

Canopus Video Editing System Base Technology

canopus®

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About this White Paper

Proprietary technologies designed to meet the rigorous demands of the industry are the key to why Canopus video editing systems outshine the rest. This white paper describes the technology for handling video images that is the foundation of all Canopus video products.

Canopus Video Editing Solutions Deliver

Speed to guarantee world-class, real-time performance

Canopus video editing systems feature high-performance, real-time video processing for editing of SD and HD formats.

Accuracy to avoid image degradation

The beauty of original, high-quality images can get damaged during any or all three phases of video processing—capture, editing and outputting. Canopus has developed its own algorithms and processes that work to minimize degradation of image quality while maintaining real-time performance.

Flexibility to support a wide range of formats

Even though Canopus develops its own video processing technologies, our products have always been compatible with industry-standard components. Canopus editing systems can be seamlessly integrated into your existing workflow, and support for open standards makes it easy to edit mixed video formats.

About Canopus

Headquartered in Kobe, Canopus Co., Ltd. is Japan's largest maker of computer graphics and video editing products. Canopus released its first video editing system in January 1998. Since then, Canopus hardware and software products for video applications have gained international acclaim as video editors around the world recognize the extraordinary qualities of Canopus video technology. Today Canopus offers a complete line of video capture, video editing and graphics accelerator solutions. Canopus products are delivered to customers in 55 different countries, through sales offices in the United States, China, Germany, the UK and Australia.

Technology Built for Speed and Flexibility

The high performance technology built into Canopus nonlinear editing systems efficiently handles a wide range of audio and video formats, making the creative process extremely fluid. Our deep understanding of the PC platform's architecture, extensive research and experience optimizing hardware and software for the PC, and our long-standing commitment to providing real-time editing solutions to our customers continue to be factors in our ongoing efforts to provide technology that is fast, accurate, flexible, and reliable.

1. Scalable technology

Scalable technology allows product performance to increase in proportion with the speed of the PC's CPU. This technique, which has been perfected by only a few select companies, relies on a balanced combination of the following technologies:



- PC technology
- High-speed software codec
- Easy algorithm optimization
- Support for multi-processor systems
- Optimized software that leverages the CPU's built-in instruction sets
- Buffering technology for faster hard disk drive access

Scalable technology guarantees that Canopus products place no limits on real-time processing, because they can take full advantage of increases in PC performance capability.

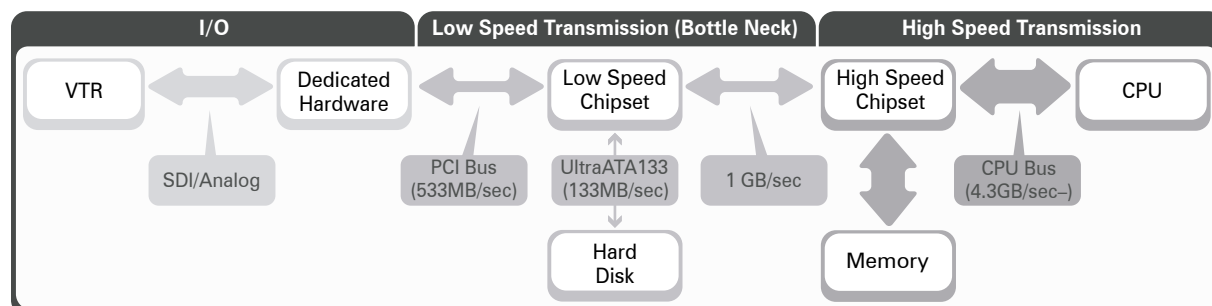
The key to putting scalable technology to use is the appropriate allocation of hardware and software processes. Improvements in the processing speed of PCs are made every day, but the speed of fixed hardware stays the same. That is why Canopus focuses on the design of both software and hardware. As a result, Canopus systems depend on software rather than hardware for many of the arithmetic processes including video effects and codec applications. By eliminating the possibility of fixed hardware speed impeding performance, improvements made in CPU speed are directly reflected in NLE performance. Scalable technology means that improvements in CPU performance are directly reflected in overall system performance.

2. Software vs. hardware

Why should the software perform mathematical processes?

When hardware is used to perform mathematical processes (for example, codec encoding/decoding), the main advantage is that it takes the processing burden off of the main CPU, freeing it up to perform other tasks. This is a point some of our competitors like to state in their comparative advertisements.

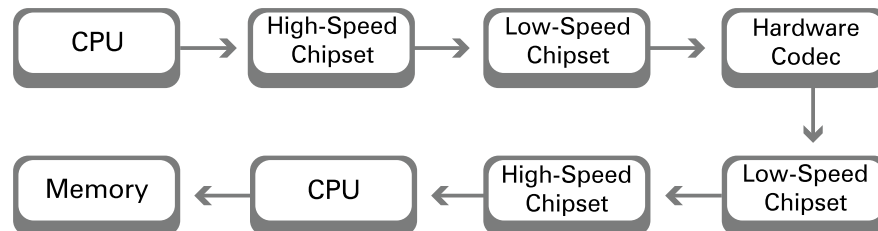
Why did Canopus choose a different route? The answer can be found by looking at the basic computer architecture, as seen in the figure below (*note that the arrow thickness denotes relative speed*).



Dedicated hardware and hard disk drives are usually connected on opposite sides of the I/O. Therefore, data transmission from the CPU to the hardware must go through the very slow data transmission path between the CPU and I/O. When processes require transmission between the CPU and memory only, data is transmitted at high speed and therefore the processes can be completed in a very short time.

Let's look at an example where codec processes are executed on hardware and the effects this has on software.

For image data to be decoded, processed, and encoded, the following round trip route will be taken:



Codec processes executed on hardware

For images to be processed in both the hardware and CPU, even if it is only being decoded, large amounts of data must be transmitted through the PCI bus twice. Additionally, each node must consider the timing of the transmission, which cannot surpass the speed in the bottleneck (lowest-speed) area.

On the other hand, the route the image data needs to take when a software codec is used and all processes are executed on the CPU is as follows:



Codec processes executed by software

In this scenario, all processes can be completed in the high-speed transmission area so high-speed CPU and memory performance can be fully utilized. Compared to the data transmission speed between CPU and I/O, the transmission speed between the CPU and memory is 50 times faster. Valuable time is **not** wasted when a software codec is used. This is especially important when working with HD video, where very large amounts of data are processed. Considering the improvements that continue to be made in CPU performance, executing processes on high-speed hardware only increases needless time spent on data transmission and decreases performance of the system as a whole. However, it is necessary that the CPU handle the software codec at a sufficient speed.

Canopus extensively studied image compression of DCT base images in order to develop a superior software codec that optimizes CPU speed and power.

PCI bus bandwidth is another reason why data transmission with hardware should be minimized. In HD video editing, a total of 250Mbytes/sec of I/O bandwidth is required (150MB/sec for video and over 100MB/sec for HDD (hard disk drive)). HD systems also require other devices (e.g., gigabit networks) that utilize PCI bus bandwidth. Unfortunately, PCI bus usability is much lower than expected—if it exceeds 70%, it is said to be very efficient. When image processing is executed in devices on the PCI bus, the system does not have much power left for executing other processes.

Flexibility is lost when all processes are executed on the hardware

You may think, "If executing only some of the processes on the hardware is inefficient, why not execute **all** processes on the hardware?" That is a good question. Suppose there were an ideal hardware product that could execute all processes, from codecs to effects, including various composites. PCI bus transmission would only be required for input and output, thereby eliminating the bottleneck. This piece of hardware would probably be very expensive and, more significantly, it would be fixed at the design stage, without flexibility to accommodate changes in the system as technology progresses. For how long could you plan to rely on this system? Think back through the years you have worked in the video industry... Is what was the "latest hardware" on the market when you began still so "hot" now? With computer and video technology continuing to make remarkable progress every day, upgrade costs must be considered even more than initial costs.

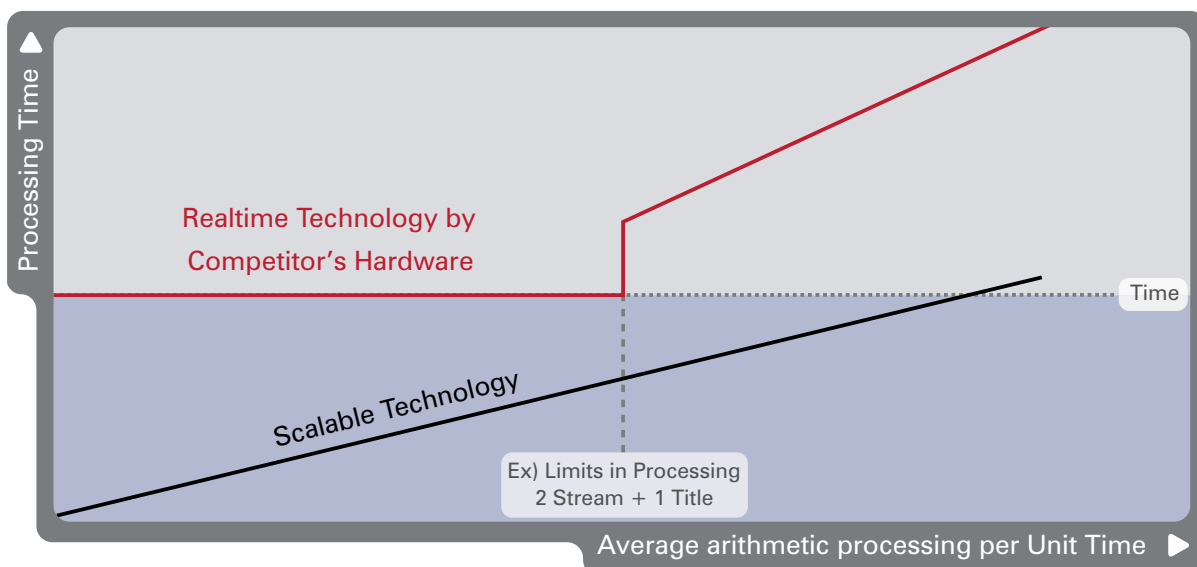
Compared to hardware, software can be much more responsive as technology advances, with shorter development time to market and without "limits" on making functional improvements. Software is inherently more flexible than hardware, and scalability applies not only to speed but also to functionality.

Real-time processing with scalable technology

The graph below compares the real-time processing of two video streams + one title by utilizing hardware versus a real-time processing system based on scalable technology. Real-time processing can be executed in the area below the horizontal real-time line.

In the scalable technology system, as the processing becomes heavier, the processing time becomes longer and, when it reaches a certain point, real-time processing is no longer available. The load, however, is basically stable.

On the other hand, the hardware processing system can execute processes in real-time up to a limit but, when it goes over that limit, rendering is needed and processing speed suddenly drops, meaning that overall processing time increases. After that, since the hardware-based system was not designed for executing processes using software, the processing time needed rises at a much steeper rate compared to the system using scalable technology.



- Needs rendering
- Processed in Realtime

Pursuing the optimal balance between hardware and software processes

Canopus editing systems do, however, selectively employ hardware. Importing and exporting from external devices cannot be executed without hardware. Through fully understanding the structure of data flow, Canopus engineers have alleviated bottlenecks by ensuring that hardware processes do not get in the way of high-speed software processes. So long as slow transmission between CPU and I/O is minimized, the negative effects of relying on hardware will be mitigated for the system as a whole.

Canopus allocates all processes that can be completed between I/O hardware and external devices to hardware (including scaling of image data, digital filter processing, and adjustment of quantifying bit numbers). Because these processes can be executed without intervention of the CPU, data transmissions between the CPU and I/O are not increased.

The appropriate allocation of processes between software and hardware is critical to the configuration of Canopus's high-speed editing systems. System performance is further improved by utilizing a buffering network to absorb the differences between the video transmission rate of the external I/O and the processing rate of the software.

3. Optimizing speed and performance

In-house development

Canopus develops and engineers all of its own systems—hardware and software—in house. This is what makes overall system optimization possible, including hardware architecture, codec, and disk I/O.

Optimizing software at the algorithm level

Peephole optimization (local optimization) methods are typically used in software development. But that alone will not drastically speed up processing. By optimizing at the architecture or algorithm levels, dramatic improvements can be achieved. A full understanding of the CPU is required for algorithm optimization.

Most video editing applications do not make use of SSE and MMX, which are multi-media command sets (even when they are used, areas used are typically limited for peephole optimization only). EDIUS, Canopus's nonlinear editing software, is built on Canopus's own architecture design, which is optimized using SSE and MMX, and was developed to speed the rendering path up to its limit. "3D Now!" is also used where applicable.

For plug-ins, as well, Canopus pursues speed without sacrificing accuracy by optimizing at the algorithm level.

Maximizing disk performance

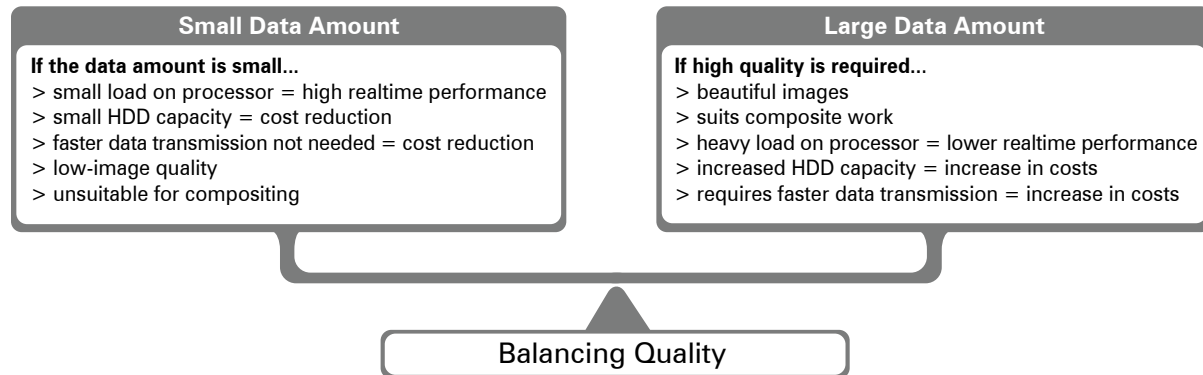
By reducing "seek" in optimal scheduling of disk I/O, reading HD broadband data was made possible on IDE software RAID systems. This is also significant for editing DV footage. The ability to read an HD stream is equivalent to being able to read four DV streams concurrently. This facilitates multi-layered composites and editing on slow, fragmented disks. It also means that unnecessarily high-speed hard drives no longer need to be used.

Reducing memory access

Adjusting memory access will improve efficiency somewhat, but this optimization method is to be expected. An even more effective mechanism for improving speed is eliminating unnecessary copies. For example, in a system where programs for reading data from the hardware, for processing images, and for outputting from the hardware are all run separately, many unnecessary copies will be made. Many popular video editing applications are designed this way. Full-frame playback of HD is problematic with this kind of technology. EDIUS software was designed considering "data flow" from input to output, resulting in systems that do not make unnecessary copies of video data.

Canopus Video Editing System Design—Keeping Total Workflow in Mind

When it comes to speed, faster is simply better. But when considering “image quality,” as accuracy is improved, the amount of data increases and this can degrade the efficiency of the system as a whole. Increased amounts of data mean increased storage costs and lower throughput.



As you can see, it is important that the NLE system be designed with optimal components and is not “over-spec’ed.” Of course, without considering costs, the ideal system may center around a high-speed PC and be one that can process huge quantities of data. But in reality, return on investment (ROI) is a very important aspect of an editing solution; one that must be considered. You should think about the system in its entirety, ensuring the optimum specifications are achieved for the right ROI.

When considering the system as a whole, compression technology becomes a critical feature. Compression that can reduce the quantity of data without any degradation is ideal and is the only way to achieve the balance between quality and data size. Canopus compression codecs achieve this balance.

1. Standards based on workflow

How can “optimal design norms” be determined for an editing system? Canopus came up with the answer by examining the total workflow in video production: from shooting to editing to delivery. Here is what we found...

With the performance (image quality) of VTRs as the norm, input/output of images with higher quality is possible and can be edited with minimal degradation.

Norms based on VTRs

There is hardly ever a time when a camera or a VTR is not used in the workflow of post-production or broadcasting including coverage, editing, and distribution. When video and broadcast professionals choose editing machines and transmission devices, they look for products that meet the image or product quality levels of the VTRs or cameras they are using. In other words, in a workflow using VTRs and cameras, the image quality level is based on the image quality level of the VTR or the camera used, and that level can be assured so long as the performance levels of the peripherals are equal to or higher than those of the VTR or the camera. Even the quality of computer graphics depends on VTR image quality, when they are recorded on tapes for distribution. The capabilities of the editing machine are also important—it must be able to perform without degrading VTR performance and image quality.

Design based on usage

There are times when the best image quality available is required, for example in compositing. Canopus systems have been designed for efficient editing of images shot using video cameras, and therefore do not cover composite editing. In composite editing, multiple tracks must be processed simultaneously, so the highest quality images

must be processed at high-speed on multi-tracks. In some competitors' systems, high image quality editing has been adopted, but it can only process 2 streams + 1 track in real time. For multiple tracks exceeding this limit, rendering must occur. In that case, it is more efficient both functionally and cost-wise to use dedicated compositing software. The bottom line is that purchasing an over-spec'ed editing system without true consideration for its actual use is likely to mean reduced efficiency and lower ROI.

2. Accuracy for preserving the beauty of original images

There are times when the Canopus codec, with its 8-bit, 1440 resolution, is said to be insufficient when compared to the standard 10-bit, 1920 resolution. The current specification has been chosen based on careful studies of sufficient balance without becoming over-spec'd.

Quantifying bit numbers

Canopus considered quantifying bit numbers for the following VTRs:

**MPEG IMX, BetacamSX, DVCAM, DVCPRO50,
D-1, D-2, D-3, D-6,
DVCPRO HD, HDCAM (8-bit when compressed)**

These VTRs are widely used in broadcast environments. This means that even the broadcasters agree that 8-bit is enough for high quality performance. Thus, increasing quantifying bit numbers to 10-bit for improving quality in images used during the editing process can be considered over-spec'ing in a workflow assuming the usage of VTRs.

Increasing data amounts from 8-bit to 10-bit means making increases by 20%. That leads to requirements for increased storage capacity and higher data transmission speed.

Another reason 8-bit is appropriate for high speed processing is that computer technology tends to be based on multiples of eight. Processing 10-bit data requires 16-bit buses and registers, which ends up requiring double the standard 8-bit load.

Video effects processing is designed for the final results to have 8-bit accuracy. For example, chroma keying requiring advanced interpolation, 32-bit accuracy may be needed for international calculations. Computing with unnecessary accuracy requires large amounts of memory and slows down the process. Therefore, eliminating waste by careful consideration of the algorithm implementation with sufficient accuracy is important.

Canopus systems guarantee accuracy at each level of effect processing due to careful planning and design.

Pixels and sampling methods

The same can be said about pixels...

	DVCPRO HD	HDCAM	Canopus HQ Codec
Brightness pixels	1280 x 1080	1440 x 1080	1440 x 1080
Color difference pixels	640 x 1080	480 x 1080	720 x 1080
Sampling method	YCbCr 4:2:2	YCbCr 3:1:1	YCbCr 4:2:2
Bit rate	100Mbps	140Mbps	Variable (max 300Mbps)

The Canopus codec exceeds that of the two popular VTR systems and can edit by oversampling. Some internal computations, for example composites, are executed in 4:4:4 sampling, minimizing degradation during processing.

YCbCr as the standard format

RGB is widely used as the norm in PCs, but YCbCr is the norm used in video equipment. Many editing systems include software to convert to RGB for easier processing on PCs. In such systems, color-related problems, such as images over 100IRE being blown-out or discoloration of rendered parts, frequently occur.

Images shot with cameras include elements over 100IRE, therefore being able to process them correctly is crucial. So Canopus editing systems simply use YCbCr to avoid unnecessary problems.

32-bit audio processing

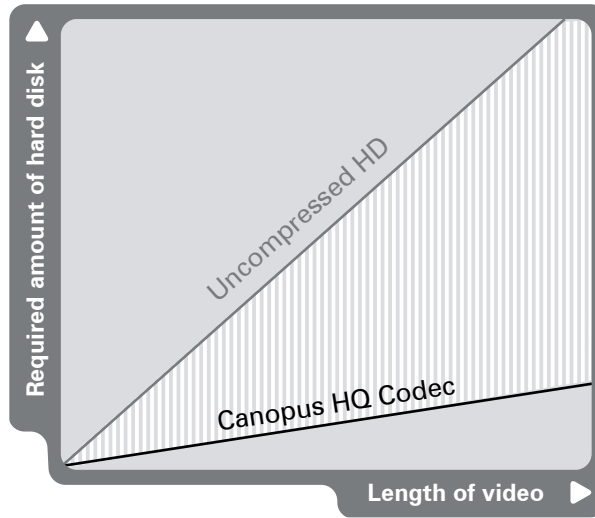
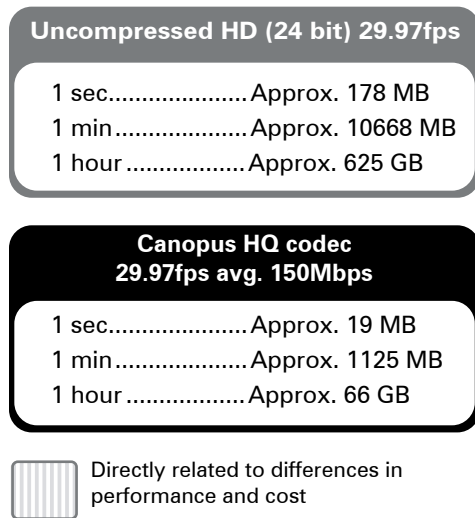
EDIUS Pro processes floating 32-bit audio, matching audio-dedicated software. SDI can I/O a maximum of 24-bit of quantifying bit numbers, therefore floating 32-bit, which will cover this specification, has been chosen.

3. Reasons for adopting a compression codec

First, we wish to make it clear that **Canopus products can process uncompressed data and full HD with alpha channel (1920x1080i)**. However, there are reasons for Canopus emphasizing its compression codec over processing uncompressed data.

Why compress?

When you calculate the amount of data for uncompressed HD images, even with larger hard disk capacities and faster transmission, it still is too much to handle realistically.



Directly related to costs

In uncompressed HD editing systems, over half of the total system cost goes to storage. Not only is large capacity needed for storing enormous amounts of uncompressed HD data, but also products with the best performance and interfaces to meet the very high requirements for transmission speed in real time must be included. In most cases, these costs by far exceed that of the editing machine itself.

The high-speed, high-quality Canopus codec contributes to a significant reduction in total costs, while preserving quality.

Directly related to performance

In HD video editing on PCs, enormous amounts of data are transported between the HDD to I/O, CPU, and memory. For uncompressed HD video, huge amounts of data are transmitted on every bus, especially between the HDD

and I/O, which becomes a bottleneck. Using compression, CPU power is used for compressing and expanding. However these tasks are handled on the high-speed bus between the CPU and memory. Therefore, the amount of data being transmitted on the low speed bus between the HDD and I/O is 1/7th compared to uncompressed data. This, as you might surmise, has great effects on the system as a whole.

In the future, when an editing system is configured on the network, data compression will be a must. Even with the fastest fibre channel server system available today, it is very difficult to play back three uncompressed HD streams on five editing machines constantly, in real time.

In addition, since Canopus's editing software (EDIUS) is designed in-house together with our codec, the software is able to fully harness the codec's capabilities.

Excellence of the Canopus HQ codec

The Canopus HQ codec provides image-quality stabilization by keeping the average bitrate low, dynamically adjusting compression rates between accurate images and simple images and using variable bitrates, which can be decoded by frames. Additionally, to maintain minimal CPU load for compression and expansion, Canopus's original technology has been introduced to the mathematical methods of the CPU. While many other HDV editing systems are forced to reduce quality and compress image data to even realize pseudo-real-time processing, EDIUS users can go on with their editing processes without worrying about decreased image quality.