



NHK would bring the high definition equipment and expertise to the production and Polygram would provide the NTSC and audio equipment and concert production expertise.

Polygram was also producing a documentary movie on the concert with Propaganda Films and would have had to invest another bundle of money in the film recording of a large portion of 40+ hours of performances, from multiple angles on two stages. The choice of high definition origination would allow the producer to select portions of the 1125 line masters for transfer to film for the movie.

Vision Unlimited, working with NHK Japan and NHK Enterprises in New York would coordinate the design, assembly and operation of the high definition production facilities and would work with the NTSC crews to assure the highest quality products to all users.

HD Vision, as the operator of the only available complete high definition mobile unit would provide the production facilities for one stage and significantly reduce the engineering headaches.

The production facilities for each stage would support seven cameras: two handheld cameras on stage, one dolly on track in front of the stage, one jib in front of stage right, two audience cameras in front of the mix tower (100 feet from the stage) and one audience right wide shot on a Condor lift (700 feet from the stage). Figure 1 shows the typical camera layout.

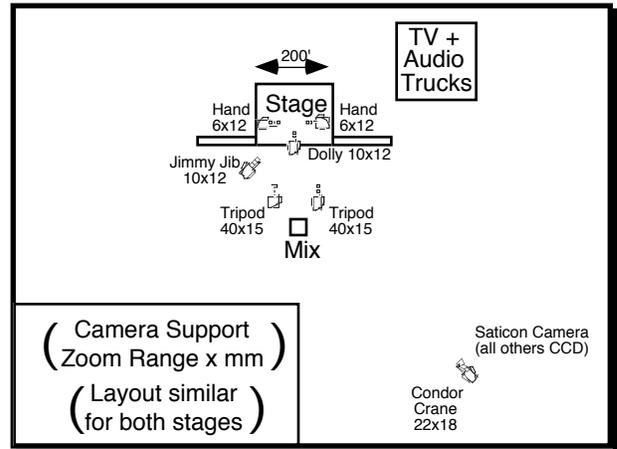


Figure 1. Camera Positions

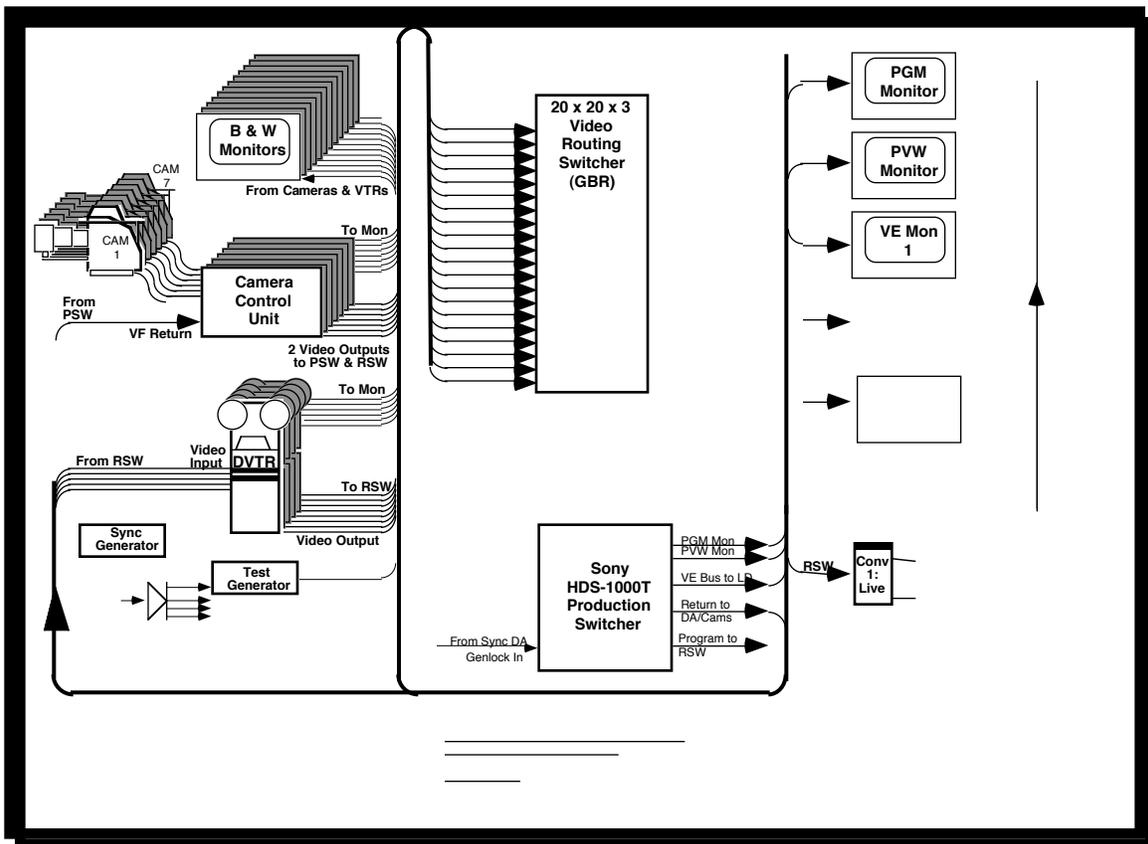


Figure 2. High Definition Video Flow (similar for both stages)

Five digital recorders would record a switched program, a switched isolation feed (ISO) and two ISO feeds from specific cameras. Two high quality converters would provide prime and backup NTSC program feeds to the NTSC integration unit and four medium quality converters would provide NTSC versions of the ISO feeds for off-line recording and feeds to the video screens adjacent to the stage. Figure 2 depicts the high definition video flow for one stage.

Audio for each stage would be handled by two independent multi-track recording units, alternating by performances, so that each one could be setting up for the next performance while the current performance was active. Prime and backup stereo feeds would be brought to the high definition control room from each audio unit and a selection would be made in order to keep the current audio on the main audio tracks and to provide proper monitor audio for the director. The eight digital tracks on the Sony HDD-1000 recorders would allow us to record prime audio from both units in case of a mistake in selection on the television board. Audio would also be delivered directly to the NTSC integration truck where audio delays would be added to compensate for the video delay through the converters, frame synchronizers and NTSC digital effects units.

Comm would be provided separately at both stages and in the integration unit. NTSC comm would be extended to a producer at each stage control room to improve integration but since each stage would produce continuously without regard for the output program, integration would not be a serious issue for the high definition production operations.

The NTSC integration unit would also provide audio support for live talent at each stage to provide commentary and introduce acts.

A position in each control room would be provided for a lighting director and he would communicate with his people on a separate comm system.

### HIGH DEFINITION SYSTEM DESIGN

We decided to use the HD VISION unit as one control room and to supplement it with an office trailer for video tape and conversion. Since the smaller South Stage was built after the North Stage and we had less time for system installation than we had on North Stage, we decided to use the mobile unit there.

The unit, originally designed and built for Telesat Canada to support three cameras and three recorders, had been recently modified to more comfortably support seven cameras and four recorders, but five digital recorders and additional NTSC conversion was just a little too much.

The office trailer was connected to the unit with an elevated walkway and outfitted with external air conditioners. Telephones and transmission connections to North Stage were provided through a fiber optic bundle and Telecast terminal equipment. Figure 3 compares the facility layout for the two stages.

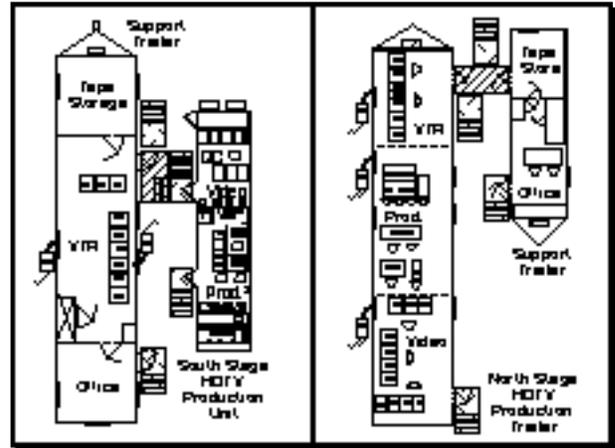


Figure 3. Facility Layout for Both Stages

We powered all technical equipment from the mobile unit to minimize hum problems and were successful once we got the loads balanced.

North Stage was slightly larger and operated for longer hours than South but the television control rooms were functionally identical as was the equipment complement. The North complex was also the integration site for NTSC and the distribution site for media release so some additional monitoring and administrative space was provided.

The high definition control room at North Stage was built around a portable production console that we designed for **Columbia Celebrates 30 Years of Bob Dylan** at Madison Square Garden in 1992. The console contains a seven-input Sony production switcher with tally, a 30x20 Dynair RGB routing switcher, sync and video distribution for up to seven cameras and five recorders and supports up to twelve 10" source monitors and three 18" output monitors.

A 12'x 60' open office trailer provided the shell for the North Stage facility, including production control, video control, conversion and video tape. A normal personnel load was approximately 15 people. Four two-ton air conditioners provided climate control for people and equipment. Power distribution was provided by Show Power at the trailer, including 300 amps of 120 VAC for technical and 100 amps of 208 VAC for air conditioning.

For the past five years, the Sony HDC-300 Saticon has been our primary camera for most high definition production. Since the Dylan concert in 1992, we have supplemented the Saticon cameras with Sony HDC-500

CCD cameras when available. It is now possible to fully equip a seven camera, five digital recorder unit with a mix of Saticon and CCD cameras from entirely within North America. Long lenses and fiber systems for long cable runs can still be limiting factors.

The Woodstock operating conditions were not conducive to operating with tube cameras, so we decided to bring additional CCD cameras from Tokyo and limit the Saticon cameras to the more accessible, less critical "Condor" shot on each stage. Most of the CCD cameras, long lenses, camera fiber transmission systems, and several digital recorders were shipped from Tokyo for this event.

### **CONSTRUCTION**

The sheer magnitude of the event placed huge loads on the construction crews and we were forced to wait in line for trailer placement, platform construction and heavy equipment.

We allowed seven days from initial equipment arrival to shoot date including one day for construction, one day for physical assembly, four days for external and internal cabling and one day for testing and integration.

The trailer positioning, leveling, and physical installation of equipment took longer than predicted, especially at the South Stage site but we had pad built into the cabling schedule so we made the deadline.

The power distribution became a problem because of the difficulty of finding enough hardware to support such a big operation. Equipment was ordered from outside suppliers and we received boxes wired with grounds and neutrals shorted and reversed. Simple, "low-tech" problems always cause the most problems.

Hanging fiber between the stages also took more time than planned and impacted our communication ability because the phones followed that path. Walkie-talkies and cell phones saved the day.

### **LOGISTICS**

Because of the large amount of equipment coming from Dallas, New York and Tokyo, it was necessary to build a facility for unpacking large crates and storing them for the outgoing shipment after the event. Woodstock was staged on a farm and there was no warehouse or other facility nearby to serve the purpose, not even a barn, so we had 40 x 40 foot gravel pad built and a tent erected over it. We were very happy to have the makeshift warehouse when the rains came.

Each stage also had a small support unit which served as a maintenance facility and equipment storage room. These were provided by NHK Enterprises, NY and HD VISION.

The difficulty of scheduling use of a large equipment package and the complexity of shipping it though customs required a lot of support from NHK Tokyo. Equipment already in the US for World Cup Soccer, as well as two shipments from Tokyo as equipment became available required us to stagger the installation schedule to accommodate shipping.

Coordinating the delivery and unloading of trucks was also not trivial because the stages were being built and access to the area became more complicated as the crowds began to press closer to the site, looking for free entry.

After the event, the issue became cleaning. The field was so muddy and rank that it was declared a health hazard area and required special protective equipment for the cleanup crews. The fiber and camera cable running through the mud had to be thoroughly cleaned and dried prior to packing. This process took most of a day.

Then the equipment had to be sorted, inventoried and packed into crates or loaded back onto the units returning to US locations.

Finally, the crates were loaded onto trucks for the shipment back to Tokyo.

### **NTSC INTEGRATION**

The high definition production operation at each stage was relatively straight-forward and not particularly unique other than in scope. The most significant aspect of this event was the use of high definition technology along with conventional NTSC production services.

In October 1991, we delivered the first NTSC pay-per-view broadcast from high definition origination. The Sting concert was produced completely in high definition and converted to NTSC for release.

In October 1992, we combined seven high definition cameras with four NTSC cameras in two production switchers to produce another live NTSC pay-per-view event. Graphics and replays were added in NTSC. The director of the Dylan concert was forced to think in terms of two programs and there was much concern about the integrity of the high definition program on tape because of the availability of additional cameras in NTSC. This approach was chosen because of the limitations on the size of the high definition production switcher and the number of cameras available.

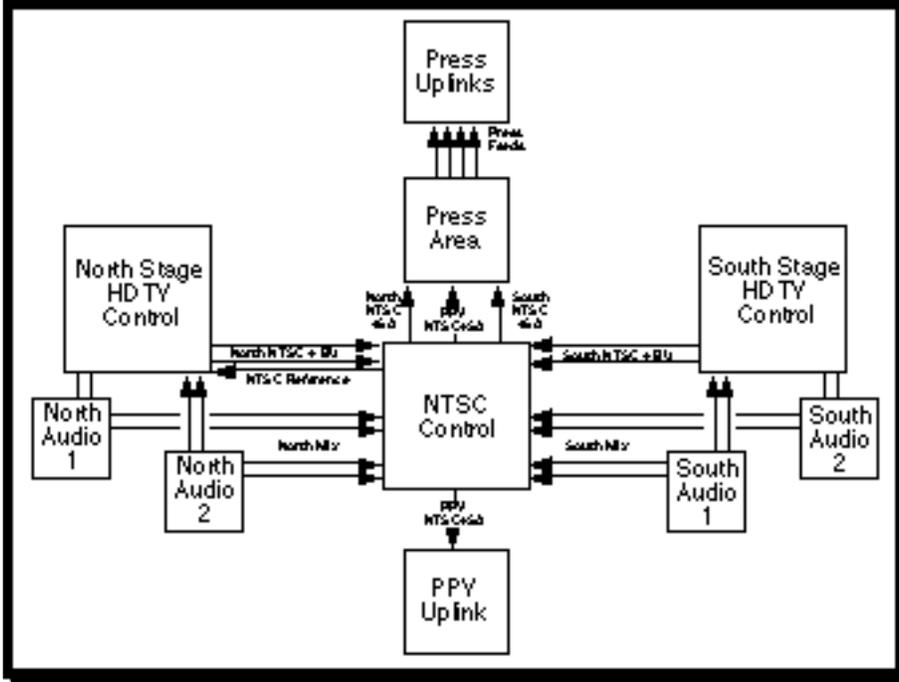


Figure 4. Woodstock Video and Audio Interconnections

Woodstock represents another step forward in our understanding of the role of high definition and NTSC in live events. It provided an opportunity to test a new way of integrating the two media. We were able to essentially divorce the stage production from the program integration by “joining in progress” whichever performance was appropriate at the time. This operation was much the same as a local station with live announcer “cherry-picking” live feeds from a number of networks. This approach obviously would not always work, but it provided a feel for the multi-stage character of Woodstock '94. Figure 4 shows the basic audio and video interconnects for the two stage production facilities and the NTSC integration unit.

The scope of the event caused another problem. Over 200 hours of material would need to be converted to NTSC off-line tapes for the film editors and video editors to select cuts for the after-market products. The estimated time to provide those tapes was considerable, so Polygram asked for additional converters to make NTSC copies of the ISO sources. The NTSC unit then recorded a common “quad-split” off-line tape for scene selection after the event and before the conversions were complete. This also reduced the cost of film conversions for the movie segments.

The large concert venue with video image magnification (IMAG or the video equivalent of public address) presents additional requirements to the high definition that would be trivial in and NTSC production. IMAG is often controlled from a different production site than the main production. The IMAG director may take feeds from the program production, may man additional cameras or may

combine the two. It was not practical to man additional cameras at Woodstock because of cost, access problems, and duration of the event so we were asked to provide additional converters for IMAG use of high definition cameras.

We used the Dynair router at the North Stage and the Utah Scientific router at the South Stage to give each IMAG director his own router bus upstream from a dedicated converter and fed each the output of the program converter and the dedicated camera conversions from his stage.

One issue which always comes up in high definition productions with strong NTSC participation is aspect ratio.

The pay-per-view promoters usually avoid the issue until late in the planning cycle and then object to the simplest solution, letter boxing. Letter boxing uses the entire 1.78:1 area of the high definition image and leaves black bars at the top and bottom of the 1.33:1 image area. Figure 5 compares the aspect ratios and the two most popular conversion options.

There seems to be a common fear in the pay-per-view world that viewers will demand money back on the grounds of “technical problems” if they see black bands. This usually leads to a decision to air the live event in “edge crop” where the sides of the wide screen image are discarded in the conversion process. Of course, the high definition users are then concerned that the director will focus his attention on the 1.33:1 area and not use the wide screen advantage. That usually leads to concerns over how the person switching the selectable ISO will cover the event for post production.

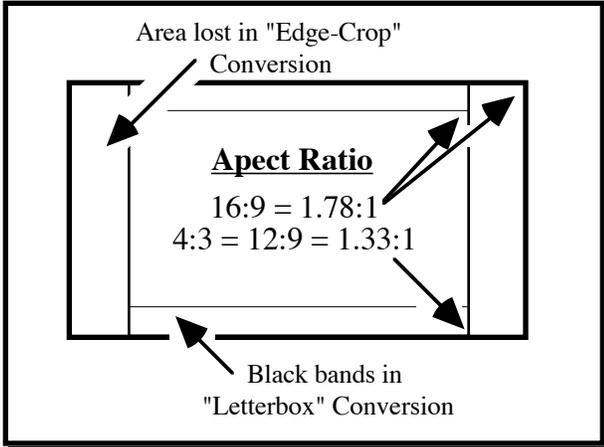


Figure 5. Aspect Ratio Comparison

A settlement was negotiated that not only quieted the concerns, but allowed the pay-per-view broadcasters to test the market in non-prime time and gave the viewers a way of identifying live and delayed broadcasts. The live broadcasts were converted in a compromise 1.56:1 aspect ratio which allowed the under scan on most receivers to cover the black border on the top and bottom. The backup converters ran in letterbox mode and the NTSC D-2 recordings for **Woodstock Overnight** were made from these signals. The **Overnight** replays were made over a stylized background which made the top and bottom area seem to be part of the program, much the same as the sports ticker on CNN Headline News. So the wide-screen format was accentuated to advantage rather than being seen as a drawback. The promoters seemed happy with this approach and even agreed not to complain if we had to switch to the letterbox mode in the live broadcast because of equipment failure.

The use of a conventional NTSC mobile unit allowed the use of all the available bells and whistles for packaging the program, including digital effects, still store, and live graphics.

Transmission was all standard NTSC so was not affected by the high definition production. No high definition was transmitted between the stages.

### COMPATIBILITY ISSUES

Frame rate conversion is still a problem between SMPTE 240M (the 1125-line high definition standard in use today) and NTSC. The commonly-used techniques for dealing with the different frame rates of NTSC (59.94 fields per second [fps]) and SMPTE 240M high definition video (60.00 fps) are both well known and generally effective. Numerous productions, in Japan and in the US, have effectively and efficiently been realized in spite of this incompatibility. Most high definition recorders can playback with some functions at the NTSC frame rate for conversion from

videotape and some converters will operate at either rate, but cameras and production switchers generally operate at only 60.00 fps.

Most current HDTV-to-NTSC converters perform live conversion by discarding one HDTV field every 16.67 seconds. This causes the NTSC video to slowly drift out of sync with respect to the original audio and time code, resetting to in-sync about four times a minute. The actual discarding of a field causes a temporal disturbance than may or may not be objectionable, depending on picture content. Figure 6 illustrates the error buildup and correction inherent in the process. There are now more expensive converters that store multiple NTSC frames and only discard frames when a camera switch or static image occurs. Although this technique removes most temporal disturbances, it allows for even greater slip between the NTSC picture and original audio and time code; and if the converter is fed an isolated camera feed than never switches or stops moving, then the delay between video and audio can build up to the maximum delay of the converter (as much as 30 frames) before a picture drop MUST occur due to an out-of-memory error. The converter delay will then be about one second and can stay that way indefinitely, dropping frames at the same rate as the common converters. Clearly, this approach is unacceptable, so almost everyone is using single-frame delay converters. Even temporal interpolation converters do not resolve the lack of a one-to-one relationship between frames in the original material and in the converted product. This problem can make post production tedious.

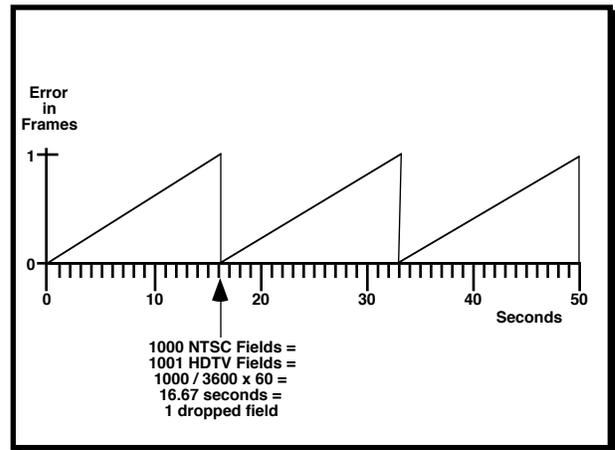


Figure 6. Error Buildup Between NTSC and HD rates

There are other timecode and audio issues in the mixed-mode environment. Not the least of these is the inability to digitally transfer 48 KHz audio from the high definition digital recorders to an NTSC recorder or R-DAT recorder when the high definition recorder is playing at 59.94 fps. (This is the preferred mode for non-live conversions since no frames need be dropped.) Direct digital audio transfer (without sample rate conversion) cannot take place because high definition recorders lock 48.000 KHz audio to the 60.00 fps vertical rate but

NTSC recorders lock 48.000 KHz audio to the 59.94 fps rate.

### THE LIVE EVENT

Music Television (MTV) carried a seven hour segment from North Stage on Friday which we used as a shakedown for the entire system. Woodstock '94 was live for 14 hours on each of Saturday and Sunday and tape-delayed for the overnight segments. The Woodstock pay-per-view feed ran from 11:00 AM on Saturday to 06:30 AM Monday. This schedule was brutal for crews, especially the NTSC Integration teams, which ran in shifts (except for the Producer, who got pretty tired). The live production crew contained several extra people who could rotate through the positions to allow for rest periods and food breaks for all personnel.

Site access got progressively worse as the crowds got bigger. The crews were brought in on busses from the hotel in Kingston (about 20 minutes away under normal conditions). On the performance nights the trip back to the hotel took about two hours. Several of the technical crew slept on site to do minor maintenance and still got more sleep than most of the crew.

The environment in the control rooms was not too bad, and although dirt generally reduces the life of tape heads, we did not see any immediate effects of the dirty environment. The air conditioners were well used both to reduce the effects of heat and to dehumidify once the rains came. August can be a fun time in North America: 90+ degrees one minute and then soaking wet.

Rain was an annoyance but we were prepared, so while the rain dampened the crowds, it had no direct impact on any equipment. The resulting mud caused us more problems than the rain. The cameras all fared well with one exception. At different times, both stages were subjected to mud throwing, rowdy, crowds in the "mosh pit" in front of the stage. The cameras were pretty well protected so recovery usually consisted of pulling the camera in and cleaning the front of the lens. One of the less responsible groups on South Stage convinced the crowds to throw mass quantities of mud at the stage, to the point where the entire stage, including the dolly, had to be washed down before the concert could continue. Somewhere in the washing process, proper grounding prevailed and a ground fault took down a camera head. It was replaced with a spare and the show went on.

The cranes provided an overview of the crowds that was at times overwhelming. The sea of mud, tents, lawn chairs and wet people was amazing. It was quite a test of the reliability of the equipment.

Woodstock '94 consumed 250 hours of digital video tape for more than 35 hours of performances by 30 major groups, not including the MTV show on Friday.

The television and audio production crew totaled 223 people of which 28 were specific to high definition. Probably half of the 28 would have been required even if the stage performances had been shot in NTSC, so the personnel overhead for the high definition production was approximately 6%.

### CONCLUSIONS

(Opinions included here are strictly those of the authors and do not necessarily reflect those of NHK or other participants in the Woodstock project.)

The HD/NTSC hybrid approach can actually simplify the high definition operation and make it more practical to originate in high definition by moving the bells and whistles items often used in live production to the NTSC domain until they are readily available in the high definition format. What remains is a clean program suitable for post production.

As HDTV/NTSC productions become more common, it would be very helpful if the NTSC and HD equipment could both be operated at the NTSC vertical rate. Because of the compatibility concerns described above and other, more subtle effects, the authors of this paper suggest that all future high definition television equipment be designed to operate at both the 59.94 fps and 60.00 fps vertical rates. This would eliminate most of the frame-rate problems. We think that the manufacturers should provide modifications for existing equipment to support either rate.

The retention of both 59.94 fps and 60.00 fps compatibility would allow the transition to high definition production and broadcasting to be less stressful, and less expensive. Production expenses would be reduced because it would be easier to mix high definition and NTSC equipment when appropriate. The Grand Alliance has recognized this need and has included both frame rates in the proposed broadcasting standard, although it is not clear whether production-equipment manufacturers will officially endorse the concept and support it in the marketplace.

There is a need for integration of digital audio among HD, NTSC and multi-track facilities without complex standards converters. The next generation of HD recorders should allow for 48.000 KHz audio rates at 59.94 fps to allow for live NTSC conversion with integral frames and direct audio transfer.

High quality, widescreen, live production for multiple release formats is alive and well and the next few years will prove to be very interesting.

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Our whole crew - the best HD guys in the world, from around the world.

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