Using Variable Frame Rates On The AU-EVA1

(excerpted from "A Guide To The Panasonic AU-EVA1 Camera")

The AU-EVA1 allows variable-frame-rate shooting in a wide selection of frame rates and frame sizes. The variable frame rates provide you with a variety of creative choices.

To start with understanding why variable frame rates even matter, let's reference back to how movie film gets shot. In film, slow motion is shot by running the camera at a faster frame rate. Film normally runs at 24 frames per second (fps), but for slow motion the camera operator might shoot it at something like 48 fps. When those 48 frames are played back at the 24 fps speed, it'll take twice as long to play back, so everything will be moving at half speed, giving that superb film-style slow-motion look. Shooting at a faster frame rate is called "overcranking," because in the early days cinematographers used a hand-crank to drive the camera, and for slow-mo they would actually crank the film faster. Similarly, shooting at a slower-than-normal frame rate results in a "fast motion" effect – think of the Keystone Kops or an old Charlie Chaplin movie and you'll get the idea. If you only shoot 12 frames in a second, but you play those frames back at the 24fps speed, it'll only take 1/2 second to play back action that took a full second to record – accordingly, the motion will be twice as fast as normal. This is referred to as "undercranking."

Using actual overcranking and undercranking can yield dramatically smoother, superior off-speed effects in your productions. Prior to the introduction of genuine over/undercrank, video shooters had to try to synthesize slow motion effects in their nonlinear editors. This led to frames being blended together, footage being de-interlaced, new frames being interpolated, motion artifacts, and all sorts of other compromises that resulted in lower-quality footage and a less-than-filmlike slow motion experience. With the true overcranking and undercranking potential of this camera you no longer have to settle for those types of compromises; now you can shoot genuine frame-accurate film-style slow motion effects (or fast-motion effects).

I will discuss some examples of what many of the frame rates might be useful for, and ways that you could use them. This is not by any means an exhaustive list, there are likely many, many more uses where each frame rate could be used, but this listing will give you a basic overview. Each of the choices listed below assumes that you're going to be playing back the footage at the film-look rate of 23.98 or 24 fps or 25fps.

2 fps: Extreme fast motion, also for time lapse type photography. If you wanted to record a city street at night, with cars smearing by and leaving trails of taillights, 2fps with the shutter off would be an excellent choice for that.

12 fps: Usable for fast motion, twice as fast as normal motion. Traditionally used for comic effect.

18 fps: This is the frame rate that early silent films were shot at, and the frame rate that most 8mm and Super 8mm home movies were filmed at. Since film has been standardized at 24fps these older films usually are played back with fast-motion effects. If you're looking for the "Keystone Kops" or "Charlie Chaplin" look, 18 fps is where you should start.

20 fps: 20 fps is a fast-motion effect that's not nearly as exaggerated as 12fps is, but it's fast. If you wanted to show someone running extremely quickly, 20 fps might be a good choice for that. It starts to push the bounds of what the audience can believe is "real," but it's very fast motion without being exaggeratedly fast (like 12 fps is).

22 fps: This is a subtle fast-motion effect. 22 fps is a very popular frame rate for karate action movies – shooting at 22 fps and playing back at 24 fps makes motion look very fast but completely believable. Shooting a car chase or a fight scene at 22 fps will lend an added edge of excitement and action to your scenes. The 50Hz mode equivalent would be 23fps.

24 fps: This is the standard movie film speed. Shooting at 24 fps and playing back at 24 fps gives your footage the temporal feel of motion picture film. This is the speed you'd normally shoot all dialogue scenes and "normal action" scenes. If you're producing footage for "PAL" territories or broadcasters who broadcast at 50Hz, the equivalent would be 25fps.

26 fps: This frame rate can add a subtle, subliminal slow motion effect to your footage, but the effect is very mild. Things moving slower than normal can be perceived as being "larger than life" – if you want to add a bit of elegance and grandeur to your scene, but don't want it to be obvious that you've done so, 26 fps can add that additional element of drama. The 50Hz mode equivalent would be 27fps.

30 fps: This is a slow motion speed. It's mild slow motion, but noticeable. 30fps is not too subtle, it's the first of the "real" slow motion speeds.

36 fps: At 36 fps, the scene is obviously slow motion. Action takes 1.5 times as long to play out as it took to shoot it. 36 fps is as slow or slower than many movie cameras can shoot.

48 fps: Full-fledged slow motion. 48 fps makes everything take twice as long to play back as it did to shoot it.

60 fps: Super-slow motion. 60 fps is suitable for shooting explosions or extreme slow motion scenes. It's the slowest slow motion possible on a conventional video camera (certain high-speed specialty cameras can go faster). Note that if you're shooting 4K or UHD, 60 frames per second is the highest frame rate you can choose that still uses the entire sensor (using the SENSOR MODE of S35 5.7K). For UHD or 4K footage, frame rates up to and including 60 fps will utilize the full quality and resolution that the camera is capable of delivering.

61-120 fps: Ultra slow motion. In 120 fps, motion takes five times as long to play back, as it took to shoot it (if shooting in a base frame rate of 24p). Even if your main project is set to 59.94p, 120 fps footage will still be quite slow motion. Be aware that you'll have to use a different sensor scanning mode in order to achieve frame rates faster than 60 fps. Setting the SENSOR MODE to S35 MIX 2.8K will enable frame rates up to 120 fps. The field of view will stay the same, but the overall image resolution will be lower. This may be quite noticeable if the rest of your project was shot in 4K or UHD, but if it was shot in 2K or 1080p the change in quality between regular-speed and high-speed footage should be fairly small.

121-240 fps: Super-ultra slow motion. In 240 fps, motion takes ten times as long to play back, as it took to shoot it (if shooting in a base frame rate of 24p). 240 frames per second is the fastest the camera can deliver, but do be aware that you'll have to use a different sensor scanning mode in order to achieve frame rates faster than 120 fps. Setting the SENSOR MODE to 4/3 CROP&MIX 2.2K will enable frame rates up to 240 fps. The field of view will crop in somewhat, and the overall image resolution will be notably lower. This will likely be noticeable when integrating the footage with footage shot at 4K or UHD, and may also be noticeable even if the rest of your footage was shot in 2K or 1080p.

Obviously, having dozens of different frame rates gives the camera operator a great degree of flexibility and creative choices. But remember

that there's also an intervalometer feature. You can use that to shoot one single frame at certain specified intervals. While not quite the same thing as having more frame rates, it does give you even more options for creative interpretation in how you want to record motion.

Next, consider that each of the frame rates can deliver a different look, depending on what your playback rate is (i.e., what you set the SYSTEM MODE>FREQUENCY menu item to, and what you set our editing system's timeline to). Since there are five basic playback rates (23.98/24p, 25p, 29.97p, 50p and 59.94p) you actually can get up to five different looks out of each frame rate. Depending on the playback rate you set, each of those frame rates can deliver a different look. Take the example of 27fps. When you set the camera to record at the 23.98p FREQUENCY, and you set the variable frame rate to 27fps, it will deliver a very mild slow-motion effect. But if you had instead set the camera to the 29.97p FREQUENCY, at the same VFR of 27fps, it would instead be delivering a very mild fast-motion effect! The frame rates and their overall perceived motion are dependent on the playback rate that you've chosen. Obviously 60fps is going to be slow motion when played back at a FREQUENCY of 29.97p, but it's even slower motion when played back at the 23.98p FREQUENCY. And when played back at the 59.94p FREQUENCY, it's not slow motion at all -- instead, it's "live", "video"-style footage!

The acquisition rate, and the playback rate, are two different things. Under normal circumstances you want them to be the same – i.e., acquire at 24 frames per second, play back at 24 frames per second, and you get real-time action. Acquire at 29.97 fps and play back at 29.97 fps, and you also get real-time action – a bit smoother than the 24fps/24fps sequence, and less film-like, but still real-time. Acquire at 59.94 frames per second and play back at 59.94 frames per second, and you also get real-time motion. 59.94fps/59.94fps looks nothing like film, it looks like "video," and gives the smoothest strobe-free motion possible. In the 50Hz mode, the equivalent would be to shoot 50fps and play back at 50fps for the "video" look.

But what happens if you acquire at 60 fps and play back at 29.97fps? The result is slow motion, a 2-to-1 slowdown factor. And what if you acquire at 60fps and play back at 24fps? It's also slow motion, but it's even slower: it's a 2.5-to-1 slowdown factor. And if you acquire at 29.97fps and play back at 29.97fps, it'll be real-time, but if you acquire at 29.97fps and play back at 59.94fps, the result is 2:1 fast motion. The same frame rate, played back at different time bases, delivers different looks to the viewer.

Selecting your time base, and selecting your acquisition frame rate, are therefore interconnected when you decide what type of look you're choosing for your program. With 24P or 25P you'll have film-like footage, and the most wide-ranging slow-motion capabilities. With 29.97P you'll have hybrid film/video footage – it'll be smoother/less stroby than 24p, but it will still have some strobing and a somewhat film-ish look to it, and it'll still be capable of up to 2:1 slow motion. With 59.94p you'll have video-looking footage, with the capability for slow motion but also with tremendous fast-motion capability: imagine 2fps acquisition played back at 59.94fps – it'd be 30-to-1 fast motion.

Because of this, you can't just think of "60p=slow motion," because it depends on your playback rate. 59.94p played back at 59.94p is the "reality" look, or the "video" look. The acquisition rate and the playback rate work hand-in-hand to generate the final look. Frame rates faster than 60 (i.e., 61 to 240 fps) are always going to be slow motion, but the question of HOW slow they are depends on what your playback rate is set to.

A simple rule of thumb to determine what the footage will look like is to divide the playback rate by the acquisition rate. Acquiring 50p and playing back at 25p, you'd divide 25/50 for a result of 0.5:1. That means the acquisition footage will play back half as fast as real-time (0.5 times as fast). That means slow motion. On the other hand, acquiring at 24p and playing back at 29.97p would give you a playback rate of 1.25:1, meaning the 24p footage would play back 1.25 times as fast as real-time, for a mild fast-motion effect. 24p acquisition played back at 24fps means film-like footage; 24p acquisition played back at 29.97fps means mild fast-motion, and 24p played back at 59.94fps means quite fast motion.

Something else to consider: sound will not be recorded when you're filming "off-speed" footage. What that means is: when shooting 23.98P, sound will only be recorded if you set the frame rate to 23.98. If you shoot at slower or faster frame rates, no sound will be recorded. The same holds true for 25.00p, 29.97p, 50.00p, and 59.94p — sound is only recorded when the selected frame rate matches the recording frame rate. Don't worry though, a warning will be displayed in the LCD display to tell you when audio won't be recorded.

You should also know that using variable frame rates may result in a brief pause in very long-form recordings. Generally, you can record up to 10 hours in one continuous recording; any more than 10 hours and the system will have to pause recording for a few frames and re-start with a new recording. When using VFR, that will still need to happen, but it will

happen at different times depending on the ratio of frames being imaged vs. frames being recorded. For example, if recording at the 29.97 FREQUENCY but imaging 60 frames per second, the recording will be paused briefly after five hours, rather than 10 hours.

As said before, frame rates faster than 60 fps will result in some quality loss. The footage will be lower in resolution than normal footage, and you may notice some aliasing and colored moire patterns. The resolution loss is milder for 61-120 fps, and more substantial for 120-240 fps.

You cannot record high-speed variable frame rates externally on an HDMI or SDI video recorder. The SDI and HDMI outputs are capable of outputting video at a maximum of 59.94 frames per second; if you set the camera to a VFR of 120 fps, the monitor outputs will show every other frame (thus lowering the actual output to the max of 59.94p). You won't see the slow motion effect during monitoring, you can only view it properly during footage playback. The exception to this rule is if you're using an external SDI raw recorder; in that case, yes, the camera can output variable frame rates up to 240 fps, but the recorder itself would need to support variable frame rate recording.

To configure for variable frame rate recording, you first have to decide what your maximum frame rate will be, and then set the SYSTEM SETTINGS>SYSTEM MODE>SENSOR MODE menu item to the appropriate setting.

S35 5.7K: This is the highest-quality mode with the highest resolution and the cleanest imagery in terms of aliasing or moire, and the widest field of view. This setting allows frame rates from 1 to 60 frames per second if internally recording 8-bit 4:2:0, or 1 to 30 fps if recording in 10-bit 4:2:2.

S35 MIX 2.8K: This mode provides optimal resolution for 2K or 1080p recordings. It is not available for 4K or UHD recording. This mode allows the same wide field of view as S35 5.7K, and allows frame rates from 1 to 120 frames per second.

4/3 CROP&MIX 2.2K: This mode allows the fastest frame rates, but it is also the lowest-resolution mode and will result in a narrower field of view. It will not be as sharp as the other modes but it should provide reasonable quality for 2K/1080p. This mode allows for the fastest frame rates, from 1 to 240 fps. It is not available when recording 4K or UHD.

Once you've selected your SENSOR MODE, you enable VFR recording by going into the CAMERA SETTINGS>FPS>VFR SW menu and choosing ON.

To select an individual variable frame rate, you can choose from the list at CAMERA SETTINGS>FPS>VALUE. If the frame rate you want isn't already included in that list, you can add it using CAMERA SETTINGS>FPS>ADD.

Another (and easier) way to select frame rates is from the HOME screen; you can touch the upper-left frame rate icon and then select the frame rate value by pushing in the menu wheel; you can then scroll through the list of available frame rates using the wheel.

Finally, there's a third way to select a variable frame rate. If you configure the SYSTEM SETTINGS>USER SWITCHES>USER TOGGLE menu item to FPS, and then set the User Toggle switch to the middle "USER" position, you can use the menu wheel to change your variable frame rate. Regardless of how you choose a frame rate, know that you can't change the frame rate during a recording. You have to settle on a frame rate before hitting RECORD.