SONY

HDTV PRODUCTION

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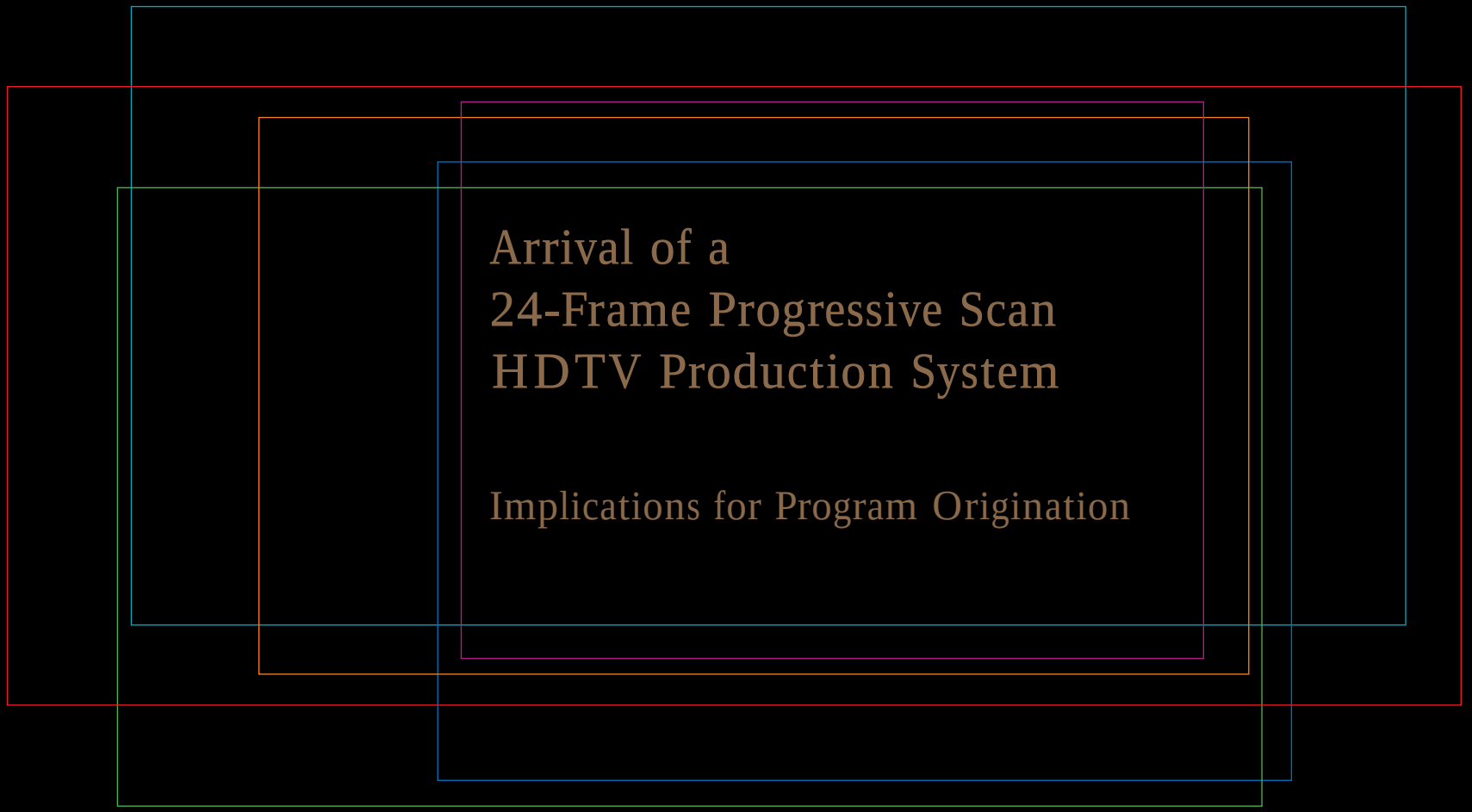

Arrival of a 24-Frame Progressive Scan HDTV Production System

Implications for Program Origination

Merits of Using Either 1080 / 24P or 1080 / 60i
for Diverse Production Applications

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INTRODUCTION

Something new has arrived on the production scene – called 24 Frame Progressive HDTV. It has stirred considerable marketplace excitement and has acquired a remarkable momentum even before the arrival of actual product. Separately, it spurred an unprecedented accomplishment this year within the international ITU standards-making process for high definition television, contributing to a breakthrough global standard for a digital HD medium for production and international program exchange – see APPENDIX 2.

Motion picture film has indisputably acquired an important new partner – see APPENDIX 1. Digital HD has now achieved basic imaging attributes that greatly narrow the former separation between video and film quality. With contemporary digital HDTV, picture sharpness ranks with that of 35mm film. And now, HDTV has just assumed a common platform with film in terms of the hugely popular capture rate of 24-frames per second (it should be noted that the new ITU standard has expanded this to also encompass progressive 25- and 30-frames per second). This new technical synergy between the two media portends a great deal in terms of expanding global production flexibilities. Yet, despite all this, 60 Hz HDTV still remains, in its own right, a very important picture capture rate.

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24 Frame Film

24 frame film is, in every sense of the word, a colossal de facto marketplace reality, a global de facto production and interchange standard – and, in the theatrical movie world, an overwhelming marketplace success. Above all, the combination of 24 frame film capture and the associated 48 Hz theatrical display is utterly familiar all around the globe. To those who hold sacred the 24 frame capture rate for television program origination – as being at the very soul of the treasured "Film -like" images – it can be at the core of what they consider creatively separates film from video. Whatever the technical limitations of 24 frame might be – it is a huge and entrenched norm in television production. It is tolerated by the majority, loved by many, and positively revered by some prominent creative producers, directors, and DPs.

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60 Hz Video

Since its inception, video for television has been based upon a 60 or a 50 Hz capture and display rate. Television is a gigantic reality in terms of its ubiquitous presence all over the world. Equally, it is an astonishing marketplace success – indeed, it is an unprecedented global marketplace success. 60/50 Hz imagery has become a quite separate viewing experience to that of the 24 frame cinematic portrayal. As such, its distinct visual imprimatur has become indelibly associated with certain forms of program genre. As will be discussed, it can create certain imagery that 24 frames per sec (fps) film cannot originate quite as well.

New Creativity in an era of 24P and 60i HDTV

Clearly, there is an enormous established reality of both 24-frame and 60-field television program creation. The advent of 24P HD adds yet another creative dimension to programming flexibilities in the emerging digital era. To better grasp the relative roles of 24-frame versus 60-field (and 50-field) pictures in the era of HDTV, it is helpful to first recall from whence these two picture rates arose, and their quite separate and profound influences on program origination.

BACKGROUND

An Old Expediency – the 24 Frame Rate of Motion Picture Film

Just about every cinema around the world runs motion picture film through their projectors at 24 fps. To avoid protracted periods of darkness between successive picture frames (and the attendant very obvious flicker) each film frame is flashed twice on the cinema screen – at the rate of 48 fps – using a twin-bladed mechanical shutter. Thanks to the persistence of vision of the human visual mechanism, they are perceived as acceptably merged moving pictures.

24 fps has been with us a very long time. The 24 fps film camera capture rate was born in the late 1920's – with the advent of sound for movies. It was the lowest frame rate that could satisfactorily reproduce the new phenomenon of audio on the film's optical track rate (although this rate was higher than that which preceded it in the era of silent movies). This is a very important historical fact: 24 fps is actually a product of sound rather than imagery! The fact that it rendered motion reproduction more accurate in the pictures themselves was a somewhat happy and fortuitous coincidence.

Over the next five or six decades, there was little impetus to raise the capture rate any further because of cost increases associated with the attendant elevated consumption of 35mm film. "Good enough" – as applied to displayed motion film imagery – was a criterion established long before the advent of television.

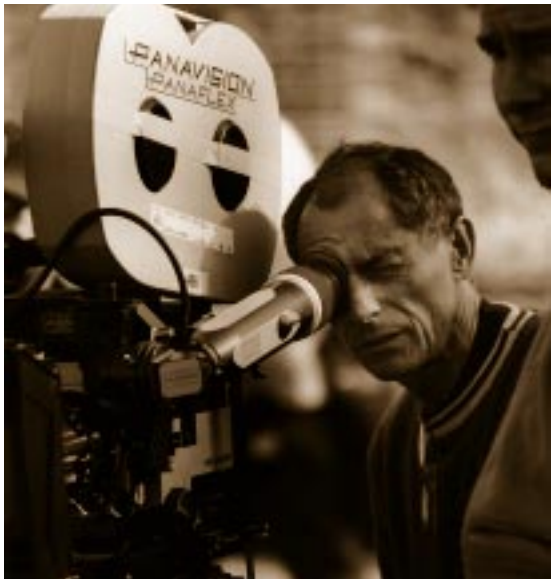
Indeed, much later, in the 1980's, SMPTE was to conduct a long study on the merits of raising the film frame rate to 30 fps, and in 1988, they published a famous report on those considerable merits. These were totally ignored by the industry. Evidently, 24 fps film had become deeply rooted in the psyche of most human beings, and few were complaining. Meanwhile, film stock costs have continued to rise. All of this has militated against any industry move to an enhanced frame rate (other than the use of high frame rate film for slow motion). Thus, 24 fps remains universally accepted as a quite adequate frame rate for capturing moving images. Hundreds if not thousands, of movies are presented to hundreds of millions of people every year in cinemas all over the world.

The Technical Aspects of 24 Frame Capture

Yet, 24 fps film does indeed have its technical limitations. Most of the populace has, at one time or another, probably wondered why the wagon wheels reversed themselves in their favorite westerns. Many have invariably endured the strain associated with inadvertent seating close to the gigantic movie screen, when fast camera pans, or fast moving scene content, assailed the eye-brain with a visual staccato judder that could almost hurt. All have probably at least noticed the "stuttering" of the windows of a building as the film camera pans across a stark cityscape. Yet, if familiarity does not quite breed contempt, it most certainly breeds a non-critical acceptance.

In purely technical terms, 24 frame image capture represents gross temporal subsampling of the moving picture. Technically, it works as well as it does only because a great deal of real-world motion is actually not all that fast. Indeed, the greater portion of today's average movie constitutes a large number of skillfully edited sequences of scenes that in themselves are largely still or quite slow moving (including the camera zooms, pans and tilts), and are thus captured really quite well. Over the decades, the refinement of camera dollies, jib arms, and Steadicam™, coupled with the expertise of film crews, has greatly contributed to the precision and smoothness of film camera moves, which in turn ameliorates the motion judder associated with 24- frame capture.

Sydney Pollack ©Panavision



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The Creative Aspects of 24 Frame Capture

Putting aside the technical aspects of 24 frame capture, the far greater creative dynamic cannot be ignored. Passionate advocates of film have long differentiated it from video on the very basis of a more subtle picture portrayal being the very essence of effective story-telling. Many largely attribute this to the shuttered camera operating at the low 24 frame rate. Over time, this unique frame rate has certainly been most skillfully exploited by legions of cinematographers to refine an entire art form in story telling. This is a core creative issue in any decision on choice of picture capture rate.

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The Electronic Newcomer – the 60 Hz Rate of Television

Sixty years ago an electronic communication phenomenon burst on the consumer scene and was forever to change the world. Television brought real time program creation (absolutely inherent to a medium initially born without concept of recording) and real time motion picture display and sound directly into the living room.

Technical Aspects of 60 Hz Capture

American television was born and raised on the basis of a 60 Hz picture capture and 60 Hz picture display. It was 60 Hz because there were technical advantages back then to locking the picture rate to the already entrenched electric power frequency. Sixty years later – it is still 60 Hz. Other regions of the world based their television systems on a 50 Hz base (for the same reason). It is all now a hugely established norm in virtually every living room in every land.

Over the ensuing six decades, the refinements to both television technology and television production have been unceasing. These encompass both the sheer breadth of program genres and the associated techniques of program creation. Very early in television's history the high picture capture rate quickly endowed television program directors and camera operators with a creative impetus that sought to push the medium to its limits. Integral to this was the speed with which the television cameras themselves could be moved – in terms of dollying, panning, and tilting. Later, the speed with which the zoom lens could be exercised would become an integral creative aspect of picture capture. The combination of camera motion and lens zooming became a distinctly recognizable "footprint" of television imagery – creating pictures that would uniquely set it apart from that of the cinema portrayal. Indeed, many are pictures that simply cannot be satisfactorily reproduced at all in 24 frame capture.

Creative Aspects of 60 Hz Capture

Certainly, the 60 Hz television system is capturing considerably more information in the temporal domain. On moving pictures this surely imparts a greater sensation of reality. On fast-moving pictures – such as those encountered in sports, wildlife, and certain drama segments – it captures and portrays a quite authentic and most compelling reproduction of the fluidity of fast motion. Of special importance, it has allowed the television display to progressively increase in brightness over the years, without an attendant disturbing increase in flicker. Even on the still image, there are more images per second being assimilated by the eye-brain, and although difficult to quantify, this too, is believed to add a psychophysical picture "presence" that is not there with shuttered 24 frame film imagery. Traditional artifacts associated with the interlaced 60Hz (and 50Hz) scanning are seemingly largely unnoticed by consumers the world over.

Sports especially, capitalized on the high picture capture rate of television. Fast moving action in the scenes themselves, in combination with vigorous movement of cameras attempting to rapidly span that action over significant distances on a ball field (further affected by the rapid and long zooms so familiar in sports shooting) – all would contribute to the "look" of live television. Slow-motion playback of recorded material, and electronically shuttered CCD cameras, would later add to the creative exploitation of that higher 60 Hz picture capture rate.

The television documentary comes in many forms: wildlife and natural history, biography, investigative projects, re-capture of historic events and places, mountain-climbing and underwater sagas, human drama stories related to medical, scientific, and societal challenges – the range of topics covered only increases every year. The very nature of the different documentaries themselves calls for wide variations in picture aesthetics, creative shooting techniques, and editing. Certainly the capture of birds in flight, racing cheetahs, etc. in wildlife shooting, almost demand the highest picture capture rate. Many documentaries, by their very nature, specifically seek a stark realism that is better imaged with the 60 Hz system. Others call for a heightened sense of drama, and indeed might specifically seek to replicate the special visual practices of movie-making – so here, the 24 frame capture might well be more attractive to a producer.

The 24-Frame Film and 60 Hz Video Debates

Over time, the emerging dialectic between proponents of film imaging and television imaging would speak of the subtle story-telling nature of the one, in contrast to the startling visual presence of the other. Ardent supporters of the 24-frame rate of film speak of a video look that is too real, and they largely attribute this to the much higher picture capture and display rate (with "television" lighting, and other practices, also contributing to this look). Within the enduringly futile debates between "video" and "film", the superior temporal resolution latent within television portrayal would be hopelessly pitted against the superior NARRATIVE capability of shuttered 24-frame film. In attempting any creative comparisons, quite different languages were used by the two sides. All of the disconnects that endure in communication to this day between advocates of motion picture film imaging and those of television imaging stem, first and foremost, from an inability to objectively recognize and adequately describe the relative merits of both picture capture rates. They are both very important.

THE “FILM-LIKE” IMAGE – A Closer Look

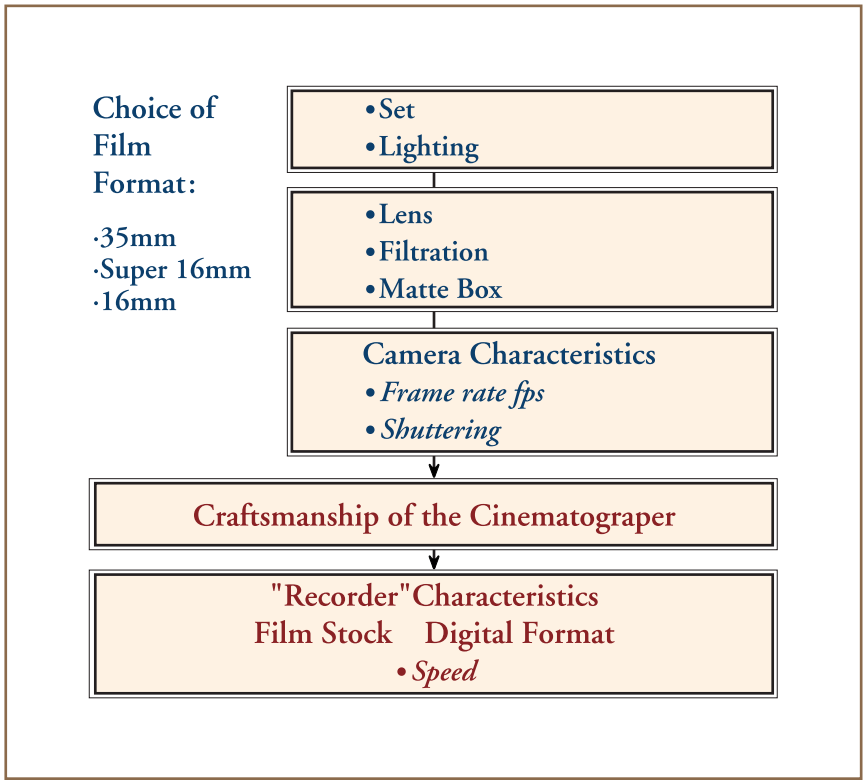

diagram A: The separate contributors to the final “Look” of captured imagery

In this new era of compelling choices among production media, it has become especially important to better describe all that constitutes the treasured “Film-like” images sought by many producers and DPs. It is far too simplistic to attribute the entirety of that look to the 24 fps capture rate. Key elements of that “Film-like” images can, in fact, be achieved with either 24-Frame or 60-Field HDTV.

Primary contributors to the many “dimensions” of imagery that collectively constitute the “Film-like” images are: Tonal Reproduction, Color Reproduction, Exposure Latitude, and Picture Sharpness. Exposure Index (operational sensitivity of a specific camera system) refers to the capture capability under specific levels of scene illumination.

Today, digital HDTV can rank with the best of 35mm motion picture film in each of these “dimensions” of the picture. 24-Frame HDTV, however, retains one singular advantage over its 60 Hz counterpart, in that the progressive scan will increase the vertical resolution and reduce some associated fast-motion edge-artifacts. This may, or may not be important, depending upon the particular degree of picture sharpness sought by the producer (after all, filtration is commonly employed to curtail excessive picture sharpness for certain scenes). Otherwise, they are equal in terms of the remaining three key picture attributes.

Other critical “dimensions” of the image relate to the specific craftsmanship of cinematographers as they exercise key aspects of camera optics – see diagram A. Certainly, traditional film-style lighting, optical filtration, and use of matte boxes, can all be applied equally to a digital HD camera (24 Hz or 60 Hz) as to a film camera. A most crucial other “dimension” of the picture – one that can be skillfully used to impart a very special attribute to the look of a scene – is that of Depth of Field. Here again, there remain significant optical differences between the 35mm optical format and the 2/3-inch HDTV optical format. The great advantage in exposure index (sensitivity) of the contemporary HDTV camera will, however, allow for a higher degree of neutral density filtering and associated lens aperture setting. That, in turn, facilitates the use of shallow depths of field in the HD camera (that can come remarkably close to the 35mm film camera) for what is generally sought in subtle image portrayal. In the case of Super 16mm film, parity in depth of field can readily be achieved with the HD camera.

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Thus, the creative discussion ultimately reduces to the one final picture “dimension” – that associated with motion capture and portrayal – the issue of 24 versus 60 pictures per second. That, in turn, reduces to the creative aspiration of a given producer and DP – for a given production. If 24 fps is important to add some final “dimension” of the film-like images, then that is what should be employed. If smooth motion rendition is more desirable, then the 60Hz capture makes more sense.

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The choice of either 24 or 60 pictures per second is readily available. As will be outlined in APPENDIX 3, the new HDTV cameras and camcorders facilitate both of these primary choices (and some others) within the one camera. The choice of what is ultimately used on a given shoot is dependent upon program genre.

PICTURE CAPTURE RATE – RELATION TO PROGRAM GENRE

To objectively examine the relative merits of 24 Hz versus 60/50 Hz picture capture it is first helpful to look at the many forms of contemporary television programming. What is certainly evident from the tabulation shown on the right is the staggering breadth of program types. Attendant with each are multiplicities of creative and aesthetic decisions, which collectively augur for choice in origination media, as well as picture capture rates. In addition, because any decision to use HDTV (at either 24-frame progressive or 60-field interlace) rather than film is bound up in budgetary as well as creative issues, it is useful to also look at today's average production costs – see APPENDIX 4.

TELEVISION PROGRAM TYPES

There are many generic forms of television program. Different terminologies are employed to classify them. The following is a not a complete listing, but it serves to illustrate the broad diversity in program types.

FICTION GENRE
TV Movies
Episodic Dramas
Multicamera Sitcoms
Miniseries
Soap Operas

NON-FICTION GENRE
Sports
Anthologies
News
News magazines
Documentary
Natural History

PROGRAM GENRE BROADCAST
Made-for-TV Movies
Prime Time Drama (One-hour)
Prime Time Sitcom (Half-hour)
Sports programming
Network News Magazine
Soap opera
Local News
"Reality" Specials
Documentaries
Wildlife / Natural History

CABLE
Cable One-hour drama
Cable 30-minute Sitcom
Cable "Do-it-yourself" Series
Sports programming

SYNDICATION
Syndicated "Action" Hour
Syndicated Talk Show
Syndicated Game / dating Show
Syndicated Court Show

SUMMARY ON 24-FRAME and 60-FIELD HDTV PRODUCTION

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Creative

The inescapable larger reality is that, from a creative viewpoint, both 24-frame and 60-field digital HD imagery are equally valid. Scripts, storyboards, and the specific aesthetic aspirations of the production team, will dictate the particular choice used for a given program.

Consumers, the world over, are very accepting of both 50/60 Hz television and 24 frame film. Both capture rates are well ingrained in the minds of virtually all. They accept either, and thus, the program origination choice reduces to that of the program producerd.

60 Hz capture will always retain a distinct advantage where fluid, smooth motion reproduction is important. Arguably, this applies to the greater degree of television production. 60i is also a major consideration if the program is to be distributed in multiple formats: digital HDTV, digital SDTV, and analog NTSC (a likely scenario for many years to come).

Technical

24-frame HD has the advantages of progressive scan (improved vertical resolution and lower scanning artifacts). This may or may not be important, depending upon the picture content – again, this comes back to program genre.

The DTV Transmission Standard is unique in that it allows transmission of a wide range of frame or field rates (with different digital sampling structures). Broadcasters might elect to transmit 1080/24P for some programs – to gain transmission data rate efficiencies – and, in doing so, they can technically capitalize upon this new digital transmission freedom. Here, 24P origination might become a major consideration – for some programs – see diagram B.

A great deal of current 525-line television programming does in fact inter-mix both 24 frame film originated material and direct 60i video. In the digital world, new choices for mixing media will be available: Shoot both film and HD at 24P; shoot both film and HD at 30P; shoot film at 24 or 30 fps and HD at 60i. While any decision might be swayed by which media dominates the mix, the technical decision as to which is the optimum mix of media and picture capture rates should probably be determined by the final primary distribution format. For example, if the final distribution is downconverted NTSC or 60i widescreen SDTV there would be much to favor the HD being shot at 60i (then, only the film material would have to contend with the frame rate conversion in post production) – see diagram C.

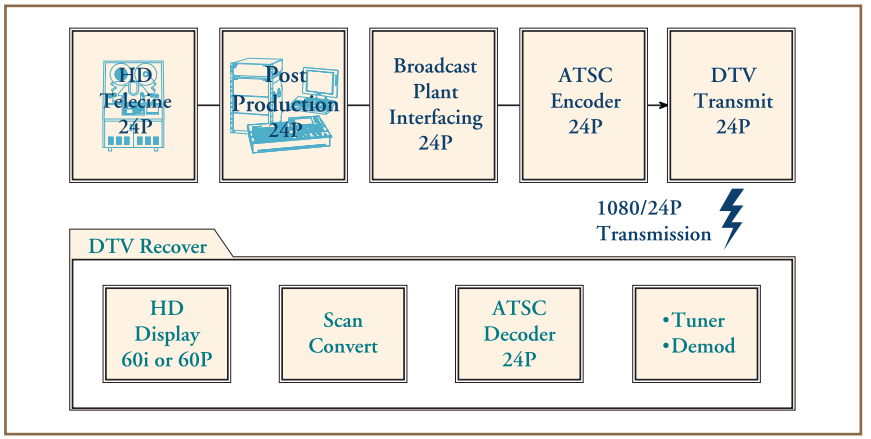

diagram B: DTV Broadcasting allows transmission of 24P directly to the DTV receiver

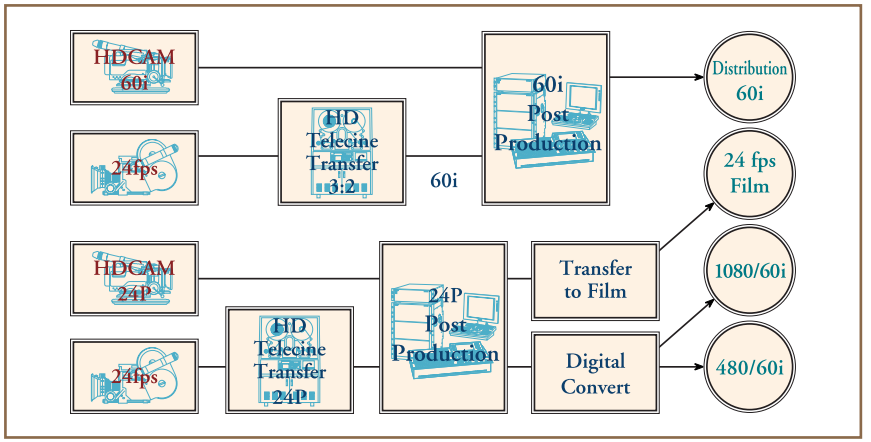

diagram C: The preferred picture capture rate may be influenced by the dominant distribution format

APPLICATIONS OF 24 PROGRESSIVE AND 60 INTERLACE HDTV

Prime Time Television Production

The greater percentage of total prime time programming is originated on the well-established 24 frame film. More recently, this has increased – a testament to a universal desire to protect shelf life of program assets in the new era of DTV. This long established tradition had the singular advantage of facilitating high quality telecine transfer to any of the international television formats (NTSC in the 60/59.94 Hz regions and PAL/SECAM in the remaining 50 Hz regions).

Production costs for prime time television programming have risen sharply over the past half-decade. A lot of U.S. shows are going abroad in pursuit of lower costs. HDTV production offers attractive possibilities for curtailment of costs:

Certainly the recording medium itself is substantially lower in cost than motion picture film stock (and then, in addition, it does eliminate the attendant film processing and transfer costs).

The ability to immediately screen a given take in full HD quality offers opportunities to strike a set on the same day of the shoot – with a new set in place early next morning. This can contribute to cost savings – assuming, of course, that such set turnover is important to a show.

Live blue/green screen work in HD is far more efficient than the traditional film/optical methodology – it can be seen in real-time on the set (facilitating, among other things, optimization of lighting and electronic controls). This is important for certain program types.

Certain labor agreements and/or workplace traditions can possibly provide for cost savings when producing on video rather than film.

Those shows presently being shot on 24 frame film are prime candidates for at least a serious consideration of shooting in 24P HD. With a DP willing to learn, they can quickly gain the expertise to create imagery very close to what they had done on 35mm film, but at a lower cost. As the DP gains in skill, new creative opportunities will arise that exploit their own innate experience and some of the truly unique creative capabilities of the digital HD camcorder or camera.

The remaining prime time programs presently being shot on 60 Hz video (with few exceptions these are shot in standard 4:3 aspect ratio) are certainly prime candidates for consideration that they be shot on digital HD. With the advent of multi-format widescreen DTV, their shelf life will be augmented. Here the 1080 @ 60i is probably the better choice, as it will retain many of the characteristics of the former 60i-based standard definition origination. In the new global DTV environment, the widescreen higher resolution HD origination will also better support high quality distribution masters of both 525- and 625-line programs.

BROADCAST	24P	60i	COMMENTS
Made-for-TV Movies	**Preferable**	Some	Common Practice
Prime Time Drama (One-hour)	**Preferable**	Some	Creative Call
Prime Time Sitcom (Half-hour)	**Preferable**	Some	Creative Call
Sports programming	Not Good	**Preferable**	Fast Motion
Network News Magazine	Some	**Preferable**	Creative Call
Documentaries	Some	Some	Creative Call
Wildlife / Natural History	Some	**Preferable**	Fast Motion
“Reality” Specials	None	**Preferable**	Common Practice
Soap Opera	Some	**Preferable**	Common Practice
Local News	None	**Preferable**	Common Practice

CABLE	24P	60i	COMMENTS
Cable One-hour Drama	**Preferable**	Some	Common Practice
Cable 30-minute Sitcom	Some	**Preferable**	Creative Call
Cable “Do-it-yourself” Series	None	**Preferable**	Common Practice
Sports programming	None	**Preferable**	Fast Motion

SYNDICATION	24P	60i	COMMENTS
Syndicated “Action” Hour	None	**Preferable**	Common Practice
Syndicated Talk Show	None	**Preferable**	Common Practice
Syndicated Game / dating Show	None	**Preferable**	Common Practice
Syndicated Court Show	None	**Preferable**	Common Practice

Television Commercial Production

A great deal of national television spots are shot on film, mostly 35mm film. While the majority of these are shot on the traditional 24 frame film, there is also a wide use of 30 frame film because of its friendlier relationship to the American 60-field television system (no 3:2 Pulldown issues). Super 16mm, and even 16mm film, are used to produce many lower budget “local” commercials.

Those commercials presently being shot on 24 frame (or 30 frame) film are prime candidates for serious consideration of shooting via 24P (or 30P) HD. Again, in the hands of an experienced DP, the picture produced will have most of the characteristic attributes of motion picture film familiar to that DP. There are other commercials however that will be well served by the higher 60-picture capture rate. Fluid, fast motion is a key element of many commercials. Others utilize slow motion techniques – a key element, for example, in many of the commercials promoting hair treatments, detergents, pouring of liquids etc. Traditionally, a high speed 35mm film (frame rates varying up to 120 fps are not uncommon) is used. Recent tests have shown that electronic shuttering in the digital 60i HD camera, in combination with slow-motion digital recorder playback, can superbly simulate what is typically achieved with film running at 90 fps.

FLETCHER CHICAGO

Rental Facilities

An extensive number of video rental houses have already invested in HDTV camera, camcorders, recorders and displays (as well as an array of accessories). They presently sustain the rapidly growing production of early DTV programming. They also support the growing number of producers who want to use a high-end capture medium to protect the "shelf life" of their program assets (and who are presently downconverting their HDCAM footage to 525-line formats for current distribution). In addition, the recent significant increase in postproduction houses embracing HDTV is further spurring the demand for rental HD acquisition equipment. Equally, the increase in HD projection systems for business screenings is fostering rental demand. Most rental facilities report an expanding HD rental business that is testament to the growing reality of high definition television origination. Traditional film rental houses are beginning to show an interest in digital cinematography.

The rental house will invariably encounter every need in HDTV production: movie-making, television programming of all kinds, television commercial, documentary, corporate, etc. It is for this very reason that it is important that the rental house be well schooled in the new HD choices they will be able to offer. Being able to clearly explain the attributes of both 24P and 60i shooting will be a major consultative service that should enhance their stature with their very diversified client base. Fortunately, the new generation of "24P" cameras and recorders will be switchable between 24P, 25P, 30P, as well as 60i and 50i – see Appendix 2. This will greatly facilitate the flexibilities offered by the rental houses.

Plus 8 Video

BANDPRO

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Independent Film Community

This constituency has grown dramatically over the past twenty years. It currently encompasses a vast potpourri of creative program makers within all facets of visual and aural communication – from low-budget movie-making, to natural history, documentary, corporate, business & industrial, commercial, television, college student, film schools, etc. This is a community who largely shoots on 16mm film because of budget constraints. Yet, often their work must be "blown-up" to 35mm for theatrical release – a process that adds to production costs and entails a further loss in image quality.

Digital origination has already been discovered by many in the independent film community. All of the major film festivals, both domestically and internationally, have recently shown a quite extraordinary number of award-winning works that were shot with digital cameras and subsequently transferred to 35mm film for theatrical showing. What is particularly astounding is that many of these have originated not on professional digital camcorders, but on the consumer Mini-DV! And, accordingly, many have been shot with either 60-field or 50-field digital cameras. Clearly, the old barriers between 24-frame and 60 pictures per second are being lowered. Story-telling is not being impaired. Creative bridge are being built, between digital video and film.

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Major Movie Production

Movie production in the U.S. is a highly refined engine of theatrical entertainment program production. It is supported by a vast "cottage industry" infrastructure of talents and facilities that can, with extraordinary efficiency, be drawn upon to assemble the well-oiled machine that is representative of creation of the most sophisticated "block-buster" movie, to the countless lower-budget movies that are a staple of an ever-thirsty populace.

This is an industry that does not in any way consider its mechanisms of operation to be "broken". To the contrary, their pride in a decades-old modus operandi is one of a creative community who believe every new movie to be a refinement on the last (in terms of creativity, innovation, profit-making). The very concept of 24P electronic cinematography is, accordingly, anathema to some veterans of an industry who intractably perceive "video" to be radically inferior to film. To them, digital HDTV is an upstart electronic technology daring to encroach on an art form they perceive to be unique, and indeed, they further maintain that anything that smacks of "television" should have no place in theatrical entertainment.

Yet others recognize that the world is changing and that technology is not all evil. They have closely followed the truly astonishing developments in digital high definition video and they wisely appreciate that 24P HD, especially, is far too important to be dismissed out of hand. One renowned filmmaker has already committed to using this technology for a major movie production in 2000.

24P HDCAM (Digital 35mm)

Digital BETACAM (Digital Super 16mm)

DVCAM (Digital 16mm)

The three tiers of film formats: 35mm, Super 16mm and 16mm are separated by both their distinct performance capabilities and by the costs associated with these stocks. In the new digital era there are approximate digital acquisition equivalents:

• Widescreen HDTV ranks with 35mm film – the HDCAM™ camcorder being the electronic emulation of that shoot and capture format.

• Widescreen digital 4:2:2 acquisition – typified by the Digital Betacam™ camcorder – ranks with Super 16mm

• Widescreen digital 4:1:1 acquisition – typified by the professional DVCAM™ camcorder – is an excellent electronic emulation of 16mm film

In the HDTV domain, there is the choice of 24-frame or 30-frame progressive scan (both are available in one camera or camcorder) – so a direct emulation of film at either of these frame rates is possible. For the 50 Hz countries, the further option of 25-frame is also built-in.

APPENDIX 1

HDTV meets Motion Picture Film – on a 24-Frame Platform

It is within the context of the two worlds of video and motion picture film that a new convergence of digital HDTV and film is about to take place. HDTV is taking a giant leap across to the domain of motion picture film by implementing the emulation of one of its most prominent characteristic – the 24-frame rate. A crucial bridge has just been built.

This new move has created a great deal of industry "buzz". As a consequence of this, many conclusions are being drawn – some perhaps prematurely. It is important to all parties – customers and manufacturers alike – to soberly acknowledge some significant realities when reviewing the applications of 24P.

What 24P HDTV does not presume to attempt is:

- Total displacement of film
- Total displacement of standard 60i HDTV

Realistic and objective assessments of what 24-frame HDTV does aspire to facilitate might include:

- More seamless transfer between motion picture film and HDTV
- Effective management of post production for multi-format DTV (from 24 frame film originated material) on the basis of a single 24P master.
- A new creative (and budgetary) flexibility based upon the following:
    - Possibility to produce some television shows – that are presently originated on film – via a digital 24P HD medium
    - Possibility to digitally produce cost-effective high-quality movies – within the realm of the huge independent film community
    - Possibility to digitally produce some movies (or segments of movies) – within the realm of the major studios

APPENDIX 2

International Implications of 24P HDTV

The 24P movement began in the U.S. It was driven initially by an agenda to bring real-time digital imaging into the arsenal of creative tools for moviemakers. The arrival of the digital HDTV camcorder in 1998 had spurred a new recognition that this technology had come a very long way in its pursuit of motion picture film imaging. The decision to utilize progressive scan and 24-frame capture rate for a new variant of the digital HD camera/camcorder was all that was required to make the last big leap into a full electronic emulation of film shoot and capture.

On a separate front, the 1998 revelation by each of the broadcast networks of the diverse digital video formats that each had tentatively adopted for DTV transmission, sent shock waves throughout the post production community. How were all of these numerous formats to be mastered? The recognition that 24 frame motion picture film constituted a large portion of prime time television program origination fostered broad support to a new proposal to transfer this 35mm film to a 1920 x 1080 progressive HD format at the same 24 frames per second. This 24P digital format would be used for all post production. The final 24P edited masters would then be digitally converted to all of the disparate DTV distribution formats of 1080/60i, 720P, 480P, and 480i, in addition to the overseas 576/50i.

Meanwhile, following a long decade and a half effort, the ITU had been steadily converging on an international consensus for a global standard for HDTV production and international program exchange. By 1998, almost all parameters, other than the entrenched 50 and 60 Hz field/frame rates had been agreed- to. The final consensus – to eliminate the 1250 total line number and achieve total unanimity on the 1125 number – was realized. In an unprecedented flurry of activity the ITU delegates then agreed to add all of the new progressive scan frame rates now elevated to a high visibility.

The new international standard was ratified in June 1999. It is based upon the principles of the Common Image Format of the 1920 x 1080 digital sampling structure. All supporting technical parameters relating to scanning, colorimetry, transfer characteristic, etc. are the same the world over. This format can be used with any of the following picture capture rates: 60P, 50P, 30P, 25P, 24P, as well as 50i and 60i. The standard is identified as ITU-R BT 709-3.

For the first time in television history manufactures are now able to cost-effectively produce switchable products for production and post production. One HD camera or camcorder, meeting this ITU standard, can be utilized anywhere in the world. The implications are immense: greater economies of scale will ultimately help lower HD equipment costs; international co-productions will be expedited; rentals will be universal as is the case with the film camera. The 24P camera and recorder have metamorphosed into multi-frame rate products. Sony's new HDW-F900 camcorder will, for example, switch between 24P, 25P, 30P, as well as 50i and 60i. Similarly, a new Sony digital HD studio camera and its companion portable HD camera will also be switchable between all of these same frame and field rates.

APPENDIX 3

24 - Frame Film and 60 Hz Television Program Creation

Film is widely accepted as the preferred medium for television production. In particular, a great deal of prime time television programming is originated on 35mm motion picture film. This is a long-established and uniquely American practice. In other regions of the world film is also used for television programming, but it is more likely to be 16mm. More recently, with the advent of widescreen digital standard definition television, it has become Super 16mm film. It is often quoted that 60-80% of American prime time television is originated on 35 mm film (that is only shown on global television screens). It is indisputable that 35mm film had long retained a picture quality "overhead" far in excess of that of analog 525-line composite NTSC and 625-line PAL/SECAM. Yet, the inevitable technological progress of video was to witness startling advances over the past decade. Contemporary digital HDTV imaging is an entirely different discussion to its NTSC forebear.

The origination of television imagery via a 24-frame capture rate has thus become a significant reality. Two somewhat imperfect techniques are used worldwide to transform that initial picture capture rate to the television image frame rates of the world. For the 525/59.94 regions of the world it is the 3:2 electronic conversion (called 3:2 Pulldown) which adds a motion artifact (visible on certain scenes). For the 625/50 regions of the world it is an issue of speeding up the video transfer from the 24 frame film by 4% – to achieve reconciliation with their 25 Hz frame rate. This introduces motion acceleration (small and generally invisible) and an audio pitch change (which at times is certainly noticeable).

During telecine transfer in 50Hz countries, the 24 fps film is run at 25 fps to reconcile the frame rates of the two media. If shot exclusively for television it is often shot at 25 fps, thus producing a perfect match between film frames and video fields. If, however, shot at 24 fps, it is subsequently played back at the 25 fps rate to maintain simple frame-field correspondence, producing, however, faster-running video and sound. Alternatively it could be run at 24 fps but additional fields have to be inserted to match the video frame rate, i.e. every 12th frame of film is transferred on 3 consecutive video fields. Therefore, half of the time, each film frame is transferred on the odd and even field of the same video frame, and half of the time odd and even field of the same video frame have content from the successive film frames, making it difficult for frame accurate editing.

In 60 Hz countries "2-3 pull down" sequence is normally used to convert 24 film frames into the 60 Hz (or more precisely 59.94) video signal, where film frames are alternatively scanned with two and three video fields. This is the working practice that calls for extra precaution during editing. Also, it produces an additional judder (over and above that sometimes seen with 24 frame capture of motion) that can be particularly noticeable on horizontal movements.

APPENDIX 4

PROGRAM GENRE	AVERAGE COST OF PRODUCTION
BROADCAST	
Made-for-TV Movies	$ 4 Million
Prime Time Drama (One-hour)	$ 1.6 Million/Episode
Prime Time Sitcom (Half-hour)	$ 1 Million/Episode
Sports programming	Very high and very variable
Network News Magazine	$ 0.5 Million and greater/Hour
Soap opera	$ 1.25 Million/Week
Local News	$ 1.35 Million/Year
“Reality” Specials	$ 0.55 Million
Documentaries	Highly variable
Wildlife / Natural History	Highly variable
CABLE	
Cable One-hour drama	$ 1 Million/Episode
Cable 30-minute Sitcom	$ 0.55 Million/Episode
Cable “Do-it-yourself” Series	$ 9000/Half-hour (Studio)
	$ 18,000/Half-hour (Location)
Sports programming	Highly variable
SYNDICATION	
Syndicated “Action” Hour	$ 1 Million/Episode
Syndicated Talk Show	$ 0.45 Million/Week
Syndicated Game / dating Show	$ 0.2 Million/Week
Syndicated Court Show	$ 0.2 Million/Week

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