1 Beyond White Paper:

Design Considerations for HD Editing / Compositing Workstations

Based on the Design of the 1 Beyond HD OctoFlex

By: Terry Cullen
CEO and Founder
1 Beyond, Inc.
October 9, 2006

Design Considerations for HD Editing and Compositing Workstations

Background:

The design considerations for High Definition (HD) workstations are entirely different from systems working with less demanding formats and certainly different from standard business PCs adapted for video where "one size fits all". HD requires increased processing power, increased storage size and significantly higher data rates. These HD requirements also introduce ergonomic considerations of size, noise and heat. Finally we have become more sensitive to customer requirements for "Balanced" systems. It can be a mistake to make a decision on a system because it does a good job of editing without investigating how it performs with HD compositing and encoding for example. Therefore to summarize customer feedback from 5 years of HD workstation experience, the "Ideal HD Workstation" should be:

- balanced and capable in all HD tasks including, editing, compositing and encoding
- cost effective - self-contained
- scaleable to all formats from SD to HD
- able to significantly improve workflow and quality
- provide editing for all Formats including or scaling to uncompressed real-time HD
- provide HD compositing minimizing or eliminating waiting for renders
- allow for simultaneous HD multi-tasking

I. First Qualify what is meant by High Definition claims:

What do we mean by HD? When you hear a claim such as "we can do 4 layers of HD in real-time", your reality check must engage. For example, once properly qualified, the system manufacturer making this claim could barely do 1 stream of full resolution HD and not even a simple effect in real-time. Everything had to be rendered to see the results -- quite a workflow and quality difference between claim and reality.

One must first clarify what type of HD. The highest quality HD, as with any format, is uncompressed. However, since many systems cannot work in uncompressed HD and some that can are not available at a reasonable price, there are still many claims for lesser systems using compressed HD being very close or "indistinguishable" from uncompressed. It is not necessary to engage in the end-less debate regarding the quality of various formats, only to recognize that there is a possibility that the future may hold requirements for additional "higher data rate" formats and if the system solution covering all format possibilities is similar in price, why take a chance and not be prepared. There is still a place for compressed HD for example in laptops or portable acquisition formats e.g. tapes, memories, small hard drives etc. However, just as compression and off-line requirements have disappeared from professional SD, the movement of the professional HD market to uncompressed will not only continue at the high-end but could be greatly accelerated downwards as soon as it is more practical and affordable. Hence one of the goals of the "Ideal HD Workstation" design is to include all HD formats including uncompressed at a reasonable price point. Also one of the most asked questions is can I start with SD or compressed HD and easily move to HD if and when I have the requirement. Therefore this is also a highly desirable goal. No one wants to purchase an expensive system today only to find they are at a technical dead-end or have to make substantially higher external storage investments, if higher requirements become necessary.

Note, today there is no shortage of capture cards that will ingest full resolution HD (uncompressed HD-SDI) including multiple cards from BlueFish444, Blackmagic Design, AJA and Matrox. Even software only solutions exist for many HD formats. Virtually every major hardware and software video manufacturer now has this capability. There are now even inexpensive HD cameras ($10K range) that will output HD-SDI. The second qualification in HD is for example the difference between 4:2:2 8-bit, 720P 24fps and 10-bit, 1080i

30fps. This represents a >75% data rate difference in these formats alone so even "uncompressed HD" can refer to a wide range of data rates. Therefore even if a user were working in reduced HD or SD today, it would be ideal if an HD system were capable or at least scalable with appropriate storage to cover all SD and HD formats in the future. The secondary immediate benefit is all lower formats will yield more performance do to the increased power now. For example more performance means more streams of video, more real-time effects and faster encoding from the beginning and a higher ROI (longer technical lifespan) for the future.

II. Trends in processor design yield new direction in power:

Processor manufacturers are hitting the practical limit of processor speed. The competition between processor manufacturers has driven increased speed (the GHz marketing war) through the years following Moore's Law by decreasing the semiconductor layer thickness. The industry is now at 65 nanometers and pushing to 45 nm, but this is about as far as physics will practically permit. Therefore the latest direction for increased processor power is a new emphasis on increased multi-processing. Technically speaking this means spreading out semiconductor design density horizontally instead of vertically.

Fortunately we have had reasonably priced multiprocessing PC systems for over ten years (witness the dual Pentium Pro circa 1995 for example). More recently (in the last five years) technology like Intel's Pentium with Hyperthreading®, IBM's PowerPC® and AMD's Opteron® allowing for up to four processing units per system, have been available and reasonably priced. This availability of systems with multi-processing units, has led software designers to respond with multi-threaded software, especially in extremely processor intensive applications like multi-media. Therefore the video industry is somewhat prepared to take advantage of this new trend toward increased multi-processing.

With this new trend in increased multi-processors, the race continues for software designers to take advantage of it. The effective design of multi-threaded software is not trivial by any means. The good news for users is this increased power not only translates into much needed faster video processing but to easier to use and more productive user interfaces and more efficient and even new workflows. As with the advent of reasonably priced dual processors, the first software companies to recognize the value and take advantage of it, will gain the reputation of the fastest and easiest to use products. As a result, they will take market share. Looking at manufacturers' future road maps, we see as many as 32 processors on one piece of silicon by the end of this decade.

III. Processing Power Solutions and Design:

The requirement of system design for the video industry is to make sure all components (graphics card, capture card, motherboard, disk controller, software, etc.) are in balance and are stable functioning together. What causes instability? For the most part computer instabilities are the result of component incompatibility. The PC "Standard" has lead literally hundreds of manufacturers to develop hardware and software for PC systems. The vast majority of the PC market (well over 90%) run three basic applications;, email, Internet and Office. The dream of "Plug-N-Play" may exist in this office market because there is no real power required. In the professional video market however, we are stressing all aspects of the system and this is where we suddenly find stable systems developing incompatibilities which cause instability. The solution to this problem is first, spare no expense, use tier 1 components. It is easy to save a few dollars in design using less expensive components that may not be tested in very demanding applications. This works and is necessary to be competitive in business and personal computers, but when putting these designs in a highly stressed environment such as video production, this savings will come back to hurt in support costs and injured reputation. Some system manufacturers are know for creating cost effective systems but an example of how this practice can backfire when these systems are placed into the video market is some video card manufacturers have flatly refused to support their capture cards in these systems due to their experience with the resulting high support costs and unsatisfied customers blaming the cards.

Second, years of experience flushing out what hardware is likely to play together and perform well with video applications provides a design starting point. High performance video cards, capture and effects cards and disks use considerably more power and in addition give off correspondingly much more heat. Heat is the number 1 enemy of electronic components and is proven to accelerate failures. Cabinet design with increased cooling and power to support the highest levels of capture and effects cards, internal HD storage and increased memory (for future 64 bit) specifically designed for professional video is critical. This is another example of how taking business and server systems and attempting to use them for video processing applications can lead to marginal power or component failure and instability over time.

Power can be especially deceptive. Business computers do not, by design, have power supplies for heavy additional loads beyond their intended use. Power can appear to be adequate at first. However, even common components like processors, memory and disks can take twice as much power when put to their full potential. When performing a compute intensive task, the processors literally heat up due to the additional power required for full out computation like effects, rendering or encoding. We have seen examples of overloaded systems that were crashing during encoding. Encoding can cause a marginal power supply to falter causing system crashes. In this situation, we see an excellent example of how processor intensive tasks have much heavier power requirements. It is well known that disk startup requires additional power. However a common believe is once spinning a disk is uses a constant amount of power. This is far from the case. When called into intense action, they can require almost twice as much power. Imagine the effect of a RAID array where by definition all disks are heavily accessed at the same time. Email or internet searching can not possibly cause this kind of stress on processors, disks and power supplies.

Once apparent stability is attained, further research and development involves testing the permutations and combinations of what experience has shown to be the most difficult workflows and finally beta test sites to put these designs to work in real world environments. Once approved the design must be frozen and careful revision control put into place.

Another hurtle in multiprocessing is the operating system. When you exceed 2 processor sockets, due to an apparently arbitrary Windows marketing decision, the Windows XP operating system assumes this must be a server requiring a more expensive operating system like Windows Server 2003. Server 2003 may support 8 processors but this operating system is not designed for or supported by any professional video applications.

A significant breakthrough was the introduction of the original 1 Beyond HD OctoFlex. It was designed to take advantage of future multi-processor trends (providing 8 processing units), was designed for video applications hardware, ran under Windows XP and therefore was fully supported by all video applications vendors. This system was the first to bring the increased multi-processor power to the video industry providing more real-time HD editing and effects and reduced times for compositing renders and encoding. For example, coupled with software for rendering and previewing After Effects, it was the first system to run 8 copies of After Effects simultaneously to produce a new concept, the self-contained “Personal Render Farm” (described more completely below).

We are now introducing our second generation, OctoFlex2 which is the first HD workstation solution with 8 full cores of processing power. This design has yielded up to 70% additional performance over the original OctoFlex.

Note: we are also currently testing the first Intel 16-processor design. While there is certainly a market for this virtual “Super Computer”, it is considered generally impractical for the typical “Ideal HD Workstation” due to its current size and cost.

IV. Editing impact - Increased Quality and Reduced workflow time:

The overall system design goal in editing is to accomplish in HD what we now take for granted in SD, namely editing in HD "On-Line All the Time" – i.e. being able to see in real-time and full HD resolution what we are editing.

a. **On-Line All the Time:** The most dramatic improvement in reduced workflow is to eliminate the necessity of off-line HD editing. Off-line editing is either a two-step process (compressed off-line followed by uncompressed on-line) or having to work in compressed HD to select and create the HD content without being able to see it in full HD resolution until final render and output. Working in full resolution is extremely important in HD as "flaws" such as a clip being slightly out of focus are much more evident in viewing the final HD and impossible to see in off-line editing due to lack of resolution.

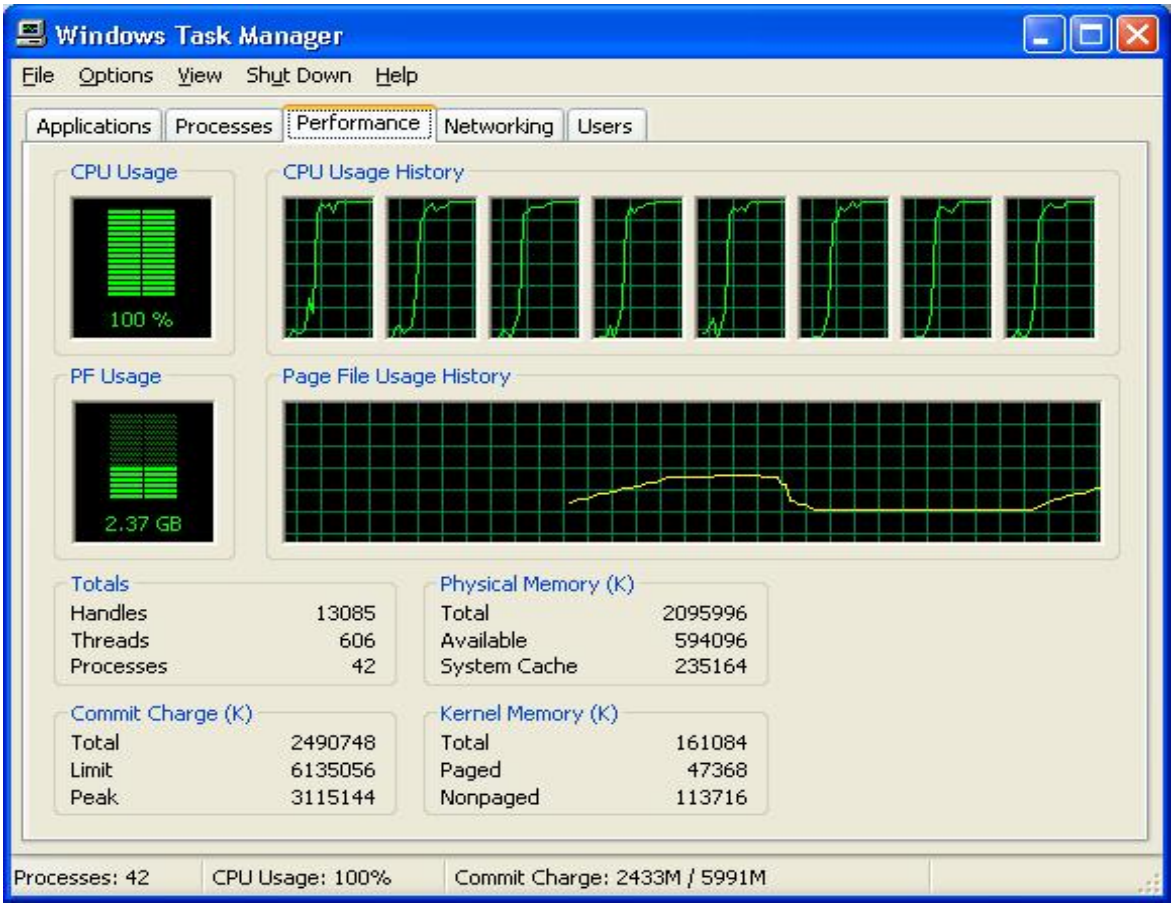
b. **Quality:** If these flaws are not discovered until the On-line process or in the final full resolution screening, they are difficult to correct. This often results in a quality compromise because backing up the production process is too expensive and time consuming.

c. **Real-Time:** With the advent of the Matrox Axio and Axio LE products for example, workflow time is also significantly reduced by editing HD in real-time. Just the ability to do color correction and color matching in real-time can save many hours or days of rendering and rework. This not only requires significant power but major increases in data rate. 1080i 30fps requires 155 MB/s minimum and more realistically close to 200 MB/s with the desired head room. This means that 2 stream real-time HD requires close to 400 MB/s. In the past, this RT HD extremely difficult data rate requirement has led system manufacturers to put more emphasis on compressed HD or off-line editing, even referring to it as a "Feature" as they did in the early 90's with SD Off-line. Solving this problem is prohibitive because it not only requires extreme processing power but expensive high performance storage as well. It is now possible to solve this storage problem cost effectively (more details below).

V. Compositing impact - Increased Quality and Reduced Workflow:

The "Ideal HD Workstation" should be able to perform at least reasonable compositing tasks in uncompressed High Definition, such as After Effects, if not full 3D modeling. When shifting graphics production from uncompressed SD to HD, the rendering and preview time becomes prohibitive. The workflow comes to a halt while waiting for processing either the graphics preview or rendering. The traditional reaction has been "it's now time for a render farm". This however adds considerable expense and a level of complication in submission forms and additional networking requirements that small to medium sized graphics departments ideally would like to avoid. Consider another approach utilizing the additional power and separate processing capability made possible utilizing multiple processors.

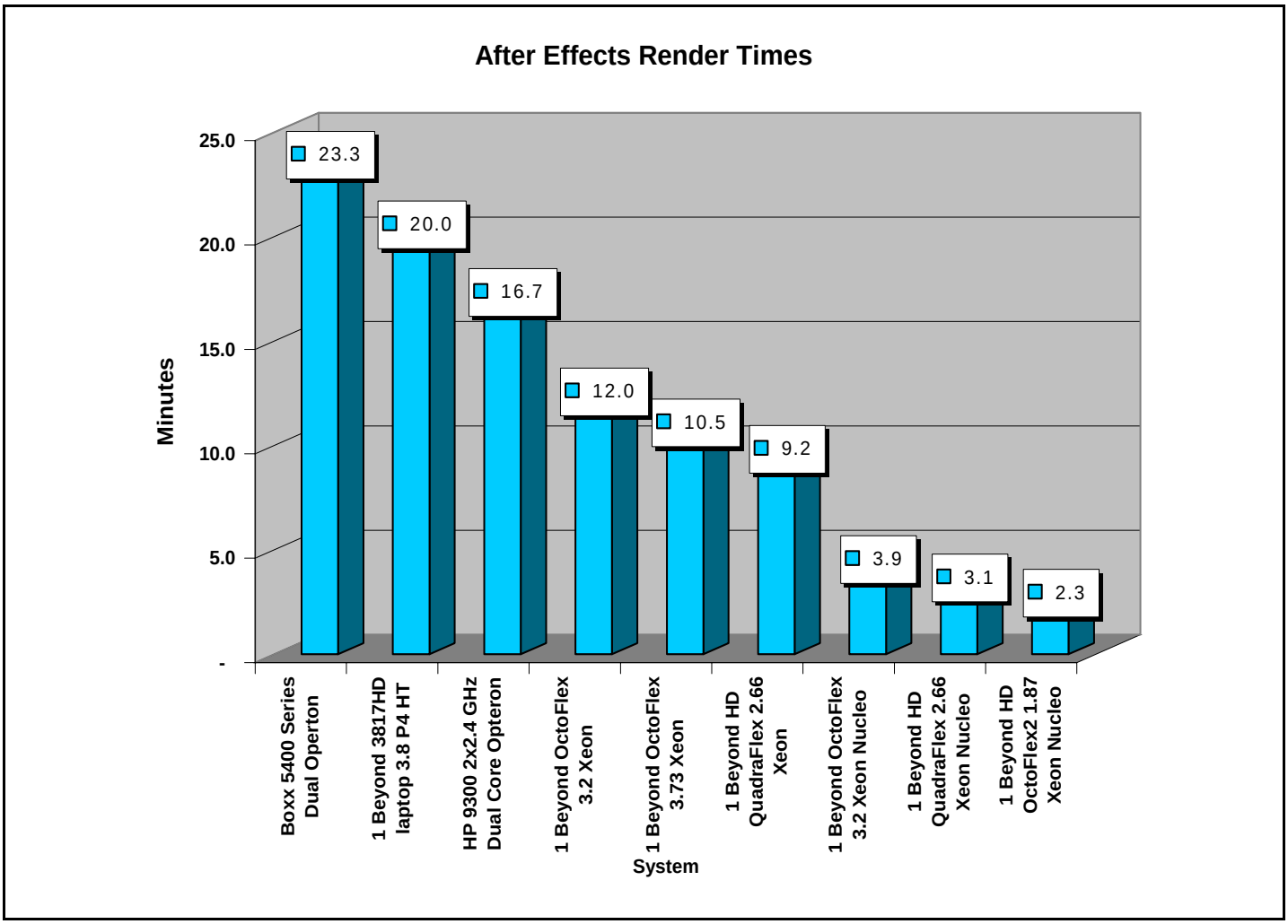
a. **The "Personal Render Farm":** The 1 Beyond HD OctoFlex 8 processor system, coupled with After Effects rendering software, offers a new alternative. Now with the OctoFlex when the Preview or Render button is pressed in After Effects, 8 copies of After Effects spring to life and provide almost instant rendering. It is identical to the approach afforded by an 8-processor render farm but without the complicated submission process and additional networking, not to mention considerable expense.



After Effects "Preview" using all 8 OctoFlex processors

b. Reduced Workflow: This new concept not only reduces render time but, the previewing can be anticipated and done in the background starting as soon as new changes are made. Rendering can also be performed without stopping production the same as with a traditional Render Farm accept again there is no complicated submission. Just switch tasks or continue in After Effects while the HD OctoFlex uses extra processors to render in the background. Note, this will also work with 4 processors and slower systems but the impact on workflow is nowhere near as dramatic or beneficial.

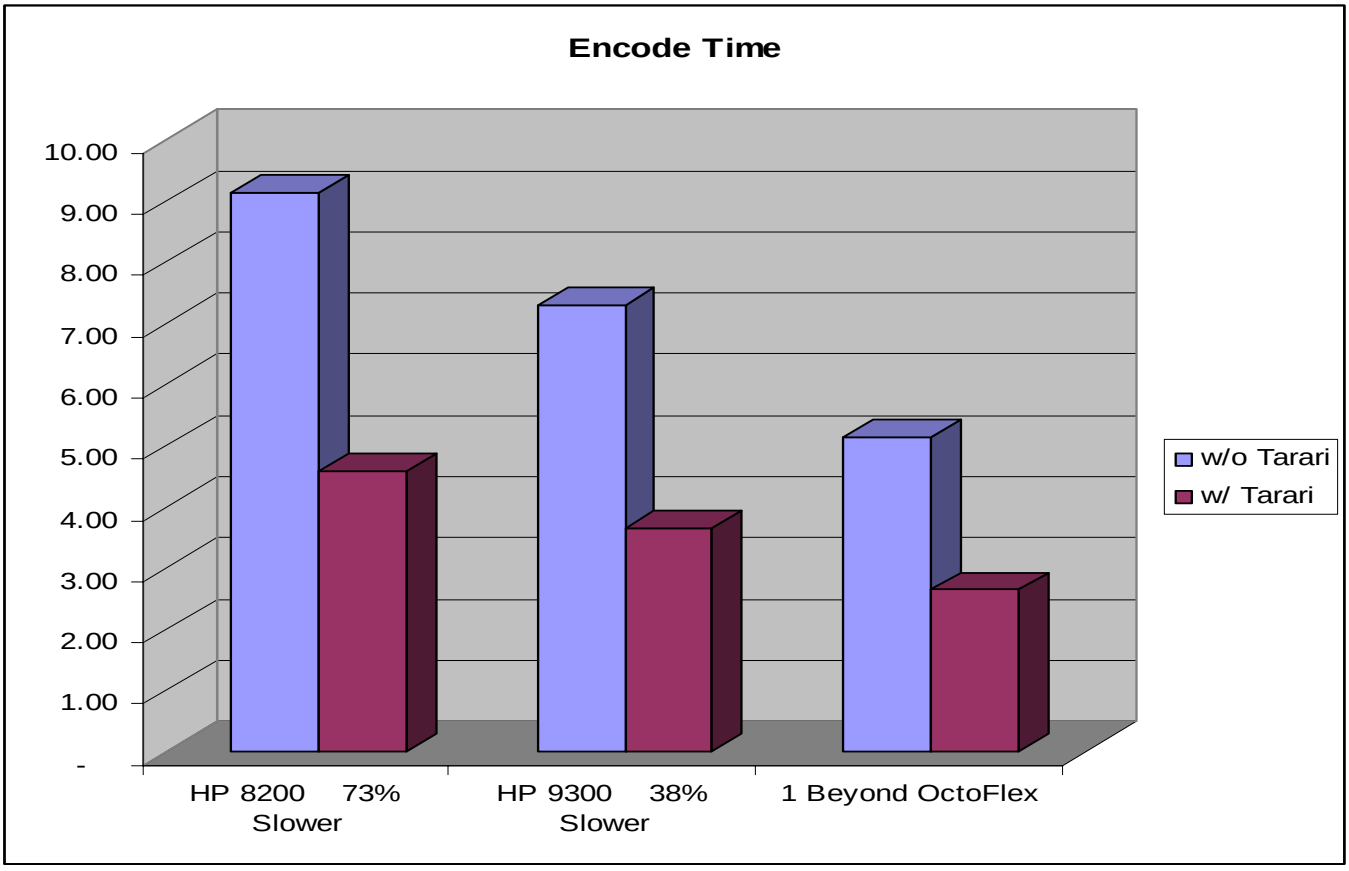
c. Quality Increase: As in the editing example, when rendering is not stopping production, there can be more iterations of improvement while still allowing improved workflow. This inevitably leads to a higher quality result**.**



Note: Even the slowest OctoFlex2 processors yield significantly faster results than the original OctoFlex with its fastest processors

VI. Impact on HD Encoding:

The problem when moving from SD to HD encoding is the time required increases geometrically. For example a simple task such as creating an HD DVD can tie up a system for hours or even days only in the end to find a problem when doing the final review. For example from HD to the AVC/VC1 standards for HD DVD's or HDV export to tape. Long form video can literally take days to render. Even for short video, this leads to encoding at night by necessity or purchasing additional systems and transferring large files to encode. The problem is that when the results are finally viewed, the quality is often not acceptable even with willingness to compromise. For production facilities that have significant encoding, this problem has led to the use of expensive encode accelerator boards. Tests with the 1 Beyond HD OctoFlex show dramatic improvements in encoding time. Even when using encoder accelerator boards, times have been reduced as much as 80% over traditional high-end systems.



Note: This data is for the original 1 Beyond OctoFlex. The OctoFlex2 is significantly faster

VII. HD Storage:

The final problem in designing the "Ideal HD Workstation" is storage. Using traditional workstations not designed for video applications, there is not sufficient space, power or cooling to increase the number of disks to allow for full resolution HD editing. This leads to the necessity of external storage. External storage adds the cost and complication of an extra cabinet, power supply, connections and disk controller in the workstation. The 1 Beyond HD OctoFlex was designed to solve this problem most importantly to maintain a reasonable price point. The cabinet is designed to allow up to ten SATA2 externally accessible, hot-swappable disks. To keep the costs at reasonable levels, the built-in disk controller can drive 6 SATA2 drives providing more than adequate sustained data rate for uncompressed HD. The total size for data can be up to 4.5TBs or 7.5 hours of 1080i. If more is required an internal controller can be added and the size can be increased to 6TBs or 10 hours. If you are using 720P 24fps, this equals 15 hours of uncompressed storage.

Of course additional storage can also be added in the future using SCSI (hybrid to SATA) or Fibre Channel connection to direct attached or shared storage such as storage area networks (SAN) or network attached (NAS) disk arrays. In this case the internal storage can be used not only for local high speed HD processing, but also for backup and archiving projects and assets.

VIII. Conclusions:

In conclusion, the "Ideal HD Workstation" is self-contained including HD capable storage (either tower or rack mount) and provides editing, compositing and encoding with significantly reduced workflow time, higher quality productions and all at a reasonable price. For example, the 1 Beyond HD OctoFlex is available for under $10K for a complete HD-SDI system including capture card, software and HD storage.

For additional information contact

1 Beyond at 877-One Beyond or visit www.1Beyond.com.