LongGOP v All-I: AU-EVA1 Recording Formats

1. Preface:

The Panasonic AU-EVA1 is a small and lightweight cinema camera designed to fill the professional production requirements between the Lumix GH5 4K mirrorless camera and the S35mm VariCam LT 4K cinema camera. The EVA1 provides very high quality cinematic imagery thanks to a combination of the newly-developed Dual Native ISO 5.7K Super 35mm sensor and the much-admired color science inherited from its VariCam cousins. The use of SD media enables substantial acquisition / production cost savings, yet the camera fully supports codecs and recordings with full 4:2:2 10-bit quality. These and other benefits provide outstanding performance, yet fit into a compact and lightweight camera body.

This paper is primarily focused on the attributes of the EVA1 recording formats.

2. EVA1 Recording Formats

Fig-1 and Fig-2 show the recording formats supported by the EVA1 (except the legacy AVCHD).

Values are noted in Megabits per second (Mbps):

	4K DCI		UHD		2K DCI		HD	
	GOP	Intra	GOP	Intra	GOP	Intra	GOP	Intra
59.94p					100	200	100	200
50p					100	200	100	200
29.97p	150	400	150	400	50	100	50	100
25p	150	400	150	400	50	100	50	100
23.98p	150	400	150	400	50	100	50	100
24p	150	400			50	100		
59.94i							50	100
50i							50	100

Fig-1: Table of 4:2:2 10-bit supported codec formats

(Red Text shows codec additions for upcoming March 2018 firmware update)

	4K DCI		UHD		2K DCI		HD	
	GOP	Intra	GOP	Intra	GOP	Intra	GOP	Intra
59.94p	150		150		100		100	
50p	150		150		100		100	
29.97p	100		100		50		50	
25p	100		100		50		50	
23.98p	100		100		50		50	
24p	100				50			

Fig-2: Table of currently supported 4:2:0 8-bit formats

3. Defining LongGOP:

   As can be seen from Fig.1 and Fig 2, the EVA1 currently supports LongGOP based H.264 10 bit 4:2:2 sampled codecs in HD, 2K, UHD, and DCI 4K. These codecs are carefully optimized to provide the equivalent image and compression quality of the AVC-Intra 4:2:2 10-bit codecs supported in the VariCams. The EVA LongGOP 4:2:2 10-bit codec uses temporal correlation across a GOP (Group of Pictures) to gain a coding efficiency increase of 200-300% over an equivalent quality Intra Frame based H.264 codec. In the case of the EVA-1 LongGOP 150 4K codec, we achieve an image quality comparable to some 300-400Mbps Intra codecs. VariCam's AVC-Intra 4K422 uses 320Mbps to encode 4K material to very high quality production standards. The LongGOP 150 codec can match that quality at less than half the bit rate. That considerable compression efficiency increase is made possible by the use of the many advanced H.264 encoding tools.

   LongGOP encoding is used where the codec bit rates possible would not provide sufficient quality with Intra-based compression schemes. On the low end, consider the quality of the many Internet streaming companies who stream HD or higher formats at remarkably low bit rates. HD is transported at amazing quality at as few as 5Mbps. Streaming at these bit rates using intra frame based schemes would require many times that of the LongGOP bit rate and would simply not prove feasible, choking most data streams. LongGOP encoding is complex, and it requires more processing than an Intra equivalent, yet the payoff is a much higher encoding efficiency and much lower encoding bit rates for the same image quality. Extrapolate this to a LongGOP codec that is much greater in size (from 5Mbps for HD streaming to 150Mbps for EVA1 4K recording) and the result is a high quality, high efficiency recording system that can be captured to inexpensive media without compromising quality.

   Quite soon, a firmware upgrade will add several All-I Intra frame codecs (as shown in red on Fig. 1 above) These are H.264 based Intra-Frame compression implementations, their bit rates and quality a close match for the VariCam AVC-Intra codecs they emulate. At 4K30p, both VariCam's AVC-Intra 4k422 and EVA1's All-I 400 use about 400Mbps. Both fully support 4:2:2 10-bit video sampling at UHD and DCI 4K.

   The higher encoded bit rates of 400Mbps will require a higher class of SD card, in this case a V60 or higher speed card at UHS-II SD card is needed to ensure guaranteed recordings (V30 is required for LongGOP 150). Here, however, the use of SD cards provides savings for the media, as well as enabling a more compact and lower weight camera body.

4. Choosing LongGOP v All-I:

   EVA1 shooters will soon enjoy the choice of two powerful recording options, LongGOP and All-I. Like any tool they differ, yet offer interesting options. LongGOP consumes less space while recording, but is more complex to decode in post. A more powerful multi-processor computer workstation may be desired in order to work with the files. Shoot LongGOP 150 for 4K and enjoy the much increased recording times and faster file transfer when offloading. If more than doubling the record time without

sacrificing image quality is an attractive option, choose LongGOP.

Should you wish to work in a more traditional Intra compression workflow, choose All-I. All-I is less complex for a computer to process but therefore must take up a far greater space on the media. All-I is simple to decode so a laptop computer may be all that is required to post the files. The choice of either will soon be a simple menu option for EVA1 users, LongGOP for longer record times and All-I where simpler workflows are more desirable.

5. Compression Quality, LongGOP v All-I:

To allay concerns over LongGOP being perceived as a consumer or inferior codec format, rest assured that testing of both the LongGOP 150 and All-I codecs has shown them to be visually comparable. Figure 3 shows a series of SNR test measurements of the two codecs on a wide variety of carefully chosen and deliberately stressful image test sequences. As can be seen, the LongGOP150 and All-I400 codecs compare well and show very similar image quality in the testing. The differences in quality generally amount to less than what is perceivable by the human eye. These two codecs are available in the EVA1 as choices for the user, the selection of which may vary for upon application or available post workflow. Panasonic does not dictate which codec you chose; we simply provide both options.

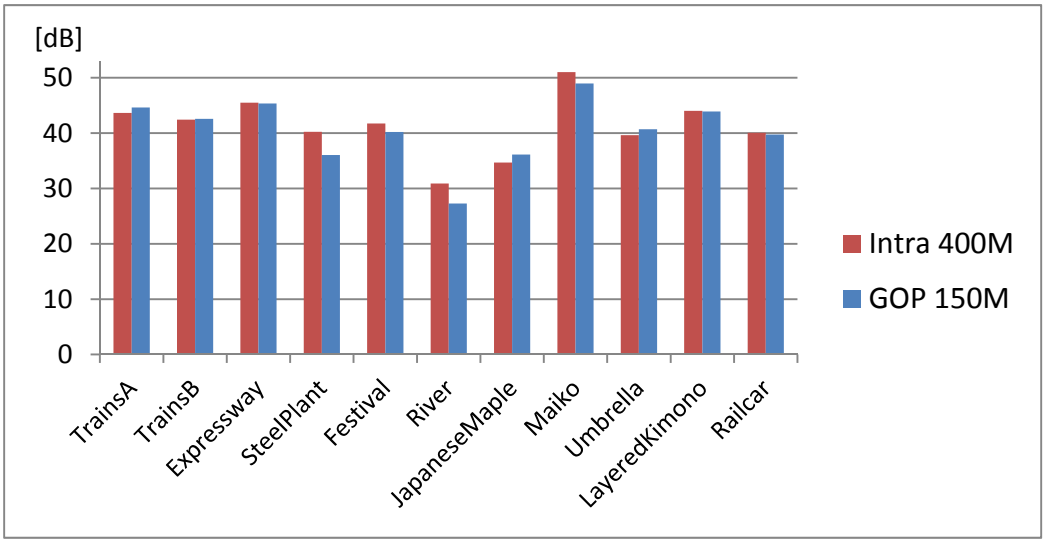

Fig-3. SNR Comparison by ITE Evaluation Image Sequence
(ITE UHD Series A: http://www.ite.or.jp/content/chart/uhdtv_a/)

6. LongGOP for high frame rates:

EVA1 also offers options for 4:2:0 8-bit recordings for higher frame rates. The uncompressed image data for a 4:2:0 8-bit codec is smaller than for 4:2:2 10-bit cases, namely, (6/8) ＊ (8/10) = 0.6. In 4K30p, it is reasonable to set a rate of 100Mbps for 4:2:0 8 bit recordings, this equates well to 150Mbps for 4:2:2 10-bit. In case of 4K60p, the number of frames per second is twice that of 30p, however, the image structure difference between adjacent frames is halved and thus easier to compress. As LongGOP

encoding relies upon encoding the difference between adjacent frames, the compression efficiency is better at 60fps. Consequently, 1.5 times the bit-rate is enough to get the equivalent quality, so we are able to use 150Mbps for 4K60p 4:2:0 8-bit recordings.

7. 2K/HD LongGOP formats:

   The number of pixels used for 2K is only a quarter of that for 4K, therefore only one quarter the bit-rate is required for an equivalent 2K codec. In the case of 2K30p 4:2:2 10-bit, 37.5Mbps (150/4) would be good enough. However, as today's media costs for SD cards are low and data transfer speeds relatively fast, Panasonic chose 50Mbps as a base data rate.

   For Variable Frame Rate (VFR) 2K / HD recordings, we will need to increase bit rates for higher frame rate recordings, rising to 200Mbps for 2K at 240p. Thanks to the high compression efficiency of LongGOP encoding at high frame late, it is reasonable to assign 1.5 times bit-rate for 2 times frame-rate. In the case of 240p (30p*2*2*2), that would translate to 169Mbps (50M*1.5*1.5*1.5). 200Mbps easily provides more than adequate quality.

8. Pros and Cons of LongGOP

   The advantage of LongGOP encoding is faster offload times and less media cost. The disadvantage is that more computational power is needed for decoding compared to an Intra codec. LongGOP also has more response delay when seeking random-access frames in playback because it needs to decode and cache multiple frames to show a specific required frame.

   However, thanks to the technological progress in CPU performance and the pre-read and cache algorithms found in the latest editing software, the user stress is greatly reduced. Fig-4 shows that 4:2:2 10bit 4K30p LongGOP clips can be played back seamlessly with a MacBookPro, yet the CPU usage rate still has some margin to accommodate other functions.

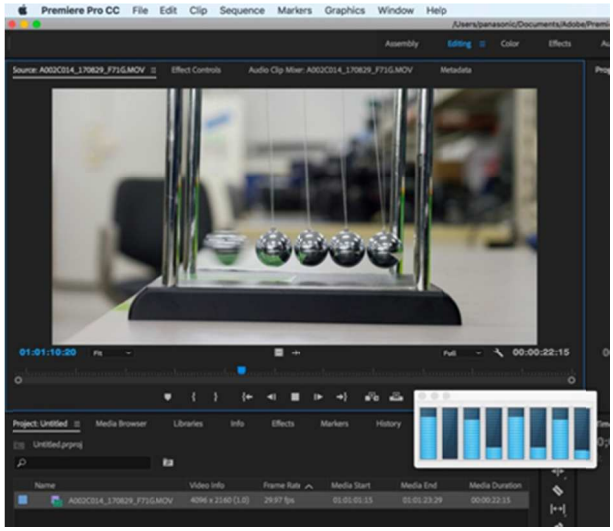

Fig-4. CPU usage, 4K30p LongGOP playback
（MacBookPro2017, Core i7, PremierePro 2018）

9. Summary

   This paper describes the concept of each of the codec / recording formats for EVA1. 4:2:2 10bit LongGOP codecs may not be familiar to production users as professional capture formats. We hope that this paper helps you understand the rationale for the implementation of the two types of codecs that will shortly be found in the EVA1. Choices make workflows easier, and this help you optimize the camera options to your needs.

The EVA1 was born based on an enormous volume of feedback from our camera clients, users of the VariCam, DVX200, GH5, etc. We would like to express our sincere appreciation for all customers who took the time to give us their ideas and suggestions for future products. We will keep listening to your requests, and deliver well balanced products that meet your requirements for the high quality capture of 4K imagery at reasonable costs. We think our dual implementation of LongGOP and All-I supports that goal. The choice of which to use is yours.

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