USING THE CINNAFILM TACHYON VIDEO PROCESSING LIBRARY

This App Note applies to Vantage version 5.0, 6.0, & later

Synopsis

The award winning Tachyon Video Processing Library (VPL) from Cinnafilm, Inc. is an exciting, optional add-on to Telestream® Vantage®. For professionals who deal in mixed standards and formats, Tachyon provides access to high-quality format and standards conversions tools, which can be included in Vantage media workflows, at a fraction of the cost of dedicated systems.

The beauty of its integration in Vantage is that all the power of Tachyon's expansive VPL can be directly accessed within Vantage and included in Vantage workflows. In addition to extremely high quality, Tachyon saves users time, expense and labor by eliminating the need for baseband standards and format conversions. Tachyon is already in broad use today and is meeting the demanding requirements of broadcasters and media content providers globally.

Tachyon is highly-optimized for GPU acceleration and operates in Vantage on the Telestream Lightspeed server. Since GPU technology changes frequently, please check with your Telestream account manager to determine the current GPU options for your system.

This app note summarizes the standards/format conversion processes adn options available using the Tachyon VPL.

Cinnafilm Tachyon VPL Features

Tachyon's feature set is built around PixelStrings™—a powerful, phase correlation motion estimation engine. PixelStrings performs analysis on each frame, mapping the velocity and direction of each individual pixel. It then uses that motion information to predict (or synthesize) new frames at any point in time. The result is smooth motion playback at any frame rate. With this level of analysis, Tachyon is able to provide advanced standards and format conversions such as:

- Highest-quality frame rate conversion to and from all standard frame rates, resolutions, aspect ratios, interlaced and progressive.
    - Full, 16-bit per color channel pipeline—computations performed in 32-bit floating point precision
    - One-pass conversion in the uncompressed domain, eliminating multi-generation compression artifacts
    - Frame rates: 23.98p, 24p, 25i (50 fields), 25p, 29.97i (59.94 fields), 29.97p, 30i (60 fields), 30p, 48p, 50p, 59.94p, 60p, 120p
    - Resolutions: all from SD to 4K
    - Modalities: progressive, interlaced, pulldown
    - Aspect: any

- Automatic 3:2 pulldown/telecine removal with advanced cadence correction capable of resolving the following issues:
    - Broken phase at scene edits
    - Out-of-phase or progressive video overlay on top of pulldown material
    - Transitions between progressive, pulldown, and standard interlaced material

- Highest quality motion-compensated de-interlacing to preserve the maximum detail

- Resolution conversion to and from any resolution up to 4K

- Insertion of common pulldown patterns: 2:3, 2:2 PsF, and frame repeat to preserve film motion when targeting high progressive frame rates.

Input/Output Frame Rate Limits

The following input and output frame rates are supported by the Tachyon VPL:

- 23.976 FPS progressive
- 24 FPS progressive
- 25 FPS progressive/interlaced
- 29.97 FPS progressive/interlaced
- 30 FPS progressive
- 50 FPS progressive
- 59.94 FPS progressive
- 60 FPS progressive

Licensing

Since Tachyon is a GPU-based technology, each GPU in the Lightspeed server must be licensed for operation. The Tachyon VPL ships with 2 GPU licenses and additional GPU licenses are available for purchase. Please contact your Telestream account manager for information about purchasing additional Tachyon GPU licenses.
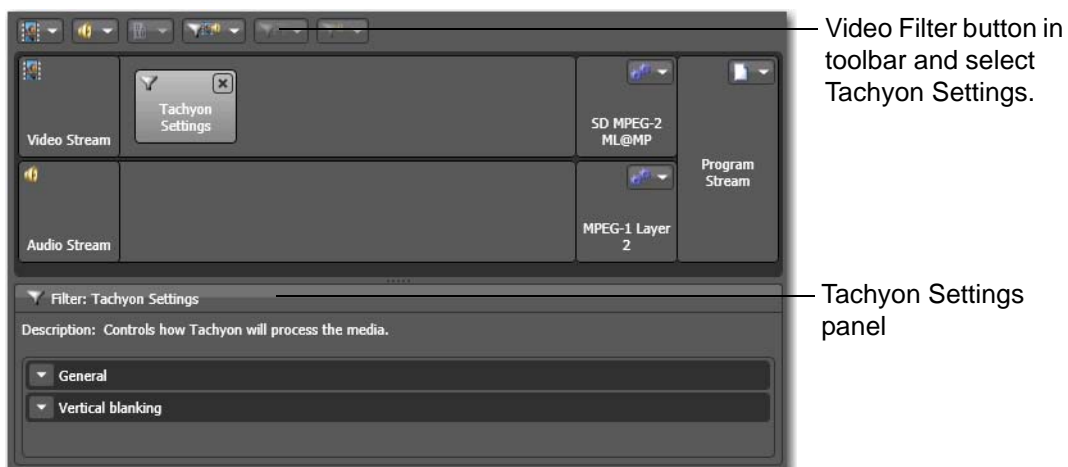
Accessing & Configuring the Tachyon VPL

The Cinnafilm Tachyon VPL, as implemented in Vantage, is a Video Stream VPL Processor option in the Flip action, as shown selected here, with the Flip inspector window open.
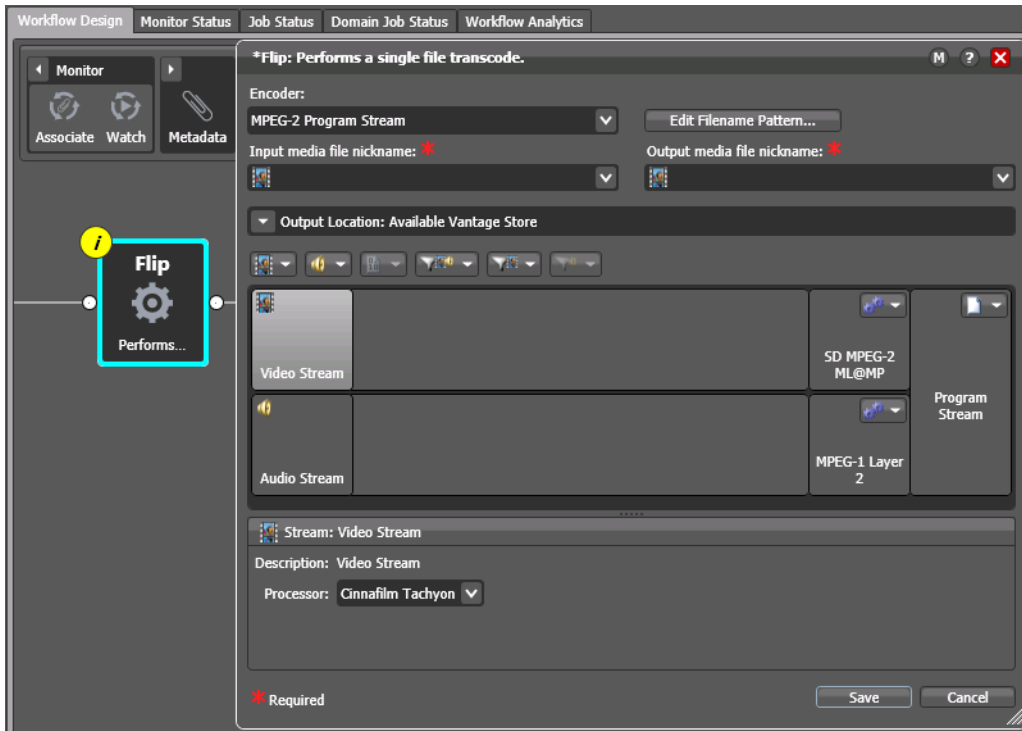
To select the Tachyon VPL, follow these steps:

1. Display the Flip action inspector in your workflow—click the *i* icon in the upper left corner.

2. Select the Video Stream element in the encoder.

3. In the editor panel below, select *Cinnafilm Tachyon* from the Processor menu.

4. With Video Stream selected, click the Video Filter icon in the toolbar (2nd from right) and select Tachyon Settings to add the Tachyon filter to the video stream, as shown here:


Video Filter button in toolbar and select Tachyon Settings.

Tachyon Settings panel

The Tachyon Settings panel has two configuration sections:

- *General*—Configuring General Tachyon Settings
- *Vertical Blanking*—Configuring Vertical Blanking Settings.

Configuring General Tachyon Settings

The General Tachyon settings section contains controls to determine how the Tachyon VPL processes media for transcoding. Settings that display a green browse button can be configured using variables which have been set in upstream actions.
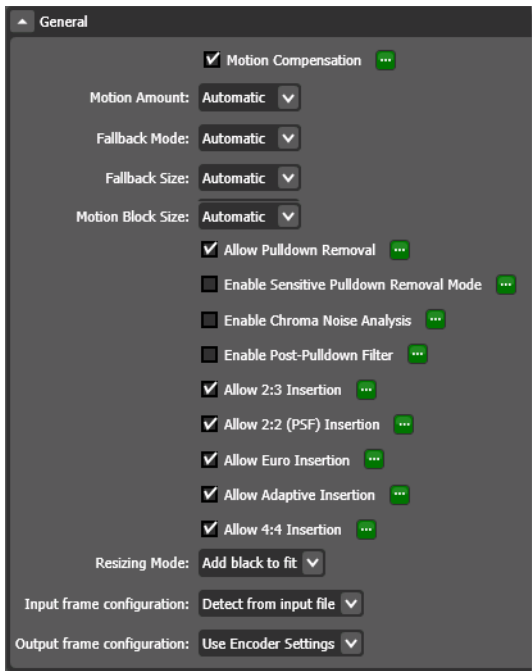
To better understand how to configure the Tachyon VPL for best use in your workflows, two terms which should be noted: *Allow* and *Enable*.

Checking an *Allow* option instructs the Tachyon VPL to—at it's option—invoke a particular algorithm only when it is the best solution to achieve the frame rate conversion selected. For example, if *Allow 2:3 Insertion* is checked and the target is 29.97i and the source material is 23.976, Tachyon will insert a true 2:3 Telecine pattern in the output.

Because of the "if it is best" nature of the Allow settings, they can be checked erroneously, and the Tachyon VPL will still produce good results.

Conversely, checking an *Enable* option instructs the Tachyon VPL enable the feature/filter, regardless of whether it is the best solution for the problem or not.

Motion Estimation Conversions

The image depicted below demonstrates how the Pixel Strings™ engine identifies direction and velocity of objects and panning within a frame, as indicated by arrows superimposed on the image.

Each arrow color represents a different direction, and the arrow size indicates velocity of the motion vector.


Zooming into this area of higher motion, it is easy to see where motion vectors collide and overlap. It is in the areas of intersection that Tachyon excels. The algorithms used by Tachyon are called *fallback* algorithms.

Tachyon's patented conversions invoke special fallback algorithms to prevent creation of artifacts which would normally occur with other motion-estimation based solutions.

In the frame depicted below, motion vectors are shown along with red *fallback* areas. The areas in red are where motion vectors intersect and become inconclusive. The red areas will not be used as motion data to create the new video frame.

Instead, the red areas will be used as *fallback* to either the closest de-interlaced frame (*Nearest Neighbor* in the Fallback Mode control), or will temporally blended (*Temporal Blending*) the closest de-interlaced frames before and after the newly-created frame.
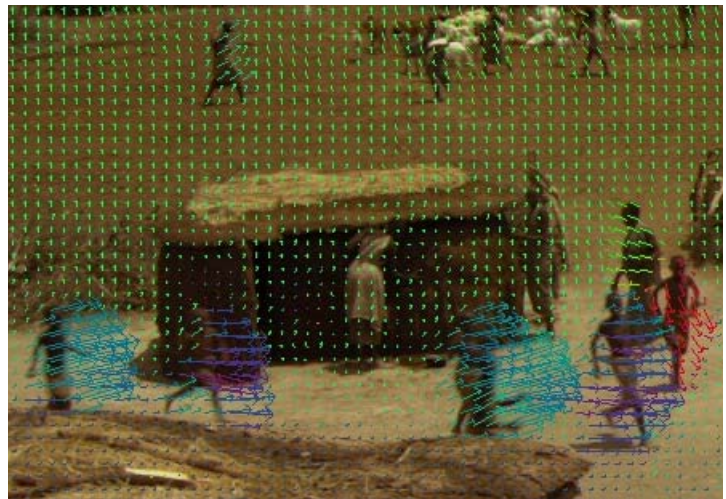
The red areas above can be made larger (as depicted here) or smaller by controlling the Motion Amount and Fallback Size used during the conversion:

Motion Compensation When checked, activates the phase correlation motion estimator to perform interpolated frame rate conversions.

Note: *When Motion Compensation is checked, the effect is applied to the entire file.*

Motion Amount. Select *Automatic | Extra Low... Extra High*. This setting determines how much Tachyon will trust motion vectors in the creation of new images. Selecting Extra-Low causes the VPL to invoke more fallback areas when motion data is inconclusive. Extra-High causes it to invoke fewer fallback areas in the frame.

Fallback Mode. *Nearest Neighbor* is the closest de-interlaced frame in time to the newly created frame. *Temporal Blending* takes the closest de-interlaced frames before and after the newly-created frame and blends the two frames together. Select *Automatic* when you want the VPL to make the appropriate choice for the content being processed.

For the purpose of fallback, interlaced video is always de-interlacing to the field rate. This allows for smoother motion in fallback areas.

Fallback Size. Select *Automatic | Small... Extra Large*. This option specifies the transition region size between fallback areas (shown as red in the preceding image) and motion compensated areas. A larger fallback size allows more blending (feathering) to occur between the regions.

Progressive Essence

Tachyon converts and formats video frames in progressive mode only. So all video, irrespective of mode, will be converted to its progressive essence prior to any conversion taking place. This progressive stream of motion compframes is then used by the motion compensation engine:

- Inverse telecine is performed to obtain the 23.976 essence

- De-interlacing is performed to obtain a progressive essence which is double the source frame rate (i.e. 25i becomes 50p)

- Progressive frames are passed through to the motion compensation engine

Rules of Thumb for Motion Estimation

The amount of motion data present in the source file is critical to the outcome of motion compensation technologies.

- Starting with lower progressive frame essence rates provide the least amount of motion data and will require higher amounts of fallback. The potential to create artifacts is highest when starting with low progressive frame rates (23.976, 24, 25, 29.97p, 30p)

- Starting with higher progressive frame essence rates will provide the cleanest conversions and will require less fallback. (25i, 29.97i, 50p, 59.94p are examples of higher frame rates which will create conversions with lower potential for artifacts.)

Motion Estimation Block Size Adjustment

When starting with low frame rates such as 23.976p, 24p, and 25p, a motion estimated conversion going to a higher frame rate than the source will sometimes require a larger block size to reduce the potential for artifacts. Block analysis sizes are 16x16, 32x32, and 64x64. Tachyon's default setting is 16x16 for frame rates higher than 25p, 32x32 for frame rates 25p and lower.

We recommend trying the default settings before adding this advanced setting to your transcode profile. If you do make this adjustment, it is recommended that you:

- Reduce the Motion Amount setting to low or extra low

- increase the Fallback Size to large or extra large

- Switch Fallback Type to nearest neighbor

Motion Block Size. Select *Automatic | 16... 256*. This option specifies the size of the motion block in pixels. To invoke the block size adjustment, select the appropriate value from the four choices in the pulldown menu.

Resolution Conversion and De-interlacing

All resolution changes are interlaced video aware. If the input media is interlaced, a high quality de-interlacer first generates a progressive stream. The progressive stream is resized using a high quality Lanczos filter. Finally, the resized progressive frames are interlaced if the output is an interlaced format. This results in the highest quality resolution change of interlaced content.

Resizing Mode is the choice of either using a stretch, center extraction, or letterbox/pillar-box methods for resolution changes.

Inverse Telecine

Tachyon's tracking of pixels and creation of motion vectors is quite robust and allows the incorporation of a very accurate scene cut detector. With each scene being accurately detected, Tachyon can apply different algorithms to each segment it encounters. Having segment by segment granularity enables an "intelligent inverse telecine" where Tachyon can not only remove 2:3 patterns, it can normalize video with intermixed mode and correct cadence errors automatically.

Allow Pulldown Removal. A combination function which removes simple 3:2 pulldown patterns, but also detects when patterns (cadence) is broken and if advanced cadence patterns are present.

Note: *Because this control is labeled using "Allow" terminology, it only invokes pulldown removal when it is detected by Tachyon, on a scene-by-scene basis within the project.*

Intermixed Mode

For projects with intermixed mode, Tachyon automatically "does the right thing". For example, if a 29.97i project has interlaced content, then changes to progressive, then changes to a 2:3 section, it treats each section accordingly:

- an interlaced section becomes 59.94 in the Tachyon mezzanine

- a progressive section is stored as 29.97 in the Tachyon mezzanine

- a pulldown section is reduced to 23.976 essence and stored in the mezzanine

Each section will then be motion estimation converted to the target output rate chosen.

Extra Sensitive Pulldown Algorithm

When pulldown is not achieved due to extremely broken cadence, or other factors like highly mixed content or if chroma noise masks motion, the pulldown engine may fall back to de-interlacing rather than removing telecine. For this reason, a more sensitive pulldown pattern was created. This algorithm favors inverse telecine and with lower thresholds for triggering pulldown identification, will maximize the number of progressive frames created from the video.

To invoke this more sensitive pulldown removal algorithm, check Sensitive Pulldown Removal in addition to Allow Pulldown Removal.

Broken 2:3 Cadence

A common problem with 29.97i material which has been edited, is broken 2:3 cadence. Broken cadence occurs when the telecine pattern that starts at frame 00:00:00:00 does not carry through the entire video.

The normal frame pattern is i1, i2, p1, p2, p3, and it should repeat through the entire project with scene cuts landing anywhere in the image sequence:

Broken 2:3 cadence occurs when editors piece clips together and end scenes based on image content only and disregard image cadence.
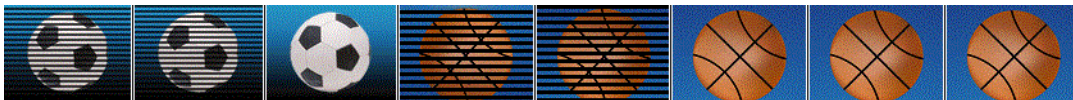
As you can see, the above sequence either should have had two more progressive football frames or started the basketball sequence with 2 progressive basketball frames.

When broken cadence is present, common problems seen at scene transitions with other inverse telecine technologies are:

- Repeated frames

- "Jump" cuts

- Combing artifacts.

With Tachyon's intelligent inverse telecine analyzing each scene cut for correct 2:3 cadence, it automatically adjusts the conversion algorithms and creates the missing field from motion data when necessary.

High Chroma Noise

When video is transferred to tape, there are many factors which could introduce chroma noise which is pattern in nature, and highly color transient. Chroma noise is not ideal for any Tachyon conversion, os it is recommended that it be removed internally priori to processing.

Below are two successive frames which had high chroma noise present in them.
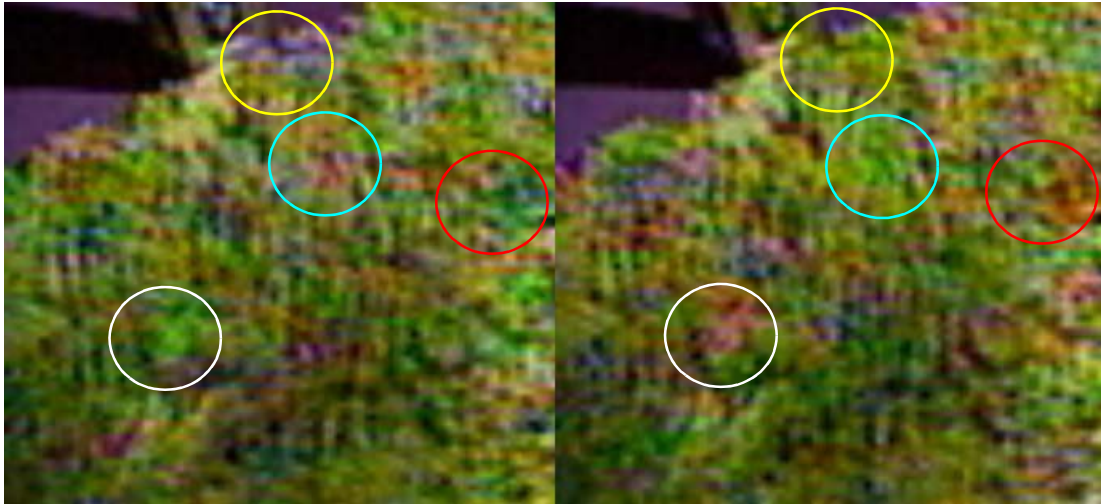
Note how the shape of the noise remained constant, but the color shifted between each frame in each of the circled areas. This level of noise can be detrimental to both de-interlacing as well as inverse telecine.

Tachyon has a setting which removes chroma noise during the analysis of the video in an effort to achieve higher accuracy during inverse telecine or pulldown removal. Check the Enable Chroma Noise Analysis to turn on this filter during the standards transcoding process.

Note: *This feature will not remove the chroma noise during the output.*

Post-Pulldown Filter

Unique to Tachyon is the ability to automatically remove composited cadence errors. The following is an example of a composited cadence error:

* Source Video 1 (V1) is 23.976 and video is telecined to 29.97i
    — V1 has a green screen
    — The pattern for the first 5 frames is: P1, P2,P3, i1, i2

* Source Video 2 (V2) is 23.976 and video is telecined to 29.97i
    — V2 is to be keyed into the green screen of V1
    — The pattern for the first 5 frames is: i2, P1, P2, P3, i1

* When keying, the editor did not match the telecine pattern, so while V1 is interlaced, V2 is progressive. There are 2 progressive frames in the 3:2 sequence which will match up in this case.

In this example, if a simple inverse telecine is applied, the result creates combing artifacts that appear in the keyed areas of frames 1, 4, and 5.

Another example of where this filter is helpful is in progressive overlays onto telecine content. A standard inverse telecine creates combing artifacts in the progressive overlay anywhere there is motion. Tachyon's Post-Pulldown Filter automatically removes the combing artifacts from the progressive overlay once the inverse telecine has been performed.

Allow Post-Pulldown Filter. If the images you are converting are composited 29.976, but the pulldown pattern was not adhered to when performing the composite, this setting is required to remove combing artifacts. It will also remove combing artifacts related to very poor 3:2 cadence.

Note: *When the Enable Post-Pulldown Filter is checked, the effect is applied to the entire file.*

Use this filter sparingly, as it may degrade vertical resolution very slightly. It is typically only used when residual combing artifacts exist *after* pulldown has been removed.

Note: *You can use both the Allow Pulldown Removal and Post-Pulldown Filter together.*

Interlaced Insertion Settings

These filters are for interlaced outputs only. Leaving them accidentally checked on will not impact a progressive output.

2:3 Insertion. inserts a standard 2:3 telecine pattern to 23.976p video stream to achieve a 29.97i frame rate

Allow 2:2 (PSF) Insertion. Creates a new series of frames which are based on duplicating the field an interlacing it into top/bottom field. Maintains film-look

Allow Euro Insertion. For field based interpolation rather than pixel-based. This is designed for interlaced or progressive integer frame rate conversions that are being converted to interlaced outputs. This method is valid for 24p to 50i conversions only.

Allow Adaptive Insertion. For field-based interpolation rather than using pixel-based interpolation. This algorithm is designed for both integer and non-integer frame rate conversion targets - as long as one of them is a non-integer rate (23.976, 29.97, 59.94, etc). This creates NTSC-PAL conversions clean of motion artifacts at the expense of potential slight stutter. Stutter is most noticeable with material that has smooth and uniform motion.

Note: *This algorithm may cause a slight stutter based on the footage. If this is unacceptable, perform the conversion using the Motion Estimator and uncheck Allow Adaptive Insertion.*

Progressive Insertion

Allow 4:4 Insertion. Repeats each progressive frame twice on output (motion rate is halved). This setting is used when you want to convert to high progressive frame rates (i.e. 50p/59.94p/60p) but want to preserve film qualities (low motion rate, such as 24p).

Resolution Conversion and De-interlacing

All resolution changes are interlaced video aware. If the input media is interlaced, a high-quality de-interlacer first generates a progressive stream. The progressive stream is resized using a high quality Lanczos filter. Finally, the resized progressive frames are interlaced if the output is an interlaced format. This results in the highest quality resolution change of interlaced content.

Resizing Mode. Select the choice of either using a stretch (*Stretch*), center extraction (*Crop*), or letterbox/pillar-box (*Add black to fit*) methods for resolution changes.

Metadata Override

Field order metadata is essential to achieving high quality results from Tachyon. If your source media is interlaced and you are performing a motion-compensated conversion, your results should be very smooth. If you notice consistent stutter motion then chances are the field order metadata stored with the file is incorrect. Use the Input Frame Configuration options to override the stored metadata to fix these issues.

Input Frame Configuration. When source metadata pertaining to field dominance is known to be erroneous, select one of these options to override the metadata so Tachyon can process the file with the correct field order:

- *Lower*—overrides metadata and analyzes the video lower field first

- *Upper*—overrides metadata and analyzes the video upper field first

- *Progressive*—overrides metadata and analyzes the video as progressive

Field Dominance Override

Certain interlaced format codecs by convention produce frames that are upper field first; others produce lower-field first frames. Use these setting to allow or override the conventions.

Output Frame Configuration. When generating output frames with an interlaced encoder, select an option to specify how frames should be configured if poor quality is observed:

- *Use Encoder Settings*—(honors the standard implemented directly in the encoder)

- *Interlaced Upper Field First*—(when using an interlaced codec, produces interlaced upper field first frames, overriding the standard if different)

- *Interlaced Lower Field First*—(when using an interlaced codec, produces interlaced lower field first frames), overriding the standard if different

- *Progressive*—(produce progressive frames).

Enabling Manual Cropping and Padding

Enabling Manual Crop and Pad (masking) mode enables you to specify how many lines to add or delete from the top and bottom of video frames. These settings override any automatic crop and mask. That is, Vertical Blanking settings won't be used when Manual crop and pad is enabled.

When you enable manual cropping and padding, you will almost always want to change Resizing Mode (General Settings) from its default value (Add black to fit) to Stretch for best results.

Configuring Vertical Blanking Settings

The options in the Vertical Blanking settings section enable you to specify (for input) and control (for output) how much vertical blanking is in the frame, and where it is located for 486- or 512-line NTSC or PAL (608-line) content. This setting instructs where and how much to crop or pad the video to either add or remove blanking during a transcode.

NTSC and 486-line content in particular may either have 2 lines of black at the bottom, or none, depending upon how it was encoded. This option also allows you to specify that the entire video is active (no vertical blanking), avoiding cropping of Web or desktop video with no blanking.

For each of these settings, select the appropriate VBI processing option from the popup menu:

Vertical Blanking for 486-line NTSC Content.

Vertical Blanking for 512-line NTSC Content.

Vertical Blanking for 608-line PAL Content.

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