THE ProHD REPORT

The future of HD ENG ...
... delivered today.

Live Remotes

First-to-Air

High HD Quality

Operational Flexibility

News Archive

Very Affordable

http://pro.jvc.com

This Report, promoting JVC's highly cost effective ProHD ENG acquisition format, is directed towards:

- **TV Station General Managers**
- **News Directors**
- **Engineering Directors**
- **Group Station Executives**
- **TV Network O&O Executives**

This Report informs the TV broadcast community of the emerging operational and technical issues facing local TV news in transitioning to HD ENG, and how JVC's ProHD format and products are delivering highly economical and professional HD solutions to TV stations in 2007.

JVC

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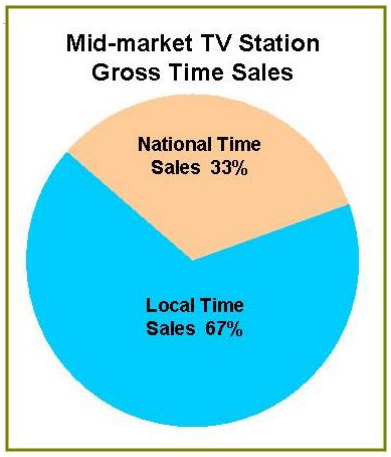
IMPORTANT: This ProHD Report has been authored by nordahl.tv LLC on behalf of JVC Professional America for publication at the NAB-2007. Competitive specifications stated herein are believed to be accurate at time of writing. Readers of this Report are encouraged to contact other sources including other manufacturers to obtain the latest specifications, as well as points of view and analysis other than those presented and concluded in this Report. **Trademarks:** All company, product and systems names and trademarks found in this Report are the sole property of their respective owners.

The Future of HD ENG … is now

Local, national, and worldwide television news must have the capability to go live on the air with the late-breaking news, with live pictures from the remote site, and, when appropriate, live interviews between the news anchors and the field reporters. Whether from ENG helicopter, ENG van, handheld or shoulder-carried, instant wired or wireless delivery of news to the TV station with HD quality is an absolute necessity for local TV news success.

Although more and more television news will be accessed on portable devices with limited resolution, TV stations' primary outlet will remain the millions of home viewers who demand HD quality content to be displayed on their HDTV sets. Content is king, but the audience ratings victor will be the TV station with the best live news images day after day, as we can assume that, in the news business, the TV stations in the same market deliver more or less the same news stories. **Differentiate your station from the others, be the first with HD news in your market, and do it economically, before the other stations do.**



Strength of local news is critical to generating local time sales. HD news and HD ENG obviously make your local market position stronger.

The competition for eyeballs is fierce, and expected to get even more competitive over the next several years, as cable, web-based and mobile video news services develop, causing local TV advertising dollars to consider moving to newer electronic media. As a TV station having done news for years, you already have the necessary base infra-structure from which you can launch your HD market attack, to increase your audience share for news and, indirectly, for day-time and prime-time programs. **Let's agree: Just as network programs lead-in and build your local news audience, great local news broadcasts will lead-in and build audience for network and syndicated programming, as your popular local news talent may promote your prime time and syndicated shows.**

Are you offering video ads on your TV station website? Increase your local news audience and your website visits increase, which in turn may get you a lot more website ad revenue. Local HD news is again the key to profitability. Extended coverage of community affairs, local events and public relations in HD support audience gains.

The objective of this Report is to give the reader, whether in engineering, news, production or executive management, a solid foundation upon which to make the best decisions in the transition from SD to HD ENG news.

You want higher audience share for your newscasts, because that is the way to higher profitability. And, similarly, you want lower cost of investment and operations. In simple terms, higher audience share for local newscasts is a competitive function of content, talent and presentation, let's say, in equal measures. **The competitive advantages for the #1 TV station for news in a given market are usually small, supporting an attack (or defending an attack) using new cost effective HD technology must be considered to be part of any larger competitive strategy.**

But HD audience is still small compared with SD audience. Why worry about HD News in 2007? This is exactly your dilemma. If you delay the HD news transition, you run the risk that your station will fall behind the other stations in your market, causing you to be on the defensive. Be assured that the other stations in your market are evaluating if not already planning or even implementing HD news right now. You really need to look at HD News in 2007, and make your decision to start on the HD track from a fully informed position.

The New Economy of Local News

In a Top-20 TV Market, it takes serious consideration and guts to justify investing in HD news and HD ENG equipment less than top of the line. But if you are not in the Top 20, should you not look at the possibility of using ProHD camcorders in a studio configuration, or should you as well just select from the traditional and very expensive HD studio camera offerings?

HD News Stations – March 2007
Source: Broadcasting & Cable

KABC	Los Angeles
KARE	Minneapolis
KING	Seattle
KLAS	Las Vegas
KOMO	Seattle
KPNX	Phoenix
KSDK	St. Louis
KTVD	Denver
KTVU	San Francisco
KUSA	Denver
WFTV	Orlando
WJW	Cleveland
WKYC	Cleveland
WNBC	New York
WPVI	Philadelphia
WRAL	Raleigh-Durham
WRAZ	Raleigh-Durham
WSB	Atlanta
WTHR	Indianapolis
WTXF	Philadelphia
WUSA	Washington
WXIA	Atlanta
WXYZ	Detroit
KAZR	Reno
KRNV	Reno
KREN	Reno
WABC	New York
WLS	Chicago
WFAA	Dallas
KTLA	Los Angeles
WFTV	Nashville
KGO	San Francisco
WEWS	Cleveland
WRDQ	Orlando, Fla.
KFMB	San Diego
KHOU	Houston

With the new economic realities in local news, where perhaps total audience has been declining and ad dollars are being shared with other forms of commercial delivery to the home, your station must explore all seemingly viable HD news technology options, where the immediate and long term goals are optimum ROI and profitability. **And don't forget flexibility**: If your station spends $5 million on HD news transition in 2007, you probably have to live with that decision for many years before additional capital becomes available. However, as an example, if you spend "just" $2 million, you may "buy" flexibility to adjust and re-direct as you experience the new realities of the local news economics as your local market dynamics change over the next several years.

The promise of JVC's ProHD is to allow any TV station to transition to HD ENG particularly (but also in other areas of HD news) quickly and highly cost effectively, while providing the professional performance and features expected by TV broadcasters. Here is a small example of the differences just in the HD camcorder pricing, between the leading manufacturers (lenses not included, approx. list price as of March 2007), **with features supporting HD ENG including pool feed, HD-SDI and (relatively) low compressed HD bitrate (excluding HD camcorders with legacy HD CODECs):**

		Compressed HD bit-rate
JVC GY-HD250U	$ 9,995	20Mbps
Grass Valley Infinity DMC	$ 23,000	50 or 75Mbps
Sony PDW-F350	$ 25,800	18 or 25 or 35Mbps
Panasonic AJ-HPX2000	$ 27,000	50 or 100Mbps

Later in the Report, we will analyze in-depth the related cost issues, which will show a remarkable cost advantage for the ProHD ENG system, and show how ProHD can in fact outperform the competing systems overall, in microwave, ENG Van, ingest, editing and archival issues.

Once you decide to go HD news, then equipment selection is governed by the products available (and working in a system) at that time. With the ever advancing state of the consumer electronics technologies and the availability of consumer HD camcorders for less than $2,000, and semi-pro HD camcorders for less than $3,000, it is even more essential that your local news presentation to your home audience be HD, and very soon. But it is difficult to justify spending $40,000 or more each for professional HD ENG camcorders with lenses for the news department these days. This Report may clarify this and other choices for your management team, and, perhaps, be great news for your CFO.

The Demographics of HD Audiences

To the TV Station GM, pretty pictures are nice but does not necessarily drive audience share and commercial demand. Numbers are needed, to convince top management that HD news investments are an essential strategy for market growth. A number of surveys have been conducted in 2006, with some very powerful market data and desirable demographics for advertisers:

- In households with annual income less than $50,000, only about 8% currently own a HDTV.
- In households with annual income over $50,000, nearly 30% currently own one or more HDTV.
- HDTV households with higher education levels are in higher income brackets, and generally watch news more than others, largely prefer news in HD.
- About 60% of all HDTV owners are sports fans, thus, presumably, would be eager to watch the HD local news and the sports reports.
- HDTV households rate as important to view national and local news in HD.
- Younger HDTV owners are affluent, sports fans, and not afraid of spending their money.
- Older HDTV owners are affluent, obviously not afraid of spending on high tech and worth-while products and services.

Value of Demographic Segments

In a survey made in 2003, commissioned by a major TV network, time sales professionals rated the extremely valuable demographic segments in the following order (with our addition about the likely HDTV viewing and purchase ability):

1) Baby Boomers (current age 42 – 60) --- Want HDTV, can afford it
2) Generation X (current age 31 – 41) --- Want HDTV, can afford it
3) Seniors (age 55 – 64) --- Can afford it, thinking about it
4) Generation Y (current age 10 – 30) --- Want HDTV, but lower priority
5) Seniors (age 65+) --- #5 for a reason

Couple this with the fact that audiences watching local and national news are on average 45 to 50 years old (not generation Y), your TV station's quick transition to HD news support an early improvement in local news audience ratings.

News Delivery in SD & HD

The NTSC Transmitter Chain vs. ATSC:

When we look at the direct over-the-air TV transmission from a TV station, we know that the analog NTSC transmission chain is the major limiting factor in the picture quality delivered to the home, all other quality factors of the (SD) viewing chain being of optimal (SD digital) quality.

	H Resolution	V Resolution
NTSC TX	331 TVL/PH	338 TVL/PH
ATSC TX of up-conv SD	535 TVL/PH	338 TVL/PH
ATSC TX of HD	873 TVL/PH	756 TVL/PH

Source: CBS Technology 1997

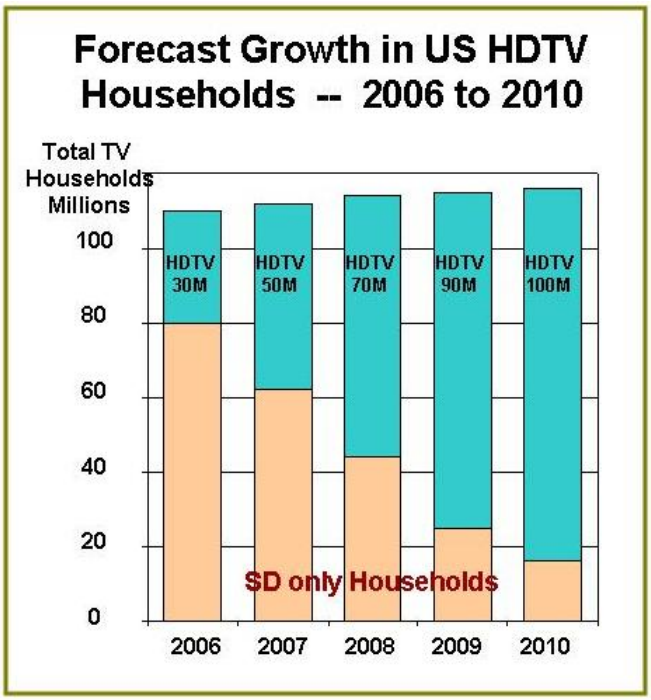
It is interesting to note that SD video of highest quality has the opportunity to be presented as a higher resolution image through the ATSC OTA (over-the-air) chain than the same video delivered through the NTSC OTA, whether SD or as up-converted HD ATSC encoded. Also, it is interesting to note that a high quality digital home (SD only) TV set has the opportunity to present the SD video at a higher resolution by using an ATSC set-top tuner box with the SD output than receiving the same SD signal over the NTSC OTA chain. **A TV station must convert to a complete HD chain in order to be picture quality competitive in the future.**

Home Audience Presentation vs. Audience Share:

The most important potential difference between SD and HD is the large screen viewing experience of the home audience, where the HD image offers up to 6x the resolution of SD, with little or no change in the viewing distance. There can be no doubt that the HDTV household will migrate to watch real HD programming when available, assuming acceptable content and talent. (Many years ago during the color TV transition, some people refused to watch B&W programs on their new color TV, desirable content or not!)

What about the home audience transition to HD? Consumer market research firms estimate that about 90% of the 110+ million TV households in the US will be HDTV households, or about 100 million, by end 2010. By end 2006, there were approx. 30 million HDTV households.

Remember the DTV sets sales statistics? CEA counted DTV sets, which included 480p capable TV sets, instead of just real HD sets. But now, nearly all purchases of DTV sets are real HDTVs, so no need to worry about the breakdown.



Let's use some round numbers to illustrate the audience share opportunity:
By end of 2007, approx. 45% of all TV households will have HDTV capability, growing to over 90% of all TV households at the end of 2010.

We use the following simplistic assumptions:

- Major local market offers 5 TV stations with major newscasts
- All stations share audience equally, for 20% for each station (5x 20% = 100% of the audience for all the newscasts)
- One station initiated full HDTV news operations, to be the only station with HDTV news in 2007
- 45% of the total audience will have real HDTV capability in 2007

If there is only one TV station in the market converting to full HDTV newscasts in 2007, that TV station has an opportunity to capture that part of the audience having HDTV viewing capability, to theoretically possibly increase its share by up to 45%, from 20% to 65%, if all viewers with HDTVs tuned in to the only HD newscast in town! This, of course, will never happen, but it certainly would be a significant audience increase, as surely a significant share of the 45% with HDTVs would tune in the only HD newscasts.

Early bird gets the worm. If you're in local news, the time to transition to HD news is 2007 and protect your local competitive position.

The Reality of the Wide Screen

The SD (NTSC) standard aspect ratio is 4:3 (1.33:1) while the HD (ATSC) aspect ratio is 16:9 (1.78:1), presenting a formidable challenge to broadcasters as they must maintain delivery to viewers of 4:3 services while transitioning to HD providing 16:9 wide screen service. Screen Viewing Area comparison between SD 4:3 and HD 16:9 at equal Picture Height, indicating that 16:9 viewing area is 1.3x larger than 4:3 area. Of course, equal picture height is not the norm as the consumer will nearly always replace the SD TV set with a HD TV set with a much larger screen.

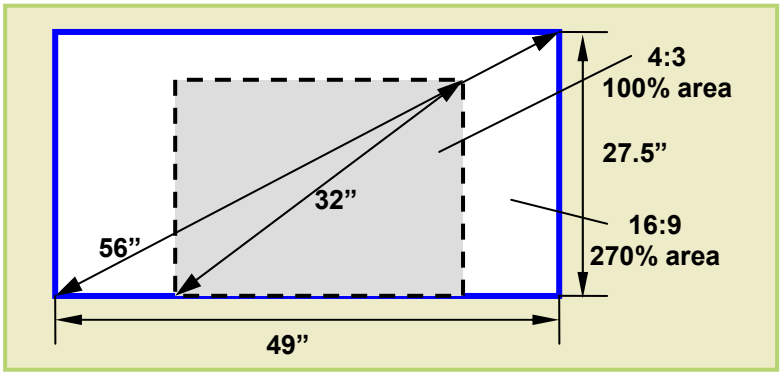


Fig. 1: Screen Viewing Area comparison between a 32” SD 4:3 TV set and a 56” HD 16:9 TV set, indicating that 16:9 viewing area is nearly 3x larger than the 4:3 area. Viewing distance is the same.

If we expand the exercise of Fig. 1, considering the most popular sizes of larger SD direct view TV sets (from 25” to 36”) and the most popular of the new HD TV sets (from the 37” flat LCD to the 62”+ rear projection D-ILA/DLP), we’ll find that we can use a viewing area comparison factor of 3x for the living/family room environment with the assumption that the viewing distance has not materially changed. **In other words, the average home audience screen viewing area increases 3-fold when the SD set is replaced with a HD set. (The 25” 4:3 SD set may be replaced by a 50” 16:9 HD set/monitor; the 32” SD with a 56” HD, and so on as perhaps an average.)**

An important observation is that high (broadcast) quality SD originated programming up-converted to HD is nothing more than high quality SD when displayed on a HDTV set, and as such is insufficient to create a real and total HD viewing experience. (Even when using a top quality up-converter.)

The Reality of 6x the Image Resolution

The SD digital video frame of 720x480 equals about 340,000 pixels, while the HD frame of 1920x1080 equals about 2,074,000 pixels, a multiple of about 6. We can introduce the old **Kell factor for viewing of interlaced TV signals**, where, depending on program material (fast or slow motion, much or little detail, bright or dim scenes), Kell says that maximum perceived viewer resolution is only 50% to 70% of interlaced program/display resolution. Kell is applicable to both SD and HD interlaced video. 1280x720 is the progressive ATSC format with an HD frame of about 921,600 pixels, but occurring 60 times a second, and substantially unaffected by the Kell factor because it is progressive. The 1920x1080 raster happens only 30 times a second, really as 60 fields per second each field being 1920x540. Also, remember that all HD encoding intended for "last mile" consumer distribution (like ATSC OTA and cable QAM) is at 4:2:0 sampling or total effective delivered "live" pixels to the HDTV display is 1.5 times luminance pixels. Now, look at total number of effective/perceived maximum pixels per second being presented to the home viewer, based on the Kell/Interlaced factor of 70%:

1280x720p60 x 1.5 = 83 million "effective maximum presented" pixels/sec (no Kell reduction because progressive)

1920x1080i60 x 1.5 (x70%) = 65 million "effective maximum presented" pixels/sec (after Kell/Interlaced factor: 70% of 93 million)

720x480i60 x 1.5 (x70%) = 11 million "effective maximum presented" pixels/sec (after Kell/Interlaced factor: 70% of 16 million)

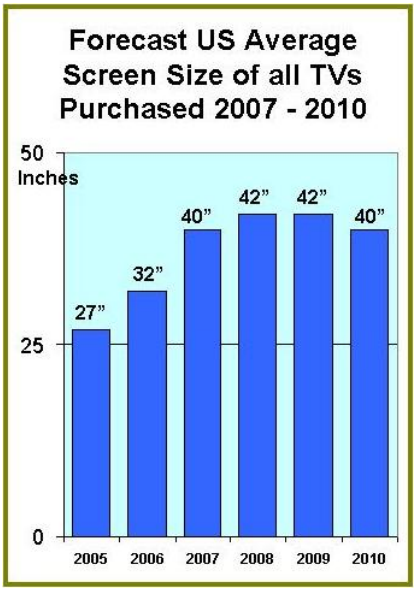
The above figures imply that the 1280x720p60 images appear to be 7.5 times the perceived temporal resolution of interlaced SD, while the 1920x1080i60 images are, as we stated above, 6 times the temporal resolution of interlaced SD.

We note that the ProHD native acquisition format is full bandwidth 1280x720 at 60 frames progressive in the GY-HD250U model.

Through the years, a number of surveys have concluded that the average TV viewing distance in the typical North American home is 9 feet. Assuming that the home viewer is experiencing optimum SD image quality and resolution (but not seeing lines or pixels) on his current SD TV set, the home viewer, when the SD set is replaced with a HDTV with 3x the viewing area placed in the same location, can potentially "experience only" twice the SD area resolution per measure of viewing angle with 1920x1080 interlaced (6 divided by 3 = 2) while 2.5 times with 1280x720 progressive (7.5 divided by 3 = 2.5). In other words, the viewer may then move closer to the HD set (reducing the viewing distance) to a distance just before lines or pixels are visible.

The real selling point of HDTV is now obvious to all of us: It is the much larger TV screen and the ability to reduce the viewing distance, resulting in the home audience' ability to immerse themselves in the TV viewing experience. And the optimum home display format for TV broadcast seems to be 1280x720p60.

The HDTV for the masses (Home Audience)

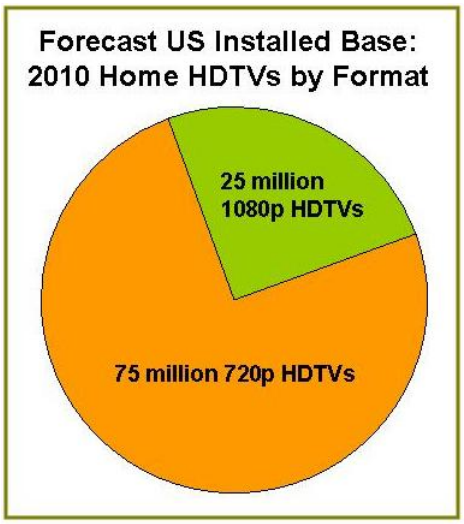


In 2006, the average screen size of all TV sets (SD and HD sets) purchased increased to 32", from 27" in 2005 (and 2004). This was no doubt caused by the sudden increase in the purchase of true HD televisions, pulling up the average by the larger displays, particularly large increases in the flat LCD TV category, which in 2006 were largely in the range 32" to 37" screen sizes. We forecast that the average screen size in 2007 will again increase significantly, perhaps to 40", as the larger screen sizes are reduced in price through the year, and the sales quantities of the 40" to 50" sizes increase proportionally more than the sales quantities of the under 40" types. However, a slowing of the increase in average screen size happens in 2009 and a possible slight decline in 2010 when the large portion of HDTVs purchased is again in the range of less than 40" driven by "middle-to-low-income household purchases".

The first question is: Is the average home viewer able to perceive a higher temporal resolution at the average screen size of 40" if the material supplied was 1920x1080i60 rather than 1280x720p60, even TV studio originated material? We believe not, not even at 50" screen size except for a very few "professional viewers" .

The second question is: What is the forecast unit sales breakdown between HDTVs having 1280x720 native pixel matrix (including the related 1366x768) and the 1920x1080 native pixel matrix?

It becomes a selling price issue. Right now (March 2007), the lowest price for a 42" flat LCD HDTV with native 1366x768p60 is about $1,400 for a major brand model, while the 1920x1080p60 sells for about $1,900. The off brand 1366x768 progressive models are now heading for less than $1,000.



Forecasters recently have projected that about 35% of all HDTVs sold worldwide in 2010 will be 1080p models, and implying that the percentages in the years leading up to 2010 obviously are less. Let's project that, of an installed base of 100 million HDTVs in the US by 2010, about 25% will be native 1080p HDTVs and about 75% will be native 720p. **It's a HDTV selling price issue**, where it's likely that the 720p models will always be around 30% less expensive than the 1080p models.

What about native 1080i displays? Sorry, all new HD display technology is progressive, thus there will likely be next to zero (0) native 1080i HDTVs in US homes by 2010.

What will 1080p do for TV broadcast local news?

An ATSC OTA (over-the-air) 720p60 transmission will hit the built-in tuner, decode internally to uncompressed 720p and then "up-convert" to 1080p60, resulting in true reproduction of the 720p60 images, for stunning TV station news studio shots, as well as HD ENG shots with the ProHD format.

An ATSC OTA 1080i60 transmission (note interlaced, as there is no 1080p60 path available or contemplated in the ATSC OTA path) will hit the built-in tuner, decode internally to uncompressed 1080i, and then "de-interlace and cross-convert" to 1080p. It is very technically challenging to convert HD interlaced to HD progressive, and, although the resulting HD video displayed will generally be very good, there is the possibility that artifacts may be visible to a trained eye, particularly HD ENG shots in 1080i which has been through several stages of processing, editing and color-space conversion.

So, what is the purpose of 1080p displays, if broadcast 1080i will not look better than 720p to the majority of viewers?

Its for HD-DVD, Blue-ray Discs and Games, once these media are produced and encoded at 1080p24/p25/p50 or p60. The home audience may at that time experience a perceived temporal resolution higher than that of 720p and 1080i.

The EBU and BBC testing and considerations:

In 2004, EBU recommended the use of progressive scanning throughout the acquisition and delivery chain. There was one overriding logical fact driving this decision: CCD and CMOS imagers are progressive devices (although we can electrically operate them in interlaced mode) **and** all future consumer displays will be of native progressive design (rear projection, front projection, plasma, flat LCD etc.) Why throw away temporal resolution and compression efficiency by making the digital intermediate processes and distribution in an interlaced format.

The European desire: Let's be progressive from glass to glass.

BBC tests concluded that the average home viewing distance in the typical UK home is also about 9 feet. At that viewing distance, with a 50" HD monitor, it was clear in these BBC tests that a 1280x720 image would saturate the human eye with details, thus to increase the acquisition, the delivery resolution and the monitor resolution to 1920x1080 would not increase the perceived resolution by the human eye.
It was noted that if the monitor was significantly larger than 50" at the same viewing distance, or the same 50" monitor at a significantly lesser viewing distance, an entire acquisition delivery chain of 1920x1080p50 would indeed improve the perceived resolution by the human eye, or, to say it differently, prevent the viewer from seeing "lines or pixels" in a 720p chain. Although the European decision is progressive, there are now planned several 1080i services, including BBC. But in the question between 1080p or 720p, the added costs in all areas of acquisition, processing, delivery and display in 1080p are NOT justified at this time, the Europeans conclude.

Your most cost effective local HD news equipment investments will be in the 1280x720p60 format area.

It is clear: About 75% of the US HDTV audience will be watching on 50" displays or smaller, and with a native resolution of 1280x720 (or the related 1366x768), and be 9 feet from the screen as an average, from now through 2010. The long term cost effective HD format choice for HD ENG & news for a TV station is 1280x720p60, even if you are a "1080i TV station". 720p converts beautifully to 1080i going into master control. The ProHD format is very well suited for great looking, economical HD news from the field.

The TV Station-to-Home Delivery Chain:

The shortest path between two points is a straight line! That says it all. The ATSC delivery over the air directly to the home ATSC receiver (whether STB or built-in) is the highest quality consumer level HD delivery available, bar none.
Not even the emerging HD-DVD and Blue-ray may be as good, with all its multi-generational processing, when compared with a TV stations live HD studio camera shots sent over the air directly to the home viewer's ATSC HD set.

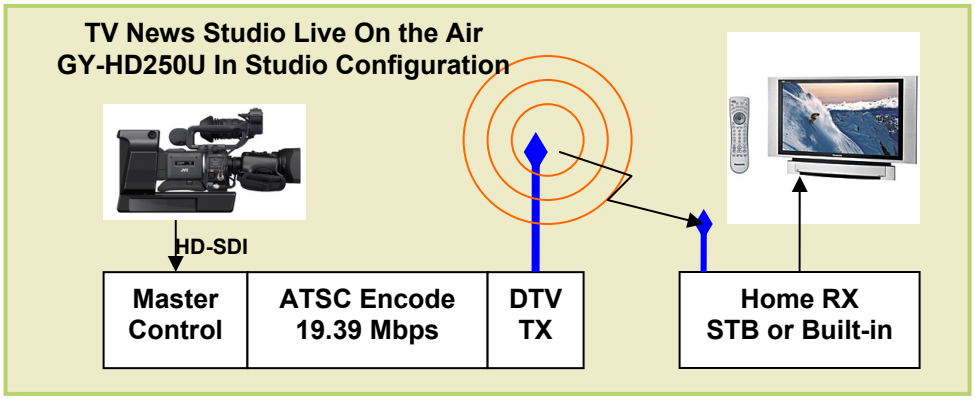


Fig. 2. Local HDTV News can bring the highest image quality of any delivery system to the home audience. The ONLY lossy stage from the live HD camera output to the home HD display input is the ATSC codec process. A great opportunity!

A live news studio HD camera supplying HD-SDI through master control directly to the ATSC encoder, then linked to the transmitter, 8VSB modulated, and beamed to the home without any server compression, with no video tape generation loss, no contribution chain artifacts. Only encoded once with ATSC!

When is the right time for HD News for your TV station?

The following two statements have a high probability of being true:

Your TV Station will **gain audience share** by the transitioning to local HD news at an early time

Your TV Station will **lose audience share** year by year if you wait to do local HD news until 2010

We think you ought to spend significant efforts in 2007 to seriously investigate your TV station's options by in-depth analysis of the financial implications in each year from 2007 through 2010 by (a) going to HD news and (b) not going to HD news. In the end, we believe that earlier is better than later, and that 2007 will be a good year for starting your transition to HD ENG and HD news.

Winning more viewers … with ProHD

The purpose of this Report is to expose the virtues of ProHD, a highly cost effective HD ENG camcorder and acquisition system, enabling any TV station to quickly and professionally convert a current ENG work flow to HD ENG.

The name of the game for TV stations is winning more viewers. And for most stations, that means getting more eyeballs for the local news casts. And to do it cost effectively. Increase the top line, control expenses and increase the bottom line. With less than two years to go to the NTSC turn off in February 2009, and with the consumer HDTV purchases accelerating, going to HD news and HD ENG must be a major part of any TV station's strategy in winning more viewers. The SD status quo is no longer acceptable.

High Quality = Full bandwidth HD

JVC's ProHD is the only cost effective HD camcorder system with full native bandwidth performance: 1280x720p60. Why is that important? The ProHD format requires an absolute minimum of pixel conversions as it maps the ATSC 720p60 4:2:0 transmission pixel for pixel. No other HD camcorder format can do that unless you pay many times the price of the ProHD ENG system. Here is a list of ALL HD camcorders available or announced with full ATSC native IMAGER acquisition bandwidth, intended for HD ENG or HD EFP for local television (March 2007):

HD Camcorder Model	Native ATSC IMAGER acquisition	Approx US list price without lens	Comments
JVC ProHD GY-HD200U	1280x720p60	$ 7,995	Shipping now
JVC ProHD GY-HD250U	1280x720p60	$ 9,995	Shipping now
Grass Valley Infinity DMC	1920x1080i60	$23,000	Shipping Summer 2007
Panasonic P2HD AJ-HPX2000	1280x720p60	$30,000	AVC-I shipping Summer 2007.
Ikegami HDN-X10	1280x720p60 1920x1080i60	New price at NAB	Shipping now?
Sony HDCAM HDW-730	1920x1080i60	$50,000	Shipping now (for many years)

Fig. 3. This table shows ALL HD camcorders below a US list price of about $50,000 (without lens), able to acquire natively in an ATSC format without bandwidth limitations in the camera front end. The newly announced Panasonic AG-HPX500 offers only a sub-HD imager of 960x640p (approx., full ATSC progressive bandwidth is 1280x720p) and the one year old Sony XDCAM HD offers 3xCCD imager of 1440x1080i (full ATSC interlaced bandwidth is 1920x1080i).

ProHD offers pixel-for-pixel ATSC compliancy from acquisition to home viewer HD set, because the GY-HD250U includes a full count 3xCCD pixel matrix according to the ATSC table, without bandwidth pre-filtering before or within the camcorder's built-in encoder, resulting in a full bandwidth compressed HD at only 20Mbps, a bitrate very advantageous for HD ENG. And the ProHD camcorder is only $9,995 (US list), or 30% less than the new Panasonic HPX500 price with the dated 100Mbps DVCPRO-HD compression not suited for microwave, or less than one-half of the GV Infinity price, or, incredibly, one-third of the new Panasonic HPX2000 price.

The 2007 HD news transition is about the realities of local news economics, the ability of seamlessly adapting HD ENG into your current work flow, and to preserve your options beyond 2007 to respond quickly to your local market dynamics and competition.

Live HD Remotes = 2GHz BAS Relocation

Local TV news success and audience growth mean lots of Live HD Remotes, which spells 2GHz BAS relocation. **What is 2GHz BAS relocation?** Simplistically, it is the FCC-mandated relocation of the current licensed broadcast microwave band from 1990 - 2110 MHz to new channels in the 2025 - 2110 MHz band. The seven current 17 and 18 MHz channels will be migrated to seven new 12 MHz channels, thereby saving about 35MHz of spectrum for other (non-broadcast) use.

But new digital microwave technology often utilizes COFDM multi-carrier transmitter, which enables non-line-of-sight links (multi-path) in metro areas and in special events coverage, coupled with a QAM modulation scheme. Cable television is using 64-QAM and 256-QAM on single carriers to pack hundreds of SD TV channels (and some HD channels) on one coaxial cable. The higher the QAM number, the higher the bitrate transmission capability over a given bandwidth, but, as the QAM number is increased, the receiver input requires an ever stronger signal (higher SNR) to reliably decode the modulation. **It is a trade-off between higher bitrates and shorter distances in the HD ENG microwave world**. 256-QAM is easily done through a fiber or coaxial cable, as it's a controlled wired transmission medium, but 256-QAM is very difficult in HD ENG wireless applications, as microwave camera-backs don't have enough TX power and need to use omni-directional whip antennas for the camera-back TX unit as well as for the RX unit (a requirement for dynamic multi-path "roving" performance), generally resulting in unreliable link for 256-QAM.

JVC ProHD Camcorder with BMS cost effective Microwave Camera-back

Fig. 4. JVC's ProHD ENG camcorder fitted with BMS 2GHz microwave camera-back unit. The BMS camera-back accepts the compressed MPEG-2 TS (Transport Stream) of 20Mbps, modulates 16-QAM and transmits COFDM over 8MHz bandwidth for roving robustness in HD ENG, sports and EFP applications. This space saving ProHD package offers excellent weight distribution both for shoulder-use and for hand-held.

From 18MHz channels down to 12MHz? The 2GHz BAS relocation reduces channel bandwidth to 12MHz. Can 12MHz do the job? For SD links, 12MHz is ample bandwidth. There is even industry talk of being able to provide reliable two channels of 6MHz each within the 12MHz channel for SD service. But with COFDM, you run into a problem called "spectral regrowth" of the large number of carriers within a single channel with COFDM transmission, causing adjacent channel interference due to the out-of-channel spectral regrowth. The solution is to limit the actual COFDM bandwidth to 8MHz within the 12MHz channel, providing for guard bands of 2MHz on each side. Thus the effective COFDM/QAM channel bandwidth becomes only 8MHz in the relocated 2GHz band (referred to as 8MHz pedestal), with the following performance limitations:

MODULATION	Max Bit Rate 25MHz	Max Bit Rate 12MHz	Max Bit Rate 8MHz	Carrier-to-Noise Threshold
QPSK	32 Mbps	17 Mbps	**10 Mbps**	**10dB**
16-QAM	64 Mbps	30 Mbps	**21 Mbps**	**17dB**
64-QAM	65 Mbps	46 Mbps	**31 Mbps**	**23dB**

Fig. 5. Table shows approx. max bitrates for microwave channels with 25, 12 and 8MHz bandwidth, using COFDM and QPSK/QAM modulation schemes. 2GHz BAS relocation provides for new 12MHz channel width, but recommends 8MHz "pedestal" digital modulation bandwidth when using COFDM due to sideband re-growth adjacent channel interference. Note the 21Mbps in the 8MHz column. ProHD's MPEG-2 TS (Transport Stream) over 1394 is 19.7Mbps, the only HD camcorder able to supply a TS within the 21Mbps limit for reliable 16-QAM link performance through the 8MHz pedestal 2GHz bandwidth.

The table above gives typical guideline numbers. There are several numbers of modulation variables including Code Rate/FEC and Guard Interval, coupled with maximum transmitter output power in various modes, to ultimately determine reliable range under specific live remote conditions.

JVC's ProHD GY-HD250U & HD200U are the only HD camcorders (bar none, as of March 2007) capable of delivering a broadcast quality full bandwidth 1280x720p60 compressed TS out over 1394 at a bitrate of less than 21Mbps, enabling robust 16-QAM microwave link performance over 8MHz bandwidth.

First-to-Air = Easy Microwave

In addition to the HD camcorder-to-ENG Van microwave link, the TV Station must even more importantly consider how to cost effectively and easily accomplish the HD microwave link back to the TV studio from the ENG Van, as this is an essential service every day in the First-to-Air quest. Again, ProHD provides an easy solution through the ability to interface and use many existing ENG Van-to-Studio links.

The key is the presence of an existing ASI input in the current digital microwave transmitter in the ENG Van, accepting a compressed MPEG-2 digital video signal within the ASI interface format. The Super Encoder in the ProHD camcorder provides a very high quality compressed HD transport stream through a 1394-to-ASI Bridge to the microwave transmitter/modulator, eliminating the need to purchase a new HD encoder or to purchase a whole new microwave transmitter with a (expensive) built-in encoder.

Can you use your existing ENG analog microwave? If your existing ENG Van microwave transmitter is of the analog FM modulated kind, you may be able to use it for HD ENG by adding a digital-to-analog transcoder unit with ASI input and baseband output to existing ENG analog transmitter. Nucomm offers the "Analog Coder System" consisting of a modulator for the ENG Van and a demodulator for the fixed station or studio. The Analog Coder uses 8VSB modulation and is capable of up to 25Mbps in a 12MHz channel, sufficient for the ProHD 20Mbps TS. However, under the BAS Relocation program, the existing ENG analog microwave is replaced with a new digital microwave at no cost to the TV station, except for optional HD capabilities.

The built-in HD Super Encoder performs comparable to a stand-alone broadcast quality HD MPEG-2 encoder costing upwards of $30,000, yet the complete ProHD camcorder (GY-HD250U) carries a US list price of just $9,995 (without lens). This testifies to JVC's broad experience in video CODEC design. Just look at the 1U rack mountable HD MPEG-2 broadcast quality encoder DM-JV600U – US list $29,999.

How do you get the 20Mbps TS from the ProHD camcorder to the ENG Van?

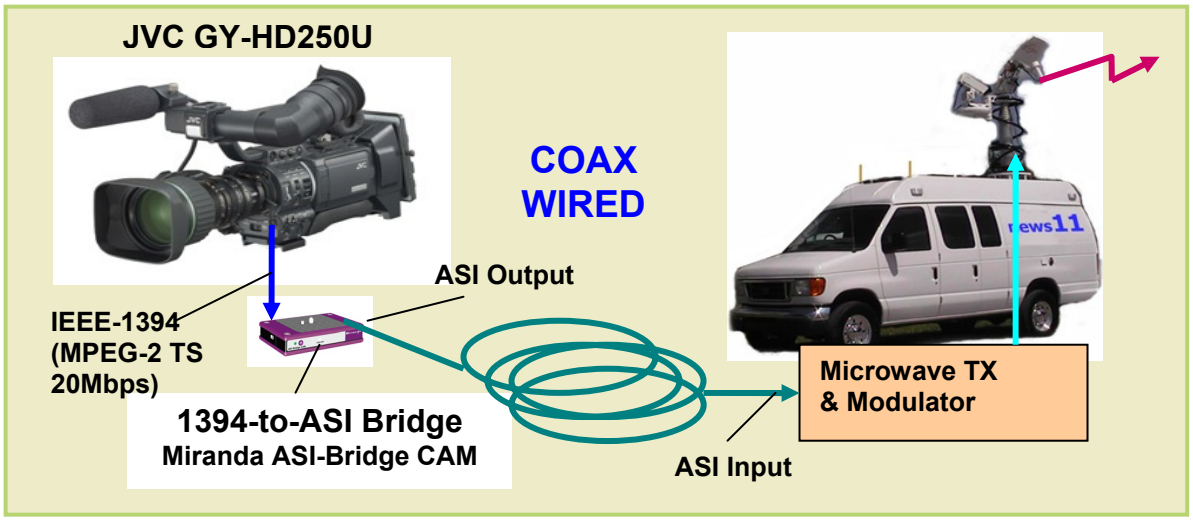


Fig. 6. You just saved $30,000 (typical HD encoder cost for the ENG Van) by using the built-in HD Super Encoder in the ProHD camcorder. Your newer digital-ready microwave transmitters in your ENG Vans may already provide the ASI input, and may be capable of relaying 20Mbps real-time back to the TV station master control. Easy microwave!

The 1394-to-ASI Bridge unit mounts on the camcorder and accepts 1394 connectivity from the camcorder, converting the 20Mbps MPEG-2 TS to ASI formatted output, easily transported by coaxial cable for hundreds of feet to the ENG Van, where the ASI signal is supplied to the ASI input of your microwave modulator/transmitter. No need for a separate $30,000 broadcast quality HD encoder.

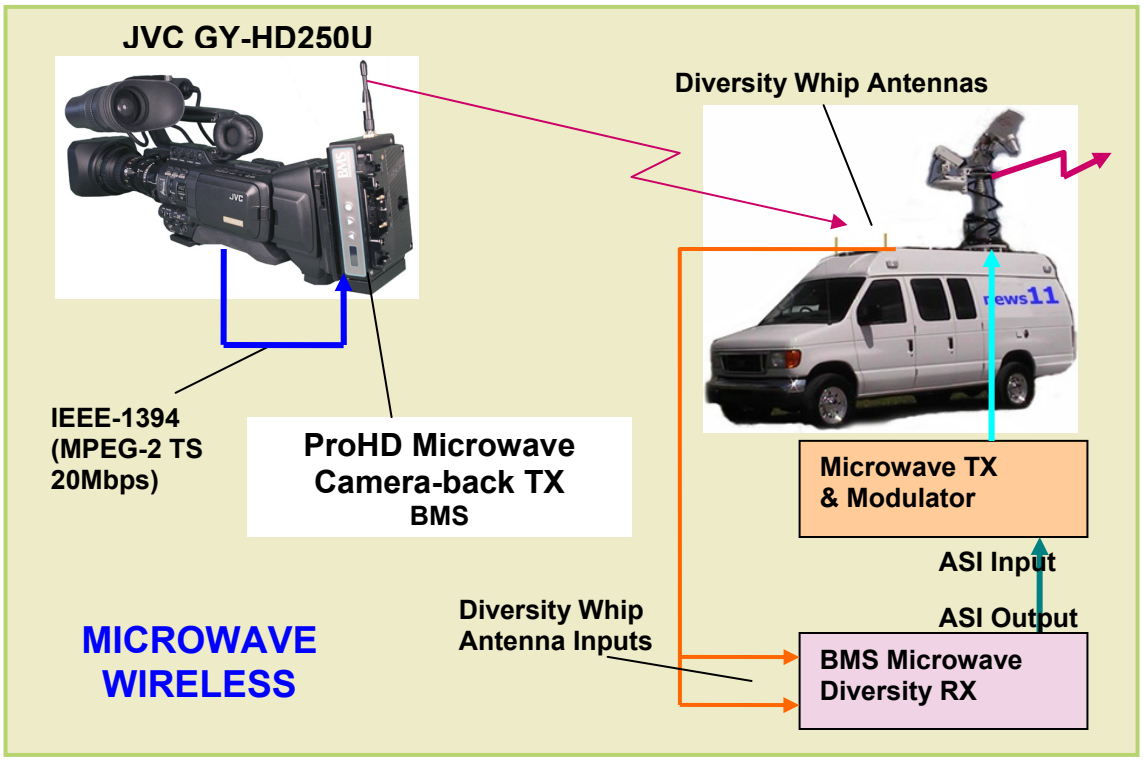


Fig. 7. You just saved $30,000 again (typical HD encoder cost for the ENG Van) by using the built-in HD Super Encoder in the ProHD camcorder. The highly cost effective BMS camera-back TX unit does not include a (expensive) built-in HD encoder, as it takes in the compressed 20Mbps HD stream from the camcorder. Easy microwave!

The BMS Microwave Camera-back unit accepts the 1394 output from the camcorder (MPEG-2 TS at 20Mbps), modulates 16-QAM and transmits COFDM in the 2GHz microwave band (12MHz channel with the 8MHz pedestal and guard bands) to the ENG Van, where a matching BMS Microwave Diversity Receiver decodes the modulation and formats the MPEG-2 TS at 20Mbps to ASI output, which is then supplied to your existing (or new) digital Eng Van-to-Studio microwave transmitter's ASI input. You have eliminated the need for that $30,000 HD encoder in the ENG Van, and your news master control receives a live, broadcast quality full bandwidth 1280x720p60 native signal. Easy microwave!

What about CODEC latency? The ProHD MPEG-2 Super Encoder compresses the 1280x720p60 using a GOP of 12, which GOP section equals 1/5th of a second or 200mS (12 frames of total 60 frames in a second). Other manufacturers employing HDV in 1080i60 (30 frames) use GOP of 15, which GOP section equals ½ of a second or 500mS (15 frames of total 30 frames in a second). Total encode/decode latency for ProHD is marginally more than 400mS, quite acceptable in HD ENG even in live remote interviews, while the HDV 1080i60's encode/decode latency of more than one second may be problematic.

Operational Flexibility = Direct-to-Edit / Direct-to-Air

The ProHD ENG system provides exceptional flexibility in work flow, in the ENG Van and in the TV station news operation. **A key sub-system is the DR-HD100**, a portable hard disk recorder which attaches to the ProHD camcorder and records up to 6 hours of full bandwidth 1280x720p60. The DR-HD100 is a rugged, shock-proofed field recorder accepting the 1394 MPEG-2 TS 20Mbps signal directly from the ProHD camcorder, recording to hard disk concurrently while recording to the built-in HDV tape cassette for acquisition archival purposes.

ProHD GY-HD250U Camcorder with DR-HD100

Fig. 8. The DTE (Direct-to-Edit) ProHD hard disk recorder can be attached on top of the camcorder or on the back side of the battery, recording up to 6 hours of live compressed material direct to disk at. The DR-HD100 can be connected via 1394 to a laptop or to a workstation with direct access to the HD material for editing, without the need to transfer to the local disk array before editing. Thus the name "Direct-to-Edit" or DTE. NOTE: DTE and Direct-to-Edit are trademarks of Focus Enhancements Inc.

JVC's Direct-to-Air work flow supports live interviews through wired coax and wireless microwave to the ENG Van, then backhaul microwave (or satellite) to the TV station studio for immediate on-air. Through the simplicity of the DR-HD100 and an edit-capable lap top in the ENG Van, minimally delayed edited "live coverage" can be easily accomplished through the Direct-to-Edit capabilities the ProHD ENG system. One advantage in hard disk recorders is the near instant random access to any material on the disk.

Play from NLE Direct-to-Air. The GV Canopus Edius ProHD editor can play direct-to-air from the NLE, enabling extremely fast turn-around of clips needing editing before airplay and avoiding the need to first record or store the clip. The Edius ProHD application may run on a laptop in the ENG Van or on a desktop in a news edit bay.

Let's take a closer look at the work flow options inside the ENG Van:

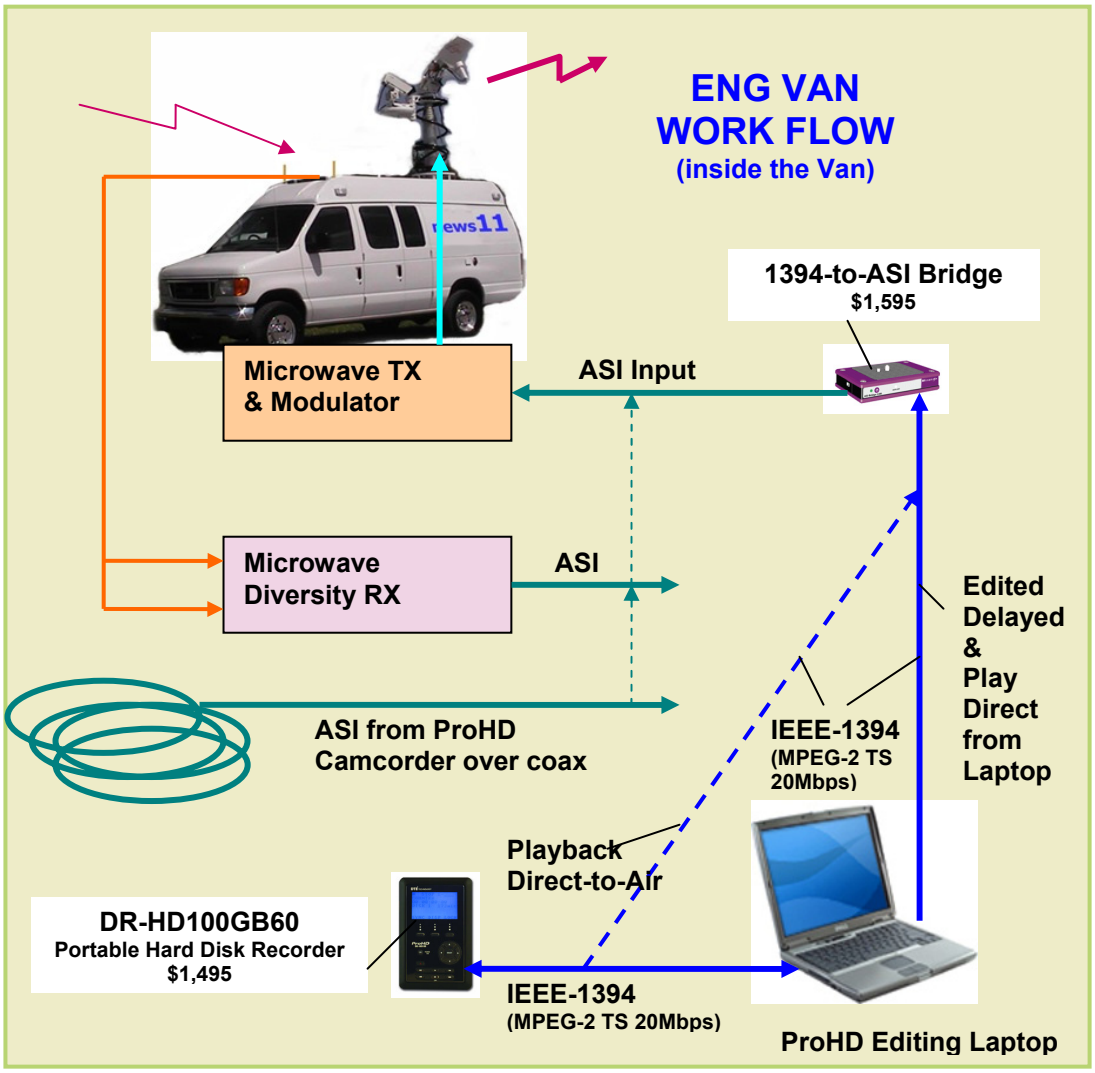


Fig. 9. Live-to-Air is at the core of the ProHD ENG system, utilizing either wired coax or wireless microwave to the ENG Van, and of course ENG Van to TV station master control by microwave. In addition, the DR-HD100 and the editing laptop enable delayed cut-edited stories to be microwaved to the TV station master control for direct-to-air purposes, or for additional editing in the TV stations news edit bays.

Operational flexibility of the ProHD ENG System includes not only the ENG Van work flow, but also the work flow within TV station infra-structure, striving for an easy conversion from the SD environment to HD and for labor saving and cost effective work flow.

The ingest of ProHD from the field is uncomplicated, whether attaching field hardware or by wireless microwave, and whether going direct-to-air, to news department edit bays or to archive.

Let's take a closer look at the ProHD work flow options inside the TV Station:

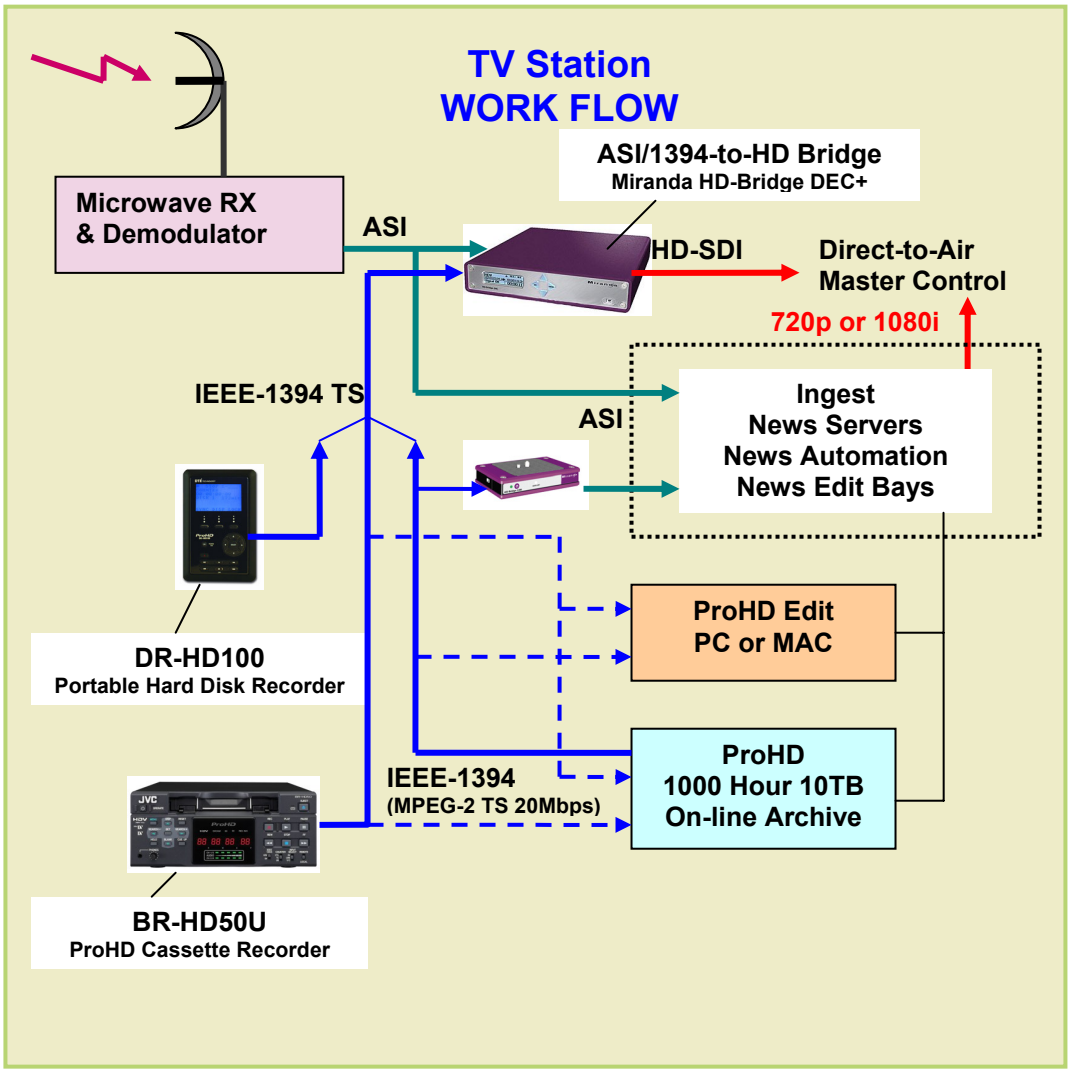


Fig. 10. In the ENG-Live-to-Air work flow, the ProHD live feed comes in over microwave, gets decoded to HD-SDI in the ASI-to-HD Bridge (Miranda HD-Bridge DEC+), with the HD-SDI output going to Air through Master Control. Simultaneously, the ASI is supplied to the ASI-I/O capable News Servers for later editing, replay and archive. All ENG material is brought back to the TV station on ProHD tape cassettes and/or DR-HD100 for further processing and archive. The ProHD On-line Archive, the ProHD Edit Workstations, and the 720p-to-1080i conversion are explained below.

720p or 1080i TV Station? In either case, ProHD is for you. HDTV experts agree that it is considerably easier (and less expensive) to cross convert from 720p (progressive) to 1080i (interlaced) than the other way around. If your station is in the 1080i camp, then you would simply do all of your HD ENG acquisition and microwave transmission in the ProHD 720p format, including the ingest process at the station, but then convert to 1080i inside the ASI-to-HD Bridge and supply a fully 1920x1080i60 compliant HD-SDI with embedded audio and time code out of the Bridge to your existing 1080i HD-SDI infra-structure. This converted 1080i will blend seamlessly with your HD news set's 1080i camera acquisition.

ProHD compatible broadcast-oriented Non-linear Editing Systems:

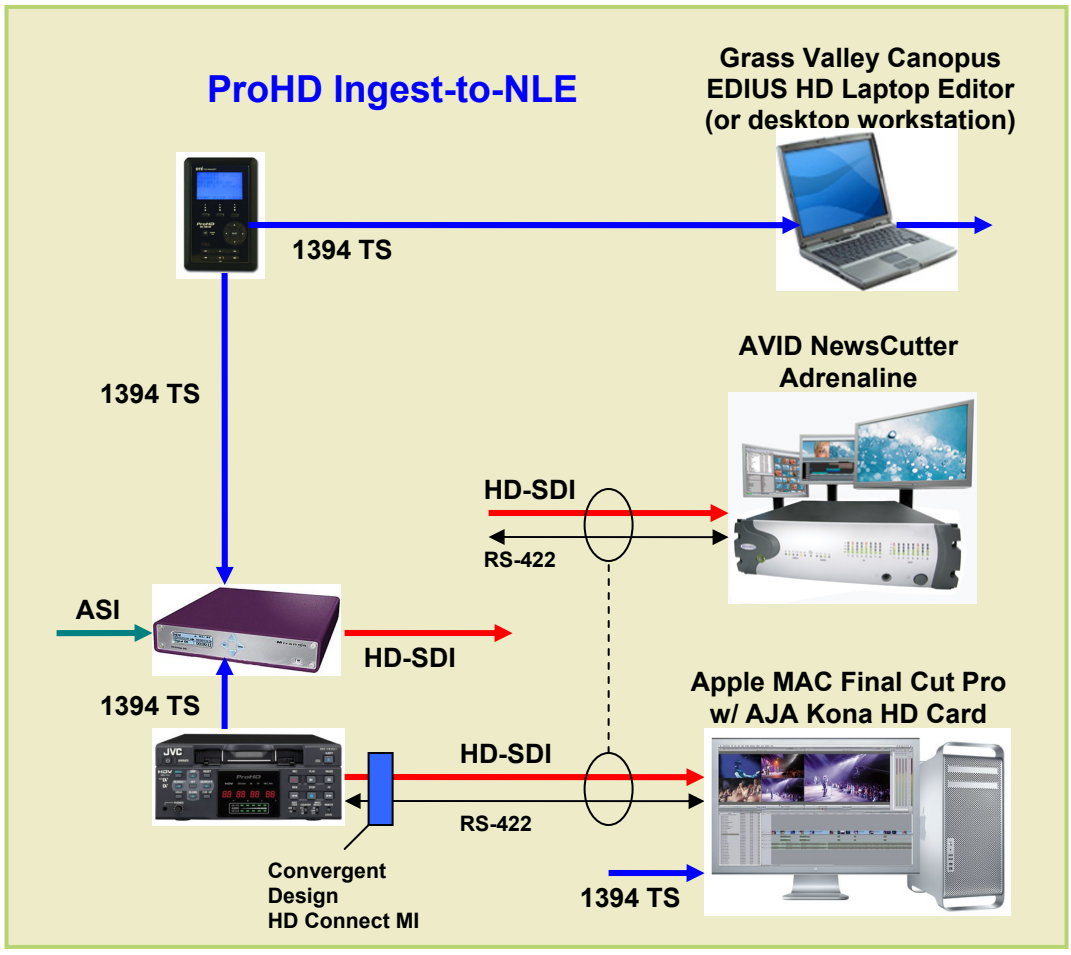


Fig. 11. The HD ENG material arrives at the TV station 3 ways: (a) Live by microwave (ASI), (b) Recorded on tape, or (c) Recorded on DR-HD100. Ingest is by 1394 or by HD-SDI. The brands featured here (Grass Valley Canopus EDIUS, Avid NewsCutter and Apple FCP) are just three of a number of turnkey NLE systems delivering HDV and ProHD capable broadcast oriented workstations.

File-based work flow inside the News Automation Server System. Once your 20Mbps ProHD news clips are delivered to the TV station and ingested into the news servers and NLE workstations, the ProHD ENG system has done its job. The M2T clips (ProHD MPEG-2 at 20Mbps) can be utilized for highly attractive low bitrate file-based work flow, but it may make sense to decode ProHD to HD-SDI and then re-encode upon ingest to the native HD compressed intra-frame format of the news edit and server system, as this will support your existing work flow and accomplish nearly 0 latency on play-out to air. If you are currently operating NLEs and/or servers with the DVCPRO-HD format, then re-encoding to intra-frame DVCPRO-HD 720p60 when ingesting is a viable option, but bear in mind that the legacy DVCPRO-HD codec will limit horizontal resolution to 960 pixels luminance and 480 pixels chrominance (from ProHD's 1280 and 640 respectively). Also, the gross real-time bitrate for DVCPRO-HD is about 120Mbps including overheads.

To assure full ProHD bandwidth, one way is Grass Valley's News Server accepting HD-SDI input and re-encode using the new (soon available) JPEG2000 intra-frame. JPEG2000 matches the full bandwidth of ProHD at local news quality HD at about 60Mbps with overheads, and at 4:2:2 and 10-bit pixel depth, will preserve the ProHD overall image quality through the re-encode (and later decode). Grass Valley is in the process of implementing full JPEG2000 support, including promoting Iomega's REV Pro (removable) hard disk cartridge as a recording sub-systems compatible with JPEG2000 HD file storage, as an attractive and cost effective "on-the-shelf" non-linear random access long term storage cartridge.

There is also Telestream's FlipFactory, delivering a workflow automation solution for broadcast and cable news, supporting the conversion of ProHD 720p60 transport stream to several other formats upon ingest in a variety of NLEs and servers, including DVCPRO-HD.

News Archive = Fast Retrieval – On line – Cost Effective

The ProHD compressed real time bitrate is only 20Mbps or 2.5MB/s, comprising full bandwidth 1280x720p60. As stated earlier in this Report, the 80GB version of the DR-HD100U stores about 6 hours (360 minutes) of ProHD or 4.5 minutes per GB. 10TB (10,000GB) disk arrays for video applications now sell for less than $10,000 with ProHD storage capacity of 45,000 minutes. That is 750 hours of news clips and stories on line. If each clip is an average of 3 minutes, that's 15,000 clips on line. And at the low real time bitrate of only 20Mbps per clip, multiple concurrent reads and writes of clips are achievable without bandwidth bottlenecks.

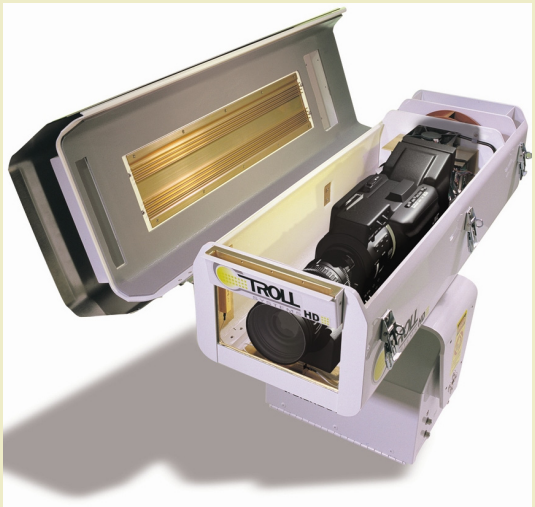
ProHD acquisition archive is automatic, as the camcorder records to the internal HDV tape cassette concurrently with live-to-air and concurrently with recording to the DR-HD100U hard disk unit.

Remote POV applications = ProHD for all seasons

More and more, remote TV cameras are an important part of local news, as a major station in a major market may operate a dozen or more fixed remote locations for traffic and weather. **Do the ProHD camcorders fit that bill? Yes indeed.** Although the ProHD models are camcorders and not just cameras, these models are ideally suited for POV applications, for the following reasons:

- Attractive price-performance ratio
- Full HD resolution native capture of 1280x720
- Excellent capture of fast freeway traffic with 60 frame progressive
- Streaming output of compressed broadcast quality HD over 1394
- Compressed HD signal is only 20Mbps
- Remote control capability of lens and camera functions
- Interchangeable lenses –right lens for the application
- Small and light weight enough for mounting in housing
- 1394-to-ASI and 1394-to-IP streaming converters available

The TrollCam HD Connection. Troll Systems, a leading supplier of complete camera/housing/remote control systems, offers the TrollCam HD system incorporating any one of two ProHD camcorders (HD200U or HD250U) within their NEMA-4 rated camera enclosure, including their "all functionality" remote control unit for camera, lens, pan, tilt and more.



TrollCam HD Remote Control Unit

ProHD GY-HD250U Camcorder (handle removed) in TrollCam enclosure

Fig. 12. Troll Systems new slogan is "HD at an SD price" integrating the ProHD camcorder models with their TrollCam HD. JVC's HD200U and HD250U deliver full 720p60, over wired or wireless.

WiMAX & Fiber IP – Broadband Backhaul for HD ENG

WiMAX wireless broadband is (almost) here

WiMAX is a new wireless digital communications system intended for wireless "metropolitan area networks" (MAN). Theoretically, WiMAX can provide broadband wireless access (BWA) up to 30 miles for fixed stations, and 3 - 10 miles for mobile stations. In contrast, the older WiFi/802.11 wireless local area network standard is limited in most cases to only 100 - 300 feet. WiMAX operates on both licensed and non-licensed frequencies, providing a regulated environment.

WiMAX is a second-generation protocol that allows for more efficient bandwidth use, interference avoidance, and is intended to allow higher data rates over longer distances. WiMAX is expected to be a very well recognized term to describe wireless Internet access throughout the world in the near future. However, much of the talk remains about one way delivery services to consumers (IPTV, mobile video etc.) although it is a fully two-way system.

But, as we can easily recognize, the powerful microwave WiMAX transmitter at the base station may reach for up to 30 miles, a small powerless transmitter in your laptop may only reach part of the way back to the fixed station. Thus, practical implementations may offer a bidirectional reach of one to several miles. A stationary ENG Van may have no problem in connecting upstream, while a moving ENG Van may be more challenging.

Frequency bands are available in the 10-66GHz range for licensed users, while the unlicensed users are delegated to selected areas within the 2-11GHz spectrum. Between Base Stations and fixed users (i.e. homes), the connectivity is the most robust as there are no moving target variables. Between Base Stations and mobile users, the range is severely limited.

WiMAX offers a theoretical bandwidth of maximum 75Mbps. This bandwidth may be achieved using 64QAM 3/4 modulation, but only under optimal transmission conditions. WiMAX supports a wide range of modulation schemes to enable the maximum bandwidth under any specific condition.

WiMAX offers a theoretical maximum range of 30 miles with a direct line of sight. Near-line-of-sight (NLOS) seriously limits the range. In addition, some of the frequencies utilized by WiMAX are subject to rainfade interference. The unlicensed WiMAX frequencies are subject to RF interference from competing technologies and competing WiMAX networks.

Is WiMAX suitable for HD ENG? Most certainly, but there are many issues to be covered before the WiMAX backhaul becomes an every-day event. The bottom line question is the required bitrate for the backhaul, and, at 20Mbps, ProHD is the most attractive professional HD compression scheme for WiMAX applications. But even at 20Mbps, the ENG backhaul would occupy a rather large part of the total WiMAX bandwidth probably requiring using the licensed WiMAX band for real-time guaranteed performance. Therefore, the 2GHz and 7GHz BAS bands currently used by the TV broadcasters are likely to be the most practical solution for HD ENG wireless backhaul for several years to come.

Fiber-wired IP backhaul

"Dark" fiber-optic cable is generally available criss-crossing metropolitan areas all over North America, which can be leased and "lit" for cost effective backhaul of HD ENG and HD POV (Point-of-View) cameras.

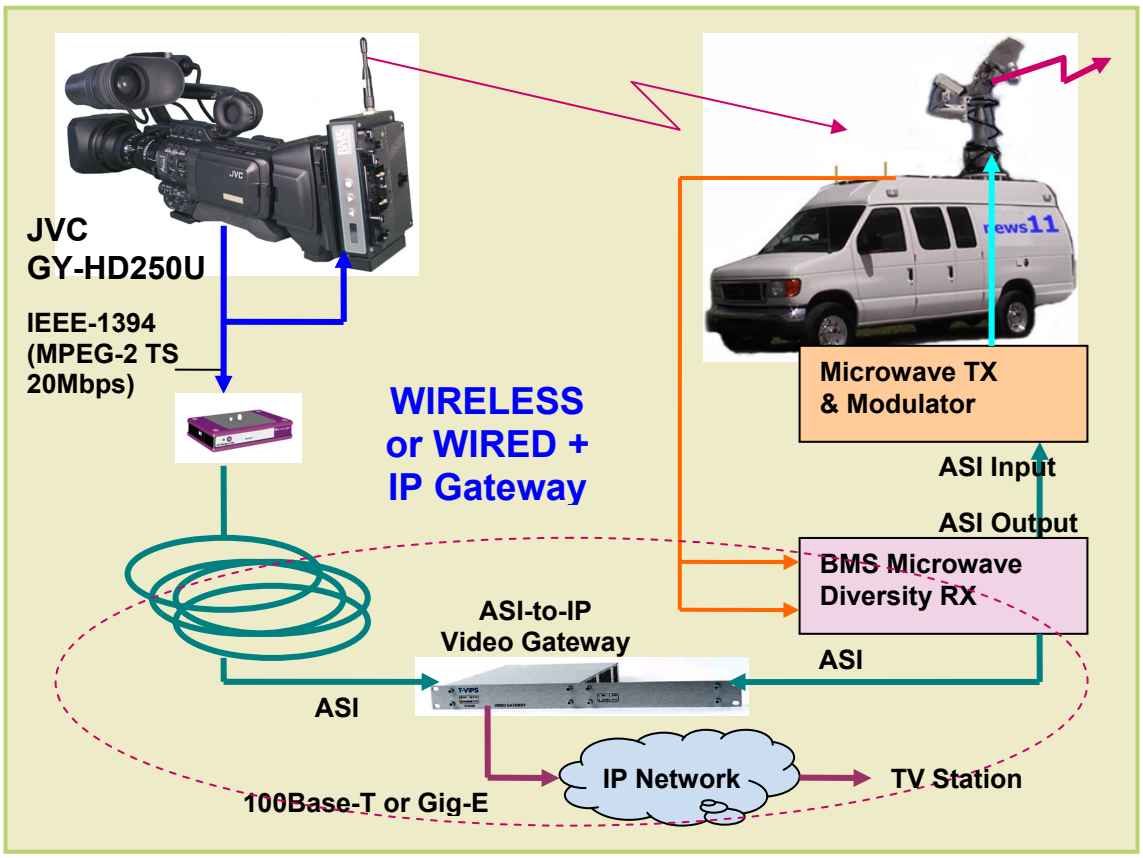


Fig. 13. HD ENG backhaul over private IP network from ENG Van to TV station, utilizing ASI-to-IP Gateway (T-VIPS TVG420), using either wired or wireless connection from ProHD camcorder to ENG Van.

The TV station can lease a dedicated fiber connection and just use a fiber line transmitter and receiver, or, in the event of multiple POV cameras (traffic cams) and multiple fixed ENG Van connection points (city hall, federal building, arenas etc.), IP connectivity can be leased from local private IP network operators based on bandwidth requirement. **With only 20Mbps bandwidth requirement per origination point, ProHD is ideally suited for such applications.**

An interesting 1394-to-IP Gateway for the ProHD format is now available:

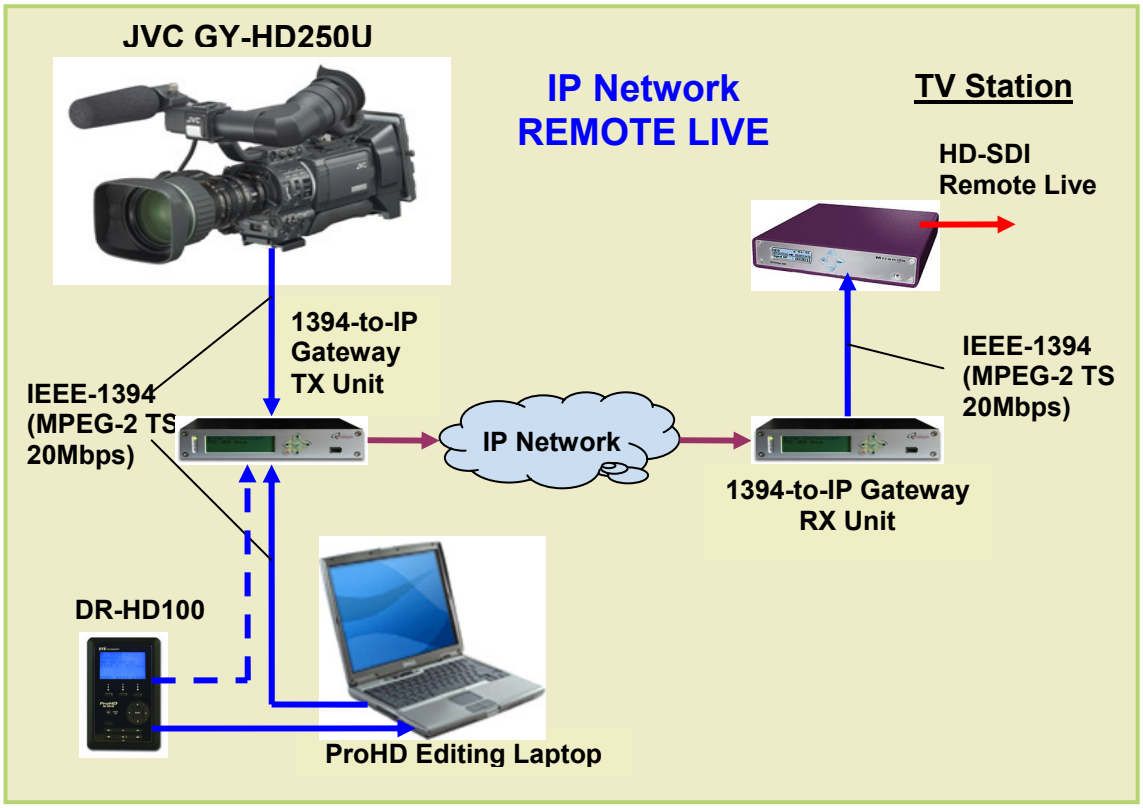


Fig. 14. HD live backhaul over private IP network from remote location, which may be Traffic-Cam or from ENG Van, using 1394-to-IP gateways by QVidium. One potential problem with a 1394 link from the ProHD camcorder is the limited physical length of a 1394 cable (max about 15' or 4.5m). A suitable application example is shooting a city council meeting with the camcorder fixed on a tripod. An unsuitable example is a "roving" camcorder where the 15' of 1394 cable is not long enough for freedom of movement. Another approach is to record "roving" into the DR-HD100, and then play back "live" from the hard disk unit into the gateway TX unit through the 1394 connection, or even from a ProHD Edit laptop.

Microwave, WiMAX or Fiber IP?

The potential savings are substantial if a TV Station can eliminate (or greatly reduce) the use of ENG Vans with link-to-studio microwave, perhaps replacing the majority of ENG Vans with mini-vans or even station wagons.

Fig. 15. In less than 5 years, HD ENG backhaul may be accomplished through a combination of WiMAX and Fiber IP within a metropolitan area. Frequent ENG program origination points may have pre-wired Fiber IP network connections while other points are in proximity to WiMAX service. The traditional large ENG Van, with costly microwave electronics, dish antennas and telescopic masts, may only be used for rural reporting where WiMAX and Fiber IP are not available.

Change is inevitable – Keep your options open.

Legacy vs. new HD CODECs

Legacy HD CODECs are 10+ years old

Sony's HDCAM camcorder was first delivered in the US in 1997, while the first DVCPRO-HD camcorder was delivered in 2000. Together, these two formats have been the foundation of the emergence of truly portable HD video acquisition, however, the two CODEC technologies have now been eclipsed by newer, more efficient compression algorithms.

In the mid-1990s, GOP (Group of Pictures) MPEG-2/4 compression technology was not yet available, thus Sony and Panasonic had no option but to work with an intra-frame DV implementations to accomplish portable HD compression for camcorders. DV came from Motion-JPEG, adding bit stuffing to deliver CBR (Constant Bitrate Recording) so the compressed DV could be recorded to constant linear velocity tape within a video tape cassette. HDCAM was developed to record on ½" tape at a bitrate of about 135Mbps video content, while DVCPRO-HD was a function of Panasonic's DVCPRO (25Mbps) format multiplied by 4, for a video content at 100Mbps, recording on ¼" tape at 4x DV linear tape speed.

There was only one way to get the bitrate down to a manageable level: bit-reduction, pre-filtering, and sub-sampling. With today's compression technology, there is little need to compromise.

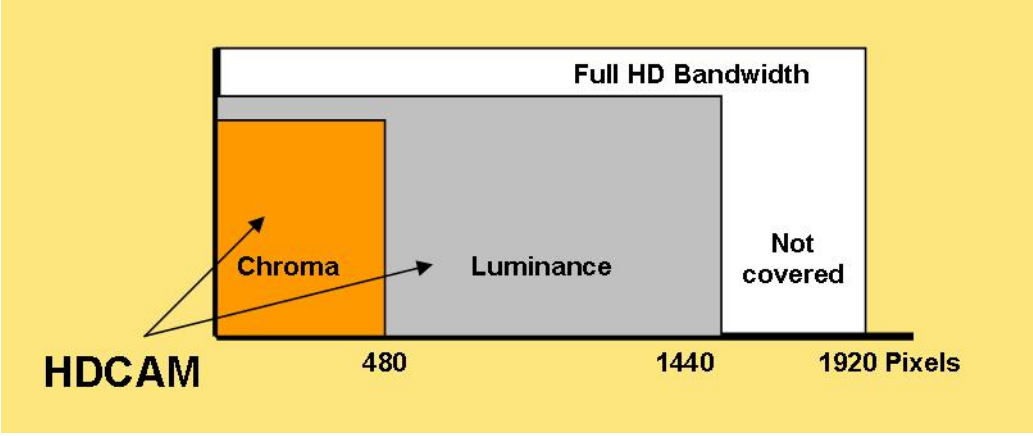


Fig. 16. HDCAM reduces the bandwidth prior to compression, down to 1440 pixels horizontally. The color sub-sampling is really 3:1:1 as the C_R & C_B is only 480 pixels or 1/3 of the 1440. The number 3 in the "3:1:1" is ¾ of 1920 (and of 4 as in "4:2:2"). 1440 horizontal pixels come from a 4:3 aspect ratio HD image, corresponding to the 1920 pixels in the 16:9 image, both producing square pixels with the 1080 line format. HDCAM only comes in the 1080i flavor.

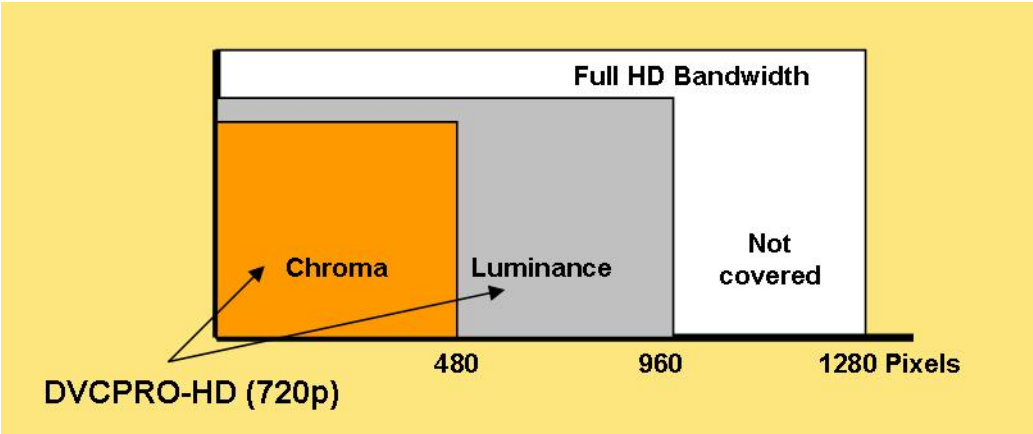


Fig. 17. DVCPRO-HD comes in both 1080i and 720p flavors. Both formats reduce the bandwidth significantly prior to compression. This diagram shows the 1280x720p60 mode, where luminance bandwidth is reduced to 960 pixels horizontally from 1280, and chrominance to 480. Panasonic claims this is 4:2:2 (and it is if you look at the 960/480 relationship) but, if you compare with full bandwidth 1280/640, it computes to 3:1.5:1.5. DVCPRO-HD reduces the 1920x1080 down to 1280x1080 with color sub-sampling at 640, which becomes 2.7:1.3:1.3 referred to 4:2:2 full bandwidth.

The new HD CODECs

The new HD CODEC technologies comprise MPEG-2 and MPEG-4 in intra-frame as well as GOP implementations, and JPEG2000 only in intra-frame.

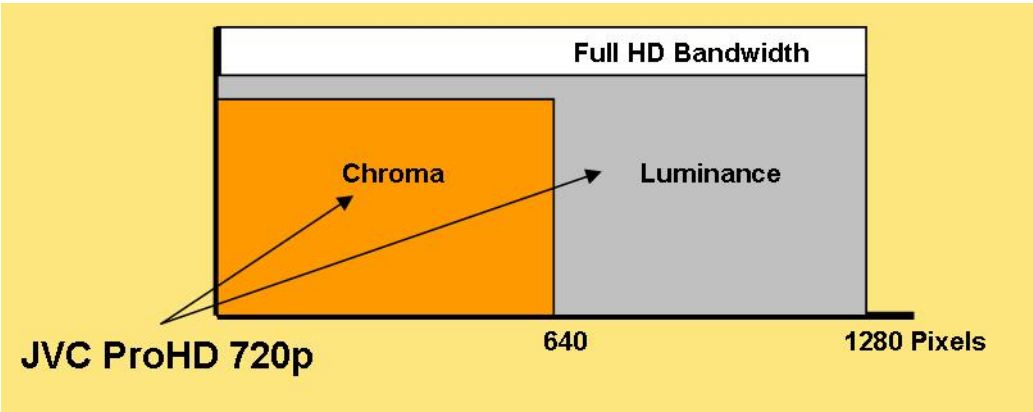


Fig. 18. JVC's ProHD Super Encoder technology, built into the GY-HD250U, is the ONLY HD compression scheme available today capable of delivering the full ATSC 1280x720 bandwidth at the full frame rate of 60p in a 20Mbps transport stream. All this in a HD ENG camcorder with a US list price of $9,995. Color sub-sampling is 4:2:0.

JVC's ProHD came out of the HDV MPEG-2 consortium (Canon, JVC, Sharp, Sony) but, of the four, only JVC elected to concentrate on full bandwidth native acquisition, recording and transport by choosing the 1280x720p60 ATSC format. Thus ProHD is uniquely qualified for cost effective HD ENG applications.

The HDV-related CODECs by Canon and Sony only covers 1080i60, with 4:2:0 sub-sampling, and reduced bandwidth:

Canon HDV 1/3-inch 3CCD (models XH-A1/G1 & XL H1)

- Native imager acquisition 1440x1080i60 plus pixel shift/offset
- HDV recording of 1440x1080i60 max resolution
- Compressed MPEG-2 GOP transport stream = 25Mbps+
- Only XL H1 & XH G1 have HD-SDI out
- Only XL H1 has interchangeable lens

Sony HDV 1/3-inch 3CCD (models HVR-Z1/A1)

- Native imager acquisition 960x1080i60 plus pixel shift/offset
- HDV recording of 1440x1080i60 max resolution
- Compressed MPEG-2 GOP transport stream = 25Mbps+
- NO HD-SDI out
- All models have fixed lenses

Sony XDCAM HD 1/2-inch 3CCD (models PDW-F330/F350)

- Native imager acquisition 1440x1080i60
- Optical disc (PD) recording of 1440x1080i60 max resolution
- Compressed MPEG-2 GOP bitrate = Hi=35/Mid=25/Lo=18Mbps
  (Hi-35 and Lo-18 are VBR recording)
- HD-SDI out only on F350
- Interchangeable lenses

Panasonic never joined the HDV consortium, choosing to offer a competitive model to the HDV camcorders with the DVCPRO-HD capable HVX-200, and, just announced before the NAB-2007, the HPX500:

Panasonic HVX200 1/3-inch 3CCD

- Native imager acquisition 960x540p60 plus 2-dimensional pixel shift/offset
- DVCPRO-HD recording of 1280x1080i60 max resolution
- DVCPRO-HD recording of 960x720p60 max resolution
- Compressed DVCPRO-HD bitrate = 120Mbps (approx gross)
- NO HD-SDI out
- Fixed lens

Panasonic HPX500 2/3-inch 3CCD

- Native imager acquisition 960x640p60 plus 2-dimensional pixel shift/offset
- DVCPRO-HD recording of 1280x1080i60 max resolution
- DVCPRO-HD recording of 960x720p60 max resolution
- Compressed DVCPRO-HD bitrate = 120Mbps (approx gross)
- HD-SDI out
- Interchangeable lens

And, here are the JVC ProHD competitive features:

JVC GY-HD250U 1/3-inch 3CCD

- Native acquisition 1280x720p60 (No tricks needed)
- ProHD recording of full ATSC 1280x720p60 resolution
- Compressed MPEG-2 GOP transport stream = 20Mbps (19.7)
- HD-SDI out
- Interchangeable lens
- SD Pool feed input

Panasonic has recently announced their new AVC-Intra CODEC which does provide for full ATSC bandwidth mode, but at a compressed bitrate of 100Mbps. A 50Mbps mode will be available, but this is still high for HD ENG implementations within existing ENG work flows. AVC-Intra is scheduled for first deliveries in the summer of 2007. **Based on prior experience with new HD compression formats, it will take some time before industry partners are ready to fully support the brand new format in workstations, laptop editors, servers and networks.**

Native Acquisition & Pixels per Second presented To the Home HDTV

Earlier in this Report (page 10), we discussed **"the total number of effective maximum pixels per second"** being presented to the home viewer through the home HDTV, and the effect of the Kell/Interlace factor in substantially decreasing the total perceived resolution for interlaced video while barely affecting progressive video. It seems obvious that such pixels per second presentation may be limited by the following:

- Native acquisition resolution in the HD camcorder
- Limiting resolutions in HD camcorder recording
- Limiting resolutions through the post & delivery chain
- Native resolution of home HDTV

The HD delivery method is ATSC OTA or QAM CATV, both being relatively equal in full bandwidth quality at their higher bitrates. (I.e. the use of sufficient bits in the 19.4 ATSC transmission for the primary HD channel, and not compromise the encoding quality due to squeezing multiple channels through the ATSC pipe.) Thus we assume 1920x1080i60 and 1280x720p60 at 4:2:0 consumer delivery is the pipe limitation, thus **the benchmark in practical terms is a live HD studio camera (full HD bandwidth 4:2:2 at 10-bit depth, HD-SDI out) at the TV station shooting a well lit (news) set, with real-time delivery over ATSC OTA to the home HDTV.**

Interlaced HD on a Progressive HDTV?

Viewing in HD is by definition viewing on a progressive HDTV, as all HDTVs sold today are of the progressive kind, with a refresh rate of 60 frames per second. (We forget about the very few CRT-based HDTVs still being sold.) The ATSC 720p60 progressive standard is of course no problem, as it maps frame by frame, and, if a native 1280x720p60 HDTV, pixel by pixel.

But, when receiving the ATSC 1080i60 OTA, the interlaced HD video must be de-interlaced, as the progressive display must draw the entire screen 60 times per second. All current displays except for CRT screens require to de-interlace 1080i. In theory, there is no reason why LCD, DLP or Plasma displays could not display two fields sequentially, but the requirement that half of the pixels remain black half of the time would result in less (half?) perceived brightness. Remember that interlaced CRTs are made with phosphorous material which illuminates when hit by the scanning electron beam through a mask, and the phosphor has an intended "illumination decay time" while a pixel in a new non-CRT display is either on (with the appropriate intensity) or off, without any intended (longer) decay time.

De-interlacing is an imperfect process and how much of the delivered ATSC OTA 1080i resolution is lost in the de-interlacing process? And, remember, in the home HDTV, de-interlacing must be a real-time process with low latency. We assume that the de-interlacing/conversion process from 1080i to progressive produces a loss in perceived resolution more or less equal to the Kell/Interlace factor of 0.7.

The pixels/sec benchmark (ATSC 4:2:0) presented to the viewer is then:

1280x720p60 x 1.5 = 83 million pixels/sec **(no Kell/I reduction, progressive)**
Luminance 1280x720p60 = 55 million
Chrominance = 28 million

1920x1080i60 x 1.5 (x 70%) = 65 million pixels/sec **(Kell/I reduced to 70%)**
Luminance 1920x1080i60 = 44 million
Chrominance = 21 million

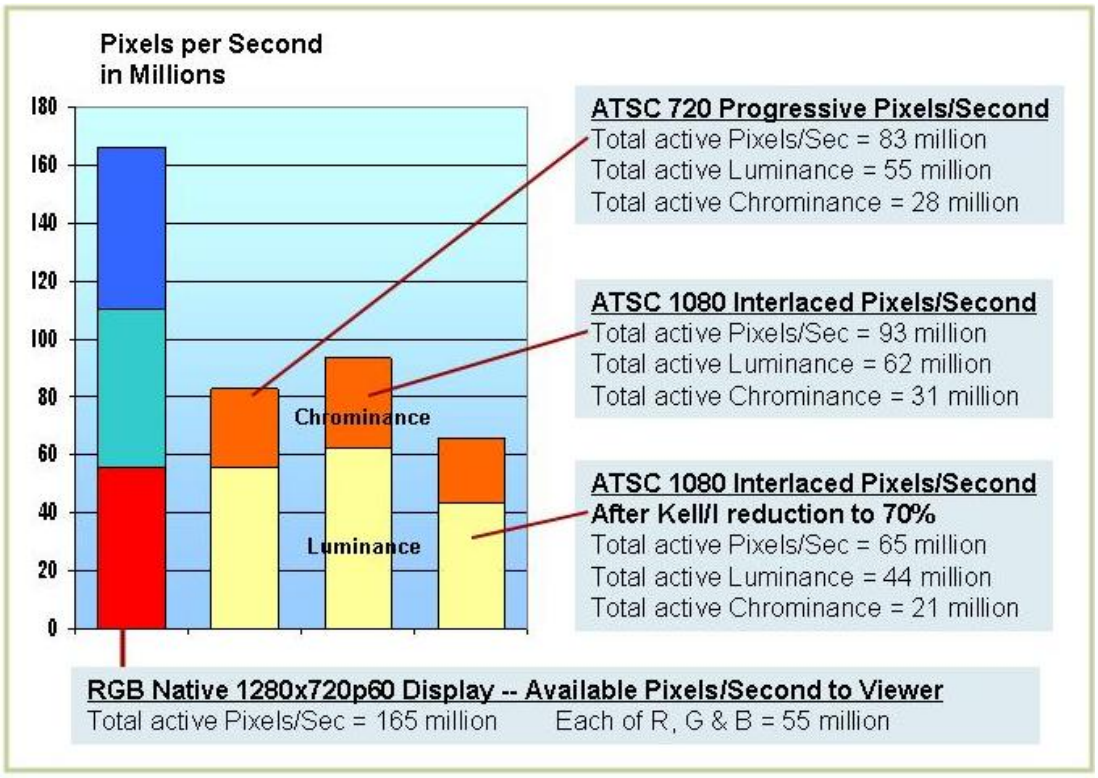


Fig. 19. The graph shows that the full HD quality of the ATSC transmission really only takes advantage of about 50% of the total available Pixels/Second in a RGB native 1280x720p60 display. It really confirms the viewing tests that 1280x720 resolution displays are more than sufficient to provide the large majority of home viewers with the best possible perceived HD viewing experience, whether the source is 720p or 1080i.

The JVC ProHD Camcorder, with native acquisition and delivery to TV station matching the full ATSC bandwidth (1280x720p60) and 4:2:0 pixel for pixel, will not degrade the pixels/sec benchmark from a pixel conversion point of view, delivering 83 million pixels/sec, although we must recognize that the 1/3-inch imager block and the ProHD CODEC will not reach the HD image quality or accuracy of the uncompressed HD studio camera output.

A Panasonic DVCPRO-HD Camcorder, delivering to the TV station through the DVCPRO-HD format 960x720p60, requires large amounts of pixel conversions due to the 960 luminance and 480 chrominance horizontal bandwidth limitations:

960x720p60 x 2 = 83 million pixels/sec **(no Kell/I reduction, progressive)**
Luminance 960x720p60 = 41.5 million pixels/sec
Chrominance 480x720p60 x 2 = 41.5 million pixels/sec

Comparing with ProHD, the total pixels/sec is the same, but DVCPRO-HD luminance falls short of the 55 million luminance pixel/sec of the ATSC, while the chrominance pixel/sec at 41.5 million is significantly higher than the 28 million ATSC, being limited by that "28 million pipe".

And, looking at the newly announced Panasonic HPX500 P2HD camcorder (DVCPRO-HD recording) stated to have a sub-HD-resolution 620,000-pixel 3CCD native imager (presumed then to be 960 pixels horizontally and, further assuming 16:9 square pixels, 540 active pixels vertically), results in each of luminance and chrominance at 31 million pixels/sec (from a native imager reference point). The HPX500 camera front end does apply 2-dimensional pixel offset and sophisticated processing, thereby significantly increasing the effective capture resolution above the native 620,000 pixels CCDs.

A Sony XDCAM HD Camcorder, delivering to the TV station through the PD optical disc format 1440x1080i60 4:2:0, also requires pixel conversions due to the limited 1440/720 to be scaled to 1920/960:

1440x1080i60 x 1.5 (x 70%) = 49 million pixels/sec **(after Kell/I reduced to 70%)**
Luminance 1440x1080i60 = 33 million (after Kell/I reduction)
Chrominance = 16 million (after Kell/I reduction)

Format	Total Pixels/Second Luminance & Chrominance	Total PERCEIVED Pixels/Second (Interlaced reduced to 70% by Kell/I factor)	Pixels/Second PERCEIVED Luminance only (after Kell/I factor)
ATSC 720p (REF)	83 million	No reduction Progressive	55 million (no reduction)
ATSC 1080i (REF)	93 million	65 million	44 million
JVC ProHD	83 million	No reduction Progressive	55 million (no reduction)
Panasonic DVCPRO-HD (720p)	83 million	No reduction Progressive	41.5 million (no reduction)
Sony XDCAM HD	70 million	49 million	33 million

Fig. 20. This table recaps the analysis that the Kell/Interlaced factor reduces the viewer's perceived resolution by about 70% average, while progressive material is nearly unaffected. JVC's ProHD is the only format matching the ATSC reference. Effective maximum pixels per second is just one of several parameters indicative of the quality of the home viewer's perceived HD video quality. Size of camcorder imager, compression type and efficiency are other important parameters affecting the viewer's HD experience, as are shooting conditions.

Lenses for HD ENG

Professional ENG requires interchangeable lenses

The SD 4:3 experience is that the average ENG shoot requires a mild wide angle lens, however, distant action may require a relatively powerful telephoto lens. The ProHD standard HD lens (Fujinon Th16x5.5BRM) offers a good compromise between wide angle and telephoto, and is highly cost effective when packaged with GY-HD250U camcorder at a US list of $10,995. One of four other optional lenses is the Fujinon HTs18x4.2BRM fitted with Fujinon's DigiPower servo system, offering outstanding HD performance at a US list of $10,800 (lens only).

Parameters	JVC GY-HD250U w/ Fujinon 1/3-inch Th16x5.5BRM	JVC GY-HD250U w/ Fujinon 1/3-inch HTs18x4.2BRM
US list price ProHD camcorder with interchangeable lens	$10,995	$20,795
Zoom Ratio	16x	18x
Range Focal Length	5.5 – 88 mm	4.2 – 76 mm
Angular Field of View 16:9 H x V Degrees	~50 x ~30 ~3.2 x 1.6	~63 x ~37 ~4 x ~2
Max Relative Aperture	1.4 at 68 mm 1.8 at 88 mm	1.4
Min Aperture	f/16	f/16
MOD	1 meter	0.6 meter
½-inch & 2/3-inch lens adapters (optional)	Yes	
Focus assist mode (not auto focus)	Yes	
Built-in ND filters	Yes (2 on body)	

Fig. 21. This table shows the flexibility of the ProHD camcorder with two standard Fujinon lenses, particularly Max Relative Aperture, Min Aperture and the availability of both ½-inch and 2/3-inch lens adaptors. The standard Fujinon Th16x5.5BRM offers mild wide angle performance indicated by 5.5mm focal length and about 50 degrees horizontal angular field of view. The optional HTs18x4.2BRM is 13 degrees wider at 63 degrees with 18x zoom. JVC also offers a wide angle converter (WCV82SC about $500) to fit the standard Fujinon lens, increasing horizontal angular field of view to about 58 degrees.

Besides the two lenses listed in the above table, three additional 1/3-inch lenses are available: Fujinon Th13x3.5BRM (very wide), Fujinon Th17x5BRM, and Canon KT20x5BKRS.

SD lenses on HD camcorders?

TV stations generally own large quantities of SD lenses, some even purchased recently. However, most of these lenses are ½-inch and 2/3-inch, and thus require lens adaptors to fit on the 1/3-inch camcorders. JVC does offer both ½-inch and 2/3-inch lens adaptors for the ProHD camcorders. There are two primary problems associated with using SD lenses on HD camcorders:

Chromatic aberration in the lens is (simplistically) that a beam of light containing different colors (as any light ray is made up of the primary colors) diffract differently through a lens element, like light is split into the primary colors by a prism. In an extreme case example, a pixel-size light ray (containing red, green and blue components) going through a lens element is diffracted into three beams of red, green and blue, and thus being "out of registration" before entering the camera front end. With HD being 6x the area resolution of SD, chromatic aberration (CA) is much more challenging in HD, and the lens manufacturers take great care in the design and the manufacture of HD lenses to reduce the CA to a minimum. SD lens design were of course performed to a SD standard with respect to CA, therefore the official recommendation is not to use SD lenses on HD camcorders. CA is particularly observable at object edges in the image, with perhaps a spurious color edge being visible in contrasted transition from light to dark or dark to light, due to the "out of registration" color separated pixels.

Longitudinal chromatic aberration happens as the light beams travel through the lens, and, not surprisingly, CA gets worse with longer focal lengths (at telephoto settings). **Lateral chromatic aberration** is measured from lens center out toward the edges, as it is impossible to maintain lens center CA performance as one approaches the lens edge. In the question of using SD lenses on HD ENG camcorders, these CA problems may not be sufficiently adverse to prevent the use of SD lenses, as most ENG stand-up remote reporting only uses the middle of the 16:9 screen for the talent and uses a wide lens setting rather than telephoto.

Lens adaptor multiplier effect. The ProHD camcorders are 1/3-inch imager where optimum matched lenses are also 1/3-inch. The use of lens adaptors of ½-inch-to-1/3-inch and 2/3-inch-to-1/3-inch produces the effect of "multiplying" the 1/3-inch focal length (reducing the angle of view). In the ProHD camcorders, a 1/3-inch lens with a focal length of 5mm produces a horizontal angle of view of 52 degrees (a relatively wide angle).

Using a ½-inch lens (with a native min focal length of 5mm**)** with the adaptor increases the focal length by a factor of 1.43 to 7mm, producing a horizontal angle of view of approx. 37 degrees, which may be acceptable in HD ENG.

Using a 2/3-inch lens (with a native min focal length of 5mm**)** with the 1/3-inch adaptor increases the focal length by a factor of 1.97 to 10mm, producing a horizontal angle of view of approx. 27 degrees, which may not be wide enough for HD ENG.

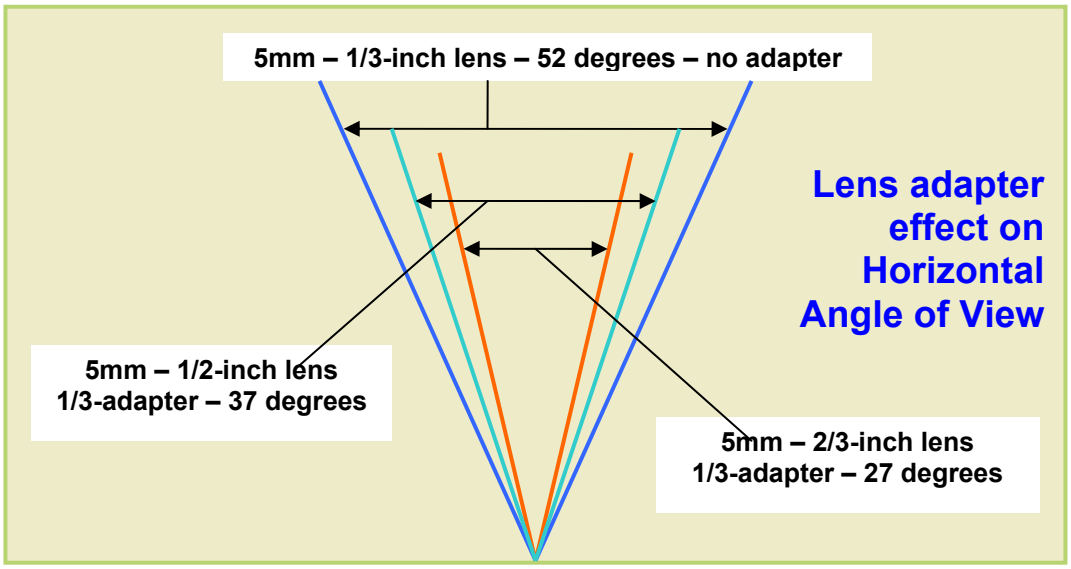


Fig. 22. This diagram shows that the Horizontal Angle of View is reduced when using ½-inch and 2/3-inch lenses with adapter to fit 1/3-inch camcorder given the same minimum focal length (in this case 5mm). Therefore, existing inventory of wide angle (½-inch and 2/3-inch) SD lenses are of particular interest to try to work with the ProHD camcorder, particularly lenses with 4mm or lower minimum focal length, and lenses with wide angle converters.

The bottom line using SD lenses in ProHD camcorders? If you have ½-inch and/or 2/3-inch SD lenses already in your inventory, then you owe it to yourself to try them out on your HD250U. The US list price for the HD250U without any lens is $9,995 and only $1,000 more ($10,995) with the standard professional Fujinon HD 16x lens. Depending upon your SD lens inventory (1/2-inch or 2/3-inch), add the ½-inch (JVC ACM-12) or 2/3-inch (JVC ACM-17) lens adapter for about $750. Shoot the same ENG test footage with the standard HD and the existing inventory SD lens, view the material (preferably) on a studio monitor with full native HD pixel resolution (JVC offers two suitable models of flat panel studio monitors) or on a JVC rear projection D-ILA HDTV, and then make your decision based on your specific situation. The wide angle models are likely to work better and be more suitable than the longer focal length models. You may perhaps decide that your HD ENG efforts may be sufficiently served for an initial period of time using some of the existing inventory SD lenses, limiting your initial investment. In the longer term, real HD lenses are required to provide optimum image quality and acquisition flexibility.

The GY-HD250U HD ENG Camcorder

JVC's new GY-HD250U is a full resolution HD progressive camcorder designed from the ground up as a professional unit. Building on the unique JVC "compact shoulder" form factor, the GY-HD250 offers significantly improved picture quality suitable for HD ENG, EFP, POV and TV station local commercial production in HD. In addition to being a comfortable and stable shoulder style remote camera, the GY-HD250 can also be converted to a studio camera using the optional KA-HD250U studio adapter.

Fig. 23. The JVC GY-HD250U ProHD product is the most competitive professional HD ENG camcorder system available, delivering a cost-performance-flexibility ratio unmatched by any other product on the market. From Direct-to-Edit and Direct-to-Air features, whether by wire or microwave, the HD250U is ready to provide reliable, high quality service in the world of HD ENG in 2007 and beyond.

Fig. 24. Using the optional studio adapter (KA-HD250U), the HD250U can successfully serve as a professional HD studio camera, delivering full bandwidth over the HD-SDI output. Remote control capability is provided through the Camera Remote Control Unit (RM-P210).

GY-HD250U Professional Features – Advanced Technology

- Bayonet mount interchangeable lenses
- Native 1280x720 progressive 3xCCD 1/3-inch imager
- ProHD 24p, 25p, 30p, 50p and 60p recording
- 60p live output (analog 4:2:2)
- HD/SD-SDI output with embedded audio & TC
- HD-SDI output of 1080i from built-in cross converter (live or recorded)
- 20Mbps Compressed Transport Stream output over IEEE1394
- Focus assist
- New wide band analog camera front end, 14-bit A/D & DSP
- High speed Super Encoder (enables 50p/60p recording)
- White shading adjustment to compensate for lens characteristics
- Pro Anton/Bauer battery mount
- 6-pin remote control connector
- Genlock
- Time code input/output
- Composite Video input (for SD pool feed)
- Studio capability with optional multi-core adapter
- 2-year warranty (parts) 1-year (labor)

Please contact JVC Professional for additional information and product demonstrations:

JVC Headquarters & East Coast Sales (973) 317-5030
JVC Midwest Sales (630) 851-7800
JVC West Coast Sales (714) 527-7500
http://pro.jvc.com

JVC ProHD GY-HD250U Camcorder System Options