,695
QMS ColorScript 210 (Networking)	QMS	A4, 300dpi, PostScript thermal wax, 8MB	Pragma: Mid.Thame: Aptec	£4,295
QMS ColorScript 230 (Networking)	QMS	A3/A4, PostScript thermal wax, 13MB	Pragma: Mid.Thame: Aptec	£7,695
QMS ColorScript Laser 1000	QMS	8ppm, A4, 300dpi, PostScript laser	Pragma: Mid.Thame: Aptec	£9,995
S3600-3OU	Mitsubishi	A4, Dye-sublimation, 300dpi, full bleed	Aptec: Reflex	from £6,495

S6600	Mitsubishi	A3, Dye-sublimation, 300dpi, full bleed	Aptec: Reflex	from £9,995
S3410-30B	Mitsubishi	A4, Dye-sublimation, 1500dpi, full bleed	Aptec: Reflex	from £4,995
S445	Shinko	A4/3 dye-sublimation, 300dpi, PostScript	Colorgraph	£11,450
SnapPrint	Microtek	Instant film colour printer	CU; Aptec	£1,295
SoftPIP	APS	PostScript 2 RIP controller	Autologic	£7,000
SpectraStar	Gen Parametrics	300dpi, thermal-wax, PostScript	InterQuad	£4,890
SST-Pro	Questar	Printer controller	Art Systems	£11,999
VY-MAC Colour Printer	Hitachi	Dye-sublimation, video printer	Hitachi	£10,950
PRINTERS – mono				
300P	NewGen	4ppm, 300dpi network printer, 3MB	PrePress Solutions, Aptec	£1,595
400P	NewGen	4ppm, 300dpi network printer, 4MB	PrePress Solutions, Aptec	£1,595
440N/ND	NewGen	15ppm, 400dpi network printer/duplex	PrePress Solutions, Aptec	£4,295/£4,795
660 B	NewGen	A3, 600dpi	PrePress Solutions; Aptec	£3,695
660 B	NewGen	A4, 600dpi	PrePress Solutions; Aptec	£1,795
880 P	NewGen	4ppm, 800dpi network printer, 12MB	PrePress Solutions, Aptec	£1,995
1200B	NewGen	8ppm, 1200x600dpi, 20MB	PrePress Solutions, Aptec	£4,990
4039-10 (basic)	Lexmark	10ppm, 300dpi, PostScript, LocalTalk	Aptec	£1,595
4039-10 RD	Lexmark	10ppm, 300dpi, PostScript, LocalTalk	Aptec	£2,195
4039-12 R	Lexmark	12ppm, 300dpi, PostScript, LocalTalk	Aptec	£2,095
4039-12 L	Lexmark	12ppm, 300dpi, PostScript, LocalTalk	Aptec	£2,775
4039-16 R	Lexmark	16ppm, 300dpi, PostScript, LocalTalk	Aptec	£3,195
7080 EC/RP	Genicom	300dpi, 8ppm PostScript laser	Genicom	£1,275/££1,395
7150-A3/A4	Genicom	300dpi, 15/8ppm PostScript laser	Genicom	from £3,295
7170	Genicom	300dpi, 16ppm PostScript laser	Genicom	£2,750
BLP Eclipse 2	GCC	8ppm, PostScript 2-compatible laser, 2MB	GCC	£824
BLP Eclipse 6	GCC	8ppm, PostScript 2-compatible laser, 6MB	GCC	£1,099
BLP Eclipse 8	GCC	As above + Eclipse Smoothing, 10BaseT/2	GCC	£1,299
CCL600S	CalComp	8ppm, 600dpi, PostScript	DirekTek	£2,995
CCL600XF	CalComp	8ppm, 600dpi, PostScript	DirekTek	£3,395
Citizen PN48	Citizen	Portable printer	DirekTek	£349
Citizen Notebook Printer II	Citizen	Portable printer	DirekTek	£349
Classic Pen Plotter	CalComp	A0 pen plotter	DirekTek	£5,495

CoStar LabelWriter II	CoStar	Thermal label printer	Computers Unlimited	from £240
CoStar AddressExpress Printer	CoStar	Inkjet printer for envel, postcards+labels	Computers Unlimited	£700
CrystalPrint Express	Qume	12ppm,600 x 300dpi, PostScript	Qume	£1,995
CrystalPrint Publisher II	Qume	Laser, 300dpi, PostScript	Qume	£2,999
DEClaser 1152	Digital	300dpi, 4ppm, PostScript 2	DirekTek	£979
DEClaser 1152 Plus	Digital	300dpi, 4ppm, PS 2,4MB, A-Talk	DirekTek	£745
DEClaser 1252E	Digital	300dpi, PostScript 2, ethernet interfaces	DirekTek	£999
DesignMate 3024s	CalComp	A18 pen plotter, 30K	DirekTek	£1,795
DesignMate 3024m	CalComp	A1 8 pen plotter, 1MB	DirekTek	£1,995
DesignMate 3036s	CalComp	A0 8 pen plotter, 30K	DirekTek	£2,295
DesignMate 3036m	CalComp	A0 8 pen plotter, 1MB	DirekTek	£2,495
Diconix 180si	Kodak	192dpi Portable inkjet	Midwich Thame	£299
EPL-7500	Epson	Laser, 300dpi, PostScript	Epson; Aptec; Ingram	£1,999
FS-850	Kyocera	18ppm laser, A3, PostScript	Kyocera	£1,648
FS-1500	Kyocera	10ppm, 300dpi, PostScript laser	Kyocera	£1,848
FS-3500	Kyocera	18ppm laser, A3, PostScript	Kyocera	£3,068
FS-5500	Kyocera	12ppm laser, A3, PostScript	Kyocera	£4,549
HJ-400	Brother	Inkjet, free 18 True Type fonts	Brother	£299
HL-4/8PS	Brother	4/8ppm, 300dpi, PostScript laser	Brother	£1,799/£2,295
HL-10H	Brother	600dpi, 10ppm, PostScript	Brother	£1,799
HP DeskWriter 310	Hewlett-Packard	QuickDraw 300dpi inkjet	Principal	£230
HP JetDirect	Hewlett-Packard	Network-printer management cards	Principal	EPOA
HP LaserJet 4Si MX	Hewlett-Packard	17ppm, 600dpi, PostScript	Principal	£4,449
HP LaserJet 4MP	Hewlett-Packard	8ppm, 600dpi enh., PostScript	Principal	£1,329
HP LaserJet 4ML	Hewlett-Packard	4ppm, 300dpi, PostScript 2	Principal	£1,019
ImageWriter II	Apple	Impact dot-matrix	Apple	£259
JetPro V50	Summagraphics	A2, 360dpi plotter	Summagraphics	£1,395
JX-9500/9600	Sharp	8ppm, 300/600dpi, PostScript	Intact; Reflex	£1,595
JX-9600PS	Sharp	8ppm, 300/600dpi	Intact; Reflex	£1,595
LaserMaster 1200XL	LaserMaster	1,200dpi, A3 typesetter	LaserMaster	£6,595
LaserWriter Pro 630	Apple	600dpi, PostScript laser	Apple	£1,599
LaserWriter Pro 810	Apple	600dpi, PostScript laser	Apple	£3,911

LaserWriter Select 310	Apple	PostScript 1, laser	Apple	£945
LaserWriter Select 360	Apple	PostScript 1, 600dpi, laser	Apple	£1,349
LBP-8 IV	Canon	600dpi, laser	Canon	£1,649
LM 1000/4 KX	LaserMaster	1,000 x 1,000dpi, PostScript	LaserMaster	£2,695
LM 12000 KX	LaserMaster	A3, 1,200 x 800dpi, PostScript	LaserMaster	£15,895
LP 4039-10R	LaserMaster	A4, 600 x 300dpi, PostScript	LaserMaster	£1,445
LQ 1070	Epson	24-pin dot matrix, LocalTalk	Aptec	£595
LQ 1170	Epson	24-pin dot matrix, LocalTalk, A3	Aptec	£809
LQ 570 Plus	Epson	24-pin dot matrix	Aptec	£449
LQ 870	Epson	24-pin dot matrix, LocalTalk, A3	Aptec	£719
LS5	Star Micronics	300dpi	Star Micronics	£609
LS-5 EX	Star Micronics	300dpi, upgradeable to PostScript	Star Micronics	£699
LS-5 TT	Star Micronics	600dpi, 5ppm	Star Micronics	£999
LZR 855	DataProducts	600dpi, 8ppm, PostScript laser	Midwich Thame	£1,149
LZR 960	DataProducts	300dpi, 9ppm PostScript laser	Midwich Thame	£995
LZR 1560	DataProducts	400dpi, 15ppm PostScript laser	Midwich Thame	from £2,795
LZR 1580	DataProducts	800dpi, 15ppm, A3/A4 PostScript laser	Midwich Thame; MacEurope	from £2,450
LZR 2080	DataProducts	800dpi, 20ppm, A3 Postscript laser	Midwich Thame; MacEurope	from £3,825
MacPLP	Avery	138dpi label printer	Avery	£229
microLaser Pro 600 PS23	Texas Instruments	8ppm, 600dpi, PostScript 2	DirekTek	£1,149
microLaser Pro 600 PS65	Texas Instruments	As above with 65 fonts	DirekTek	£1,299
microWriter PS23	Texas Instruments	8ppm, 300dpi laser, 23 fonts	DirekTek	£595
microWriter PS65	Texas Instruments	As above with 65 Adobe fonts	DirekTek	£859
MobileWriter PS	Mannesmann Tally	Portable printer	Frontline	£869
Network 440N/ND	NewGen	15/17ppm, 400dpi, PostScript	PrePress Solutions	EPOA
Océ 6122/3	Océ	9ppm, 300 x 300dpi, PostScript laser	Océ	from £1,315
Océ 6142/3	Océ	16ppm, 300 x 300dpi, PostScript laser	Océ	from £2,320
Océ 6450 PS	Océ	8ppm, 600dpi, PostScript2 laser	Océ	£3,695
Océ 6500 PS	Océ	17ppm, 600dpi, PostScript2	Océ	£5,995
Océ 6750 PS	Océ	23ppm, 508dpi, PostScript laser	Océ	£35,000
Oki ML280	Oki Systems	24-pin dot matrix	DirekTek	£299
Oki ML320	Oki Systems	24-pin dot matrix	DirekTek	£479

Oki ML321	Oki Systems	24-pin dot matrix	DirekTek	£579
Oki ML/3410	Oki Systems	24-pin dot matrix	DirekTek	£1,349
Oki ML380	Oki Systems	24-pin dot matrix	DirekTek	£349
Oki ML395C	Oki Systems	24-pin dot matrix	DirekTek	£1,149
Oki ML390FB	Oki Systems	24-pin dot matrix	DirekTek	£899
Oki OL 830	Oki Systems	8ppm, 300dpi, PostScript laser,2MB	DirekTek	£999
Oki OL 850	Oki Systems	8ppm, 300dpi, PostScript laser,2MB	DirekTek	£1,499
Oki OL 870	Oki Systems	8ppm, 300dpi, PostScript laser,4MB	DirekTek	£1,849
P3400PS	Agfa Compugraphic	400dpi, PostScript	Agfa	£4,995
Portable StyleWriter	Apple	Portable printer for PowerBook	Apple	£299
PowerPrint	GDT	Printer driver	Academy	£135
PPI 1200	Chelgraph	1,200 x 600dpi, A3, PostScript 2	Spectra	£11,231
PPI 1800	Chelgraph	1,800 x 900dpi, A3, PostScript 2	Spectra	£13,846
PPT 600	Chelgraph	600dpi, A3, PostScript 2	Spectra	£10,000
Premiere Pro 840/880	NewGen Sys.	8ppm, 800 x 400/800dpi, PostScript	PrePress Solutions	from £3,895
ProofMaster	CalComp	400dpi, PostScript	CalComp	£35,250
PS 400P	NewGen	400 x 400dpi, PostScript	PrePress Solutions	£2,495
PS 600T	NewGen	600 x 600dpi, PostScript, A3	PrePress Solutions	£11,995
PS 630	NewGen	600 x 300dpi, PostScript	PrePress Solutions	£3,195
PS 840	NewGen	800 x 400dpi, PostScript	PrePress Solutions	£4,995
PS 1200T	NewGen	1,200 x 600dpi, PostScript, A3	PrePress Solutions	£14,495
QMS 420 Print System	QMS	4ppm, 300/600dpi, PostScript laser	Pragma; Midwich Thame	£1,495
QMS 860 Print System(Network)	QMS	As above with 8ppm, A3/A4	Pragma; Midwich Thame	£3,695
QMS 860 Plus Print Sys.(Network.)	QMS	As above with 1,200x600dpi	Pragma; Midwich Thame	£4,995
QMS 1725 Print System(Network.)	QMS	17ppm, 300/600dpi, PostScript laser	Pragma; Midwich Thame	£4,295
QMS 1725 SLS Print Sys.(Network.)	QMS	As above with 12MB	Pragma; Midwich Thame	£4,995
QMS PS 2025 (Networking)	QMS	20ppm, 300/400dpi, A3/A4, P.Script laser	Pragma; Midwich Thame	£13,995
QMS PS 2025 TIS (Networking)	QMS	As above with Turbo Imaging	Pragma; Midwich Thame	£13,995
QMS PS 3225 (Networking)	QMS	32ppm, 300/400dpi, A3/A4, P.Script laser	Pragma; Midwich Thame	£19,995
QMS 3225 TIS (Networking)	QMS	As above with Turbo Imaging	Pragma; Midwich Thame	£19,995
Q-Script 2000 controller	Quintar	PostScript controller	Colourgraph	£3,995
RX 7100PS	Fujitsu	300dpi, PostScript	Fujitsu	£1,895

SelectPress 600	GCC	8ppm, 600dpi, Clone PostScript,8MB	GCC	£3,949
SelectPress 600 Pro	GCC	8ppm, 600dpi, Clone PostScript,16MB	GCC	£4,999
SelectPress 1200	GCC	8ppm, 1200dpi, 24MB	GCC	£6,699
Silentwriter S102P	NEC	10ppm, 600dpi, PostScript	NEC	£1,695
SketchMate	Roland	A4 Plotter	Roland	£380
Smart Label Printer Plus	Seiko	Label printer	Ambitron	£189
Smart Label Printer Pro	Seikosha	Label printer	Seikosha	£329
SP3500	Minolta	10ppm, 600dpi, RISC laser	Minolta	£2,199
StyleWriter II	Apple	2ppm inkjet	Apple	£235
The Feeder	Gradco	1000-sheet paper feeder	Gomark	£600
The Stacker	Gradco	Output stacker	Gomark	£185
The Witch	Point Systems	Cable/driver for non-Apple printer	Academy Software	£55
T Series	NewGen	12ppm, 1,200 x 600dpi, PostScript	PrePress Solutions	£12,995
Turbo/PS300P	NewGen	300dpi, PostScript	Merisel	£1,950
Turbo/PS360	NewGen	300 x 600dpi; PostScript	Merisel	£3,695
Turbo/PS400p	NewGen	400dpi, Clone PostScript	Icicle	£999
Turbo/PS600T	NewGen	600dpi, A3, PostScript	Merisel	£11,995
Turbo/PS630En	NewGen	600 x 300dpi, Ethernet standard	Merisel	from £3,795
Turbo/PS1200T	NewGen	1200 x 600dpi; A3, PostScript	Merisel	£14,395
Unity XLT	LaserMaster	8ppm, 1,000dpi, PostScript laser	LaserMaster	£6,995
Unity 1200XL-O/T	LaserMaster	8ppm, 1,200dpi, A3 laser	LaserMaster	£8,495
WideWriter 360	GCC	Wide-format360dpi, bubblejet	GCC	£1,599
WriteMove II	GCC	Thermal fusion,360dpi, portable	GCC	£399
Xante 81/60	Xante	A3, 600-1200dpi, RISC PostScript laser	Tekware	£6,295
Xante 81/80	Xante	A3, 600dpi, RISC PostScript laser	Tekware	£3,695
Xante 81/96	Xante	A3, 600-800dpi,RISC PostScript laser	Tekware	£4,395
Xante 81/120	Xante	A3, 600-960dpi, RISC PostScript laser	Tekware	£5,195
Xante AAW6/8	Xante	Upgrade controller to 600dpi for Apple lasers	Tekware	£995
Xante AAW6/12	Xante	Upgrade controller to 600dpi for Apple lasers	Tekware	£1,245
Xerox 4220	Rank Xerox	8MB, 20ppm, 300dpi	Rank Xerox	£8,120
PROJECTORS				
Datashow	Kodak	Range of projectors	Reflex	from £1,595

Desktop Projector 2300	Proxima	Capable of projecting 24,389 colours	Reflex	£3,995
Desktop Projector 2700	Proxima	Colour projection with video +audio option	Reflex	£6,495
Desktop Projector 2800	Proxima	Multimedia projector+dig. video processor	Reflex	£7,250
Desktop Projector 8300	Proxima	Multimedia projector+dig. video processor	Reflex	£9,995
DP5200	NEC		NEC	£7,600
VPH-1042	Sony	Video projector	Sony	£6,200
XG-3800E	Sharp	Colour multi-sys. compati.+amp/speakers	Reflex	£8,495
SCANNERS				
AmScan 2400RT	Amcad	1,200dpi 10-bit colour scanner	Amcad	£3,395
Animas Flatbed	Animas	600dpi, colour	Caro-Line	£699
Arcus Plus	Agfa	1,200x600dpi, A4, colour	Agfa	£3,745
Artiscan 6000C	Tamarack	A4, 300x600dpi, slide/flatbed, colour	Tekware	£1,095
Artiscan 8000C	Tamarack	A4, 400x800dpi, slide/flatbed, colour	Tekware	£1,495
Artiscan 12000C	Tamarack	A4, 600x1200dpi, slide/flatbed, colour	Tekware	£1,995
AS C105B	Animas	12-bit colour; handheld	Caro-Line	£639
AS B105G	Animas	300dpi greyscale; handheld	Caro-Line	£399
BS-300GS	Brother	300dpi greyscale	Brother	£1,245
Caere OmniScan	Caere	Hand-held scanner,400dpi,8-bit greyscale	CU	£229
CIS 3515	BarneyScan	35mm slide scanner, 1,000dpi	Chromos	£2,500
Coolscan	Nikon	8-bit colour, 2,700dpi film scanner	Principal	from £1,750
DT-S1015	Screen	2,500dpi drum scanner	Computers Unlimited	POA
DT-S1030	Screen	5,200dpi drum scanner	Computers Unlimited	POA
Espresso	RasterOps	35mm slide scanner, needs capture board	Ingram Micro	£525
Focus II S800GSE	Agfa	600dpi	Agfa	from £4,435
FocusScan 800C	Focus	400x800dpi, colour	Focus	£735
G6000 scanner	Océ Graphics	300dpi AO scanner	Océ Graphics	£9,995
G6035	Océ	500dpi	Océ	£12,990
G6045	Océ	800dpi	Océ	£16,190
GT-6500	Epson	1200dpi,slide/flatbed,colour	Aptec	£745
GT-8000	Epson	800dpi,slide/flatbed,colour	Aptec	£875
Hasselblad MacSie 35A	Hasselblad	35mm slide scanner, 2,200dpi	Hasselblad	from £3,300
Horizon	Agfa	2,400dpi (mono); 1,200dpi (colour); A3	Agfa	£14,950

JX-100	Sharp	200dpi handheld colour	Principal:Reflex	£495
JX-325	Sharp	300dpi, A4 colour, slide/flatbed	Principal:Reflex	£1,495
JX-450	Sharp	A3 Colour scanner	Principal:Reflex	£3,995
JX-450	Sharp	Mirror Unit	Principal:Reflex	£465
JX-600S/610	Sharp	600dpi, A3 colour, slide/flatbed	Principal:Reflex	from £7,495
JX-32F12	Sharp	Film scan unit	Principal:Reflex	£1,255
LeafScan 35	Leaf Systems	38mm slide scanner, 4,000dpi	Photobition	£7,000
LeafScan 45	Leaf Systems	4"x5" slide scanner, 5,080dpi	Photobition	£12,500
Lightning Scan	Thunderware	400dpi, handheld greyscale	Principal	£399
LS-3510AF	Nikon	35mm slide scanner (8-bit/ 12-bit)	Nikon	£6,995/£7,995
M3GS/OCR	AVR	300dpi, A4, greyscale; inc. Typereader OCR	Tekware	£845
M3GS/PRO	AVR	As above + PhotoshopLE	Tekware	£995
M3CL/IME	AVR	300dpi, A4, colour; inc. Photoshop v.2.5	Tekware	£1,025
M3CL/PRO	AVR	As above + Typereader OCR	Tekware	£1,315
M6CL/IME	AVR	600dpi, A4 colour; inc. Photoshop v.2.5	Tekware	£1,155
M6CL/PRO	AVR	As above, with TypeReader OCR	Tekware	£1,445
M8GS/OCR	AVR	800dpi, A4, greyscale and TypeReader OCR	Tekware	£1,175
M8GS/PRO	AVR	As above, with Photoshop LE	Tekware	£1,325
M8CL/IME	AVR	800dpi, A4 colour; inc. Photoshop 2.5	Tekware	£1,295
M8CL/PRO	AVR	As above, with Typereader OCR	Tekware	£1,585
MirrorScan 600/Pro	Mirror Tech.	600dpi, 24-bit colour; inc. PhotoShop	Mirror Tech.	£899/£1,199
MirrorScan 800/Pro	Mirror Tech.	600dpi, 24-bit colour; inc. PhotoShop	Mirror Tech.	£1,099/£1,399
MirrorScan 1200/Pro	Mirror Tech.	600dpi, 24-bit colour; inc. PhotoShop	Mirror Tech.	£1,699/£1,999
MT600C	Tamarack	600dpi, A4 colour, with Photoshop v.2.5	Tekware	£1,075
MT600CT	Tamarack	As above, with transparency unit	Tekware	£1,650
MT800C	Tamarack	800dpi, A4 colour, with Photoshop v.2.5	Tekware	£1,355
MT800CT	Tamarack	As above, with transparency unit	Tekware	£1,930
MT1200C	Tamarack	1,200dpi, A4 colour, with Photoshop v.2.5	Tekware	£1,895
MT1200CT	Tamarack	As above, with transparency unit	Tekware	£2,490
OneScanner	Apple	300dpi, Greyscale	Apple	£685
OneScanner - Colour	Apple	Bundled with Ofoto 2.0 & HyperScan	Apple	£989
Personal Colour Scanner	Howtek	600dpi, colour	Techex	£1,395

Primascan Scanner	Primagraphics	A3,flatbed,colour	Primagraphics	from £12,600
QCS 35	Imapro	35mm slide scanner, 4,000dpi	Protocol	£10,415
QCS 600	Imapro	A3 slide scanner, 600x600dpi	Protocol	£14,995
QCS 2462	Imapro	2,400dpi slide/flatbed	Protocol	£21,950
RFS 2035	Kodak	2000dpi film scanner	Midwich Thame	£5,750
RFS 2035Plus	Kodak	2000dpi film scanner	Midwich Thame	£6,495
RS322 Plus	Ricoh	300dpi, greyscale	Heyden & Son	from £895
RS632	Ricoh	600dpi, greyscale	Heyden & Son	from £1,390
SC6000C	Shinko	600dpi,colour,with Photoshop+ ColorShop	Colorgraph	£799
SC-7500	Shinko	400dpi,A3,full colour	Colorgraph	£3,950
Scan-X 1500	HSD	1,500dpi, greyscale	Forester	£1,595
Scan-X	HSD	6"x9" colour slide scanner/flatbeds	Forester	from £2,095
ScanJet IIcx	Hewlett-Packard	400dpi, flatbed, PhotoShop LE, OCR software	Principal	£930
ScanJet IIp	Hewlett Packard	600 dpi, greyscale	Principal	£690
ScanJet Document Feeder	Hewlett Packard	IIc and IIp auto document feeder	Principal	£470/£270
ScanMaker II	Microtek	1,200dpi, 24-bit colour, 3-pass	CU; Aptec, Ingram	£795
ScanMaker IIxe	Microtek	1,200dpi, 24-bit colour, Photoshop,3Pass	CU; Aptec, Ingram	£1,095
ScanMaker IIsp	Microtek	1,200dpi, 24-bit colour, Photoshop LE	CU; Aptec, Ingram	£895
ScanMaker IIspxe	Microtek	1,200dpi, 24-bit colour, Photoshop	CU; Aptec, Ingram	£1,195
ScanMaker IIG	Microtek	1,200dpi, 24-bit greyscale, OmniScan	CU; Aptec, Ingram	£595
ScanMaker 35T	Microtek	36-bit film scanner,3pass, 2,000dpi	CU; Aptec, Ingram	£1,295
ScanMaker 45T	Microtek	36-bit film scanner(35mm-5"x5") 2,000dpi	CU; Aptec, Ingram	£5,995
ScanMan Model 32	Logitech	300dpi, handheld, Image Editing software	Frontline; Ingram	£249
ScanMan Model 32	Logitech	300dpi, handheld,CatchWord Pro OCR	Frontline; Ingram	£389
ScanMaster 3	Howtek	400dpi, A3	Techex	£5,995
ScanMaster 3+	Howtek	1200dpi	Techex	£6,995
ScanPartner	Fujitsu	300dpi, 10ppm, 50 page feeder	Fujitsu	£1,550
Silverscanner II	La Cie	400x800dpi, colour, slide/flatbed	Third Wave	£1,995
Slide Scanner	Ektron Applied Imaging	2,800dpi, 12-bit slide scanner	Controm	£7,200
ST135	Santos	35mm slide scanner	Tamarack	£1,995
StudioScan	Agfa	300x600dpi, optional transparency adaptor	Agfa	£1,245
Synergiser	Animas	300dpi, colour	Caro-Line	£1,499

Transparency Adaptor	Mirror Tech.	600dpi, 24-bit colour	Mirror Tech.	from £499
TrannyAdaptor	Microtek	For MRS Z/ZS, ZT/ZST	CU; Aptec	£695
UC1200SE	Umax Technologies	30-bit, slide/flatbed, 2,400dpi	IMC	£2,695
UC1260	Umax Technologies	24-bit, slide/flatbed, 2,400dpi	IMC	£1,595
UC630	Umax Technologies	slide/flatbed, 1,200dpi, Photoshop LE	IMC	£875
UC840	Umax Technologies	slide/flatbed, 400 x 800dpi	IMC	£1,050
Umax PowerLook	Umax Technologies	Pre-press scanner, 2,400dpi	IMC	£7,995
Vision 35	Agfa	3,175dpi, A3, b&w/colour film scanner	Agfa	£7,990
Xerox 7560/7560C	Xerox	A4/A3 greyscale/colour, Quickscan	Tekware	£7,395/£9,950

STORAGE

Athena	Microtech	From 50MB to 101MB	Mygate	from £199 to £799
Blue Disc Range	Ideal Hardware	External hard disk subsystem 170MB-4GB-	Ideal Hardware	from £355
Collegiate Transportable	MicroNet	From 40MB to 200MB	Cal-Abco; Ideal Hardware	from £420 to £985
Coyote	Microtech	From 4MB to 10MB	Mygate	from £198
Dart	Newer	Non-volatile RAM (max224MB)	Tekware	£1,795
d2	Électronique d2	From 200MB	Apple Dealers	from £760
D-range	Qisk	External hard drives	Computer Capability	£398
Europa	Microtech	From 40MB to 500MB	Mygate	from £275 to £999
External Drives	Procom	45MB to 2.7GB	Expert Systems	from £299
External Drives	Mac & More	120MB-540MB	Mac & More	from £320
FlexArray	RAIDtec	Enhanced RAID3/5 4-200GB	MacEurope	from £10,000
Frog I/E	Frog Systems	SCSI drives: from 45MB to 2GB	Frog Systems	from £139 to £2,229
hammer	FWB	From 210MB to 2,800MB	Midwich Thame	from £369 to £4,139
Hardpac	MindFlight	External hard drives	Senate Computing	from £350
Micro/Sync SCSI-2	MicroNet	External hard drives with SCSI-2 card	Ideal Hardware	from £2,006
MicroNet	MicroNet	External hard drives	Ideal Hardware	from £1,099
Micro/Raven twin disk	MicroNet	From 606MB to 2.6GB	Ideal Hardware	from £4,013
MicroStor range	MicroStor	From 170MB to 4GB	Performance Direct	from £125
MiniPak	Optima	External hard drives	Apple Centre W.Lon	from £599
Mirroring	RAIDtec	Independent hardware disk mirroring	MacEurope	from £750
Nova	Microtech	From 100MB to 1.6GB	Mygate	£570-£3,110
Nova XL	Microtech	From 650MB to 2.7GB	Mygate	£1,820-£5,071

pocketHammer	FWB	From 530MB to 2,100MB	Midwich Thame	£1,299-£3,039
PocketDrive	La Cie	40-120MB drives for PBs	Principal	£469-£799
PowerUser Pro	MacWarehouse	From 210MB	MacWarehouse	£475
PR-External and Internal	Procom Technology	From 120MB-1.9GB	Expert Systems	from £545
PR-External	Procom Technology	Two drive enclosure; up to 1.35GB	Expert Systems	from £4,095
ProDisc External	Formac	From 200MB to 3GB	Formac	from £425
ProDisc Array	Formac	Mass storage system	Formac	£3,295
PR-QD	Procom Technology	Internal fixed drives for Quadra	Expert Systems	from £555
Roadrunner	Microtech	From 80MB to 500MB	Mygate	from £399
SledgeHammer	FWB	From 1,060MB-5,600MB,SCSI-2 RAID	Midwich Thame	£2,299-£9,099
StorTek	MacEurope	External hard drives 170MB-4GB	MacEurope	from £235
Strategy	MacEurope	1GB and up	MacEurope	from £1,500
Tekware	Tekware	External hard drives from 520MB to 4.0GB	Tekware	from £695
Tsunami	La Cie	From 50MB to 1.2GB	Principal	£529-£2,399
ZFP	La Cie	650MB/1.2GB external drives	Principal	£2,249/£2999

STORAGE – optical

20MB Floptika	Procom Technology		DigitalMedia	£525
Concept 128	Concept	MO 128MB	Universal Trading; Mygate	£849
Concept 650	Concept	MO 650MB	Universal Trading; Mygate	£1,999
Concept 1300	Concept	MO 1.3GB	Universal Trading; Mygate	£2,499
DPL650HM	DPL	650MB	DPL	£2,300
EasyFix	DPL	21MB floptical	DPL	£349
EX	OR Computers	Floptical drives-21Mb for desktop/p.bk	DPL	from £289
Frog drives	Frog	MO 128MB	Frog Systems	£699
Fujitsu DynaMO 128	Fujitsu	MO 128MB	Tekware	£795
Fujitsu M2511A	Fujitsu	MO 128MB	Tekware	£1,195
Genesis 120E	Microtech	120MB; M-O drive	Mygate	POA
Genesis 650	Microtech	650MB; M-O drive	Mygate	POA
hammerDisk 1300FMF	FWB	Upto 1.3GB	Midwich Thame	£4,199
hammerDisk 600S	FWB	MO 650MB	Midwich Thame	£3,199
hammerDisk 130	FWB	MO 128MB	Midwich Thame	£1,159
Infinity Optical 3.5	PLI	128MB; M-O drive	Computers Unlimited	£1,699

Infinity Optical 600	PLI	650MB; M-O drive	Computers Unlimited	£3,195
Infinity Max Optical	PLI	1GB; M-O drive	Computers Unlimited	£3,645
Iomega Floptical	Iomega	21MB floptical	Ambar	£315
La Cie drives	La Cie	128MB drives	Principal	£1,699/£1,899
LaserSafe Plus	Iomega	Upto 1.3GB	Iomega	£3,499
Logical	Logical Engineering	From 120MB to 1.3GB	Profyle	from £1,120
MacinStor MaxOptix T3	MaxOptix	1.3GB	Ambar	£3,070
Magstore drives	Magstore	128MB-1.3GB MO drives	Magstore	£899-£3,900
MEOD 128	Procom Technology	128MB; M-O drive	DigitalMedia	£949
MEOD 650	Procom Technology	650MB; M-O drive	DigitalMedia	£2,999
MicroNet MO/SB	MicroNet Tech.	Up to 882MB; M-O drives	Cal-Abco; Ideal Hardware	from £1,599
MultiDisk 150	Iomega	150MB, downwards-compatible	Iomega	£925
Optistore 128	Data Peripherals	MO 128MB	Data Peripherals	£799
Optistore 650/650HM	Data Peripherals	MO/MO,WORM 650MB	Data Peripherals	£1,799/£2,199
Optistore 1000	Data Peripherals	MO 1GB	Data Peripherals	£2,749
Optistore 1300	Data Peripherals	MO 1.3GB	Data Peripherals	£2,199
Oscar	Lockside Comp. Sol.	128MB 3.5" rewriteable drive	Lockside Comp Sol.	£856
PMO-650	Pinnacle Micro	650MB M-O drive	UK Flex	£1,899
PR-External Removable	Procom Technology	Up to 1.3GB	DigitalMedia	from £495
Profyle drives	Profyle	170MB-2GB drives	Profyle	from £395
ProOpt130/650	Formac	MO 128MB, 650MB	Formac	£1,038/£2,645
ProOpt1300/1300HP	Formac	MO 1.3GB, High speed	Formac	£3,325/£3,955
RF-3010	Reflection Systems	128MB; M-O drive	Reflection Systems	£1,250
RF-7010	Reflection Systems	1GB; multifunction drive	Reflection Systems	£2,800
RF-7030	Reflection Systems	1.5GB; multifunction drive	Reflection Systems	£2,895
RMO-S350	Sony	128MB, M-O drive	Principal	£1,379
RMO-S550	Sony	650MB, M-O drive	Principal	£2,249
SCO-650	DAC	650MB; M-O drive	DAC	£2,495
SCO-1000	DAC	1GB; M-O drive	DAC	£3,495
Sierra	Pinnacle Micro	1.3GB drive	UK Flex	£2,699
Strategy 2128SR	Ricoh	128/600MB M-O drive	MacEurope	from £899
Strategy 2652SR	Hewlett Packard	1.2GB; M-O drive	MacEurope	from £3,495

Tekdata drives	Ricoh	MO 128MB-1.3GB drives	Tekdata	from £995
STORAGE – removable				
50MB Removable	MicroTech	Ricoh Mechanism	Mygate	£499
Blue Disc	Ideal Hardware	44/88MB SyQuest	Ideal Hardware	from £515
Diskovery 45R/88R	Optima	44/88MB SyQuest	Principal	from £375
Dual 90 Pro	lomega		Merisel	£898
EQR-40	OR Computers	44Mb SyQuest	DPL	£336
EQR-80	OR Computers	88Mb SyQuest	DPL	£390
Frog Removable	Frog Systems	SyQuest drives; 45MB to 88MB	Frog Systems	from £329 to £459
hammerDisk	FWB	44MB to 250MB drives	Midwich Thame	from £499 to £769
Infinity Floptical	PLI	21MB floptical	Key Exchange	£325
Infinity	PLI	44/88MB SyQuest drives	Key Exchange	from £415
MacInsider Multidisk 150	lomega	150MB downwards-compatible Bernoulli	lomega	£499
MacTransportable Multidisk 150	lomega		lomega	£599
MR-45/90	MicroNet	42/88MB SyQuest drives	Cal-Abco; Ideal Hardware	from £555
MRD	Procom	44/88MB SyQuest drives		from £399
MultiDisk 150	lomega	150MB Bernoulli	lomega	£489
ProDrive 40/80	Formac	40/80MB SyQuest drive	Formac	from £375
R45/R90	Rodime	44/88MB SyQuest drives	Frog Systems	from £405
SQ40e/80e	Électronique d2	44MB/88MB SyQuest drives	Apple dealers	from £530
Viper 21	Second Wave	21MB floptical	AM Micro	£695
UPGRADES				
16MHz FPU	TechWorks	FPU for Classic II and LC	TechWorks	£65
Accelerator	TechWorks	25-44MHz 030/040	TechWorks	from £408
AEHD Plus Drive	Applied Engineering	Reads 400, 800, 1.44MB floppies	Frontline	from £295
Apex	Second Wave	Maths coprocessors	AM Micro	from £125
RAID Warrior	68000	Quadra PDS SCSI 2	MacEurope	from £625
RAID Warrior Kit	MacEurope	RAID software/hardware for digital video	MacEurope	from £895
Axion Switch	Axion	Serial port expander	Nexus Western	£75
Cache-It Bundle	PSI	SE 30 Extender Card	MCMXCIX	£325
Centris 610 NuBus adaptor	Apple	Lets 610 take 7" NuBus cards	Apple	£85
Classic Memory	LMP	1-3MB for Classic	Mygate	from £41

Classic II Co-Pro	LMP	16-25MHz coprocessor	Mygate	from £63
ClockItUp		Accelerator card for power sapping applic.	Mac Connect	£195
Crunch-It	PSI	LC coprocessor	MCMXCIX	£325
DuoDock	Apple	PB docking connector	Apple	£560
Duomate 16sc	RasterOps	PB docking station, includes PowerPath	Frontline; Ingram Micro	£545
Duomate 8	RasterOps	Entry level PB docking station	Frontline; Ingram Micro	£495
Duo MiniDock	Apple	PB docking connector	Apple	£305
Enterprise 030	Total Systems	33MHz 030	AM Micro	£849
Enterprise LC/LC II	Total Systems	32MHz 68030 card, + maths co-pro	AM Micro	£995
Equalizer LC	DayStar Digital	16MHz 68030 accelerator	Ingram; Merisel	from £150
Expanse	Second Wave	4 SE PDS slots for SE	AM Micro	from £1,075
FastCache	DayStar Digital	32-128k, for lIci, lIsi, Quadra	Ingram; Merisel	from £165
Fastmath	Applied Engineering	16MHz 68882	Frontline	£145
Focus cards	Focus	25-33MHz 030/040 accelerator cards	Focus	from £324
FPU for Centris 610 and 650	Performance Direct	25MHz 68040 FPU	Performance Direct	£249
Gemini	Total Systems	20-50MHz 030 accelerator	AM Micro	from £695
Gemini Ultra	Total Systems	50MHz	AM Micro	£1,195
HomeBase	Second Wave	2 PDS slots for Mac Portable	AM Micro	£895
Image Compressor	Neotech	JPEG-compression card & software	Neotech	£600
Impact 030	Extreme Systems	32MHz 030	Performance Direct	from £199
Intensifier 030	Total Systems	16MHz 030	AM Micro	from £229
LC 475/Centris 610 FPU	Motorola	Full version of 25MHz 68040 processor	Mygate	£249
LC Co-Pro	LMP	16MHz Maths coprocessor	Mygate	£49
LC Video RAM	LMP	Image enhancing for LC	Mygate	£35
Diimocache	Logica Research	64k cache	Performance Direct	£349
LXPI 2B	PSI	2MB portable	MCMXCIX	£375
Magellan 040	Total Systems	25/33MHz 040 accelerator	AM Micro	from £1,299
Mercury 030	Total Systems	16MHz 030 accelerator	AM Micro	£225
Mercury Classic	Total Systems	030 accelerator for Classic	AM Micro	£695
Multi-Colour	PSI	LC Video SIMM	MCMXCIX	£125
Neotech Image Compressor	Neotech	Image-compression NuBus board	Neotech	£600
PB PowerMemory	PSI	2-4MB for PowerBooks	MCMXCIX	from £225

Performance Direct FPU	Performance Direct	16-33MHz 68882FPU	Performance Direct	from £41
Performance Direct Memory	Performance Direct	Memory upgrades for all Macs	Performance Direct	from £12
PhotoBooster	Radius	Photoshop accelerator for Quadra/Centris	Computers Unlimited	£999
PhotoBooster for StageTwo Rocket	Radius	Photoshop accelerator for ST Rocket	Computers Unlimited	£799
PhotoBooster for Rocket 33	Radius	Photoshop accelerator for Rocket33 + 25i	Computers Unlimited	£799
PhotoPro	RasterOps	JPEG accelerator for Photoshop	Frontline, Ingram Micro	£795
PowerBook Memory	LMP	2-6MB for PowerBooks	Mygate	from £100
PowerCache	DayStar Digital	030 accelerator for SE/30, LC, II/x/cx/ci/si	Merisel, Ingram Micro	from £845
PowerLink DeskNet	E-Machines	Docking connector forPB	H.& Son;Frontline:D.Tek	£625
PowerLink Presenter	E-Machines	Docking connector forPB	H.& Son;Frontline:D.Tek	£399
Powermath	DayStar Digital	16MHz 68882 FPU	Ingram, Merisel	£113
Pro33	Formac	33MHz CPU accelerator for LC1-LCIII	Formac	from £275
Pro50	Formac	LCIII accelerator	Formac	£425
Performer II	Harris Inc.	16MHz030 accelerator SE/Classic	Mygate	from £99
Performer Pro Accelerator	Harris Inc.	25MHz030 accelerator SE/Classic	Mygate	from £199
Quadralink	Applied Engineering	4 serial ports	Frontline	£275
Quick!	PRD	JPEG NuBus compression card	PRD	£350
QuickCache IIci	Total Systems	For IIci	AM Micro	£345
RenderEdge Board	StarTech	For MacRenderMan	Ap.Centre Kidderminster	from £4,995
Rocket SCSI-2 Booster	Radius	PDS daughtercard connects SCSI-2 devices	Computers Unlimited	£279
Rocket 33	Radius	040 accelerator for NuBus Macs	Computers Unlimited	£1,499
SCSI Jackhammer	FWB	20Mbps SCSI accelerator	Midwich Thame	£799
Silicon Express II	Atto Technology	SCSI accelerator	MacEurope	from £695
Silicon Express 3D	Atto Technology	SCSI2 for 25m SCSI chain	MacEurope	from £875
Silicon Express 4	Atto Technology	7-inchS CSI 2 NuBus FAST/WID	MacEurope	from £1,125
SCSI Expander	Atto Technology	Gives 49 SCSI addresses	MacEurope	from £875
StageTwo Rocket	Radius	40MHz 68040 multi-processing for NuBus	Computers Unlimited	£1,999
ThunderStorm	SuperMac	JPEG accelerator for Photoshop	Principal; Frontline	£895
TransWarp	Applied Engineering	25-50MHz 030 accelerator	Frontline	from £239
TransWarp Classic	Applied Engineering	40MHz 030 accelerator	Frontline	£425
Turbo 040	DayStar Digital	25/33MHz 040 accelerator	Ingram; Merisel	£1,599
Universal PowerCache	DayStar Digital	32-64k cache	Ingram; Merisel	from £392

VIDIexpress	VIDI	16MB RISC co-processor	MGA	£2,663
Virtual/030 3.0	Connectix	Virtual memory	Computers Unlimited	£90
Voyager 030	Total Systems	33/50MHz 030 accelerator	AM Micro	£799
VIDEO				
24STV/XLTV	RasterOps	24-bit frame-grabbers	Frontline	from £695
Cameo	CLI	Video conferencing	Gomark	£1,900
Connect 918	NUTS	Video conferencing	Computers Unlimited	from £3,499
DCS 200	Kodak	Digital camera	Midwich Thame	from £5,995
Digital Camera	Dycam		MCMXCIX	from £795
Digital Film	SuperMac	High-end video package	Principal	£3,495
DVA-4000	VideoLogic	8/24-bit video digitizer	VideoLogic	from £1,295
Falcon	Graphics Unlimited	Video capture card, 7"	Neutral	£695
FotoMan	Logitech	Includes Aldus Digital Darkroom	Logitech	£649
Harlequin	Graphics Unlimited	Video output card	Neutral	£1,295
Hasselblad/Leaf DB4000	Hasselblad	Digital camera	Hasselblad	approx. £26,500
HyperConverter	Data Cell	Converts Mac display to PAL+S-Video	Data Cell	from £1,300
Image Grabber	Neotech	Video digitizer	Computers Unlimited	from £1,250
Ion RC 560	Canon	Digital camera	Canon	£1,999
Kingfisher	Graphics Unlimited	Video capture card	Neutral	£995
Lumina	Leaf Systems	Digital camera, 12-bit colour	Leaf Systems	£5,000
Media Suite Pro	Avid	High-end video package	Avid	£8,000
Mediator	VideoLogic	Video digitizer	VideoLogic	£1,875
MoviePak2	RasterOps	High-end video package	Frontline	£1,695
NuVista+	Truevision	Video input/output, 2MB/4MB	Techex	£2,891/£3,098
ProgRes 3012	Kontron	Digital camera	Kontron	£13,345
Proxima LCD Tablet	Proxima	Range of tables, Mac - screen via projector	Reflex	from £4,750
QuickView Studio	E-Machines		Heyden & Son; Frontline	£1,695
RSVP	Graphics Unlimited	Video digitizer and output card	Graphics Unlimited	from £995
Scan Vision	Analogue Way	Wide scan converter, Mac to TV	Greyhawk Europe	from £795
Screen Machine	Fast Electronic	Video digitizer	Fast Electronic	£998
TK-F7300 camera	JVC	Digital camera	JVC	£5,750
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Video Machine Mac	Fast Electronic	Video package, includes software	Fast Electronic	£3,440
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VideoVision Studio Upgrade	Radius	Video-editing system	Computers Unlimited	£1,999
VIDIMac	Satelcom	Video conferencing system via ISDN	Satelcom	£4,595
VISIT	Northern Telecom	Video conferencing system	Principal	from £2,800

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