QuickTime MOV versus Videotape Workflow

WHITE PAPER

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Introduction

Since the first day about twenty-five years ago when digital video disk recorders were first introduced into mobile television trucks, there existed the need to get "pre-produced" video / audio content from the production studio and into the video disk recorders installed in the mobile television trucks.

Within a few years, there was also a need to transport associated "keying" matte signals to the digital video disk recorder as well. These matte images perform "hole-cutting" in live background video, into which foreground video is inserted—all executed within a "keyer" inside a video switcher/mixer. Please refer to **Figure 1** below for an illustration of this keying process.
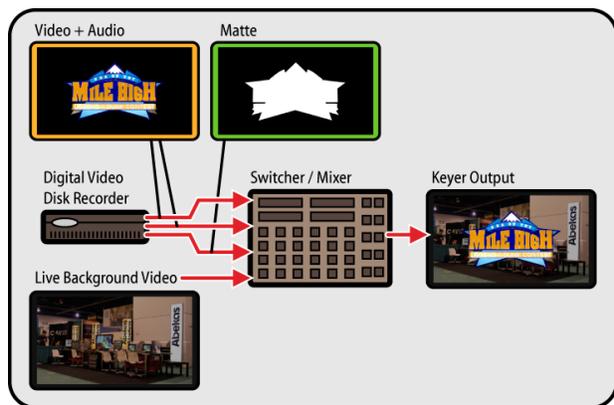

Figure 1: Video / Audio / Matte "Keying" Process

The only viable media in existence back in the early 1980's to transport the video, audio and matte images from the studio and into the digital video disk recorder in the mobile television truck was the ubiquitous videotape.

This videotape "transport medium" at the time did the job well enough. Surprisingly, even though we're now almost a decade into the 21st century, this basic videotape workflow has remained largely unchanged since it was first dreamt up twenty-five years ago. And with the evolution from standard-definition (SD) to high-definition (HD), the production of these transport videotapes typically includes three (and sometimes more) compression / de-compression steps, coupled with one or more HD-to-SD and SD-to-HD conversion steps along the way.

The result is a significant degradation in the image quality at the output of the mobile television truck—and then *that* video gets down-sampled and compressed to 19Mb/s (or less) for the broadcast, satellite and cable television distribution to the home viewer. The consequence of expending a great deal of money and labor in this process is to end up with rather awful results.

This white paper addresses an alternative transport workflow—which, when compared to the traditional videotape workflow, provides several impressive benefits; including:

- Dramatic improvement in final image quality.
- Completely accurate import into digital video disk recorder.
- More reliable "live" control over the digital video disk recorder.
- Much simpler overall operation.
- Much less labor involved.
- Large reduction in materials costs.
- Meaningful clip names provided in digital video disk recorder.
- Substantial monetary savings by both clients and mobile television truck owners.

The remainder of this white paper details the traditional videotape workflow, and contrasts it to the QuickTime MOV file-based workflow. A summary explanation of the benefits along with a conclusion is also provided.

Overview—Traditional Videotape Workflow

The videotape "transport medium" mentioned in the paragraphs above has been widely adopted, and is still in use even today. As technology advanced over the years, the process evolved to

account for changes in production equipment, such as non-linear editing systems and tools with various compression schemes.

However, the basic workflow remained the same, and in most cases has worsened with introduction of high definition (HD) content. This may seem counter-intuitive, but many times, the pristine HD content created in the studio is down-converted to standard definition (SD) in order to accommodate the VTR equipment fitted in the mobile television trucks—since some trucks have not invested in expensive HD-native videotape machines. The content is then up-converted back to HD at time of play out.

At the time the videotape workflow was originally developed, it did the job well enough. Even today, it still works well enough—but this question begs to be answered: at what cost?

How is the traditional videotape workflow structured?
We will first investigate the existing videotape workflow. This process is rather convoluted and there are several variations on the concept—but in most cases there are <u>fourteen</u> (!) steps in all. The listing of these steps below is accompanied by an indicator of the relative degree of difficulty for each step in the process:

1) Content rendered .... `SIMPLE`
2) Content ingested into non-linear editor .... `MEDIUM`
3) Video / audio elements edited to one timeline .... `DIFFICULT`
4) Matte elements edited to another timeline .... `DIFFICULT`
5) Project render to base-band video / audio / matte .. `SIMPLE`
6) Base-band video / audio edited to videotape .... `DIFFICULT`
7) Base-band matte edited to videotape .... `DIFFICULT`
8) Create "Look-up" document .... `DIFFICULT`
9) Videotapes duplicated .... `MEDIUM`
10) Ship or hand-carry videotape .... `SIMPLE`
11) Ingest videotape into digital video disk recorder ..... `SIMPLE`
12) Intermediate Controller programmed .... `DIFFICULT`
13) Switcher/mixer memory programmed .... `MEDIUM`
14) Air the content .... `SIMPLE`

As anyone can plainly see, it takes a tremendous amount of human labor and very expensive equipment just to get these videotapes produced, copied, shipped, and ingested into the digital video disk recorders mounted in the mobile television trucks. Notice also the number of steps marked `DIFFICULT`, which roughly indicates the relatively large amount of human labor required for those steps in the process.

Following is a detailed explanation for each step in the process (*please refer to* **Figure 2** *on page 3 below*):

1 **Content rendered:** This step does not account for the content creation, but only the rendering of the content. In the vast majority of studios where the original HD content is produced, the computer-generated content is output to high-quality movie files—for purposes of in-house review, approval

and archiving. This step in the process is already quite familiar and very well established for content producers.

2 **Content ingested into non-linear editing system:** In order to begin the editing process to prepare the content for transfer to videotape, the rendered material is played out through real-time hardware into a non-linear editing system. In more cases than not, this step involves a compression process which degrades the quality of the video images.

3 **Video / audio elements edited to one timeline:** After the content has been ingested into the non-linear editing system, the laborious process begins to place all the video / audio content onto a single edit timeline.

4 **Matte elements edited to another timeline:** The above step is repeated a second time; to place all the associated matte content onto a separate edit timeline—taking great care to ensure the duration and placement of the matte elements exactly match the duration and placement of the video / audio content. If this care is not taken, the matte will not match the associated video / audio elements once they are all ingested into the digital video disk recorder in the mobile television truck.

5 **Render video / audio and matte timelines:** After the video / audio and matte timelines are created, these timelines must be rendered to output base-band video once again, for layoff to the videotape machine.

6 **Edit video / audio to videotape:** With the edit timelines now back in base-band, this content is edited to the videotape machine, to lay off the video / audio portions of the clips. This step usually incurs another compression step, affecting image quality once again.

If the videotape medium to be used must be standard definition (SD) because that's the only type of VTR available in the mobile television truck, then this step also includes an incredibly image-damaging process to down-convert the HD video to SD.

7 **Edit Matte to videotape:** The above step is repeated a second time, for the matte elements of the clips.

8 **Create "Look-up" document:** Another painstaking step, to create a document to help locate sub-clip "in" and "out" points within the "mega-clip" on the videotape. This step is performed twice; once for video / audio—the other for the associated mattes.

9 **Videotape duplicated:** An archive copy of the videotape is made, along with another copy destined for the mobile television truck. If the videotape must be shipped to more than one mobile television truck in the field, then the "master" videotape is duplicated multiple times.

10 **Ship videotape to mobile television truck:** The final product videotape is shipped or hand-carried to the mobile
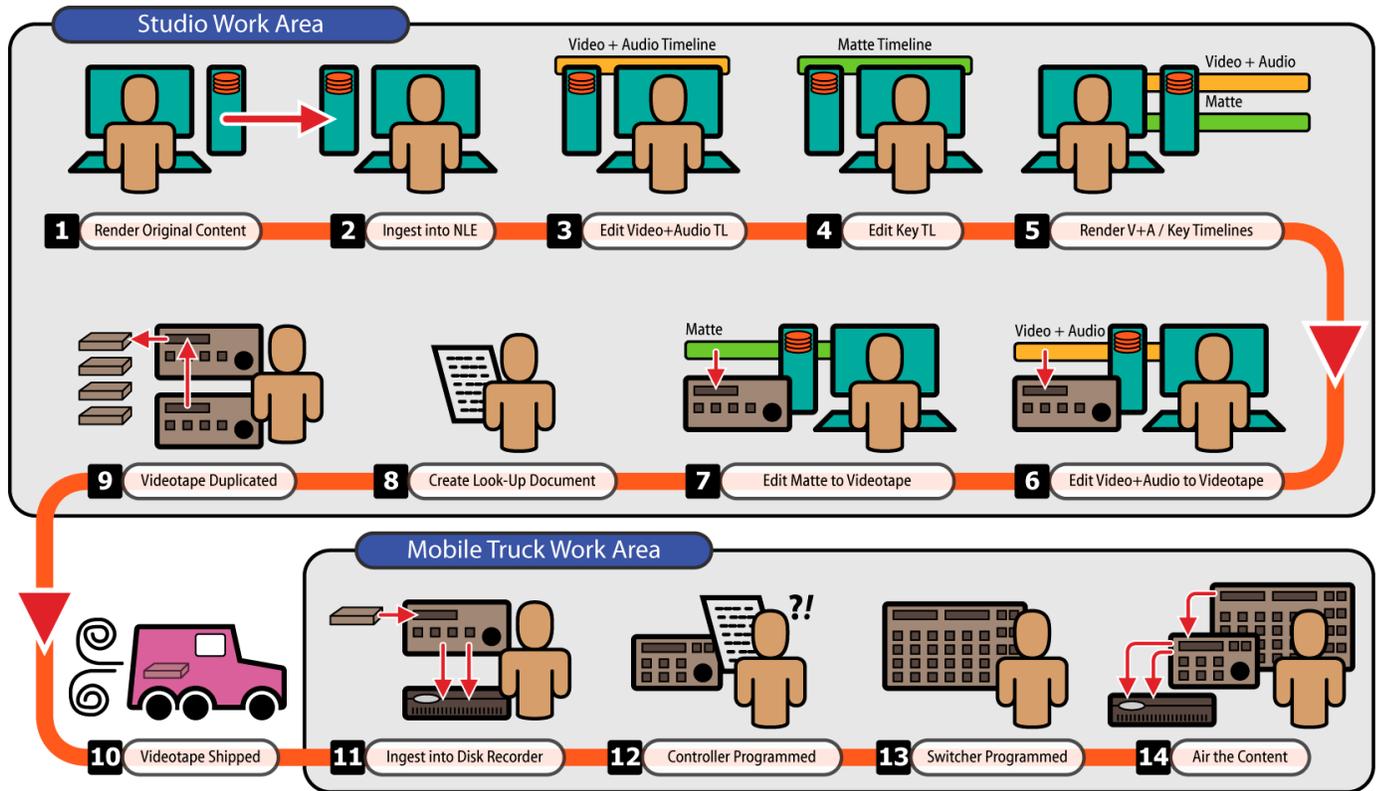
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Figure 2: Traditional Videotape Workflow

television truck(s) located in the field. The helpful "Lookup" document accompanies each videotape.

11 **Ingest videotape into digital video disk recorder:** Once the videotape arrives at the mobile television truck, it's loaded into a VTR and played out while the digital video disk recorder captures the content. The disk recorder receives two of the VTR video outputs at the same time, recording video / audio on one channel of the disk recorder, while recording the matte images on another channel.

This is a real-time capture process, but it actually ends up being more than *twice* real-time because the matte content comes *after* the video / audio content on the videotape.

If the videotape is produced in SD, but the broadcast is to be in HD, then there is further degradation to the image quality in this step when "up-converting" from SD to HD.

12 **Intermediate Controller programmed:** A Technical Director programs memory registers inside the intermediate controller to associate the controller's registers to the "in" and "out" points that define each sub-clip within the mega-clip. The "Look-up" document is used to determine where the sub-clips are located within the "mega-clip".

13 **Switcher/mixer memory programmed:** Memory registers inside the switcher/mixer are programmed by the Technical Director to associate timeline triggers in the switcher's memory with the memory registers inside the intermediate controller. The control between the two is provided via PBUS protocol.

This step associates the clip registers defined inside the intermediate controller to the switcher's given memory locations—so that later, when the switcher "clip load" operation is performed, that particular clip is loaded into the digital video disk recorder, as commanded by the intermediate controller. A subsequent "clip play" command is also programmed into the memory of the switcher/mixer.

These "clip load" / "clip play" commands are placed into the switcher's "timeline" memory to load and trigger clip play events at desired times during the on-air process.

14 **Air the Content:** The switcher's memory registers are loaded and run at the direction of the Technical Director.

Whew! What a load of work that is. And what's worse, during the production of these "transport" videotapes, there are usually three or more compression/decompression steps—sometimes with one or more HD-to-SD and SD-to-HD conversion steps along the way.

That pristine, visually-impactful high definition content produced in the studio ends up looking like mushy mish-mash (*not a very technical term, but you get the idea*) once it hits the video output at the mobile television truck—and then *that* video output gets down-sampled and compressed to 19Mb/s (or less) for broadcast, satellite and cable television distribution to the home viewer.

Another issue that arises for "flying graphics" content in the videotape workflow is precisely aligning (within a single video frame) the video / audio within the clips to the associated matte images. The reason? In the originating studio, the video / audio elements are typically all recorded at the head end of the transport videotape, while all the associated matte elements are recorded at the tail end of the tape. Aligning these three elements is a tricky business, and there are several points along the workflow where this alignment can drift from perfection.

After ingesting the mega-clip into the digital video disk recorder, the Technical Director must then carefully align the video / audio to the matte located at a distant point within the mega-clip. And it doesn't always end with happy results.

Furthermore, this step entails controlling the digital video disk recorder over *two* serial control ports from the switcher/mixer (via the intermediate controller); adding yet another level of complexity and possible points of failure during live on-air operations.

Overview—QuickTime MOV Workflow

Fortunately, there is now an alternative to the videotape transport medium, involving the use of portable Hi-speed USB (or Firewire) disk drives which are populated in the production studio with QuickTime MOV files. Coupled with these portable disk drives is deployment of modern digital video disk recorders in the mobile television trucks, which are capable of importing these QuickTime MOV files.

While importing these QuickTime MOV files, the digital video disk recorder creates *individual*, extremely high-quality HD clips containing video, audio and matte elements. Users can now say "goodbye" to meaningless "mega-clips" which by nature lack individual clip names.

The end product image quality obtained with this file-based workflow is *far* superior to that obtained with the traditional videotape workflow, and is *identical* to the image quality seen in the production studios where the HD content is originally created.

The labor-intensive process to edit, duplicate and distribute the videotape media can now be history. Gone is the labor-intensive and painstakingly complex ingest, alignment and programming operations in the mobile television truck. And as a result, a greatly improved home viewing experience is achieved, with the added benefit of huge reductions in operational and materials costs.

How is this QuickTime MOV workflow structured?
There are basically just **seven** steps involved. The listing of these

steps below is accompanied by an indicator of the relative degree of difficulty for each step in the process:

1) Render content as QuickTime MOV files .... `SIMPLE`
2) Copy MOV files to portable USB disk drive .... `SIMPLE`
3) Clone portable disk drive (*optional*) .... `SIMPLE`
4) Ship portable disk drive to mobile television truck ... `SIMPLE`
5) Import MOV files into digital video disk recorder ..... `SIMPLE`
6) Switcher/mixer memory programmed .... `MEDIUM`
7) Air the content .... `SIMPLE`

Contrast this list with the corresponding list for the traditional videotape workflow found on page 2 above. There are much fewer steps, and the steps for the QuickTime MOV workflow are mostly `SIMPLE` procedures, with no `DIFFICULT` steps involved. If you're responsible for maintaining operational budgets, this equates to a rather substantial reduction in human labor costs.

Following is a detailed explanation for each step in the process (*please refer to **Figure 3** on page 5 below*):

1 **Render content as QuickTime MOV files:** This step does not account for the content creation, but only the rendering of the content. In the vast majority of studios where the original HD content is produced, the computer-generated content is already output to high-quality QuickTime MOV files—for purpose of in-house review, approval and archiving. So this step in the process is already quite familiar and very well established for content producers.

2 **Copy MOV files to portable USB disk drive:** The content producers simply copy the desired MOV files to a Hi-speed USB or Firewire disk drive using simple and common computer tools.

For a fifteen to twenty-minute set of real-time transitions, opens and closes used in a typical live broadcast program, a 250GB to 750GB capacity disk drive will much more than suffice, with loads of extra space remaining on the disk.

As of the time of this writing, this variety of SATA disk drive fitted inside a Hi-speed USB enclosure with this capacity range will roughly cost from \$95.USD to \$175.USD (*and this cost is sure to come down over time*). This cost is comparable to the cost of similarly-sized HD videotape cassettes used in the traditional videotape workflow.

3 **Clone portable disk drive (optional):** If the content must be distributed to multiple mobile television truck locations, then the MOV-populated portable disk drive is cloned using inexpensive cloning software and PC hardware.

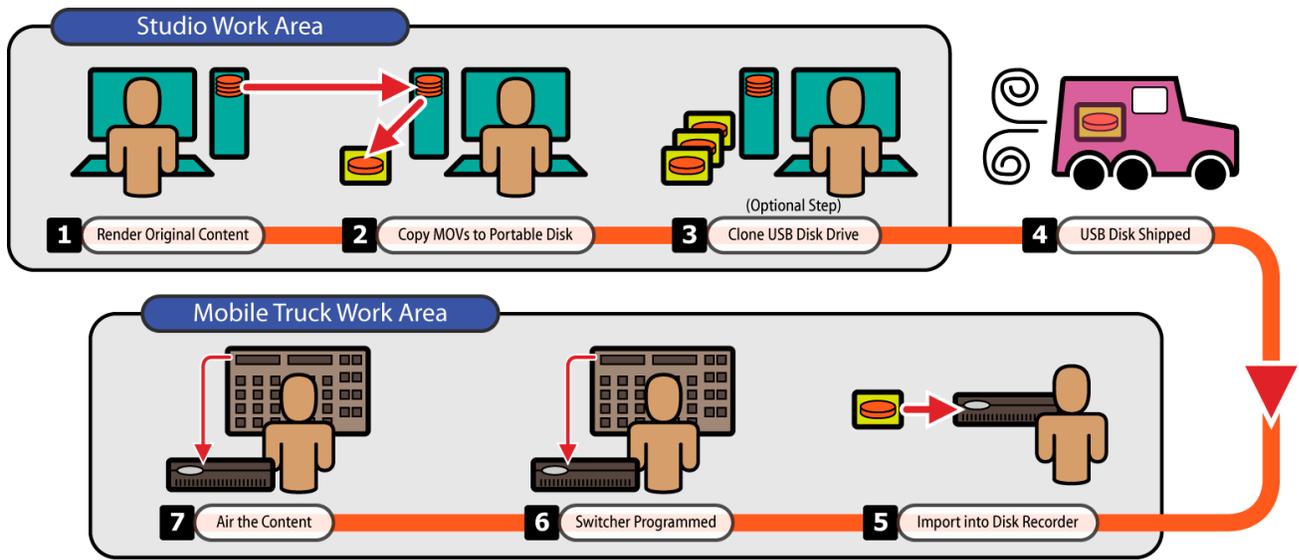If the content is destined for only one location, then this step is skipped.

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Figure 3: QuickTime MOV Workflow

4 **Ship portable disk drive to mobile television truck:** The portable disk drive is shipped or hand-carried to the remote mobile television truck(s).

5 **Import MOV files into digital video disk recorder:** The portable Hi-Speed USB (or Firewire) disk drive is connected to the digital video disk recorder, which is easily programmed to electronically import the QuickTime MOV files into real-time, extremely high-quality clips; each with video, audio and matte elements—and all with absolutely no visual loss or degradation in the image or sound quality.

As an added benefit, the import process creates separate and individual real-time clips in the digital video disk recorder, each with the same clip name as given to the MOV file being imported. This benefit greatly enhances and streamlines the overall workflow organization of the clips.

Compare this to the traditional videotape workflow, in which there are absolutely no clip names in the digital video disk recorder, and a "Lookup" document must be employed.

Furthermore, this import process simultaneously imports video, audio and matte with guaranteed precise alignment of these three elements inside each and every media clip.

6 **Programming switcher/mixer memory via PBUS control:** This is a step with which every Technical Director is already quite familiar. The only variation is during time of switcher/mixer memory programming; the desired clip is first loaded in the player of the digital video disk recorder—and then a switcher PBUS "Learn" operation is performed for a given switcher memory register.

This action associates the loaded clip to the given switcher memory location—so that later, when the switcher's "clip load" operation is performed, that particular clip is loaded into the player hardware inside the digital video disk recorder. A subsequent "clip play" command is then programmed into the switcher's memory.

These "clip load" and "clip play" commands are placed into the switcher's memory "timeline" to load and trigger the events at desired times during the on-air process.

7 **Air the Content:** The switcher's memory registers are loaded and run at the direction of the Technical Director.

As one contrasts this process with the traditional videotape workflow, one can readily see the QuickTime MOV workflow is much simpler, less labor-intensive, and is much lower in cost.

With this QuickTime MOV workflow, the visually-impactful high definition content produced in the studio ends up with much the same pristine, visually-impactful high definition quality on the home viewer's television screen.

And since there is a *single*, direct control connection between the switcher/mixer and the digital video disk recorder (as opposed to three control links in the traditional videotape workflow with the intermediate controller), there is a 67% improvement in control reliability—greatly reducing the chances of clip load and trigger failures during live on-air operations.

Which QuickTime MOV Codec to Use?
Any QuickTime Codec can be used to create MOV files for import into the ClipStoreMXc —with one exception: the DVCPRO-HD codec *cannot* be used, since Apple and Panasonic offer only a proprietary and extremely expensive codec to read these MOV files on the WindowsXP platform. The digital video disk recorder doesn't support that particular codec because the licensing costs for this codec were considered excessively high. As a result, MOV

files created with the DVCPRO-HD codec cannot be imported.

However, since MOV files created with the DVCPRO-HD codec have inferior image quality (*compared with most other available codecs*), the DVCPRO-HD codec is rarely used in this workflow anyway; and this point is therefore moot.

Otherwise, any other QuickTime codec may be used. The most flexible codec available is the "Animation" codec—since this codec supports very high quality images with an alpha channel for the matte images. Self-contained MOV files created with the Animation codec carry video, audio and matte; and they are efficiently imported by the digital video disk recorder.

If no matte signal is required, then the "H.264" codec is an excellent choice, providing impressive high definition image quality, with support for multi-channel audio.

What about multi-channel Surround Sound?
The modern digital video disk recorder in the mobile television truck supports eight tracks of uncompressed digital audio, with 48-kHz sampling and 24-bit resolution. As long as the QuickTime MOV files are rendered with 5.1, 6.1 or 7.1 surround sound with individual tracks of audio; the digital video disk recorder will faithfully import and play the surround sound audio.

QuickTime MOV Workflow—Direct FTP Site Upload/Download

For that future moment when "hyper-speed" internet access becomes available (perhaps in the range of 15-30Mb/s, as compared to 1.5-6.0Mb/s commonly available today), this QuickTime MOV Workflow will gracefully advance; simply by eliminating the three steps to copy the MOV files to a portable disk drive, cloning the disk drive, and shipping the disk drive to the field

(*illustrated as steps* **2** – **4** *within* **Figure 3** *on page 5 above*).

Instead, these three steps are replaced with just two steps, in which the studio production staff copies the MOV files to an FTP server—with a corresponding step in the remote mobile television truck in which the production staff downloads the MOV files and imports them directly into the digital video disk recorder.

This alternate QuickTime MOV workflow can even be employed today on a limited basis, in order to upload / download several short (and thus small file-sized) QuickTime MOV files as an adjunct to the primary workflow. This alternate workflow is therefore useful in cases where minor last-minute changes and/or additions must be made to the play out content.

This alternate variation of the QuickTime MOV workflow is illustrated in **Figure 4** below.

Benefits of QuickTime MOV Workflow

Following is an outline of the many benefits of the QuickTime MOV workflow over the traditional videotape workflow:

- **Superior Image Quality**: The traditional method of ingest into the digital video disk recorder via videotape will invariably require several compression steps (up to three or four), and the final delivery is sometimes made on standard definition (SD) videotape—which is then up-converted to HD for purposes of ingest into the digital video disk recorder. Such SD videotape ingests result in very poor on-air image quality.

  In contrast, the QuickTime MOV import into the digital video disk recorder provides far superior HD image quality—and this image quality is identical to the quality of the content originally produced in the studio.

  Supplying downstream transmission compression systems with

Figure 4: Alternate QuickTime MOV Workflow using FTP Site on the Internet
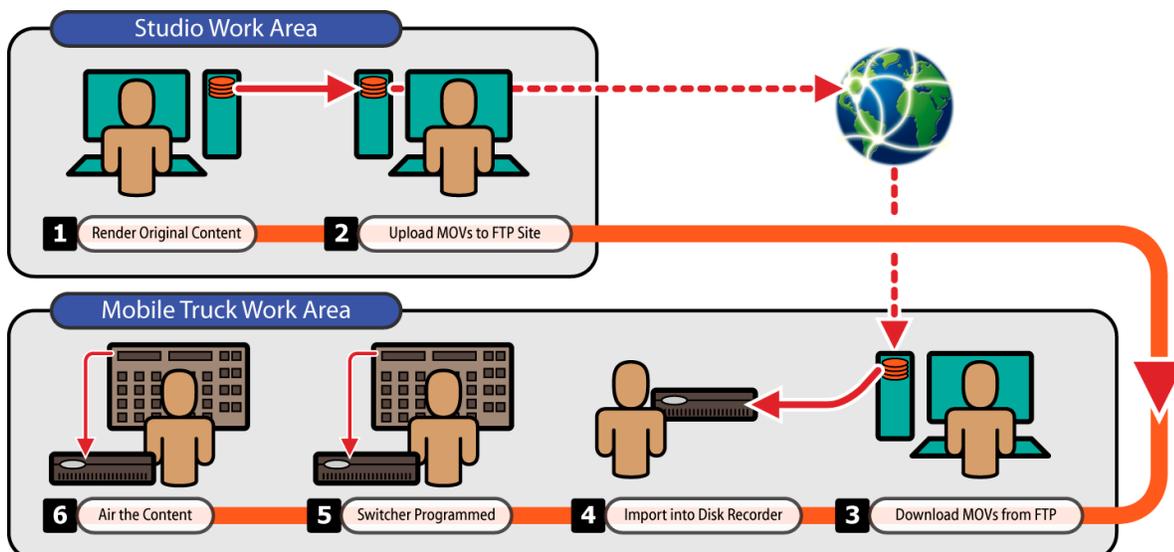
superior-quality video will result in a home viewing experience vastly improved over the current method of supplying up-converted content from SD videotape.

- **Accurate Import**: When importing QuickTime MOV files into the modern digital video disk recorder, the video, audio and matte are *always* guaranteed to be aligned with each other—with complete frame accuracy. This is compared to ingesting two passes of videotape (*one pass for video / audio, the other pass for matte*)—which is prone to having an offset introduced between these three elements.

- **More Reliable Control**: The traditional videotape workflow requires an intermediate controller to be in the control path between the switcher/mixer and the digital video disk recorder. The QuickTime MOV workflow eliminates the need for the intermediate controller, with the switcher directly controlling the digital video disk recorder via PBUS protocol.

  The QuickTime MOV workflow therefore has two fewer points of failure in the control pathway, and is therefore 67% more reliable, from a control point of view.

- **Meaningful Clip Names**: The traditional videotape workflow mandates just one very long clip stored in the digital video disk recorder, with multiple timecode "in" and "out" points defining each "sub-clip". This method therefore provides no meaningful names for each sub-clip, and a paper "Lookup" document must be employed to correlate the sub-clip "in" and "out" timecode values within the mega-clip, to locate the individual clips.

  In contrast, the QuickTime MOV workflow allows each clip to be stored individually inside the digital video disk recorder, each clip featuring its very own alpha-numeric name. These clip names are identical to the names given to the QuickTime MOV files in the studio where the content is created, so much better organization of the clips is realized throughout the workflow process.

- **Easier to Add New Clips**: Part way through any viewing season, there is invariably a need to add new transitional elements or motion clips to the body of clips already stored in the digital video disk recorder. The traditional videotape workflow requires "appending" videotape content to the end of the "mega-clip" stored inside the digital video disk recorder. The Technical Director must then utilize the intermediate controller to carefully pick out and mark the newly recorded elements from within the modified mega-clip. The switcher memory registers are then programmed by the Technical Director to load and trigger these new elements.

  In contrast, the QuickTime MOV workflow allows new transitional elements to be directly imported as independent clips, with no need to pick them out from within a mega-clip. These new clips may arrive at the mobile television truck on a compact USB "thumb drive" or memory stick, instead of a cumbersome videotape. Or better yet, the MOV files can be uploaded to an Internet FTP site, and downloaded directly into the disk recorder located in the mobile television truck.

- **Time-Savings | In the Studio**: In the studio where the original content is created, software packages such as Adobe After Effects, Adobe Premier, Apple Final Cut Pro, etc. are used to create this original content. And nine times out of ten, these projects are already rendered into QuickTime MOV files for purposes of in-house review, approval and archiving.

  In the traditional videotape workflow, these MOV files are then played out in real-time using equipment containing video compression hardware, so the elements can be copied to videotape for distribution to the mobile television trucks; and this copy is done twice—one pass for video / audio, the other pass for matte.

  In contrast, this very time-consuming process to create videotapes can be completely eliminated when employing the QuickTime MOV workflow—and replaced with a simple copy of the rendered MOV files to a portable USB disk drive.

- **Time-Savings | In the Mobile television truck**: Consider the time it takes to ingest *two* segments of videotape for all the content (one segment for video / audio, the other for matte); and then the additional time it takes to program the intermediate controller to "pick out" the individual clips from within the "mega-clip"; and this is performed twice—once for the video / audio portion of the clip, the other for matte.

  In contrast, importing individual QuickTime MOV files from a portable USB drive is a bit faster, and has much fewer headaches, as outlined in this white paper.

Conclusion

The videotape delivery workflow has been around for over a quarter century. Times have changed, and technology has greatly advanced in the meantime.

Huge amounts of time, money, human labor, and very expensive video equipment is employed in the process to support the videotape delivery workflow. As with any human behavior, making changes tends to be initially resisted; and this is part of the reason the videotape delivery workflow has persisted for so long.

Another barrier to change is a lack in many mobile television trucks of the modern high-definition digital video disk recorders capable of importing QuickTime MOV files.

In turn, this lack of modern machinery in the majority of mobile television trucks tends to prevent their end-user clients (who produce the target content) from adopting the QuickTime delivery workflow, since to do so means they must support *both* workflows at the same time. If even *one* mobile television truck in the fleet lacks the modern digital video disk recorder in question, then the client is forced to distribute their content with the old-fashioned videotape delivery method to support use of that *one* truck. The result is a "chicken-and-egg" situation which inhibits change.

Clearly, the defined QuickTime MOV workflow has many superior advantages, with absolutely no disadvantages. The only barrier to

wide adoption of this practice is the lack of wide deployment of these modern digital video disk recorders in the majority of the mobile television trucks located in the field.

Amazingly (and happily), the cost of this modern digital video disk recorder is less than *half* the cost of a video head drum replacement in the professional HD-VTRs typically employed in these mobile television trucks—which are largely used to support the traditional videotape workflow. Or to put it in other words, *two* of these modern digital video disk recorders can be purchased for less than the cost of a *single* video head drum replacement in a professional HD-VTR.

It would be a very wise and quite prudent investment for the mobile television truck companies to quickly outfit the majority of their fleet with these modern digital video disk recorders—to as quickly as possible wean their clients off the traditional videotape delivery workflow, and onto the modern QuickTime MOV file-based delivery workflow. This purchase will certainly help to remove a large chunk from their VTR maintenance budgets.

For those clients out there who must deal with this workflow issue, it's in their best interest to actively and heavily campaign the mobile television truck owners to quickly make the very modest investment in these modern digital video disk recorders. This action will most certainly help to reduce the client's human labor and materials costs by a very significant amount—while at the same time vastly improving workflow efficiency—coupled with quite a substantial boost to the image quality of their broadcasts for the home viewers.

Workflow Proven in Real Life
This QuickTime MOV workflow isn't just a wishful concept. There are several forward-thinking mobile television truck companies and their clients in the field who have adopted the QuickTime workflow to their advantage during the airing of demanding, live sporting events.

One such client is New England Sports Network (NESN), of which their Director for Bruins Hockey has conveyed her experience in a published press release. Anyone may read this press release from the following Abekas web page link:

- http://www.abekas.com/main.php?action=newsitem&Page=1053&id=4

Please help get this exciting workflow widely adopted, by sharing this information about the QuickTime MOV workflow with your friends and work colleagues. □

About the Author

Douglas Johnson is the Chief Product Manager for Abekas, Incorporated; headquartered in Menlo Park, California. Douglas has been actively working in the professional broadcast video marketplace for over twenty-seven years, starting with Ampex Corporation in 1981 working as a field support engineer in Los Angeles. In 1984, Douglas moved northward to the San Francisco bay area, and helped lead the management of technical support services at the original Abekas in Foster City, California.

Over the next several years, his career at Abekas expanded to product management positions for several products, including digital video disk recorders, digital effects systems, and production editing systems. In 1992, Douglas joined Accom as product manager for digital video disk recording products, and led the development of several key products at Accom. In 2006, Douglas joined the new Abekas as lead product manager for all new product development.

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