

# Technical workflow in TV coverage of Mountain Bike events

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## **Abstract**

*This project focuses on the technical requirements needed for the television production of a live action sport event, especially the RedBull's Mountain Bike competitions in the Catalan cup 2010. There are three main stages: the TV production on location, the editing and the deliver of the final video to the customer. Each different stage requires several technical decisions to be made and this document provides a detailed and comprehensible steps to achieve each purpose.*

## **Keywords**

Workflow; TV coverage; Recording; Broadcast; Video; Codec; Camera;  
Tapeless;

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# Chapter 1. Introduction

## 1.1 Summary

FGFdesign, a TV production company, is responsible for the TV media coverage of the Catalan Mountain Bike Championships in collaboration with RedBull Spain and La Federació Catalana de Ciclisme.

The TV coverage of a live event is a technical challenge where there are technical decisions to be made from the acquisition of the pictures to the final delivery of the produced contents to the customers.

This document focuses on the technical requirements for the production of a live action sport event in three stages. The first one is the acquisition of the images where the TV production crew records the live action with several purpose-specific cameras. The second stage is the editing and post-production process where pictures, audio and graphics are selected, trimmed, adapted and put together in a single format. Finally, the last stage is the video delivery to the different types of clients which require specific video compression schemes.

All three stages are linked together as an end-to-end optimized **tapeless** workflow. The concept "tapeless" has a strong significance in this context because it is a completely new way of working in the television environment. This is essentially the concept of shifting workflow from videotape to data. In other words, an IT environment where frames are now files that will be stored and managed. The workflow in this sort of setting would be more similar to the nonlinear postproduction environment found in editorial, which brings an increased speed, flexibility, and creative options.

The technical decisions taken along the development of this project may serve as a model of how to provide coverage of similar live events. In our particular case, we have been provided very strict image quality technical requirements on behalf of RedBull as it can be seen in annex B RedBull guidelines for moving images

contribution. Technical requirements. . Moreover, a requirement from La Federació Catalana de Ciclisme was to document all the steps needed to technically organize the TV production crew providing a sort of manual of style. These prove that within this project, we have provided some solutions to combine the new technologies available nowadays for the design of a light, flexible and fast television production workflow.

My job at this company is as a technical director and I propose the best solutions to face the technical challenges we encounter and most of these solutions are precisely detailed in this document. It is not the first time I deal with these kind of technical environments as I stayed in similar positions in the last two companies which I worked with. But this is the first time that I am alone in the decision making process because the company is small and I am the only person with a strong technical profile in there.

To sum up, **my objectives** in this project are the following:

- Document the technical decisions which I adopted to face the technical challenges we faced in the real world television coverage of the events. That includes the type of camera equipment we choose, the type of editing software we choose, and so on.
- Establish a useful, fast and flexible tapeless workflow from acquisition to delivery and prove that it not only works in theory but it also works in real situations.
- Write a manual of style of how to technically organize the TV production crew for la Federació Catalana de Ciclisme. See this manual in Annex Error: No se encuentra la fuente de referencia.

Last but not least, it is important to point out the the videos produced with these workflow have been broadcasted on TV in the channel 3/24, and other local televisions as well as uploaded to specialized websites such as [www.ciclisme.cat](http://www.ciclisme.cat), [www.redbull.es](http://www.redbull.es), or [www.elmundodeportivo.es](http://www.elmundodeportivo.es).

## **Chapter 2. State of the art and project requirements**

The coverage of a live sports event can be clearly divided in three stages that are correlative in time. First of all the actual recording of the event which is the stage where more people is involved and the one that is technically more complex. Then there is a need to select, trim and edit all the pictures and sound and make up a proper video programme of the event. Finally, it is important to adapt the final product to the different customers, each of one with different needs.

There is great difference whether the event is broadcasted live or it is not live and edited later on. First we will discuss the typical procedures when producing a live event and then we will focus on how we actually do each stage in our particular case.

### **2.1 TV event recording**

Typically television sport events are broadcasted live. This means that the video sources of all cameras must be mixed in real time as well as superimposing the needed graphics or effects. In order to actually produce the final video on location an outside broadcast truck, which has all the television equipment inside, is required.

#### **2.1.1 Outside Broadcast truck**

Producing a mixed live video feed of an event is perhaps the most technically demanding situation one can think of. Whether it is a tennis match or a mountain bike competition or even a boat race, lots of things are happening at the same time and must be captured without delay. These situations require placing many cameras in

strategic locations and mixing them in real time to produce a continuous live video feed. The master heart of the system is the Outside Broadcast (OB) truck or van where all the broadcast equipment and the staff operating them is present.

The OB trucks are special trucks which have been adapted and have a complete master control room inside. They basically have a video mixer, audio mixer, a monitor stack, graphics generators, intercommunication sets, videotape or harddisc recorders among other video and sound equipment.



*Figure 2.1: HD Grassvalley video mixer of the Eurosport's OB van*

The television director is inside the OB truck and his role is to say which camera must be incorporated into the live video feed and the mixer operator is who actually operates the video mixer panel.

### 2.1.2 Electronic Field Production (EFP) Camera Chain

Attached to the OB truck there are the EFP cameras. The EFP cameras are cameras without VTR which provide a live video feed to the OB truck. All the different parts that configure a single camera link are called the camera chain;

- **Optical head:** it is actually the camera which has the lens, the CCD's block and the viewfinder. The camera operator is responsible for framing the shot, zooming and focusing. He or she does not modify any of the camera configuration settings because this is done remotely by the CCU operator.



- **Camera Adapter Unit (CAU):** it is attached to the back of the camera and it is basically an adapter box that connects the triax<sup>1</sup> cable to the camera. This adapter receives signals from the triax and connect those to the camera.
- **Camera Control Unit (CCU):** it is the other end, inside the OB truck, where the triax cable connects to. It enables to remotely adjust camera parameters such as the iris, shutter speed, knee, gamma matrix, white balance, detail settings.
- **Operation Control Panel (OCP):** this is the actual panel that uses the CCU operator. The main aim of the CCU operator is to match the color of all the cameras so that switching between them does not produce any color jump. Moreover, it keeps adjusting the brightness of each camera so that the picture exposure is correct all the time.

## 2.2 Editing and post-processing

When a sports event is produced live, there is no need to edit any video because the images are already mixed in real time. That is the greatest advantage of having all the cameras connected to the OB truck and mixing them on location. While the event is being produced, the output of the video mixer is sent to a videotape recorder or to a harddrive video server. The production team ends up with a full-length video, mainly cut edited<sup>2</sup>.

## 2.3 Delivering needs

The main point of live coverage is to produce a video signal to be broadcasted in real time so that viewers can follow the competition on TV wherever they are. The most common way to broadcast the signal worldwide is to use satellite links.

### 2.3.1 Digital Satellite News Gathering (DSNG)

The mixed live video signal from the OB truck is routed to the DSNG van in order to be uploaded to the satellite. Inside the DSNG, the audio and video from the OB truck are encoded to an ASI signal and modulated to a Ku-band prior to uploading it to the satellite.

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1 **Triax cable:** rugged coaxial cable that connects the camera's CAU to the CCU.

2 **Cut edited:** A cut edited video is a video where the shots are connected by cuts. This means that there are no transitions between them like crossfades, just one shot after another. This is the simplest way to put shots together and the most unobtrusive edit for the viewer. Live events are typically cut edited unless a transitional effect is justified like going from the live images to a recorded replay for example where a image swoosh is used.

## 2. State of the art and project requirements

The Ku band is a portion of the electromagnetic spectrum in the microwave range of frequencies from 10.7 to 12.75 GHz (in Europe). Ku band is primarily used for satellite communications, particularly for broadcast video and audio feeds from remote locations back to a television network's studio (See Figure 2.2 and Figure 2.3).

Compared with C-band, Ku band is not similarly restricted in power to avoid interference with terrestrial microwave systems, and the power of its uplinks and downlinks can be increased. This higher power also translates into smaller receiving dishes and points out a generalization between a satellite's transmission and a dish's size. As the power increases, the dish's size can decrease.

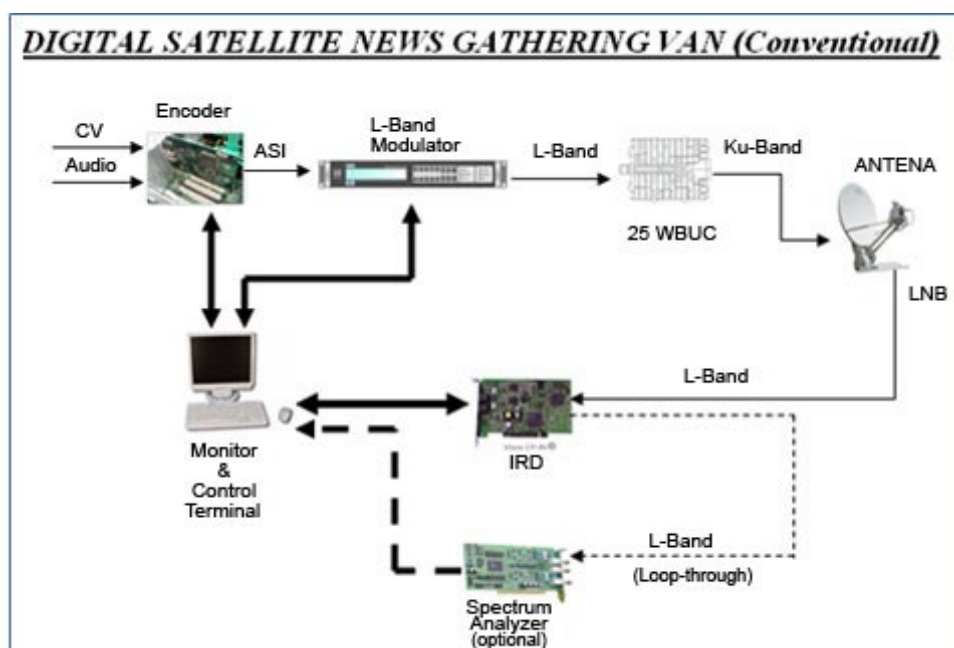


Figure 2.2: Digital Satellite News Gathering signal flow



Figure 2.3: DSNG van at Vallnord' Mountain Bike WorldCup

Once the video feed is uploaded to the satellite, the TV station can receive the live video feed of the event by using a digital IRD (integrated receiver decoder) connected to a satellite dish pointing at the specified satellite (typically Eutelsat W2). *Scopus* or *Tandberg* are common manufacturers of professional IRDs. The host broadcaster of the event provides the satellite technical parameters to correctly tune and decode the signal. For example, these are the parameters used by Eurosport TV crew:

- **Satellite:** Eutelsat W2
- **Transponder frequency:** 11731 Mhz
- **Polarization:** horitzontal
- **Symbol rate:** 28,126 Msps
- **Viterbi/FEC:** 5/6
- **Additional parameters:**
  - Service ID (SID): 3
  - Network ID (NID): 40
  - Video Packet ID (VPID): 301
  - Programme Clock Reference (PCR): 301

## 2.4 Non-live production (our case)

### 2.4.1 Customer requirements

We have basically three main customer requirements regarding the television coverage of the events. First of all, it is not necessary to produce a live video feed, so we shot the event in a ENG style but with several cameras at once as if it were live which are edited a posteriori. The second requirement is that we do have to follow the strict picture quality guidelines detailed in Annex B RedBull guidelines for moving images contribution. Technical requirements. Finally the third requirement is that we must deliver the final video in several formats for each purpose, for example, a highlights clip just after the event, etc. The delivery formats are further explained in the chapter 5 Delivery .

### 2.4.2 Non-live event image acquisition

Live production of sports events is extremely expensive and technically demanding. In the current project, our customer does not require us to produce a live video signal of the event, our approach for the television coverage is completely different. First of all, we do not have use an outside broadcast truck or any video mixer because the video will be mixed later on the editing stage. Our cameras are not EFP type because they are not connected to any mixer. They are camcorders which record the images on solid-state media. We basically produce the event in the same way as if it were live, but without having to mix and produce a final video on location. This enables us to use less equipment and human resources and produce a high-quality video with a tighter budget. This way of working is also known as "recording a **fake-live** event" in the sense that it is not really live, but we are shooting with several cameras simultaneously as if it were live.

### 2.4.3 Non-live video editing

If the event is not produced live, then there is a need to edit all the images stored in each camera producing a final video. Our customer does not need a full video coverage of the event, that is, if the competition lasts 2 hours the video is 2 hours long too. We produce a shorter highlights video which has the best moments (or highlights) of the competition but not the real-time coverage of everything that happened. The goal of editing is to produce a enjoyable video for anyone who wants to know what happened in the sports event. This is another point for deciding not to produce the event live.

#### **2.4.4 Non-live event video deliver**

Satellite links are expensive and they require DSNG vans in order to upload the signal. In our case, there is no need to broadcast the signal in real time so the deliver of the video takes place 3 days after the event has been held.

So, once the video has been edited, then several version of it are produced for delivering purposes. All of the different target outputs require specific compression schemes, whether it is a high-quality version for TV broadcast or just a small clip for the web. All of these will be further discussed in Chapter 5.

## Chapter 3. TV event recording

This document explains how a live sports event can be technically covered. There is a huge variation of sports events ranging from small sets such as tennis games to huge scenarios like The Tour of France where the action spreads hundreds of km from side to side.

Every sport needs different TV coverage and when the area of action broadens the coverage turns out to be extremely complex. This document focuses on recording Mountain Bike races. There are mainly three types of races:

- **4X races:** Riders compete each other in a closed circuit which can be the size of a football field.
- **Urban races:** The race occurs inside a city where the bikers ride in a fixed track from one point of the city to the other.
- **Downhill races:** The race happens in the countryside in a rough track that has a typical length of 2-4 km all way to the down.

The first type of circuit is the easier to cover because it is possible to view the whole circuit from a high position. The last type of circuit is the most technically challenging because action happens in an expanded area and most of the times inside a wood, with steep terrain and difficult accessibility.

These type of circuits and its specifications will be further explained in section 3.8.

### 3.1 User requirements

There are some basic user requirements to be fulfilled in each race:

- **Main audiovisual coverage:** shot audio and video pictures of all the track, riders, sponsors sets, public, etc.
- **Interviews:** make interviews to riders, organizers and personalities.
- **Mid-point circuit live video:** provide a live TV signal from parts of the track to feed a plasma screen located at the finish line for the public.
- **Raw footage clip:** edit a short clip (4-6 min) with highlighted raw footage and original audio right after the event for media networks. The purpose of this clip is to upload it to an FTP server and to give access to authorised TV stations, electronic newspapers or sports website portals, so that they can download the raw footage and edit it themselves as a news item.
- **Edit a final video:** Produce a high quality video with superimposed graphics, timings and results of the whole event. This video is edited and post-processed in the next 4 days after the event.
- **Vimeo, youtube:** Generate a low resolution highly compressed version of the video for uploading to Vimeo and Youtube websites.
- **Make a DVD:** Produce a compliant DVD-video with a 16:9 standard definition version of the final video for giving it to the companies that sponsor the event as well as to the organizers.

#### Live vs non-live event

As we mentioned early in section 2.4 Non-live production (our case), it is important to point out that the customer is not asking for a live broadcast of the event. Live broadcast means having more cameras spread along the track, each one with its camera operator and mixing them in real time producing a live ready-to-watch television feed. This setup is extremely expensive because it requires an Outside Broadcast Van (OB Van) with state-of-the art television equipment.

Although, at postproduction stage, it is possible to simulate an almost-live broadcast (so called fake-live) by mixing shots captured by different cameras at the same time producing a single uncut clip. This technique is widely used, specially in 4X races where several cameras can capture the whole action continuously.

## 3.2 Technical requirements

In order to fulfill the user identified requirements, several technologies are integrated. First of all, it is necessary to purchase the cameras for capturing the action. Section 3.4 provides an in-depth review about the different formats, recording media and camera bodies. Other camera options such as onboard cameras, slowmotion cameras or HD/SLR are presented in the following sections. Section 3.9 gives an overview of the different wired transmission systems and section 3.10 explains a specific wireless video transmission equipment. When it comes to editing the captured images there are several software options that are further discussed in section 4.2.6.

### 3.3 High Definition acquisition format

Nowadays, camcorders offer the possibility to shot in a great variety of HD formats but not all of them really match the sports recording requirements.

- **1080/24p<sup>3</sup> and 1080/25p** are filmic formats which deliver cinema-like images and are adequate for slow moving pictures. When using these formats with fast action scenes, flicker becomes too evident.
- **1080/50i** is an interlaced HD format. It captures movement better than the previous progressive formats but has some several problems when dealing with slow motion effects. Besides, as most of the content produced will be uploaded to web, there is a need to deinterlace the final videos which is a process that degrades the picture quality.
- **720/50p** has a resolution of "only" 1280x720 but thanks to the high frame rate it gives a much more natural motion look. This format makes very easy to produce lower resolution versions for web uploading and it downconverts very nicely to standard definition DVD which is a very common way to deliver the video to the customers.
- **Others.** Apart from the previous ones, other formats have been used in special occasions. For instance, the **960p** (1280x960 pixels) which is like the 720p but with an increased vertical resolution and 4:3 aspect ratio. More on this format in section 3.5.

For additional information see Annex A: BBC framerates guidelines

#### Interlaced vs Progressive

In Europe, the EBU is definitely in favour of progressive formats because they compress more easily and most of the major sports TV stations like Fox Sports, ABC or ESPN decided to use 720/50p as its primary HD transmission format.

#### Transmision vs Adquisition

Technology is advancing very quickly nowadays. High-end broadcasters will soon begin to adquire 1080/50p footage even if then the final programe is transmited to our home in 720/25p or even at 576i standard definition. This is due to the fact that high resolution pictures will downconvert very well to any other format and partly to maintain a futureproof archival content.

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<sup>3</sup> **1080/24p:** This is the way of abbreviate the format. It correspons to lines/frames{p: progressive scan; i: interlaced scan}. So in this case, 1080/24p means 1920x1080pixels at 24 progressive frames per second.



### **Internet video broadcast**

Produced video content is not only viewed on TV anymore. Youtube or Vimeo video hosting services have nowadays a great impact. 720p is the standart for internet video broadcast. Vimeo and youtube handle videos with a 1280x720 resolution at a maximum framerate of 30fps.

### **1080/50p**

1080/50p has the best of both worlds (high resolution and high framerate) but cameras that can shot in that format are rare and extremely expensive. Realistically, 1080/50p is still in the future at the moment, so it becomes a question of which is the least objectionable compromise. If the highest resolution is desired, then 1080/25p is the best choice but if what it counts is to capture fluid motion, basic for sports coverage, then 720/50p is the way to go. Until 1080p does 50p at a reasonable cost, 720 will always have a place.

That being said, it is also important to point out that 1080p, which means 1920x1080 pixels, will only be really appreciated when the user screen is 42" or more. With smaller screens, there is not really much difference in subjective picture quality between 720p and 1080p. And honestly, 42" and larger screens are not yet so common in the average living rooms.

### **Our format choice:**

To sum up, **720/50p** is the format of choice for shotting live sport events because it handles fast motion without flickering, it is natively progressive and it downconverts to SD (Standard Definition) versions flawlessly.

## **3.4 Selecting the cameras for sports coverage**

When it comes to deciding which camera best fits the user requirements there are three main aspects to take consideration and with the following order of importance:

- Recording format
- Camera body
- Recording media

The following section presents the various technologies available at the moment and justifies which equipment best fits the technical requirements and the budget.

### **3.4.1 Recording format**

The recording format is the codec that the camera uses to compress the pictures captured by the sensor. All the HD formats are compressed and lossy formats; the more professional the format, the less compressed it is.

There are a great number of video formats from high-end cinematography formats like HDCAM-SR to consumer formats like HDV. There is no standard HD format and each manufacturer has its own proprietary video format.

The search of the best format has been narrowed to these four formats because they are widely used in the industry and offer enough flexibility and picture quality:

Recording Format Comparison				
	Sony XDCAM EX	Panasonic DVCPRO HD	Sony HDV	Canon DSRL codec
Media	SxS or SDHC cards	P2 cards	MiniDV tape	Compaq Flash cards
Bitrate	Up to 35 Mbps (VBR)	Up to 100 Mbps (CBR)	25 Mbps (CBR)	Up to 48 Mbps (VBR)
Color Space Sampling	4::2::0	4::2::2	4::2::0	4::2::0
Compression scheme	Long-GOP MPEG-2 MP@HL	DCT based	Long-GOP MPEG-2 MP@H14	MPEG-4/H.264
Maximum resolution supported	1920x1080	1440x1080	1440x1080	1920x1080
HD formats supported	<u>PAL area:</u> 1080/25p 1080/50i 720/50p; 720/25p  <u>NTSC area:</u> 1080/30p; 1080/24p 1080/60i; 720/60p; 720/30p; 720/24p	<u>PAL area:</u> 1080/25p 1080/50i 720/50p; 720/25p  <u>NTSC area:</u> 1080/30p; 1080/24p 1080/60i; 720/60p; 720/30p; 720/24p	<u>PAL area:</u> 1080/50i; 720/25p  <u>NTSC area:</u> 1080/60i; 720/30p	<u>PAL area:</u> 1080/25p; 720/50p  <u>NTSC area:</u> 1080/30p; 720/60p 1080/24p;
Audio	2 channels of uncompressed PCM audio	4 channels of uncompressed PCM audio	2 channels of audio compressed at MPEG-1 layer 2 at 384 kbps	2 channels of PCM uncompressed audio.

Table 3.1: Recording formats of choice comparison

The HDV is a consumer and prosumer<sup>4</sup> format. It was the first affordable HD format and many manufacturers released camcorders which record using that codec. It is MPEG-2 based and it offers reasonably good picture quality even though its low bitrate.

Canon has developed its own format for the HD SLR<sup>5</sup> cameras. It is based on the MPEG-4/H.264 standard using high bitrates up to 48 Mbps for video and audio streams. This codec is heavily compressed (both intraframe and interframe) so editing

4 **Prosumer:** Term that means that something is in between the consumer and the professional world.

5 **HD SLR:** Term used to name the group of SLR (Single Lens Reflex) photo cameras that can record high definition video as well.

it in its native format is extremely slow. It may be a good delivery format but definitively it is not a good acquisition format.

Panasonic's DVCPRO HD codec is an industry standard used by millions of broadcasters. It is the least compressed format of them and it uses only intraframe compression based on the DCT. It has the advantage of using a 4:2:2 color sampling scheme. It is a very good acquisition format due to its high bitrate and relatively low compression.

**Our choice:**

Finally, Sony's XDCAM EX format is a professional codec and it can be seen as an improved version of the HDV format. It raises the bitrate from 25Mbps (CBR) to 35Mbps (VBR), it offers uncompressed audio tracks and it supports all existing HD formats. This format is a trade-off between highly compressed formats like MPEG-4 and low compressed formats like DVCPRO HD. Moreover, it can be smoothly edited with a powerful workstation.

Sony XDCAM EX is our the format of choice for sports coverage.

### **3.4.2 Recording media**

The search has been narrowed to these two file-based media supports:

Recording media comparison		
	SxS Cards	P2 Cards
Interface:	Serial	Parallel
Technology:	PCMCIA ExpressCard	PCMCIA PC Card
Chips:	1-block flash memory	Raided flash memory
Write speed (Mbps):	800	640
Data transfer speed (GB/seg):	2,5	1,2
Power consumption:	Requieres less power	Requieres more power
Capacities (GB): <sup>6</sup>	8, 16, 32	8, 16, 32
Dimensions (mm):	75 x 34 (5mm thick)	85,6 x 54 (5mm thick)
Hot swappable:	yes	yes
USB 2.0 support:	yes	no
Modern laptop compatibility:	yes	no
Availability:	Sony & Sandisk	Panasonic only
Aftermarket ExpressCard to SDHC adaptors	yes	no

Table 3.2: Sony SxS vs Panasonic P2 comparison chart

As it can be seen in the previous table, the SxS cards are a step forward in comparison with the P2 cards. They use ExpressCard PCMCIA bus, which is a newer technology than the old PC card, and they can be written and read at a much faster speed.

Price is pretty much the same, around 700€ per each 16GB memory card. But there are aftermarket brands<sup>7</sup> that sell ExpressCard to SDHC adapters so it is possible to use generic (and cheap) SDHC cards instead of the proprietary (and expensive) SxS Sony cards.

#### 6 Definition of a Megabyte:

- Operating systems define 1 MEGABYTE as 1.048.576 BYTES (1024K x 1024K or 2 to the 20<sup>th</sup> power).
- Disk drives companies (Sandisk, ...) define 1 MEGABYTE as exactly 1.000.000 BYTES

7 ExpressCard to SDHC adapters distributed by (among others):

<http://mxmexpress.com/>

[http://www.hoodmanusa.com/SxSxSDHC\\_Memory\\_Adapter\\_FAQ.asp](http://www.hoodmanusa.com/SxSxSDHC_Memory_Adapter_FAQ.asp)



*Figure 3.1: SDHC card with adapter and original SxS card*

**Our choice:**

Our choice for the media storage is the Sony SxS because it is technologically superior and more affordable when using a special adaptor. We have tested these adaptors with successful results, but it is required to upgrade the camera's firmware to the latest version (v1.11) and use fast SDHC cards (class 6 minimum).

**3.4.3 Sensor Size**

The sensor size is probably the best single parameter to classify or rank the different types of cameras, from consumer to professional models. In general, the larger the sensor, the better the overall picture quality in terms of dynamic range or noise levels.

Larger sensors are more difficult to manufacture and, because of that, they are more expensive. Here is a list of a very common way of classifying the different types of cameras according to its sensor size:

Category	Sensor Size	Sensor dimensions with x height (mm)	Camera example	Price range
Consumer cameras	1/4"	3,92 x 2,2	Sony HVR-A1	2.000€ and less
Prosumer cameras	1/3"	5,23 x 2,94	Sony HVR-Z1	3.000€ - 4.500€
Industrial Professional cameras	1/2"	6,97 x 3,92	Sony PMW-EX1	5.000€ - 8.000€
Broadcast Professional cameras	2/3"	9,6 x 5,4	Sony PDW-700	25.000€ and above
HD SLR	APS-C	22,3 x 14,9	Canon EOS-7D	1.600,00 €
	Full Frame	32 x 24	Canon EOS-5D Mark II	2.300,00 €

Table 3.3: Cameras classified according to its sensor size

Consumer cameras use the smallest CCD or CMOS sensor available, which is 1/4" and in some recent tiny cameras even 1/6" sizes are used. Smaller sensors require smaller optics so the overall size of the camera can be very reduced and portable. The downside is that squeezing so many pixels in a 3,92 mm x 2,2 mm area results in very small pixels which require a lot of light to produce reasonable picture quality. Therefore, low light performance of consumer camcorders is awful and not acceptable in professional environments.

Prosumer (in between professional and consumer) cameras such as the Sony Z1 features 3 CCD's of a 1/3" which improves sensitivity and noise levels. Industrial and Broadcast cameras offer the best performance in terms of noise and sensitivity thanks to their larger sensors and they are the way to go for capturing professional looking images.

Note that there is a new category of cameras: the HD SLR cameras, which will be further explained in the section 3.7. These are still cameras that have movie recording capabilities and its main characteristic is that they have the largest sensor available. Its effective sensor area, 768mm<sup>2</sup>, is almost 15 times larger than the industry standard 2/3" size which has approximately 52mm<sup>2</sup>.

Here is a representation of the relative sizes of the HD SLRs (both Full Frame and APS-C sizes) compared to the 2/3" broadcast cameras and the 1/3" consumer cameras.

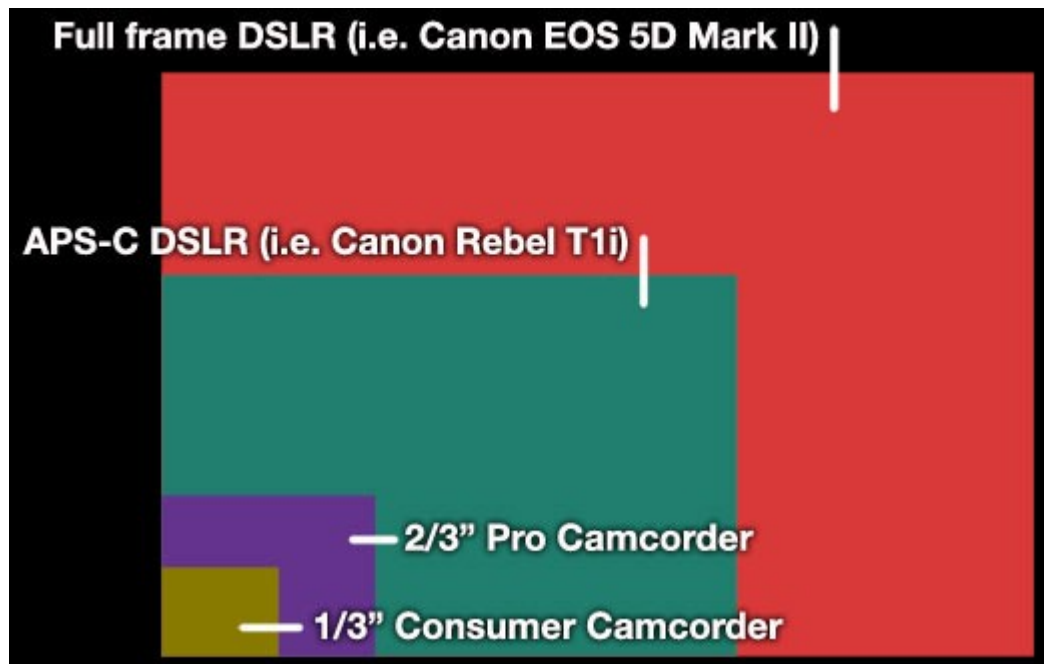


Figure 3.2: Camera's sensor size comparison

Larger sensors can have many benefits over smaller sensors, if all other things are equal (such as pixel count, etc). When comparing a 1/3" sensor to a 2/3" sensor, all other things being equal, typically the 2/3" sensor would have better performance in terms of:

- Better sensitivity
- Better dynamic range
- Less noise
- Less depth of field (cinema-like pictures)

It is important to keep in mind that the industry has begun to approach the limits of physics in the design of practical high definition cameras. A 2/3" sensor is actually about 11 mm diagonal, or roughly 9,6 mm × 5,4 mm. On that chip, each pixel is about a 0,005mm<sup>2</sup>. To achieve full resolution, an HD camera system, lens and camera, must produce about 81 lines per mm<sup>8</sup>. That means that a stunning optical system is needed to produce such a sharp picture on the sensor, or the image focused on the sensor must become much larger to allow practical optics (or less expensive) to be used.

On the other side, consumer and prosumer camcorders have sensor sizes ranging from 1/6" to 1/3". Extrapolating the numbers above means that on a 1/3" sensor, the pixels for 1080p images are about 0,0025mm<sup>2</sup>, and the lens system performance would also have to double to achieve the same results of the cameras

<sup>8</sup> It is common to measure the maximum resolution of a lens by giving its resolving lines per mm. The theoretical resolution of a f8 lens is 200 lp/mm and that is assuming it is totally aberration free and is limited only by diffraction.



with larger sensors. But the truth is that inexpensive cameras use inexpensive optics. Performance has to unavoidably suffer. The pictures of consumer HD cameras are demonstrably better than SD cameras, but cannot equal the quality of a studio camera and lens.

Therefore, it is clear that the larger the output format is, the larger must the sensor be or, at least, use high-end optics, which is not usually the case. Here is where the HD/SLR shine as they use much larger sensors.

### 3.4.4 Camera body

Once the recording media has been chosen, it is time to decide which camcorder best fits the needs and the budget. The search has been narrowed down to two major manufacturers: Sony and Panasonic. Both of them offer a wide range of camcorders, from consumer 1/4" CCD cameras to broadcast 2/3" CCD cameras. As it has been seen in section 3.4.3, cameras can be classified in terms of its sensor size. The larger the sensor, the greater the sensitivity, the dynamic range and the overall picture quality. So, when speaking of sensor sizes, larger is always better.

In our case, the decision is up to whether 1/3" or 1/2" cameras. 1/4" means consumer gear and they are not up to professional requirements. On the other side, 2/3" cameras are extremely expensive and it is synonym of large shoulder-mount cameras which offer great functionality but also low portability.

The two cameras under consideration are the Sony PMW-EX1 and the Panasonic AG-HPX171, both with a price tag between 5.000€ and 8.000€:



Figure 3.3: Sony PMW-EX1 1/2" professional camera



Figure 3.4: Panasonic AG-HPX171 1/3" professional camera

The next two tables summarize the pros and cons of each other and they will justify the final choice.

Sony PMW-EX1 pros and cons (compared to Panasonic AG-HPX171):	
Pros	Cons
1/2" CMOS sensor gives shallower depth of field than 1/3" equivalent	CMOS sensor has significant rolling shutter effect, as well as wobble and partial exposure issues. <sup>9</sup>
Has less image noise at higher gain levels	XDCAM EX 4:2:0 color sampling instead of professional 4:2:2
Captures full raster 1920x1080 high definition picture and produces a sharper image	35 Mbps XDCAM EX codec is lower data rate than DVCPRO HD.
Uses a 35 Mbps XDCAM EX codec, which is a low bitrate and enables longer record times on same storage cards	Much heavier than other similar cameras
Very good low light sensitivity (in part thanks to its larger sensor).	Price 20%-30% more expensive than the HPX171
Outstanding hitg-resolution LCD screen	

<sup>9</sup> These sensor artifacts problems are further explained in Annex C

### 3. TV event recording

After-market adapters for use instead of original SxS media cards. Cheap SDHC cards can be used.	
It has BNC SDI output	

Panasonic AG-HPX171 pros and cons (compared to Sony PMW-EX1)	
Pros	Cons
Excellent image quality in normal to good lighting.	Not as light sensitive as the EX1.
DVCPRO HD is a 100 Mbps 4:2:2 professional low compressed format. Very easy to edit with a lot of margin for colour correction.	Noisier pictures in low light
Relatively affordable	CCD sensor resolution is only 960x640 pixels. The captured image is then interpolated to 1920x1080 using pixel shift techniques which results in a softer picture than the native 1080p sensors of the EX1.
Built-in great quality wide angular lens (72mm at wide end)	Low resolution LCD screen which makes focusing difficult.
Lighter camera than the EX1.	Shorter recording times per P2 card of the same size of the SxS card.
Acknowledged great colorimetry. Very filmic look	Extremely expensive P2 cards and no aftermarket workarounds.

#### **Our camera choice:**

Looking at the pros and cons it has been decided to purchase two Sony EX1 instead of the Panasonic ones. They are more expensive but they offer great functionality and, what is more important, better image quality either in good and bad lighting situations thanks to its larger CMOS sensors.

## 3.5 Onboard cameras

Nowadays, onboard cameras are a must in action sports events. These, also known as point-of-view (POV) cameras, bring first-person views of what the riders see and the footage captured by them is highly appreciated for the viewers due to its spectacularity. Until now, onboard cameras were known for its low picture quality because it was difficult to put good lens and electronics in such a small package. But nowadays, there are small onboard cameras that have reasonable good image quality

and record even at HD resolutions. That is the case of the purpose-specific professional GoPro HD camera which can record at 1080/30p and it comes with a selection of mounts that enable the camera to hang on to just about any part of the bike or the rider.



*Figure 3.5: Onboard GoPro HD camera mounted on a bike helmet*

When attaching the camera to a helmet it relies on two-sided 3M adhesive pad that grips fiercely to the smooth surface of the helmet. It also has a small rubber washer (in white in the previous figure) that virtually eliminates any vibration. It has built-in wide-angle lens which helps to capture more of the action and reduce the flicker of the picture. Moreover, it is waterproof up to 60m and impactproof thanks to the removable polycarbonate plastic housing.

This onboard camera is usually mounted on location on a professional rider in order to record his or her run. We also have a customized clamp for mounting the camera to the bike frame or attached to the handlebar pointing to the face of the rider which brings an unparalleled point of view.



Figure 3.6: Video frame of the onboard camera attached to the bike's handlebar

It records the video on a SDHC card up to 32 GB and it can be set to record in 4 different video formats:

- **1080p** = 1920x1080 pixels (16:9), 30 fps, 15 Mbit/s data rate
- **960p** = 1280x960 pixels (4:3), 30 fps, 12 Mbit/s data rate
- **720p** = 1280x720 pixels (16:9), 60 fps, 15 Mbit/s data rate
- **720p** = 1280x720 pixels (16:9), 30 fps, 8 Mbit/s data rate

But only two of them are really useful for our needs. These are the 720/60p and the 960/30p. With such a camera, there is really no visual difference in shooting 1080p versus 720p because neither the optics nor the electronic processing circuits are good enough to really take advantage of the increased pixel count of the 1080p. After some tests we have found that in 720p the picture quality is even better than in 1080p because it has more bitrate-per-pixel to be coded. Definitely, 15Mbps is not high enough to compress a 1920x1080 8 bits video, but at 720p, 15Mbps is quite acceptable.

Apart from that, for the action sports visual requirements, an increase in the framerate (60fps vs 30 fps) it is better than an increase in resolution (1080p vs 720p) because the extra framerate smoothens the video and it is visually more fluid. Moreover, flicker-free slowmotions can be accomplished.

There is another recording format which is very useful, the 960p. It is not a standardized HD format whatsoever but it is very handy because of the increase in the vertical resolution. It has an effective resolution of 1280x960 pixels instead of the standardized 720p at 1280x720. These extra 240 pixels combined with a wide-angle lens results in an extraordinary increase of the angle of view. That is very important when mounting the onboard camera in the rider's helmet because it captures a wider perspective.



Here is an example of the benefits of the 960p instead of the 720p. The picture on the left side show the extra vertical resolution and more things "appear" on the frame, like the handlebar of the rider. The picture on the right has a widescreen format but the handlebar and the upper part of the frame becomes trimmed.



Figure 3.7: Comparison of the angle of view of the 960p and 720p modes

The problem is that it produces a high-definition 4:3 aspect ratio image, which is rather weird. Because of this, in post-production the 4:3 image is horizontally stretched so that it fills the 16:9 aspect ratio. Everything gets wider and fatter but that is considered to be a minor drawback compared to the benefits of recording a greater angle of view of the action.

#### **Our choice:**

Our video format choice for the onboard cameras is the 960p because of the extra vertical resolution compared to 720p which delivers a greater angle of view.

## **3.6 Slow motion cameras**

### **Phantom HD GOLD**

Nowadays, there are basically three possible choices for shooting slow motion footage. The first choice is to actually use a dedicated high-speed camera like the Phantom HD GOLD which can shot in 1080p mode at 1000 fps or in 720p mode at a maximum of 1500 fps. The recorded footage is stored in a hot-swappable non-volatile solid state memory and can store up to 512 Gigabytes of video data. This camera offers the highest possible slow motion picture quality and it is mainly used in commercial spots. Obviously, its price tag is completely out of range; at around 100.000€ for the standard configuration. Even the rental prices are very high (2000 € / day).

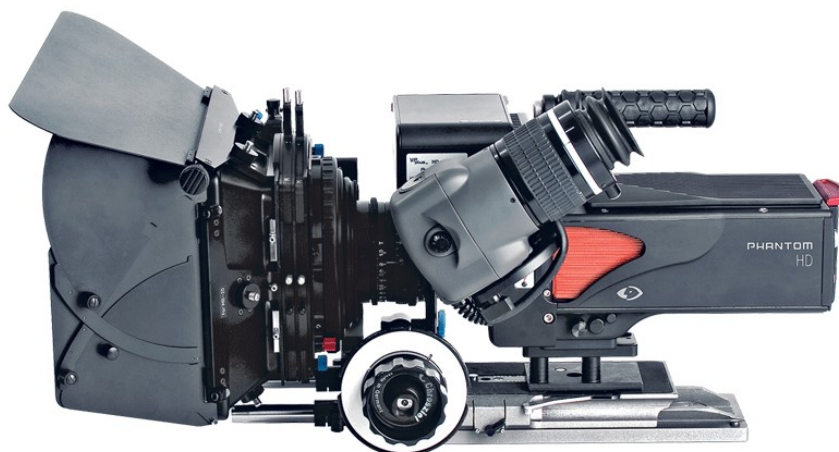


Figure 3.8: Phantom HD GOLD high-speed camera

### Red One digital cinema camera

The second choice is to use a digital cinema camera that can shoot above 50 fps, for example the Red One camera. This camera can shoot high-definition pictures at a maximum framerate of 120fps. The rental price of this camera is approximately 400 € /day. This would be the camera of choice if the project highly demands for slow motion sequences and the customer is willing to pay for the higher rates.



Figure 3.9: Red One digital cinema camera

### Casio EX-F1 high-speed camera

Finally, the most affordable choice is to use a new range of digital photo cameras by Casio that can shoot at very high framerates like the Casio EX-F1 which can shot 512x384 pictures at 300 fps. It is truly a high-speed camera but at the expense of resolution. The EX-F1 costs 1000€, which is way more affordable than the previous two cameras. The maximum resolution available is 512x384 pixels which is an "almost-PAL" resolution with 4:3 aspect ratio. But even with this low resolution, the pictures that these cameras bring is impressive and, 2 years ago, it would have been impossible to shot those videos at this price.



Figure 3.10: Casio EX-F1 high-speed camera

### Our slow motion camera choice:

To sum up, the Casio EX-F1 is the camera of choice for shooting slow motion scenes and it is the camera that has been purchased for this purpose. But knowing that, in some projects, renting the Red One is a viable option too.



## 3.7 HDSLR cameras

### 3.7.1 HDSLR main characteristics

The introduction of a new concept of video-enabled still cameras, so-called HDSLRs, has really shaken up the camcorder marketplace in terms of the access to affordable cameras that produce high quality video. HDSLR means High Definition Single Lens Reflex.

At first it may seem that a photo camera has not enough video quality as it was not designed to shot video from scratch but soon people realized that these kind of cameras have unique advantages compared to real camcorders.

The first and most distinguishable feature that HDSLR have is larger sensor sizes compared to the the typical sensor sizes of a camcorder. As it has been mentioned in the previous section, larger sensors mean better light sensitivity, less image noise and better dynamic range.

The HDSRL cameras have CMOS sensors of basically two sizes, the APS-C and the Full Frame. The latest is as large as a 35mm film while the APS-C is a little smaller (see fig. 3.2: Camera's sensor size comparison).

### 3.7.2 Multiformat capabilities

These cameras use more pixels in the sensor than the image format requieres because they are initially designed for photo purposes. For example, the Canon EOS 7D APS-C sized camera has a sensor of 18Megapixels when an 1080p frame would require only 2 Megapixels (1920x1080). Individual pixels are formed by the combination of pixels, either at the time of A/D conversion or later in post processing. This allows a camera with more pixels to create a multitude of standard formats.



*Figure 3.11: Canon  
EOS 5D Mark II Full  
Frame video capable  
camera*

For instance, one manufacturer's sensor is 4320 x 1920 pixels. By combining 6 samples vertically into 1, a 720p format is created. Combining 4 vertical into one makes a 1080p format. The same is true in the horizontal direction, with 1920 pixels natively or by combining 3 pixels into 2 output pixels, a 1280 pixels structure is achieved to create a 720p (1280x720 native image). These has a clear advantage because by changing the resolutions and the aspect ratios different format can be created without the need of purpose-specific cameras. It would be prohibitively expensive to create a multitude of chips for each output format, and from a practical standpoint, a multiformat camera is a much smarter approach.



*Figure 3.12: Canon EOS 7D  
APS-C sized HD SLR with a matte  
box kit*

### 3.7.3 Advantages and disadvantages of HD SLRs

#### Depth of Field (DoF)

The sensor size also affects on the achieved depth of field. The larger the sensor, the shallower depth of field can be obtained. Just a few years ago a 2/3" sensor was the largest sensor commonly available in the video world and now, substantially larger sensors (such as those found on the Canon EOS 7D and EOS 5D Mark II) are much larger than anything existing before.

That means that it is easy to get cinema-like pictures, with very little depth of field, by using cameras that cost a lot less than cinema cameras.



*Figure 3.13: EOS 7D frame which shows the small depth of field that can be achieved*

#### Interchangeable lenses

One of the other main advantages of these type of cameras is that they have interchangeable optics. This opens up a wide range of optical choices from wide angulars to telephoto lenses which are much cheaper than broadcast TV lenses for professional dedicated camcorders. But, again, they are photo lenses and are not optimized for video in terms of usability. That means that for example, the focus ring travel is very short so manual focusing with these type of lenses is very inaccurate. The other main problem is that photo optics have not built-in servos for zoom so manual zooming is the unique way to zoom. But apart from that, its optical quality is enough for video purposes.

#### Ergonomics

Not all are advantages though. One must remember that HD SLR cameras are primarily photo cameras and the buttons or ergonomics are designed for stills

purpose. That means that these cameras are difficult or awkward to operate and are not indicated in non-controlled shooting environments where you have to take decisions quickly and there is no time to plan the shots and configure the camera.

### **Recording format**

The other main drawback is that they record video using a MPEG-4/H.264 format which is a too much compressed codec and it is hard to edit natively so it must be converted to an intra-frame format prior to editing. The issues of editing such format will be covered in chapter 4: Editing and Post-Processing.

### **Rolling shutter effect**

Nowadays, all the HD/SLR cameras have 1 CMOS sensor instead of the traditional 3-CCD's found in professional camcorders. While CMOS and CCD sensors do the same basic job, that is gathering light and turning it into a electric signals, they go about it in different ways, and the differences can have very significant impact on the resulting footage.

The following figure shows an example of the rolling shutter effect which makes the vertical lines to skew when a sudden pan is done.



*Figure 3.14: Rolling Shutter effect causes skew verticals*

Here is a summarized list of pros and cons of the HD/SLR in comparison to traditional professional camcorders such as the Sony EX1 XDCAM camera.

Pros	Cons
Overall picture quality	Awkward ergonomics for video use
High dynamic range	No professional sound inputs and controls
High light sensitivity	No viewfinder
Low light extraordinary performance (very low noise levels)	Too much compressed MPEG-4 recording format. 8 bits and 4:2:0 codec.
Shallow depth of field	Time limitation of 12min. per clip
Interchangeable optics	Lack of dedicated video functions like timecode, zebra patterns, peaking controls...
Competitive price	Rolling shutter effect
Compact size and weight	Non professional video outputs/inputs

Table 3.4: Pros and cons of HD SLRs in comparison to traditional video cameras

### Our choice for HD SLRs:

For live sports TV recording it is clear that the main acquisition cameras must be video cameras with dedicated video controls such as the Sony EX1 XDCAM. But the EOS 7D HD SLR camera has been chosen as a great additional camera for artistic purposes or cutway shots. Its high picture quality combined with its shallow depth of field and interchangeable lenses led to capturing very attractive shots that can be mixed very well with the ones recorded by the other cameras.

### 3.7.4 High Dynamic range configuration

We have found that the EOS 7D HD SLR tends to over-saturate and over-contrast the recorded video in its default mode. While the resulting images may look very crisp and vivid that's not a good way to acquire the footage. Contrasty pictures do not have a good dynamic range as the underexposed areas tend to become black and the overexposed areas tend to become white, thus losing all the detail of those zones.

Although it is good for still pictures to be razor-sharp, video is another matter. Extremely sharp video does not look beautiful and, in addition, it stresses the in-camera processing and compression processings and results in undesired effects like moiré and motion artifacts.

It is needed to tweak the shooting parameters of the HD SLR so that it resembles as much as possible to the picture produced by the Sony EX1. That will greatly

simplify the work in postproduction because it would be possible to intercut between both cameras without noticing the differences.

After some tests, we have set the following parameters like this:

Sharpness: 0 (0 to 7 scale)

Contrast: 0 (-4 to +4 scale)

Saturation: 0

Color tone : 0



Figure 3.15: EOS 7D picture parameters adjustments

The resulting image has a flatter, less contrasty look, but it mixes better with the Sony EX1 and also offers much more control in post because it has more information to work with.

The previous parameters have been adjusted taking in consideration that most of the footage will be visualized on a computer screen and not in a TV set. People usually prefer to watch contrasty pictures on the screen and softer, less saturated pictures on TV. After some tests uploading and visualizing the video on youtube and vimeo, these parameters offered the best visual experience.



## 3.8 Circuit camera placement scheme

### 3.8.1 Downhill races

DownHill Individual (DHI) racing is a mountain bike discipline where the bikers ride in a natural track in the countryside. DH races are held in a rough and steep terrain, resulting in higher speed than in cross-country racing for example. Riders start at intervals of 30 sec, one by one, and the rider who finishes the track with the lowest time wins. The bike is a specialized one which is large, tough and it has a long travel suspension and powerful disc brakes.

An example of downhill track is the one of Sant Andreu de la Barca's, as shown in the next figure:

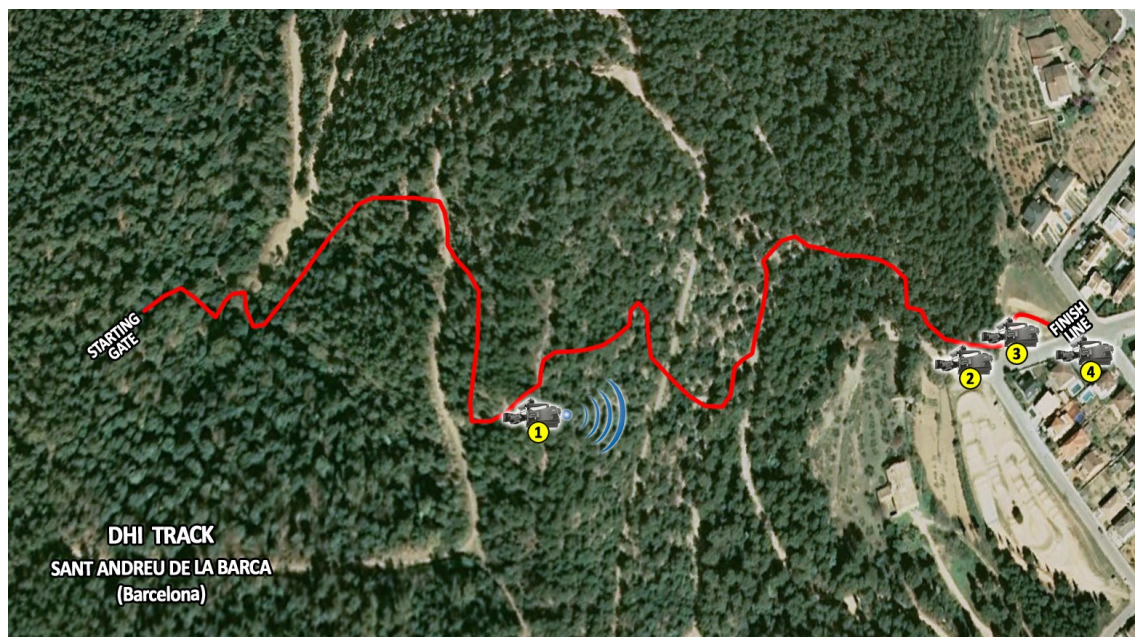


Figure 3.16: Sant Andreu's DHI track

The total distance of the circuit is 1.100m and the height difference between the starting gate and the finish line is 140m. The best rider completes it in 1:48,980 (minutes:seconds).

The downhill tracks of the World Cup are a bit longer (up to 2km maximum) and steeper, but the concept of the race is exactly the same.

Given the length of the track and the rough conditions or the terrain, it is quite difficult to cover the entire circuit with cameras. In order to broadcast the downhill race and cover the whole track a minimum of 6 or 7 cameras spread along the circuit will be needed. That is how, for example, Eurosport TV channel broadcasts the downhill World Cup worldwide (see Figure 3.17 and Figure 3.18). They place the cameras in elevated platforms and each camera is connected to the outside broadcast truck with a triaxial (commonly known as triax) cable that carries component analog video, intercommunication audio, data signals and power for the camera.



*Figure 3.17: Eurosport's camera position in the Vallnord Downhill World Cup 2009*





Figure 3.18: Eurosport's camera operator at the finish line

Triax cables are heavy duty cables that can handle distances of several km with minimum attenuation loss. (See section 3.9 for more detail of the transmission cables). In the last downhill race held in Vallnord (Andorra) in 2009, Eurosport had used more than 6 km of triax cable to cover the entire track<sup>10</sup>.



Figure 3.19: Eurosport's OB van with triax cable rollers

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<sup>10</sup> This "behind the scenes" information was kindly provided for the chief TV engineer of the Eurosport's Outside Broadcast truck in Vallnord (Andorra).

Such coverage deployment is only possible to be carried out by large companies with a lot of technical resources. But if the event is not needed to be broadcasted live, which is our case, things turn out to be easier.

Therefore, the decision which has been made is to concentrate the maximum number of cameras at the finish line because there is where most of the action happens and to not cover the whole circuit with static cameras, but to have one camera that moves up and down the track. This mobile camera can capture a great variety of shots which then, in the edition stage, can be mixed with the shots captured with the other static cameras and give the overall impression that the whole circuit has been audiovisually covered.

As it can be seen in Figure 3.16, the downhill track is highlighted in red and the camera positions in yellow.

Note the mobile camera located along the circuit which, not only records video but also can transmit wireless video to the plasma screens at the finish line. This camera is used to shot the rider in the middle point of the track so that the public at the end of the circuit can follow him/her by looking at the screens in the RedBull truck.

Because of the great distance between this camera and the screens located at the truck in the finish line (600m) it is not possible to transmit the video with a simple RG-59 coaxial cable because the attenuation will be extremely high. Such distances can only be covered with triaxial cable which it is only available in EFP<sup>11</sup> broadcast cameras connected to an OB truck.

For this reason, a wireless digital radiowave link is used. (See section 56 for more details on the wireless links).

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<sup>11</sup> **EFP** stands for Electronic Field Production. It is the common way to refer to the type of production where there is an OB van and several cameras attached to it by triax cable. Note that these cameras are not camcorders (they do not have an attached VTR) because its purpose is to only capture and transmit baseband high-quality video to the OB van. In the OB van there is a video mixer pannel that receives all the video and the mixer operator combines the signals of each camera producing the live feed of the event. This is the video that is broadcasted live and typically uploaded to a satellite using a DSNG (Digital Satellite News Gathering). It is also recorded on VTR for archival.

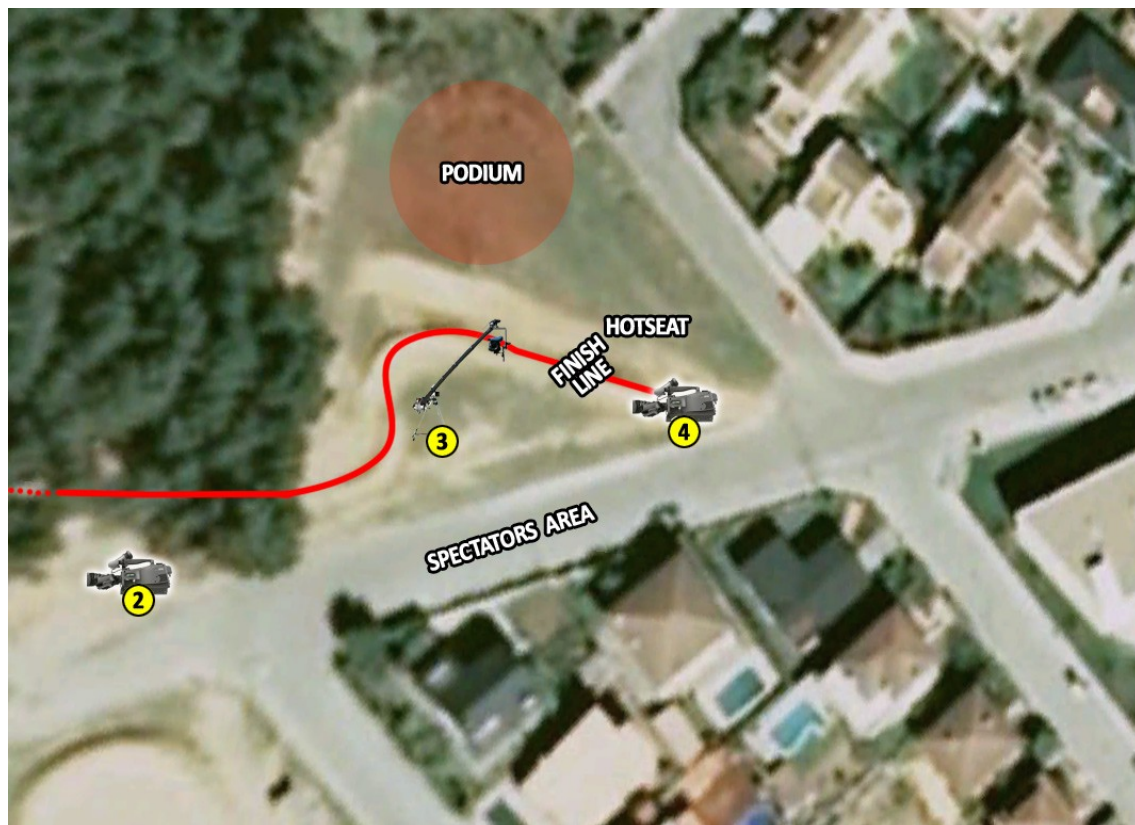


Figure 3.20: Sant Andreu's finish line zone

There are three cameras at the finish line. Camera number 2 shots the rider approaching the last curves of the circuit. Camera number 3 is mounted on a crane which shots the rider doing the two banked curves and it also captures the public area. Finally the camera number 4 captures the rider when he/she crosses the arrival arch. It is also used to shot the actual rider sitting in the hotseat<sup>12</sup>.

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<sup>12</sup> The **hotseat** is the place where the rider who holds the best time waits until another rider breaks its time. If so, this last rider takes his/her place and keeps waiting there.





*Figure 3.21: Detail of the camera 3 mounted on a crane shooting the rider at the finish line*

At the end, camera number 3 and number 4 are moved to the podium zone in order to shot the awards ceremony.

### 3.8.2 Four Cross races

Four-cross racing (4X) is a relatively new style of mountain bike racing where four bikers compete each other down the hill on a prepared, BMX<sup>13</sup> like, track, simply trying to get down first. The track is usually steep and rough with some artificial obstacles like trunks, doubles jumps or banked turns.

4X circuits tend to be short in length (around 1km). The case of the 4X track of La Poma Bikepark <sup>14</sup>in Premià de Dalt (Barcelona) is shown in Figure 3.22. This circuit is pretty short, with a total length of roughly 500m and the fastest rider completes it within 36 seg.

4X races are the only circuits that can be fully covered with a small number of cameras. An example of camera placement using 4 cameras is shown in Figure 3.22.

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13 **Bicycle motocross** or BMX refers to the sport in which the main goal is extreme racing on bicycles in motocross style on tracks with inline start and expressive obstacles. In 2003, the International Olympic Committee made BMX a full medal Olympic sport for 2008 Summer Olympic Games in Beijing, China.

14 La Poma Bikepark (Premià de Dalt, Barcelona). <http://www.lpomabikepark.com>



Figure 3.22: La Poma 4X track camera placement

Each camera has an specific purpose and covers a limited shotting area.

- **Camera 1:** *Sony EX1 on a tripod.* This camera picks a frontal shot of the starting gate with the sponsor's arch in the background. A frontal shot is needed for superimposing a chyron<sup>15</sup> with the names of the riders prior to starting the race.
- **Camera 2:** *Sony Z1 on a crane.* It is best to locate this camera in an inside curve of the circuit. In this case, it is placed at the first baked turn. The crane moves from a low position to the highest position while panning to the right at the same time to follow the riders. It offers one of the most spectacular shots of the circuit.
- **Camera 3:** *Sony EX1 on a tripod.* This camera is placed on an elevated platform and covers almost the whole circuit. It is basically used to follow the riders with a general shot. It is mounted on a tripod with a fluid video head for smooth pans and tilts.
- **Camera 4:** *Canon EOS 7D on a tripod.* This is the camera located at the finish line. It basically gives us a front shot of the winning rider while he or she crosses the finish line.

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<sup>15</sup> **Chyron** stands for the lower thirds titles composed with text and graphic elements that are placed in the lower third of the screen (names of people, locations, etc). For example, see the classification lowerthird in figure 3.4. The origin of the word comes from a broadcasting device called "Chyron" which superimposes the lowerthirds live during a broadcast. But now this word is used even when the lowerthirds are added later in postproduction.





Figure 3.24: Frame from the frontal camera of the WorldCup 4X race in Houffalize (Belgium) covered by Eurosport



Figure 3.25: Frame from camera number 2 mounted on a crane rig





Figure 3.26: Frame from camera 3



Figure 3.27: Frame from camera number 4 situated at the finish line

### Axis jump issues

It is important to maintain the cameras always in the same side of the track in order to not to incur in an axis jump. An axis jump happens when two diferent shots of riders running in opposite directions are put together (one shot followed by the other one in the edited video). This happens when camera placement has not been perfectly planned and one camera is shotting riders who go from the left side of the screen to the right side and the next camera is shotting the same riders but moving in the opposite direction (from right to left). It is very important to place the cameras always

in the same side of the circuit. For example, in Figure 3.22, if camera 4 had been placed on the opposite side, there would have been an axis jump when switching from camera 3 to camera 4. Note that this does not apply to camera 1 as this camera picks a frontal view of the starting gate.

### **TV signal feed for audience**

One of the cameras in the circuit feeds a giant plasma screen located at the sponsor's truck where people can follow the race. In this case, it has been decided to feed the plasma screen with the video signal of the crane. The distance from the camera to the screen is about 100 metres so there is no problem in achieving this distance using a coaxial RG58 video cable carrying a composite video signal.

### **Podium coverage**

After the race, there is the prize-giving ceremony. There is little time to move the crane rig and the camera 1 to the podium zone and get ready to shot the prize-giving ceremony. The configuration of this scenario is the following. The camera on the crane has a wide angular lens and it is only used for wide shots of the podium and public. The other camera is placed in an elevated platform and it is always zoomed-in giving us close up shots of the riders picking up their prizes.



*Figure 3.28: Photo of the crane rig in the podium ceremony*



### 3.8.3 Downtown races

These races occur in towns, along small streets cramped of people all around. These are the most crowded competitions as they happen inside the town and a lot of people come to see the race live. Typically, distances are somewhat shorter but camera placing is also a challenge.

The competitions held in towns have similarities both to the downhill races and the 4x races. Distances are shorter than downhill, like 4x tracks, but on the other hand there is no line-of-sight between the start gate and the finish line so a LED screen is a must have. Unlike 4x races, where all the public can see the full circuit, in downtown races it is necessary to put a giant screen at the end of the circuit so that the people can watch the rider in a mid-point section of the track. Technically speaking, it is necessary to use a wireless camera transmitter and receiver.



Figure 3.29: Picture of a downtown race

digitalRoot





### 3.9 A/V transmission cables

There is a need to transmit video signals across medium distances in order to provide a video feed from a camera of the circuit to the public screens.

There are different types of cables which are used for transmitting video signals across great distances. In this section, different transmission technologies will be analyzed in order to decide which one best fits the needs. Finally, a specific test has been carried out in order to compare different cables and its maximum video transmission length.

#### 3.9.1 Coaxial video cables

There are a lot of coaxial cables but the most common for video applications are the following:

	RG-59	RG-11	VK-7	Triax
Section:				

<b>Application:</b>	Analog video	Analog video	Digital video	Analog video
<b>Impedance (<math>\Omega</math>):</b>	75	75	75	75
<b>Core diameter (mm):</b>	0,81	1,63	0,81	1,7
<b>Outer diameter (mm):</b>	6,1	10,5	6,1	18
<b>Conductor material:</b>	Copper	Copper	Copper	Copper
<b>Isolation material:</b>	Polyethylene	Polyethylene	Gas injected foam high density Polyethylene	3-layer Polyethylene
<b>Attenuation: (dB/100m) @ 50 Mhz</b>	8	3,3	5,1	2,6

The RG designation stands for Radio Guide, the VK-x is the manufacturer (Percon) name of the cable and triax is the short name for triaxial cable.

All of them have an impedance of 75 ohms which is an international standard, based on optimizing the design of long distance coaxial cables. Generally, all baseband video applications that use coaxial cable (both analog and digital) are matched for 75 ohm impedance cable. 5 ohms is the telecommunications standard, because in a dielectric filled line, somewhere around 77 ohms gives the lowest loss.

The RG-59 is the most common video cable for interconnecting video equipment and transmitting video across short distances (0-150m typically). It carries baseband composite video or analog component video (Y, Y-R, Y-B), in this case, 3 coaxial RG-59 cables are necessary. It is the cable that has the highest attenuation (8 dB/100m).

The RG-11 is like the RG-59 but it is more isolated from interferences and it is also thicker and less flexible. It can be used up to 300m of distance. The VK-7 is the "digital equivalent" of the RG-59 and it is used for transmitting SDI<sup>16</sup> signals. It has better shielding than the RG-59 cable.

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<sup>16</sup> **Serial digital interface (SDI)** refers to a family of video interfaces standardized by SMPTE. ITU-R BT.656 and SMPTE 259M define digital video interfaces used for broadcast-grade video. These standards are used for transmission of uncompressed, unencrypted digital video signals (optionally including embedded Audio and/or Time Code) within television facilities; they can also be used for packetized data. They are designed for operation over short distances (less than 300m. with coaxial cable); due to their high bitrates they are inappropriate for long-distance transmission. For all serial digital interfaces, the native color encoding is 4:2:2 YCbCr format. The luminance channel (Y) is encoded at full bandwidth (13.5 MHz in 270 Mbit/s SD, and the two chrominance channels (Cb and Cr) are subsampled horizontally, and encoded at half bandwidth (6.75 MHz).

Triaxial camera cables are used in professional studio applications for simultaneous transmission of energy and multiplexed image signals between the camera head and the CCU of the OB Van. (See Annex Error: No se encuentra la fuente de referencia for more details of these terms). They are heavy-duty cables optimized for use inside studios and outdoor applications when long cable runs are needed. Triaxial cable or triax is a coaxial cable with a third layer of shielding, insulation and sheathing. The outer shield, which is earthed (grounded), protects the inner shield from electromagnetic interference from outside sources. This results in very low attenuation (2,6 dB/100m / Triax 14 type) and it is possible to transmit video up to 2 Km.

In conventional analog triax, the signals (component standard definition video, audio, intercom, control etc.) are modulated onto different frequency FM carriers which are carried through the same cable.

It is important to point out that the attenuation highly depends on the bandwidth of the signal to be transmitted. The higher the frequency, the higher the attenuation:

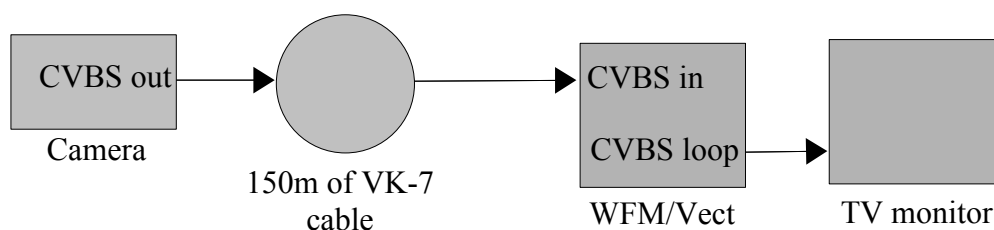
Bandwith (MHz)	RG-59 cable attenuation (dB/100m)
5	2,5
50	8
100	12
200	18
400	24
500	27,5
900	39,5

Table 3.5: Attenuation depending on bandwidth. Data extracted from Percon RG-59 datasheet.

### 3.9.2 Real-world coaxial cable attenuation test

A test has been carried out in order to compare the real effective distance that video can be transmitted across coaxial cable with enough picture quality.

- **SCENARIO 1:** Composite video baseband signal (CVBS) from a Sony DSR-570 camera over 150m of VK-7 coaxial cable.



### 3. TV event recording

The professional standard definition DSR-570 camera has been set to output color bars. The signal from the composite BNC output has been connected to a cable reel of 150m of VK-7 coaxial type and the end of the cable to a Waveform/Vectorscope (WFM/Vect) and a TV monitor in the loop-through. The VK-7 is the type of cable optimized for transmitting digital component SDI signals but it can be used for analog composite video as well.

150m of cable has a theoretical attenuation of 7,65 dB. The advantage of analog video is that, no matter how long the cable is, the video will always be transmitted although the picture quality will be degraded. On the other hand, digital video will either transmit perfectly or not transmit at all.

The test shows that the composite video over 150m of cable has the luminance signal attenuated. It is 0,55V and it should be 0,7V. The visible effect on the TV screen is that the video looks unsharp, with rather low definition.

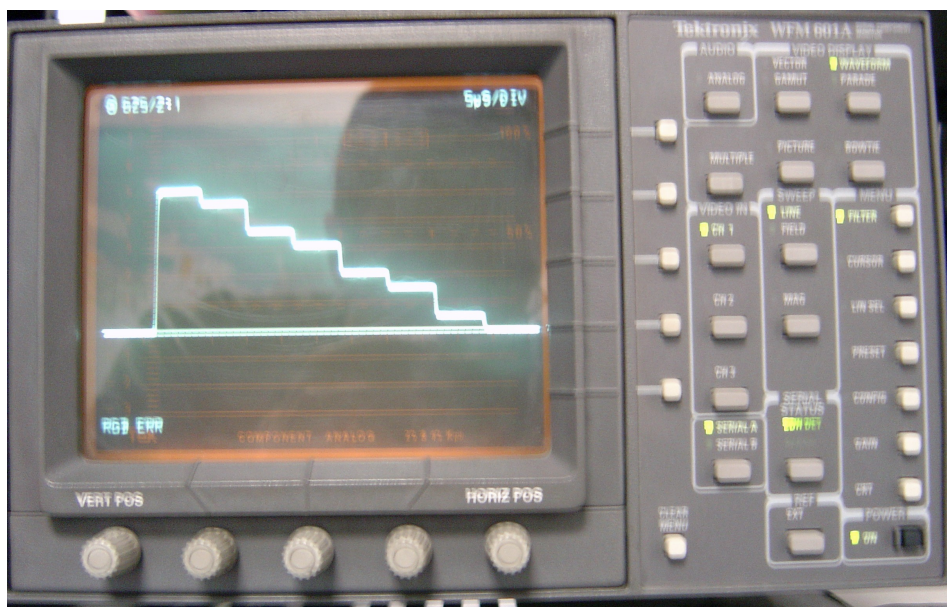


Figure 3.30: Attenuated luminance signal shown on a Tektronix WFM601A digital waveform monitor (with a A/D expansion card).



The chroma signals suffer much more attenuation than the luminance signal. A 75% color bars should produce a vectorscope diagram that reaches the marked boxes in the screen whereas the real dots of the signal do not reach them at all (see Figure 3.31). The noticeable effect on the TV screen is that the image looks washed out, with very little saturation and contrast.

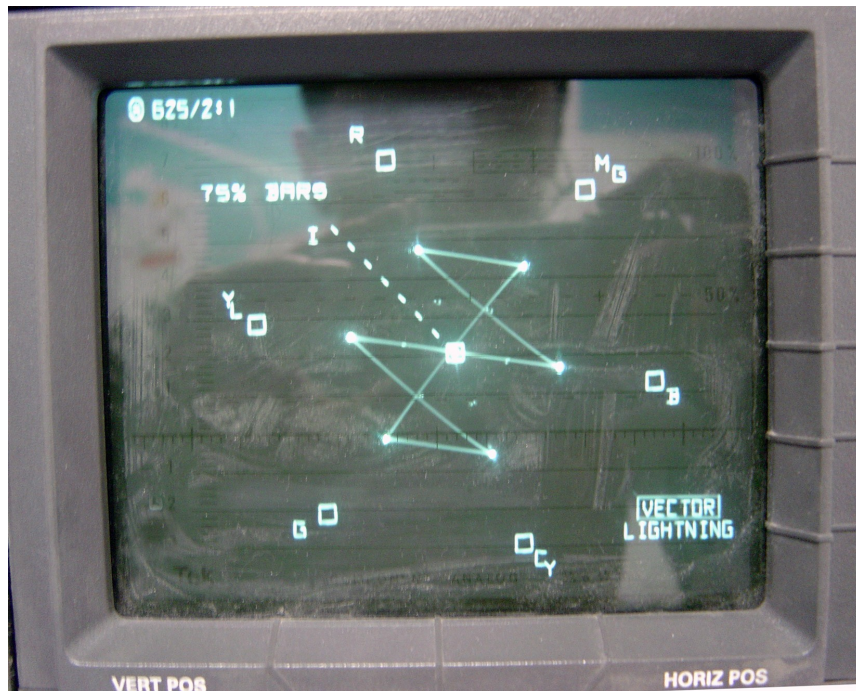


Figure 3.31: Attenuated chroma signal shown on a Tektronix WFM601A digital waveform monitor

Even though, the video signal still has reasonable picture quality to be broadcasted or played on a screen for the public. Furthermore, it can be improved by simply adding a video equalizer amplifier at the end of the cable line in order to increase the levels of the luminance and chroma signals to the PAL standard.

Increasing the cable length from 150m to 300m produces more interferences due to the high levels of attenuation and the result in the final picture is that it is not usable whatsoever as it can be seen in Figure 3.32.





Figure 3.32: Video signal after 300m of VK-7 coaxial cable

- **SCENARIO 2: SDI video from a Sony EX-1 camera over a 150m of VK-7 coaxial cable**

The maximum cable length in which the digital component SDI signal can be transmitted depends on the sensitivity of the decoder of the video device at the end of the cable. This means that if the signal level is lower than the sensitivity of the decoder because of the attenuation, the receiving device will not show any picture at all. On the

other hand, if the level is higher than the sensitivity, the device will decode a perfect SDI signal with no degradation. There are no possible mid-points or gradual picture qualities.

The test has proved that with 150m of cable the monitor is not capable of decoding the SDI signal of the camera and nothing is shown on the screen. Decreasing the length to 100m of cable solves that and the monitor perfectly decodes the video signal.

- **SCENARIO 3: Composite video from a Sony DSR-570 camera over 300m of RG-11 coaxial cable.**

The last test consists on doing the same as in scenario 1 but with 300m of RG-11 cable instead of VK-7 as it be seen in Figure 3.33.



*Figure 3.33: Composite video from camera going through 150m of RG-11 cable*

As in scenario 1, the monitor shows the attenuated video signal. Because of the better shielding of the RG-11 cable, it is possible to transmit video as far as 300m with an acceptable picture quality.

## Conclusions

These tests proved that analog composite video can be efficiently sent across 150m using RG-59 coaxial cable and up to 300m using RG-11 cable. This is the most affordable way to transmit video over medium distances. It has also been demonstrated that digital SDI video is much more interference-sensitive and we only have accomplished to transmit SDI video up to 100m.

#### **Our cable choice:**

The following is the procedure that is used to send the video signal of the mid-point circuit camera to the public screens at the finish line:

- FourCross circuits (short distance): RG-11 or RG-59 cable reels up to 300m
- Downtown races (medium distances): RG-11 cable reel up to 300m
- Downhill races (long distances): radiowave link.

### **3.9.3 Fiber optic cables**

For very long runs, where coaxial cable would experience attenuation problems, it is preferably to use fiber optic cable. Fiber optic cables are widely used in large fixed places like stadiums or Formula one circuits where the camera positions are always the same. Therefore, there is a fixed fiber optic cable installation and the camera operator only has to go there and connect their camera to the fiber point. The main problem of fiber optic is that it requires extra expensive equipment for converting the electric signal of the camera to an optical signal and then do the opposite in the other side: convert the optical signal to an electrical one again. Optical converters are very expensive and require power supply, moreover, fiber wires and connectors are expensive and fragile. They are thought to be used in fixed installations, not on location.

For these reasons, the only way to effectively transmit video at long distances, in location, and at a moderately price are radiowave links.

## **3.10 Wireless camera link**

In downhill races it is necessary to transmit video from a mid-point circuit camera to the screens at the finish line. Distances over 300m can not be covered by using coaxial video cable because the attenuation is too high.

There is a need to go wireless. Analog microwave radiolinks work very well if there is line-of-sight between the transmitter and the receiver. Unfortunately this is not always the case of the downhill tracks because they tend to be in the middle of the

countryside and there are trees and vegetation that makes impossible for the two antennas to be visible each other in straight line.

**Our wireless transmission system choice:**

There is no other choice than using digital COFDM radio link systems. We have choosen the *Link XPc* camera transmitter which is a compact standard definition wireless transmitter that attaches to an external active antenna and it can be fit at the rear side of a Sony EX-1 like we did in the Sant Andreu de la Barca's downhill race (See Figure 3.34).



*Figure 3.34:  
Camera with  
wireless video  
transmitter*

This device has a built-in MPEG-2 hardware encoder that compresses the PAL or SDI video signal to an MPEG-2 4:2:2 MP@ML feed in real time. This produces a signal delay of 40ms end-to-end.

The amount of compression (the MPEG-2 bitrate) can be configured dependant on the environment conditions and the type of modulation used. The audio is always encoded at 224 kbps with MPEG-1 layer 2 codec.



This transmitter uses DVB-T modulation to transmit the video and audio signals in the 2,295 GHz frequency and it can be configurable by using: these three modulations schemes:

- **QPSK:** this modulation allows for a low quality highly compressed MPEG-2 signal but it is very robust against interferences. It must only be used when the distances between the camera and the decoder is very long.
- **16-QAM:** this modulation is a trade-off between quality and link robustness.
- **64-QAM:** this modulation allows for a better quality video signal with a higher bitrate but it is more sensitive to interferences and is a less reliable radio link. This mode must be selected when the distance between the transmitter and the receiver is short.

The following table shows the modulation modes supported for DVB-T operation, together with the corresponding bitrates. It should be noted that this corresponds to the total data rate which includes the video, audio and user data.

Modulation	GI	1/4	1/8	1/16	1/32
	CR				
QPSK	1/2	4.97	5.52	5.85	6.03
QPSK	2/3	6.63	7.37	7.80	8.04
QPSK	3/4	7.46	8.29	8.78	9.04
QPSK	5/6	8.29	9.21	9.75	10.05
QPSK	7/8	8.70	9.67	10.24	10.55
16QAM	1/2	9.95	11.05	11.70	12.06
16QAM	2/3	13.27	14.74	15.61	16.08
16QAM	3/4	14.92	16.58	17.56	18.09
16QAM	5/6	16.58	18.43	19.51	20.10
16QAM	7/8	17.41	19.35	20.49	21.11
64QAM	1/2	14.92	16.58	17.56	18.09
64QAM	2/3	19.90	22.11	23.41	24.12
64QAM	3/4	22.39	24.88	26.34	27.14
64QAM	5/6	24.88	27.64	29.27	30.16
64QAM	7/8	26.12	29.02	30.73	31.66

Table 3.6: Available data rates in Mbps of the DVB-T depending on modulation, code rate and guard interval.

After some tests we have decided that given the characteristics of the Sant Andreu's track (long distance, tall trees) and the fact that it is preferably a reliable link than a high-quality video signal, the mode that will be used is:

- **Modulation:** QPSK
- **Code Rate (CR):** 1/2

- **Guard Interval (GI):** 1/8
- **Total bitrate (video+audio+data):** 5,52 Mbps

This prioritize the robustness of the radio link above the picture quality. And we have found that 5,52 Mbps MPEG-2 has enough quality for the screens at the finish line.

These equipment is very specialized and expensive, so all the Link gear is rented for 1 day.

## 3.11 Audio configuration

The Sony EX1, the main camera, can record high-quality audio signals as its audio circuits are designed to meet professional requirements. The audio track is recorded with a sample rate of 48 kHz and a bitdepth of 16 bits in a stereo PCM uncompressed file format. While 44,1 kHz is the standard sampling frequency for audio CD's, 48 kHz is the standard for broadcast applications.

Professional industrial cameras rely on sturdy XLR audio connectors instead of 3.5mm minijacks found in consumer cameras. The XLR plug has three important advantages over other audio interfaces:

- **It can carry a balanced audio signal:**

In a balanced audio line, the signal is carried twice, and one of them has inverted polarity. In order to carry a balanced line, a three-pin connector (like XLR type) is necessary. One wire is the shield or chassis ground, while the other two are signal connections. The main advantage of the balanced line is that it has good rejection of external noises. This is how it works:

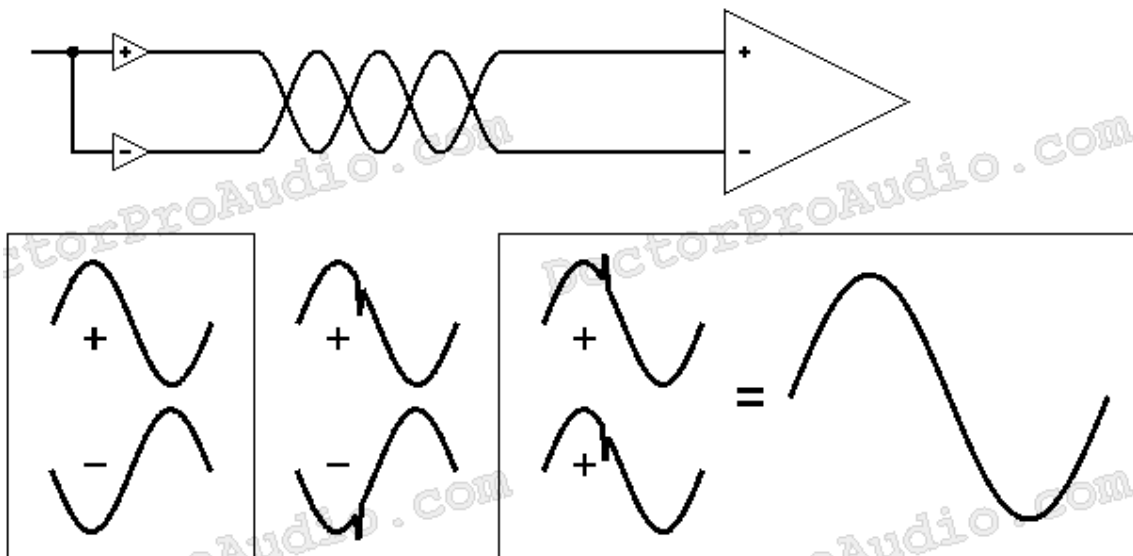


Figure 3.35: Balanced audio line illustration

The electromagnetic interferences that are not rejected by the cable shield will affect the two wires that carry the audio signal. The camera's audio input will do what is known as disbalancing the line, which consists in adding the two signals after inverting one of them (See Figure 3.35). This results in a signal which has a higher level (twice of the original audio level) and with the interferences cancelled. The successful rejection of induced noise from the desired signal depends in part on the balanced signal conductors receiving the same amount and type of interference. A balanced line is a must in long cable distances.

- **Phantom power can be supplied through it**

Phantom powering consists of 48V direct current applied equally through the two signal lines of a balanced audio connector. The supply voltage is referenced to the ground pin of the connector (pin 1 of an XLR), which normally is connected to the cable shield or a ground wire in the cable or both. Some microphones, such as the condenser ones, require phantom power, others, like the dynamic, do not. It depends on the technology of the microphone. For example, the shotgun ambient microphone, which is on top of the camera, does require phantom power while the microphone used for the interviews does not.

- **It is a reliable connector in terms of physical construction**

It is metallic, and it does not get loose when it is plugged. When shooting on location it is very important to have reliable connections in order to avoid audio cuts, hisses or interferences. This is specially true when it comes to audio signals as they tend to be very sensitive to external noises. It is always a priority to ensure that the best audio possible is captured.



### 3.11.1 Types of microphones used

- **Electret-condenser shotgun microphone (Sony ECM-673):** This is the shotgun microphone that is mounted on a shockmount on top of the Sony EX-1 camera. It is a high-sensitive directional microphone that is used to pick up the ambient sound. It is a condenser microphone which requires phantom power to operate. When working outdoors it is necessary to put a windshield in order to avoid the wind impacting to it and creating undesired noises. Softy windshields like the Rycote ones work better than foam windshields.
- **Wireless microphone (Sennheiser Evolution G2):** This is a microphone set that consists in a wireless transmitter that works in the UHF band (around 518Mhz), and a receiver. The plug-on transmitter (rectangular black box) connects to a XLR-type microphone and converts a wired mic to a wireless one. It can also provide phantom power if needed. We typically use a Shure SM-58 dynamic microphone connected to the wireless Sennheiser transmitter. We have chosen this microphone because it is dynamic, which is ruggier than the condenser ones and it attenuates a lot the off-axis audio which is really good for isolating the speech of the person being interviewed. The receiver can be configured to output a mic/line level adjusting the AF output setting. It is best to let the receiver amplify the audio signal by outputting a line level instead of the lower mic level. This results in a better quality amplified audio signal.

The Sennheiser set also includes a lavalier microphone that plugs into the wireless bodypack transmitter.



*Figure 3.36: Sennheiser Evolution G2 wireless microphone set*

### 3.11.2 Good audio working practices

When dealing with location audio, especially when doing people interviews, there are some common procedures that are important to take in consideration.

**Camera channel audio settings:**

The Sony EX1 camera can record two audio tracks separately. That means that the user can choose independently which audio signal wants to be recorded in each (of the two available) channel. There are several combinations, but the following two are the ones that tends to be more useful when recording interviews.

	Signal	Audio level	Audio level control	Phantom power
<b>Two audio sources:</b>				
Channel 1	wireless receiver (main audio)	line level <sup>17</sup>	manual	off
Channel 2	built-in shotgun (bakup audio)	mic level	AGC <sup>18</sup>	on
<b>One audio source:</b>				
Channel 1	main audio signal (whether it is the wireless receiver or any other external microphone)	line/mic	manual	it depends on the mic
Channel 2	Same as channel 1	line/mic	Channel 1's level attenuated by 6dB	it depends on the mic

*Table 3.7: Channel audio routing configuration*

<sup>17</sup> **Line level / Mic level:** Line level is a term used to denote the strength of an audio signal used to transmit analog sound between audio recording devices. In contrast to line level, there are weaker audio signals, such as those from microphones, which are known to have mic level. A line level describes a line's nominal signal level as a ratio, expressed in decibels, against a standard reference voltage. The most common nominal level for consumer audio equipment is -10 dBV, and the most common nominal level for professional equipment is 4 dBu. By convention, nominal levels are always written with an explicit sign symbol. Thus 4 dBu is written as +4 dBu.

<sup>18</sup> **AGC: Automatic Gain Control.** This is an electronic circuit that automatically adjusts the audio level so that it has a consistent level over time. Sometimes it causes undesired effects because it amplifies the weak sounds and lowers the loud ones.

### 3. TV event recording

When doing interviews it is very common to record the main audio using the reporter's microphone connected to the plug-on wireless transmitter. This signal is wirelessly received by the receiver mounted on the camera, which is connected to the audio XLR input 1 of the camera. It is better to manually control this input so that the camera operator knows exactly the level of the audio signal. For example, if the incoming signal is too low, manually increasing the level using the audio rotatory knob may produce an ugly hiss so it is necessary to increase the level of the audio source and keep the camera's audio level to a mid-point adjustment.

Apart from the main audio signal, it is a really good practice to simultaneously record ambient sound of the rider being interviewed with the built-in camera microphone in channel 2. This audio may not be as much clear as the main audio (because the microphone is not as close to the sound source) but this is only for backup purposes in case of the audio of channel 1 has a problem. In this case we do turn on AGC mode so that the audio level is adjusted automatically and we can focus our attention on the main audio channel.



Figure 3.37: Camera crew doing an interview

There can be another situation where there is only one audio source. But as we have two available channels, a common trick used among professionals is to record the same audio signal on both tracks but one of them at a lower level. For example, if someone shouts very loud, track 1 will clip (thus recording saturated sound) while

track 2 will not. So, then in the editing stage we will mainly use the track 1 which has a higher level but when an unexpected loud sound causes saturation, there is always the possibility to use the unclipped audio of channel 2.

### **Audio monitoring**

Finally, audio monitoring is very important to ensure that the recorded audio is being captured with the best quality possible. We use the professional *AKG k171 studio* headphones. These headphones are closed and they isolate external ambient noises very well. Moreover, in the camera audio settings, it is possible to select which audio tracks to monitor in several ways (CH1/CH2, CH1 only, CH2 only or CH1+CH2). It depends on the situation and on the signals being recorded.

# Chapter 4. Editing and post-processing

This chapter describes the steps needed to produce a high-quality video of what has been shot. It focuses on the tapeless workflow and how to seamlessly mix different kinds of formats on the timeline. It also discusses the various stages of either video and audio post-production. Here the importance of the tapeless video acquisition is clearly shown because the editing stage is strongly dependant on how the images have been captured. That is, shooting a live event or shooting a non-live event has a great impact on how the images will be edited.

## 4.1 Technical requirements

The editing stage can be divided in some steps that are typically done in a sequential way:

- Transfer the footage to the editing suite the quicker the possible
- Transcode or rewrap the footage for easy editing
- Edit the footage
- Add superimposed graphics, intros, credits...
- Blend the footage's colours

## 4.2 Video editing

### 4.2.1 Tapeless workflow overview

A tapeless end-to-end approach begins with the acquisition of the footage. Manufacturers have released video cameras that can shoot audio and video as files and store on a variety of media, including solid-state memory, optical disk and hard drive. These original camera files can be ingested in the Non-linear Editing (NLE<sup>19</sup>) of choice. The software developers have been implemented the codecs needed to import those files painlessly.

Tapeless acquisition has several advantages, one being the speed with which the rough cuts<sup>20</sup> can be loaded to a laptop editor for the process of logging and shot selection for instance and finally to the NLE for editing.

#### **New workflow implies new procedures:**

With a tape-based workflow, video crews have worked out a logical way to handle tapes, for example, set the record lock to avoid the tape being erased or make notes to the tape case in order to identify what has been recorded on it.

Now, with the tapeless recording there can be new problems. Files can be accidentally deleted or become corrupt. With files recorded on solid state memory, there is no way to physically write which clips are in each memory. There is a need to change procedures. File shooters must figure out a way to systematically back up files as they shot, log metadata and create a routine that is as safe as legacy workflows.

Much of these "new problems" due to a lack of established procedures and a consequence of the use of small crews. That is one camera operator that has several roles when shooting on location(camera operator, journalist, sound technician, editor...). One of the purposes of this chapter is to document a solid tapeless workflow procedure from acquisition to delivery that suits the needs of the mountain bike sport coverage.

#### **File formats**

A media file (for example an AVI) is usually a container of video, audio and metadata essence files. The files in the container must be synchronized so that the audio plays in

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19 **NLE:** Non-linear editing in television is a modern editing method which involves being able to access any frame in a digital video clip with the same ease as any other. Video and audio are first captured to hard disks and then can be edited in a computer using any of a wide range of softwares, known as NLE editors. See more detail in chapter

20 **Rough cuts:** are the un-edited original clips shot by the camera operator.



a correct time relationship to the video track. But not all multimedia files have the features that are needed for professional broadcast use. Time Code for example is a good example of this. A broadcast acquisition file format must work with existing videotape formats and ideally support streaming and conventional file transfer.

With a tape-based format, the only way to get video off that tape was to play it out at a real time as analog or SDI, and then ingest and convert back to a file format. To improve this rather inefficient workflow, the Digital Video Digital Interface Format (DV) used the IEEE 1394, commonly known as firewire, protocol as a transfer format. This enables data to be transferred from the videotape to a hard drive without the need to use an intermediate video connection. It removed the need to digitize video into an NLE. Instead, the files can be ingested lossily over firewire.

Here comes the problem with the proprietary codecs. Camcorders typically use a proprietary file-based format to encode the recorded video. That means that camcorders from different manufacturers have different file formats and mixing those files can be really a mess. With tape based workflows happened the same, but with the difference that once the tape is played off a videotape, the resultant SDI signal is always the same as SDI is an international standard. So with file-based workflows it seems that there is a need to set up a unique standard to maximize compatibility. And this standardization comes with the Multimedia eXchange Format, also known as **MXF**, and that is the format we will use (See section 4.2.4).

**Advantages and disadvantages of tapeless and tape-based workflows:**

File-based	Tape
▲ Faster than real time ingest	▼ Real-time capturing
▲ Metadata friendly	▼ Basic metadata written on the cover of the tape case.
▲ Solid-state memories can be re-used thousands of times	▼ Tapes have a limited number of re-uses (known as generations)
▼ Solid state memories are expensive	▲ Tapes are cheap
▼ Memories not designed for archiving	▲ Tapes are an effective archiving media
▲ Camcorders that shot on solid-state memories have less mechanical parts. Less chances to a mechanical failure. The absence of tape transport parts makes the camcorder lighter too.	▼ Tape-based camcorders have the tape transport mechanism that is more sensitive to vibrations, temperature changes or mechanical problems.
▲ File-based camcorders enable the user to instantly review the recorded clip or access any clip by simply navigating through thumbnails. Some camcorders can even play a previously recorded clip while keeping recording at the same time.	▼ User needs to stop recording, rewind or fast-forward the tape when searching a specific video sequence.

*Table 4.1: Pros and cons of tapeless and tape-based workflows*

## 4.2.2 Transferring the clips

### Connecting the media

It is necessary to transfer the files from the SxS memory card to the computer via an external SxS card reader or a dedicated ExpressCard port in the computer.

## Clip Preview

It is possible to transfer all the clips recorded by the camera or just transfer some of them. With the Sony XDCAM EX Clip Browser<sup>21</sup> it is possible to preview the clips recorded onto the memory.

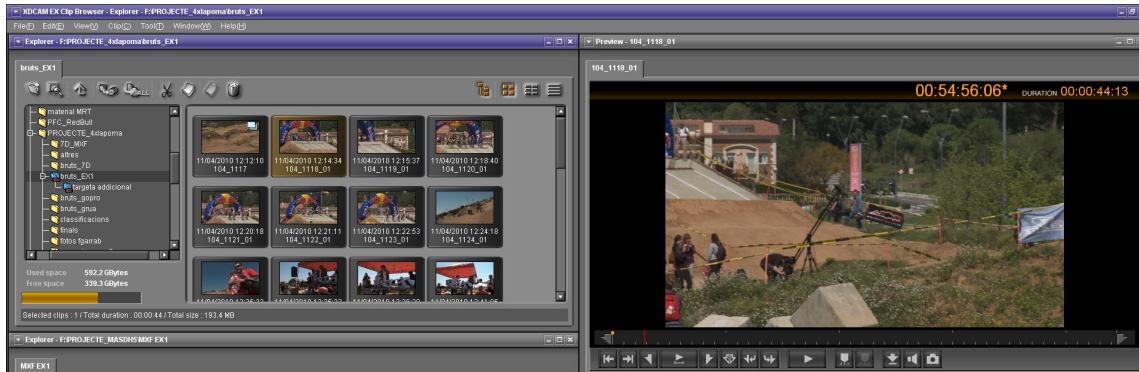


Figure 4.1: XDCAM EX Browser clip preview

## Backup files on disk

The next step is to copy the clips (all of them or just the needed ones) to the computer hard disk. It is a good idea to copy all the clips unless it is a time-critical situation because then the user is ready to erase all the memory card, put it in the camera and start recording again.

To ensure data integrity the user must check marking the *Perform CRC Check After Copy*.

<sup>21</sup> The **Sony XDCAM EX Clip Browser** is an application bundled with the Sony EX1 file-based camcorder which helps the user to transfer and log the recorded clips. For more information: <http://www.sony.ca/xdcamex/software.htm>

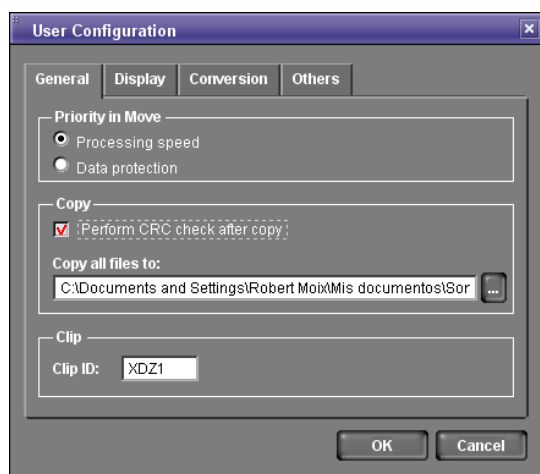


Figure 4.2: Copy CRC Check

A new folder will be created with all the files from the memory card and it is important to point out that the name of the folder will be always unique as it takes the name from the current date and time (e.g. 20100312192503) thus avoiding future overwritings.

When moving files from the memory card to the hard disk there are two possible ways:

- **Processing speed:** provides the fastest possible transfer.
- **Data protection:** creates a duplicated file before deleting the original clip. That ensures that the best protection from corrupted moved files.

### **Split and Spanned Clips**

The XDCAM EX camcorder has a file limitation of 4GB per file because of the FAT32 file limit of the memory card. This corresponds to [16min@25Mbps](#) or [12min@35Mbps](#).

Nowadays FAT32 seems an odd old-fashioned choice for media storage but it has a reasonable explanation. Mac computers can read and write to this format. They can also read NTFS but can not write to it. Moreover, some NLE have problems dealing with large single files on the timeline so working with single 4GB chunks is easier.

- **Split clips:** When a recording surpasses the 4GB limit, the clip is then divided into single 4GB clips. When this happens in a single card, these clips are called split clips.
- **Spanned clips:** The EX1 XDCAM camera has two memory slots. When clips are divided across two or more SxS cards, these clips are referred as Spanned Clips.

The XDCAM Clip Browser application takes care of Split and Spanned clips and creates the necessary metadata so that the editing application “sees” the separated chunks as a single clip. So, no special interaction on the part of the editor is required.

### Rewrapping XDCAM EX media for use in any NLE

Once the clips from the SxS cards are copied to the hard drive there is an extra step to be done in order to be ready to use them with the non-linear editing application. The XDCAM EX media (natively MP4) must be converted to MXF format so that the NLE recognizes them.

It is a good idea to copy all the clips from the card but only rewrap the ones that the user will need. In order to do that, just select the desired clips, and go to File\export\MXF for NLEs

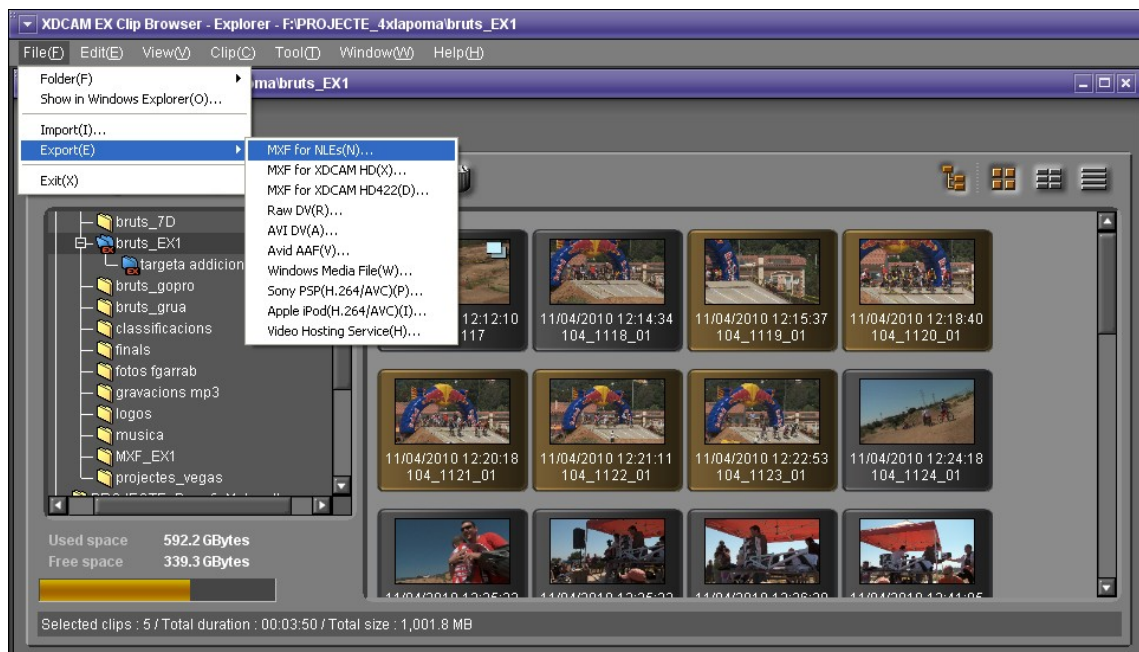


Figure 4.3: XDCAM EX Browser export options

### 4.2.3 Transfer process speed test

Here it is a real-world example of the total time needed to transfer 1 hour of footage from the camera to the editing suite.

**Test clip:**

1h of 720/50p @ 35Mbps XDCAM EX footage

File size: 15667 MB (aprox: 15,3 GB)

Operation	Time to complete	Real transfer rate
Transfer the clips from the SDHC memory card <sup>22</sup> to the computer via Sony USB reader <sup>23</sup>	15 min 26 s	16,913 Mbytes/s
Rewrap <sup>24</sup> 1h of footage from XDCAM EX to MXF	6 min 8 s	15,607 Mbytes/s
<b>Total time:</b>	<b>21 min 34 s</b>	

The total time needed to get 1h of footage ready to edit is roughly 21 minutes, which is **64% faster** compared to ingesting 1h of video recorded on tape.

We also have to take in consideration that with tapeless camera recording, the cameraman can preview and delete useless clips on location just browsing them with the camera. Therefore, the clips on the memory are only the good ones and it is much more efficient for the editor who only has to transfer and revise the previously selected clips. That would be impossible with tape-based camcorders because of the inherent lineality of the media.

The previous figures can be vastly improved by using the original Sony SxS cards and a professional and dedicated SxS card reader .

<sup>22</sup> Memory card under test: *SanDisk 16 GB SDHC Extreme III class 6*

<sup>23</sup> Card reader under test: *Sony MRW62E consumer card reader*

<sup>24</sup> Processing done using a quad-core PC based workstation at 2,40GHz and 4 GB of RAM





Figure 4.4: Sony SxS card and dedicated USB reader

Media	Write &Read speed	Price
SDHC class 6 card (16 GB)	20 Mbytes/s	70,00 €
SDHC class 10 card (16 GB)	30 Mbytes/s	90,00 €
Sony SxS card (16 GB)	100 Mbytes / s	700,00 €

Even though the dedicated Sony reader (Sony SBAC-US10) cannot read the card at full 100 Mbytes/s but at a true 30 Mbytes /s that means that transferring 1h of footage would take approximately 10 minutes. Put a more powerful computer and expect conversion times of 4 minutes instead of 6 minutes. That sums a total of 14 minutes which is 77% faster than capturing from tape. That is a huge efficiency step.

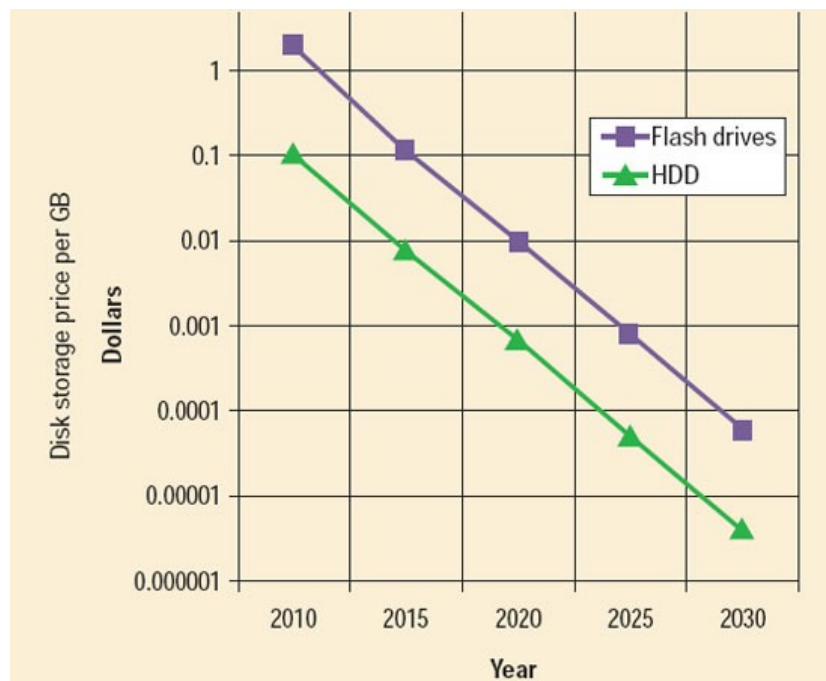


Figure 4.5: File-based media storage cost

Non tape-based storage media is still expensive, especially the fast state-of-the-art SxS cards, but costs are being cut down every year. As it can be seen in Figure 4.5 by the end of the 2025 a GB is expected to cost less than \$0,0001.

#### 4.2.4 MXF format overview

The use of a MXF format is one of the possible solutions for the problems of the great number of different codecs described in section 4.2.1 Tapeless workflow overview.

##### Overview

The Material eXchange Format (MXF)<sup>25</sup> is an open file format aimed at the interchange of audiovisual clips along with its associated metadata. It enables the user to interoperate between different devices or software applications used in a broadcast television environment (see Figure 4.6). This leads to a better operational efficiency in a tapeless workflow compared to the traditional mixed and proprietary file formats that each manufacturer imposes.

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<sup>25</sup> The development of the Material eXchange Format (MXF) is a remarkable achievement of collaboration between manufacturers and major organizations such as Pro-MPEG, the EBU and the AAF Association.

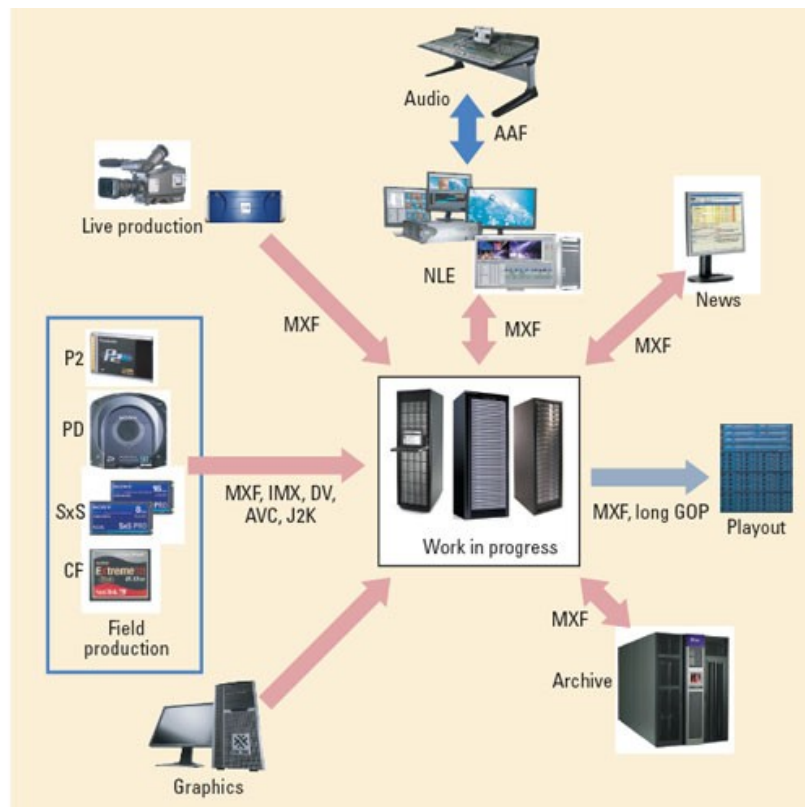


Figure 4.6: MXF file wrapping in an end-to-end tapeless workflow

The MXF wrapper is not compression-specific although it can handle from DV to MPEG-2 or MPEG-4 video formats or any future compression scheme. This means that the transportation of these different files will be independent of the content, and will not dictate the use of specific manufacturers' equipment. Any required processing can simply be achieved by automatically invoking the appropriate hardware or software codec.

### Streaming versus file transferring

It is important to note the difference between streaming files and transferring files. Traditionally, television equipment has been built around streaming video and audio. This is, for example, a video taper recorder (VTR) playing a tape and streaming this video to another videotape for dubbing purposes. This is logical as the original scene action and the viewer expectation is of continuous real-time video and audio. Analog PAL composite video or SDI digital video are all stream. But in a tapeless workflow things are different and computer systems exchange data by means of file transfers.

#### Streaming media:

- It is viewable during transfer and before all data is delivered.

- It offers minimum delay for live action.
- It is point-to-point with no bottlenecks offering reliable, continuous operation.

#### Networked media:

- uses low-priced, standard IT components such as ethernet wires.
- may be stored on a wide variety of media supports such as harddisks, solid-state memories...
- offers faster, more flexible data exchange, sharing and distribution.

Both real-time streaming and file transfer have their advantages and both will continue in use. Although tapeless workflows based on transferring files are becoming more popular day after day. It is essential that both (streaming and file transfer) have some degree of compatibility so they can co-exist and allow material exchange between them. With this in mind, the design of MXF makes it a file format that can stream thus creating a seamless bridge between the two transfer types.

#### MXF file structure

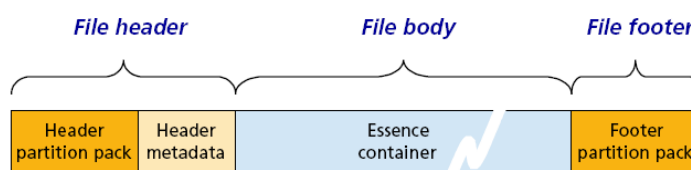


Figure 4.7: MXF file structure

As it can be seen in Figure 4.7, a simple MXF file has a header, a footer and some essence in the body of the file. Every item in an MXF file is KLV-coded. This means that every item within the file is identified by a unique 16-byte key and by its length. Defining the length of every field in the file (including the essence) allows simple MXF decoders and processing engines to ignore bits of the file they don't understand i.e. keys they don't recognize. This in turn allows the file format to grow, and for extra features to be added as new compression techniques and metadata schemes are defined. The header metadata area of the MXF file is where much of the benefit of MXF comes. It is the area where metadata is added, and the timing and synchronization parameters of the file are defined.

## Metadata

The major aim of MXF is the seamless transfer of programme content and its associated metadata. Metadata has a greater importance in a tapeless workflow. The problem with metadata is that, due to incompatibilities, the information is currently lost as the content moves between systems. MXF-enabled systems will communicate using metadata, video and audio, so no information is lost.

The simplest example of metadata is the timecode data., but the list of what MXF metadata can carry is endless. Just a few examples of what kind of data can be stored:

- The format of the content (MPEG, DV, 525i, 720p...)
- Key words or titles
- Reference numbers or information about the shot
- Editing notes
- Location, time, date...

For example, the Sony EX1 camera that we use has the possibility to add metadata information in its recorded clips using the camera itself. So, the cameraman could make annotations about the clips he/she has recorded just by filling in the desired text fields. This information will be visible later in the editing stage where the editor will actually see those annotations. This is one of the major points of the MXF file format, the metadata information is not lost through the production chain.

The metadata can also be added when transferring the clips from the camera to the computer. It is very common for the camera operator to transfer the clips by using a laptop and filling in the desired metadata fields with the help of the *Sony XDCAM EX Clip browser* application (See Figure 4.8) in his/her way back to the workplace. This way, the editor will receive the video clips with richer metadata information. A real-world use of that information is, for example, typing the competition results such as podium names, categories and finishing times to the video clips itself so the editor will have these information included in the clips. There is no need to give the editor extra files (such as PDF) with the riders classification. This is one of the possible uses of metadata, but there can be tens more.

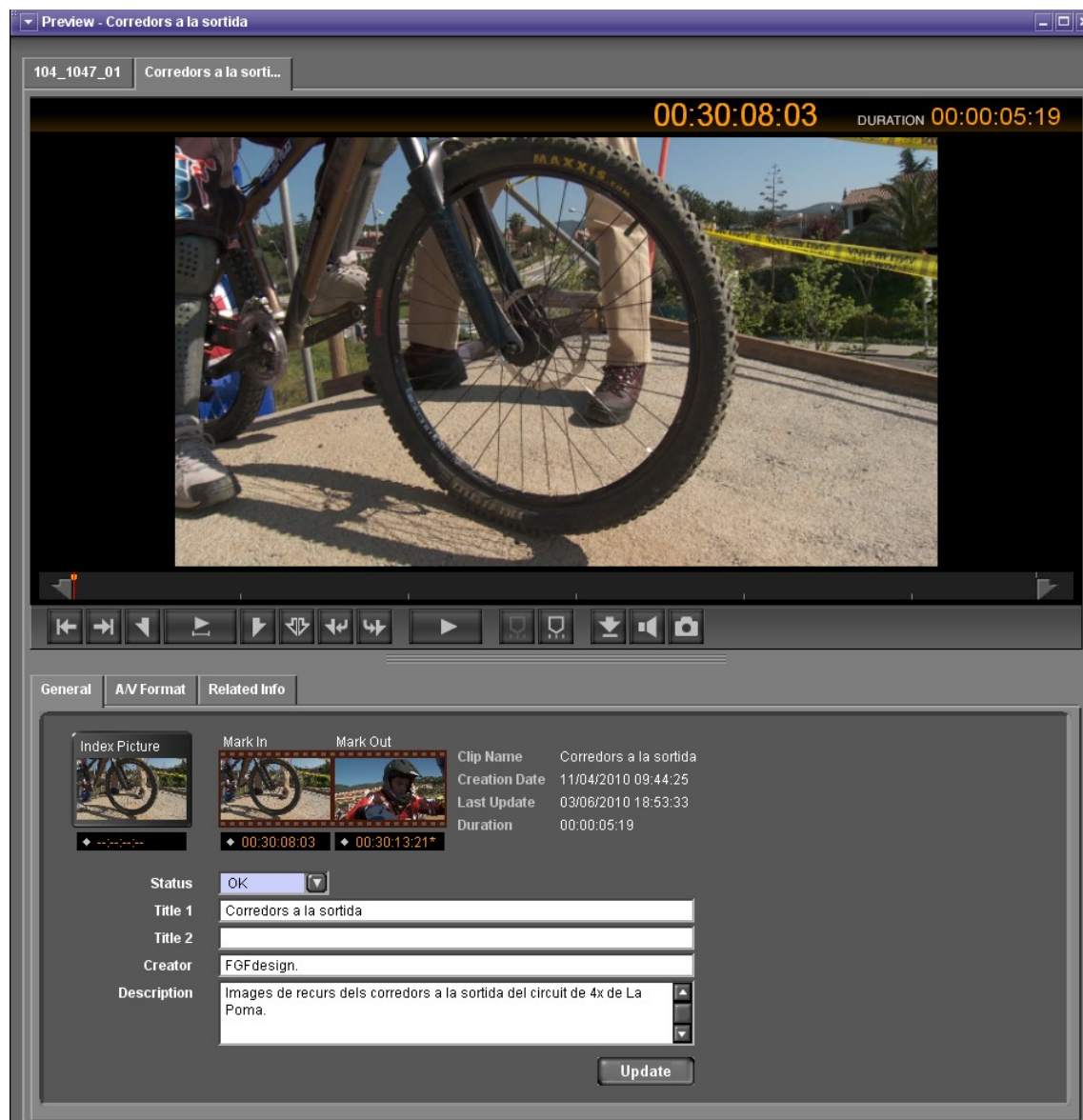


Figure 4.8: XDCAM EX Clip Browser metadata editing window

**Our choice:**

To sum up, MXF file format will be our primary video format. That is, all the video formats from all the different cameras will be wrapped with the MXF standard in order to simplify the edition of the footage.



## 4.2.5 Intermediate codecs

### Intermediate versus delivery formats

There are video formats that are meant for editing work (intermediate formats) and other formats that are meant for "sharing and displaying" (delivery formats). There are times when it is needed to do things like the following:

- Edit video
- Transfer video from one application to another
- Mix different video formats and framerates in the same project and timeline
- Time-stretch the footage for slow-motion or fast-motion purposes
- Color correcting
- Inserting superimposed graphics

For these usages, it is needed to use an almost-lossless codec that does not lose quality during the process. There are several intermediate codecs in the market and the most important ones are these:

- Apple ProRes 4:2:2
- Cineform Neoscene
- Avid DNxHD
- Mainconcept VC-3

What these codecs do is re-encode the original footage to a 10bit 4:2:2 intraframe-only video format. This results in a larger file with higher bitrate. Although it is important to point out that intermediate codecs will not improve picture quality . They can not add information that was not initially captured by the camera's format.

However, the advantage is that the resulting file is much easier and faster to work with. That means it is easier to edit, multi-generational friendly, and allows for less artifacts during image processing procedures like color grading.

Most of these intermediate codecs are saved as "AVI" or "MOV". These filetypes are not codecs, but containers formats. They simply "host" inside them different kinds of codecs.

We have chosen the *Avid DNxHD* because it is the only codec that is an open standard although it has been developed by Avid<sup>26</sup>, which is one of the most important software editing companies. *Apple Prores 4:2:2*, *Mainconcept VC-3* and *Cineform Neoscene* are proprietary codecs. Besides, the *Avid DNxHD* is known for having one of the best industries' intermediate codec in terms of efficiency (minimum bitrate for high image quality).

The two problems of the intermediate codecs is that the resulting files are larger and the user ends up with duplicated files. One can choose to either delete the original files or keep both the original and the transcoded files. But it is always a good idea to always keep a copy of the original files because codecs are in constant evolution and they get better and better and it is important to always keep the original format just in case there is a need to use it some time later and have still the possibility to re-encode it to a newer codec.

Opposed to the intermediate codecs there are the "end user" viewing formats, also known as "delivery formats". These are, but not limited to, codecs like H.264, DivX, XviD, Mpeg-4, Windows Media Video, and many more. These are all lossy codecs which its only objective is to get the best quality with the minimum possible bitrate which results in small filesizes that helps with the delivery.

The rule of thumb is that it is better to export to a lossless (or almost-lossless) codec as many times as it is needed during the editing process, but only export to a lossy final "delivery" codec once. This way the render loss of quality is minimized.

#### **Canon EOS 7D footage**

MPEG-4/H.264 is a 8bits 4:2:0 intra and interframe video format that is very difficult to edit with the NLE softwares due to its high compression codec. In order to overcome this, it is necessary to transcode it to an easier-to-decode format generically called "intermediate format". We will use the *Avid DNxHD* codec which has some interesting characteristics as described before.

#### **Transcodification software**

- Install MPEG streamclip<sup>27</sup> conversion software
- Install the latest AVID DNxHD<sup>28</sup> quicktime codec v2.1
- Open the MOV clips you want to convert with the MPEG streamclip application. *List > batch list and Add Files...*

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26 Avid Technology Inc. <http://www.avid.com>

27 **MPEG Streamclip**: <http://www.squared5.com>

28 **Avid DNxHD**: <http://avid.custkb.com/avid/app/selfservice/search.jsp?DocId=263545>

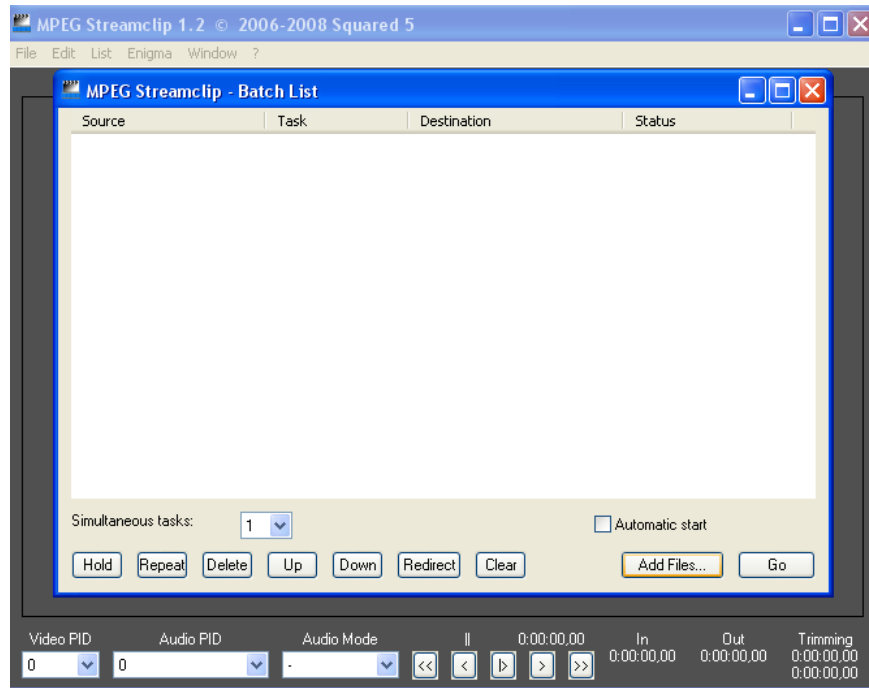


Figure 4.9: MPEG Streamclip batch window

- Select *export to quicktime* and choose a different folder for the destination files
- In the next window, make sure to select the *Avid DNxHD codec, quality at 100%, uncompressed audio*, select the appropriate format (in red).

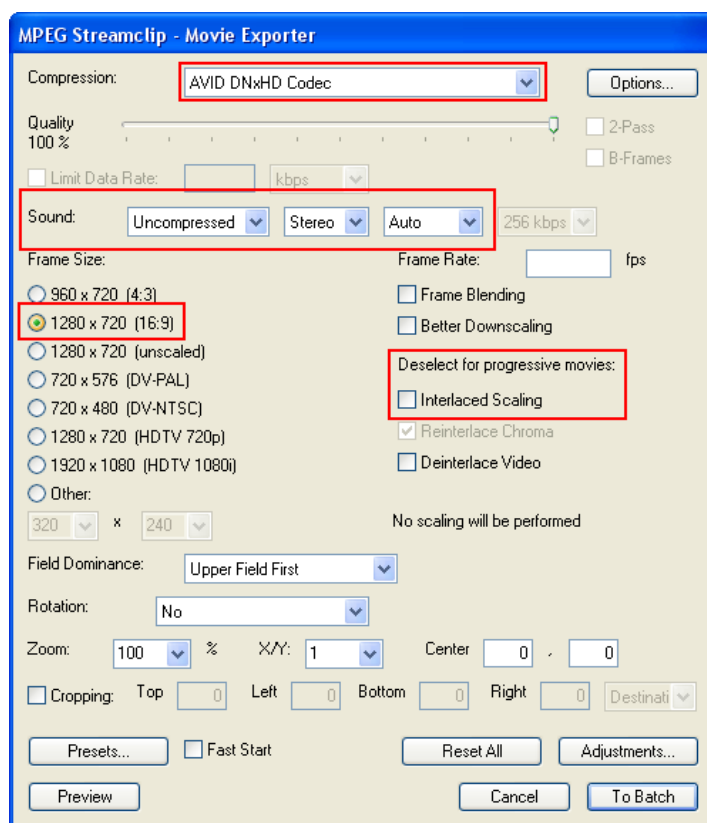


Figure 4.10: Avid's DNxHD codec configuration parameters

- Go to *Options...* and choose the appropriate codec, resolution and framerate. Note that given that the chosen resolution and framerate (720/50p in our case) there are three different codec options.
  - 720/50p DNxHD 185 10 bits
  - 720/50p DNxHD 185 8 bits
  - 720/50p DNxHD 120 8 bits

The DNxHD codec gives three possible bitrates for the transcoded file. The first one is the highest quality one with a final bitrate of 185Mbps and 10 bits of color quantization. This will give the best picture quality with minimum loss in the conversion process but also the highest file size. The last one has a bitrate of 120Mbps and 8 bits colorspace.

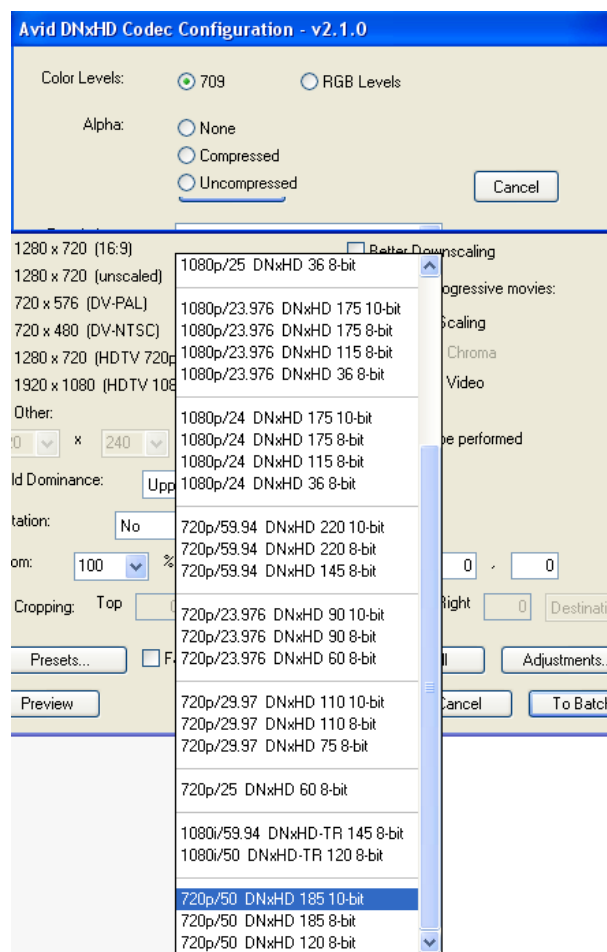


Figure 4.11: DNxHD resolution and framerate parameters

- Finally hit *To Batch...* and wait for the files to be transcoded.

<i>MVI_4260.MOV</i>	Original file	Transcoded file
Codec	MPEG-4/H.264	Avid DNxHD 185
Colorspace and bit depth	4:2:0 ; 8 bits	4:2:2 ; 10 bits
Resolution/framerate	720/50p	720/50p
Lenght	19 sec	19 sec
Size	113 MB	440 MB (389% more)
Bitrate	47,6 Mbps	185,2 Mbps
Conversion time	--	42 seg (221% of original duration).

Table 4.2: Comparison chart between the original and the transcoded file

One of the drawbacks of this transcodification is that the file size increases. With a sample clip of a duration of 19 sec and 113MB, it turns into 440MB, which is almost 4 times larger. But apart from the increase in size and bitrate, the advantages of the new transcoded file are clear. The new clip is only intraframe compressed so decoding and editing is much easier. This is clearly shown in the Sony Vegas NLE playback window:

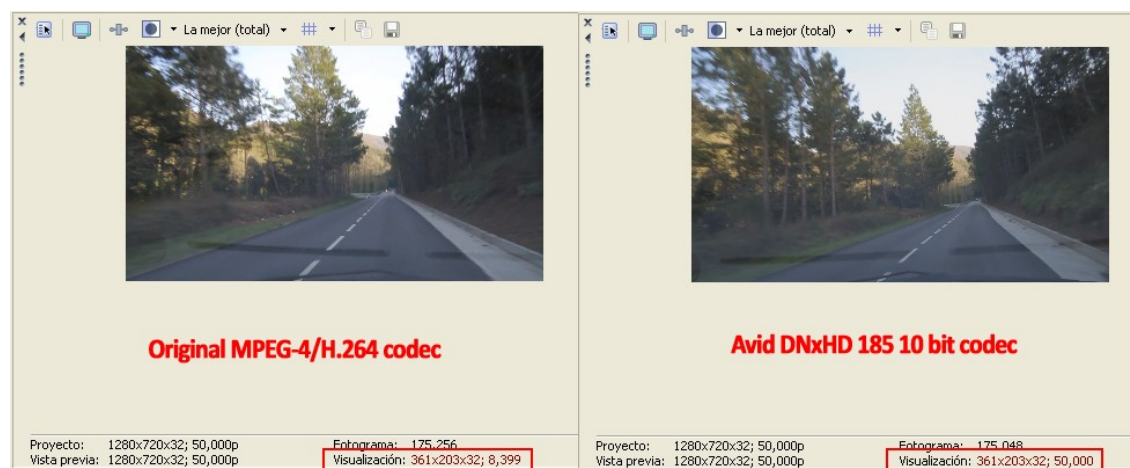


Figure 4.12: Sony Vegas NLE playback window comparison

Highlighted in red there is the maximum framerate at which the video editor software can decode and playback the video. It can be seen that when playing the original video file the editor is only capable of playing it back at **8 fps** while the same editor is capable of playing the transcoded file at **50 fps** (full framerate). Obviously, with a more powerful computer the first playback rate could be improved but it would be nearly impossible to get full playback framerate because decoding the MPEG-4/H.264 is highly processor demanding while decoding the intraframe only DNxHD codec is much easier.



Moreover, it is better to process a less compressed file with a 10 bits bit depth than doing it with the original file because there is much more room to work with.

**GoPro HD onboard camera footage**

The GoPro footage raises some technical challenges. First of all, again, it is MPEG-4/H.264 at 12Mbps so it must be transcoded to an intermediate format prior to edit it.

The camera cannot be switched to record in European HD formats and it does so using the American special framerates. That is 720/29,97p and 720/59,94p. It will be necessary to conform these framerates to 50p.

The audio is also highly compressed with the codec MPEG-4 AAC LC at 128kbps stereo.

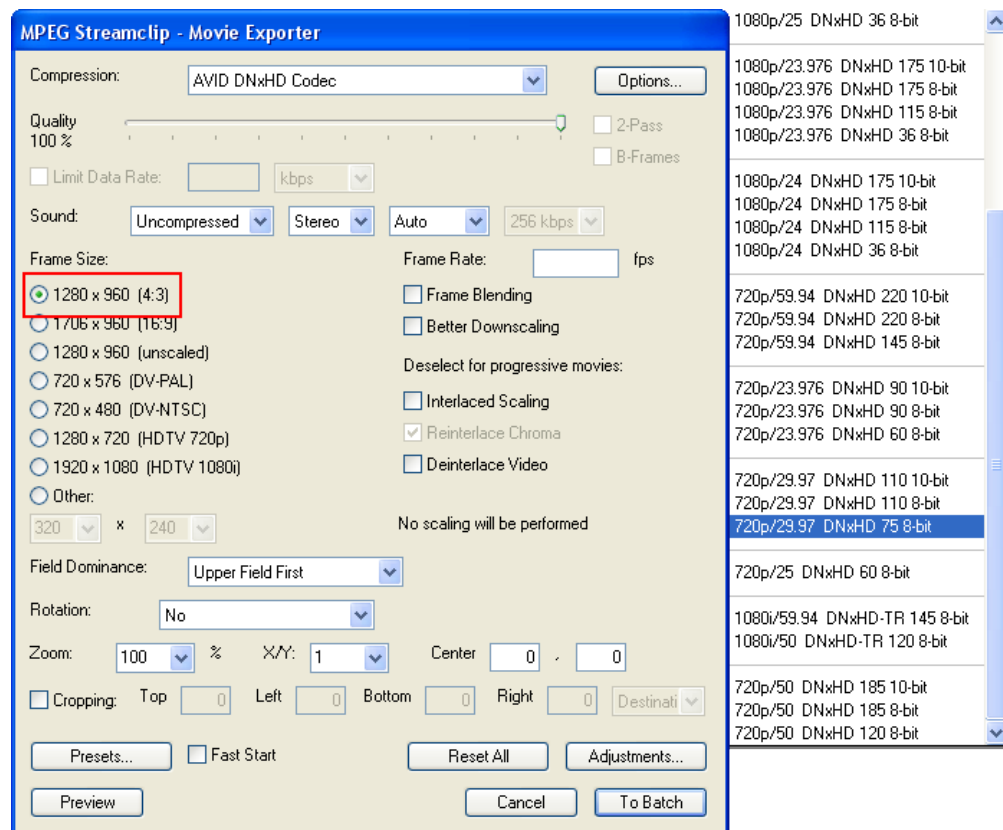


Figure 4.13: Avid DNxHD transcodification parameters for the GoPro footage

The previous screenshot shows the correct parameters of the MPEG Streamclip transcodification software for the GoPro HD footage. In this case, the original frame

size is 1280x960 and the final transcoded file must be 1280x720 at the same framerate 29.97 fps at a 75 Mbps. This will horizontally stretch the video converting the 4:3 aspect ratio footage into a 16:9 aspect ratio footage. In this case, we choose the lowest possible available bitrate because we will not actually benefit for the 10 bit 110 Mbps DNxHD format as the GoPro footage has not such quality. Going from 15Mbps MPEG-4 (original camera's codec) to a 75Mbps intraframe-only DNxHD codec is enough. Furthermore, that will result in smaller files compared to the other two format choices. The framerate is not changed at this time because it will be conformed to 50p along with all the other camera footage when exporting the final video from the Sony Vegas video editor.

### 4.2.6 NLE (Non-linear editing software)

The NLE is the main tool for selecting, trimming and putting together all the captured clips from the various cameras generating a mastered final video. This process is known as video and audio editing. In a non-linear editing software, the original source files are not modified during the process, so many generations and variations of the original source files can exist without the need to store many copies, allowing for a very efficient and flexible workflow.

There are tens of different NLE softwares, to name a few of the most important:

- Avid Media Composer
- Sony Vegas Pro
- Apple Final Cut Pro
- Adobe Premiere
- Grassvalley Edius

Professional NLE softwares are complex, with thousands of functions and require a powerful computer and expensive dedicated processing hardware. No one is better than other. It has always been the classic debate between which NLE is the best but there is no straight answer to that, and it basically depends on the needs and the budget. Avid, for example, is known for being the standards industry and in fact, it is the most used application in broadcast environments like TV news. It relies a lot on proprietary hardware and it is a very closed system that evolves slowly but firmly. This is good for big companies which need a solid system that needs few updates or tweakings over the years but not so good for small companies that can benefit from other NLEs that become updated quicker incorporating newer functions and are more flexible to use like the Sony Vegas or the Apple Final Cut Pro.

### Our editing software choice:

We have decided to use Sony Vegas because it runs on a PC platform and has the professional tools we need at an affordable price. Furthermore, it interprets and plays the Sony XDCAM EX footage flawlessly and it is a reliable software from a reliable company.

### 4.2.7 Mixing different formats on the timeline

The best scenario would be to avoid transcoding anywhere in the system, but that is relatively unfeasible. For now, we have to acknowledge that the acquisition codec, the editing codec and the transmission or delivery codec are going to be different and optimized for each area.

Sony Vegas NLE has the possibility to mix several different video formats in the same timeline and smoothly play them all. The Figure 4.14 shows the working timeline of the editing process of the Sant Andreu de la Barca's race project.

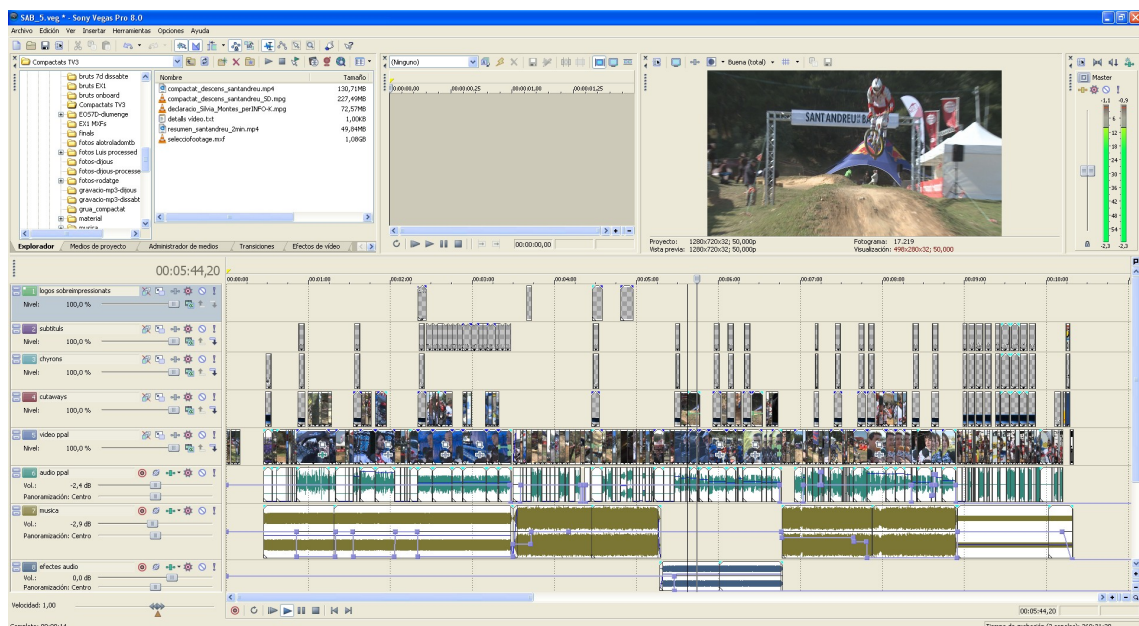


Figure 4.14: Sony Vegas NLE timeline

The timeline is divided into several layers which are basically the same in each project:

- **Superimposed graphics:** logos or another graphics that go on the top of the video.

- **Superimposed subtitles:** track that contains the superimposed text subtitles. Used when someone speaks a foreign language and needs to be translated into Catalan.
- **Superimposed chyrons:** track that contains the lowerthird graphics with the names of people or locations.
- **Cutaways:** cutaways are extra shots, without audio, that are used to exemplify or show what an interviewed person is saying. For example, if a rider is talking about his bike, instead of appearing his face it is better for the viewer to actually see images of what the rider is talking about. This technique is known as adding cutaway shots. So, when covering an event on location it is always a good idea to shot some general shots of the place or the people in order to use those shots later on the editing stage.
- **Main video:** In this track there is all the footage from the various cameras. That is the XDCAM EX footage rewrapped to MXF, the EOS 7D and GoPro onboard DNxHD transcoded footage and finally the Sony Z1 HDV MPEG-2 footage.
- **Main Audio:** audio track which has ambient audio from the cameras or speeches from interviews.
- **Music:** music layer that is where the chosen music is laid.
- **Audio effects:** sound effects like transitional swooshes among others.

Superimposed graphics are in separate layers because it is possible to deactivate a layer so it becomes very easy to generate several versions of the video. For example, one version without any superimposed graphics which is called *clean version*, another one with chyrons but without subtitles, and so on.

#### 4.2.8 Camera synchronization techniques and multicamera editing

In some cases, the mountain bike race is recorded by more than one camera simultaneously, especially in the 4X tracks because of its reduced size compared to other types of tracks. It is possible to place several cameras which capture the action from different points of view. This has several advantages, one being the possibility to simulate a real live TV production as if a mobile TV truck was producing the signal. But this is not accomplished in real time but later on in the editing stage. Most of the professional NLE softwares have multicamera capabilities. The trick is to synchronize all the cameras on location and then seamlessly cut between them in post.

**Camera synchronization techniques:**

- **Genlocking**

The best way to accurately synchronize the cameras is by using the timecode data. This is known as genlocking the cameras. Genlocking allows two cameras to be synchronized together so that each recorded frame starts at the exact same time. To lock timecode it is needed to connect the timecode output from one camera to the timecode input of the other camera. These are physical BNC plugs named as TC IN and TC OUT. If there are more than two cameras it is also possible to daisy chain all the cameras.



*Figure 4.15: BNC timecode input and output from a broadcast camcorder*

It is always important to check the video every 30 minutes to see if there is any visible drift in the synchronization. In the past, with tape-based camcorders, the chances of having one or two frame drift after an hour or so were great and there was the need to recorrect the sync. Today, with tapeless camcorders we have not run into any synchronization problems whatsoever because the clocks of the cameras are extremely accurate.

Unfortunately, neither the Sony EX1 nor the Z1 have those physical genlock BNC plugs. This is a true professional feature only found in broadcast shoulder-mount camcorders. The Sony EX1's big brother, the Sony EX3, has those TC connectors though. So another synch method must be used.

- **Slate**

Another way to sync two or more cameras is by using a slate. All the cameras must be training to the slate and the slate's person must clap it. In the post stage, each of the cameras can be synchronized by looking at the picture or at the peak in the audio waveform. The editor operator will slide the clips so that all of them have the audio peak at the same time. The problem with this method is that each time a camera operator decides to stop shooting and then starts shooting again, sync has to be found again, which is very time consuming.

- **Strobe or flash light**

The problem of using a slate is that most of the times cameras are too far away from each other and it is difficult to point all the cameras to the slate. Sometimes, one or more cameras even have not a line of sight of the slate. Furthermore, if the cameras are too far from the slate, one can not rely on the sound sync because there will be a drift as speed of sound is low. For example, taking into consideration that the sound speed is 343 m/s and each consecutive frames are recorded at 0,02 seg when shooting at 50fps. That means that there will be a drift in one frame every 6,86 m. In other words, if two cameras have a difference in distance from the sound source of 6,83m, there will be 1 frame difference in the recorded audio. The workaround is not to use a slate but use a strobe or a flash light such as a still camera's flash.

This proved to be the best way to get perfect sync between all cameras because the speed of light is higher than the speed of sound and, moreover, a flash light is easier to be captured by all the cameras than a small slate, even outdoors.

### **Sony Vegas multicamera approach**

In order to do a multicamera edit in Sony Vegas each clip of each different camera must be placed in a separated video track onto the timeline. If the footage has been timecode-synchronized then in Vegas select **Tools > Multicamera > Layout Tracks Using Media Timecode**. This adjusts the position of each clip as necessary so that the timecode for the media in each track precisely matches the timecode in every other track.

If the clips are synchronized by the "flash method" it is as simple as sliding all the clips so that the "white frame" of each camera is aligned to the other ones.

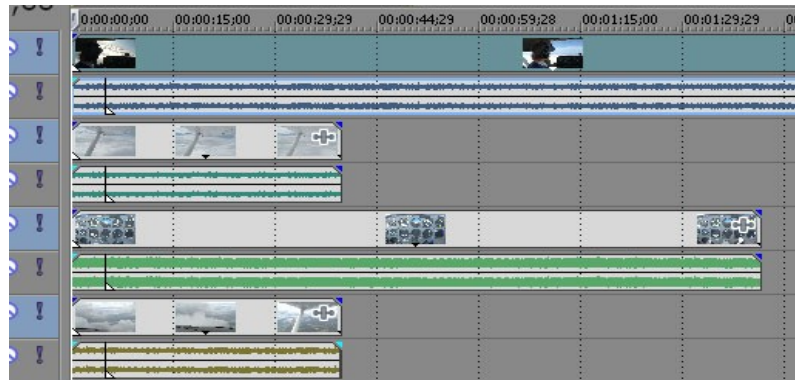


Figure 4.16: Synchronized tracks in Sony Vegas

Next it is necessary to consolidate each of the video tracks into one single track that contains one event with multiple takes. Click the track header for the first video track to select it and then hold the **Ctrl** key while you click the other video track headers to add them to the selection group. Now that all of the video tracks are selected, choose **Tools > Multicamera > Create Multicamera Track**.

Now you can assign each take to a keyboard key (like F1, F2, F3 and F4) and neatly cut back and forth between clips. It is also possible to change the display window so that it shows the 4 streams (if 4 cameras are being synchronized) playing at the same time. To do so, choose **Tools > Multicamera > Enable multicamera editing**. The blue highlight around the shot clip identifies that this is the currently active take, that is, the clip that will show in the final project.



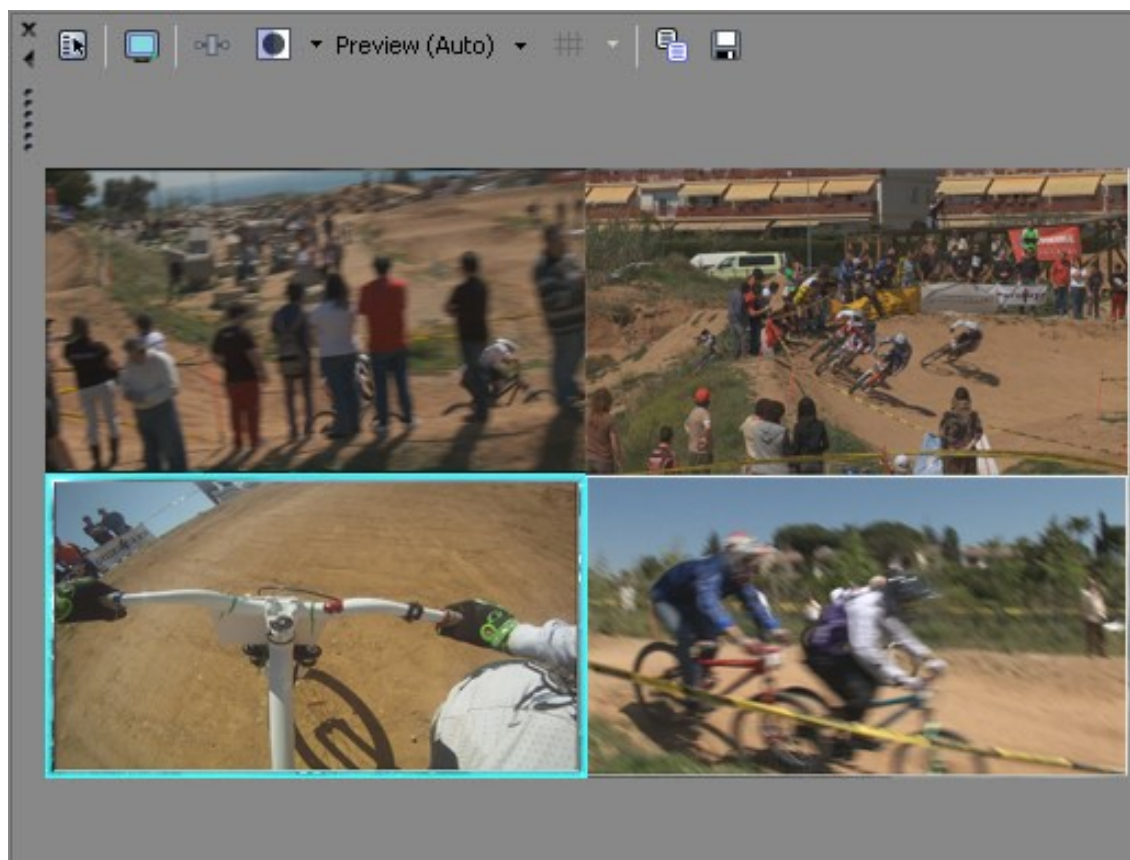


Figure 4.17: Sony Vegas multicamera display playing 4 streams simultaneously

### 4.2.9 Aspect ratio conversion issues

When dealing with different camera formats it is very important to take into account the differences between pixel aspect ratios. The **pixel aspect ratio (PAR)** is a ratio that describes how the width of a pixel in a digital image compares to the height of that pixel.

**Display Aspect Ratio (DAR):** is the aspect ratio of the image as displayed on TV. Typically either 4:3 or 16:9.

**Storage Aspect Ratio (SAR):** is the ratio of pixel dimensions. If an image is displayed with square pixels, then DAR and SAR ratios agree; if not, then non-square, "rectangular" pixels are used, and these ratios disagree.

Our cameras record in different formats thus having different pixel aspect ratios. The Sony EX1 cameras, the Canon EOS7D and the GoPro onboard cameras all record at 720p. But the Sony Z1 shots in HDV format. The following table summarizes all the different aspect ratios that we need to take into consideration:

Format	SAR	DAR	PAR = DAR/SAR
XDCAM EX 720p	$1280/720 = 16/9$	16/9	1 (square)
HDV 1080i	$1440/1080 = 1,3333$	16/9	1,3333
PAL	$720/576 = 1,25$	4/3	1,0666
Widescreen PAL	$720/576 = 1,25$	16/9	1,4222

Table 4.3: Video formats pixel aspect ratios

Both PAL and widescreen PAL have been included because they are not acquisition formats but possible delivery formats. It is very common to having to downscale the high definition master video to widescreen PAL versions for the customers. That would be the case of rendering the video for DVD distribution.

Sony Vegas editing software handles different aspect ratios but it is necessary to set it to make sure it correctly identifies each clip with the correct aspect ratio. For example, this is specially critical when it comes to rendering a widescreen PAL version for DVD purposes (See Figure 4.18). It results in a widescreen picture with lateral black bars on the sides. This is due to the pixel aspect ratio differences between the source material and the target format. One possible solution would be to horizontally stretch the picture but that would mean processing the whole video and losing picture quality. Our decision is not to do that processing because the black bars are very thin and they will be hidden to the viewer thanks to the overscan effect of the monitors, especially television sets.

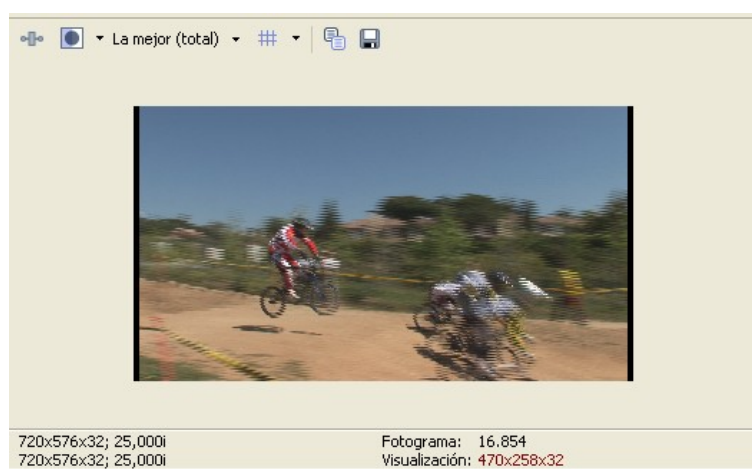


Figure 4.18: Lateral black bars due to pixel aspect ratio differences

## 4.2.10 Color correction software

Once all the shots are put together it is the time to apply color correction, also known as color grading, to each shot. Because the source clips have been captured with different cameras not all of them have exactly the same appearance even when shooting the same scene at the same time. The color correcting process is intended for overcoming these differences, avoiding color jumps and homogenizing the tone of all clips so that it seems to the viewer that all of them have been captured by the same camera.

Sony Vegas offers several tools for color correcting the clips. One of the most useful is the color corrector tool found in the effects tab.

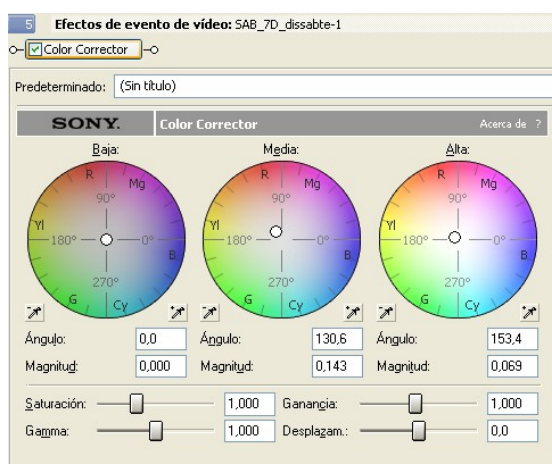


Figure 4.19: Color corrector tool in Sony Vegas

Typically, minor adjustments are needed and a subtle adjust in the midtones and saturation is enough.

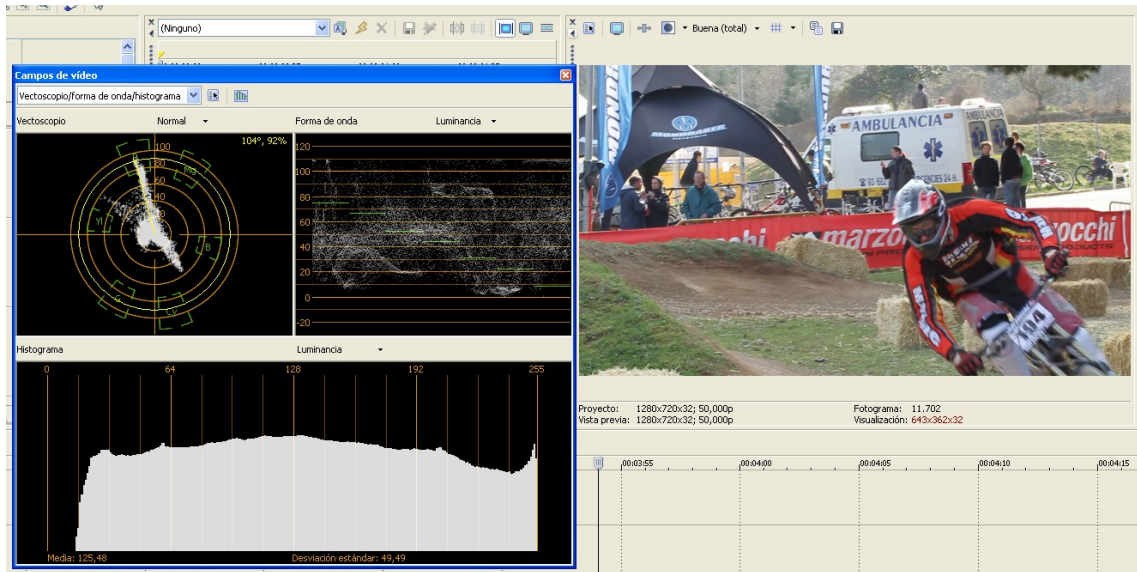


Figure 4.20: Vectorscope, Wavform and Histogram monitor in Sony Vegas

It is also possible to display a real time vectorscope and waveform monitor which help to accurately color correct each clip. The vectorscope is very useful when doing white balance adjustments.

## 4.3 Graphics editing

## 4.4 Graphics editing

### 4.4.1 Animated graphics

Complex graphics animations like opening intros or lowerthird animation effects cannot be accomplished by using only the NLE editing software. NLE are the best tools for selecting, trimming and putting together all the clips and generate a final render output. But NLE are not video graphic composing tools, so, when dealing with complex animations or effects it is needed a dedicated video composing application like Adobe After Effects.

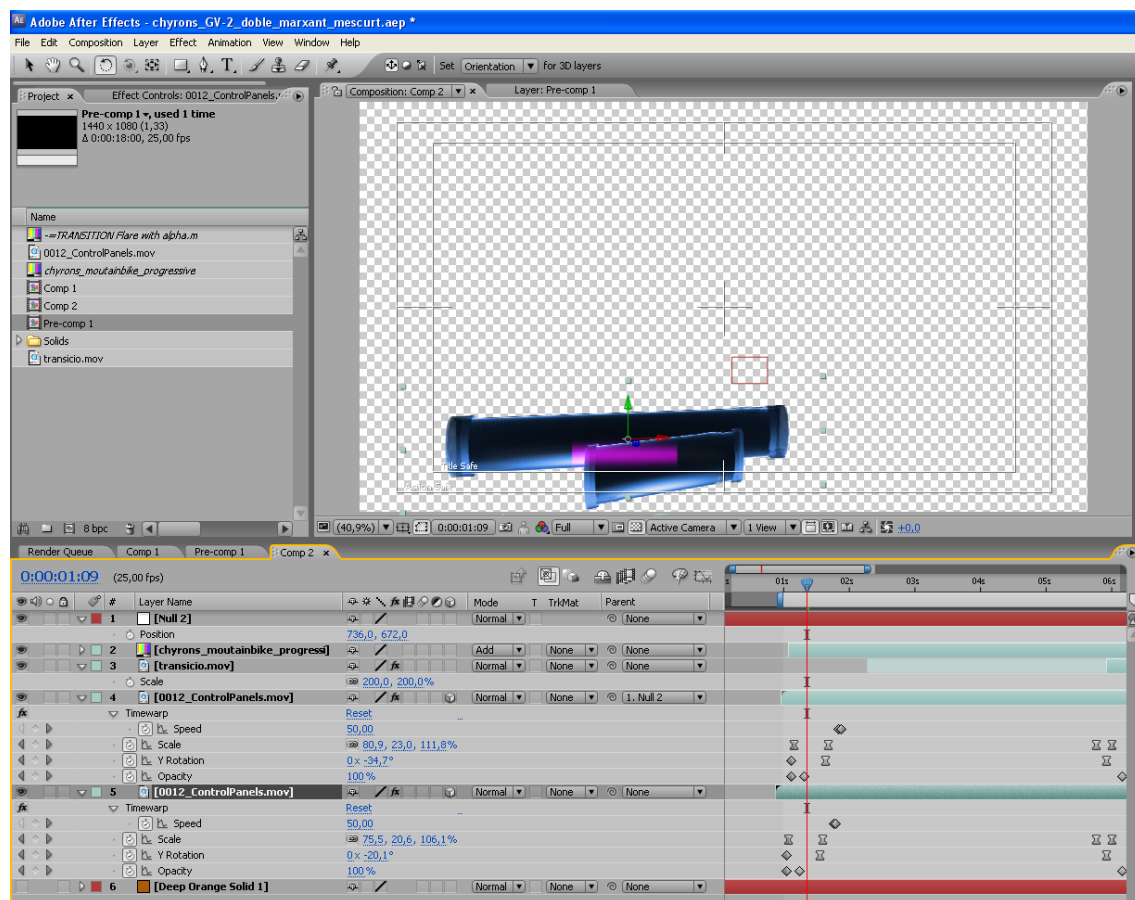


Figure 4.21: Adobe After Effects project of the animated chyron effect

Adobe After Effects is a hugely complex application for creating visually stunning graphic effects. Completely mastering this tool requires years of experience and it is not the purpose of this project to go deep in the software features but to provide a basic overview of which tool best fits each specific purpose.

#### 4.4.2 Lowerthirds and subtitles

The lowerthirds are titles composed with text and graphic elements that are placed in the lower third of the screen. They typically show names of the people, location, etc. Figure 4.21 shows the design of the standard chyron for all the videos. The effect is only the background animation which consists in two blue rectangles which move in the 3D space. This animation is rendered from After Effects in an uncompressed MOV format with an embedded alpha channel, the transparency information. Next, this animation is imported into the Sony Vegas editor and duplicated as many times as needed. The text is not rendered from After Effects because it will be very time consuming to generate a full graphics animation for every title. Therefore, it is only generated once and the text is placed on top of it directly



from the Sony Vegas editor. This is a much more elegant form of producing reusable graphics.

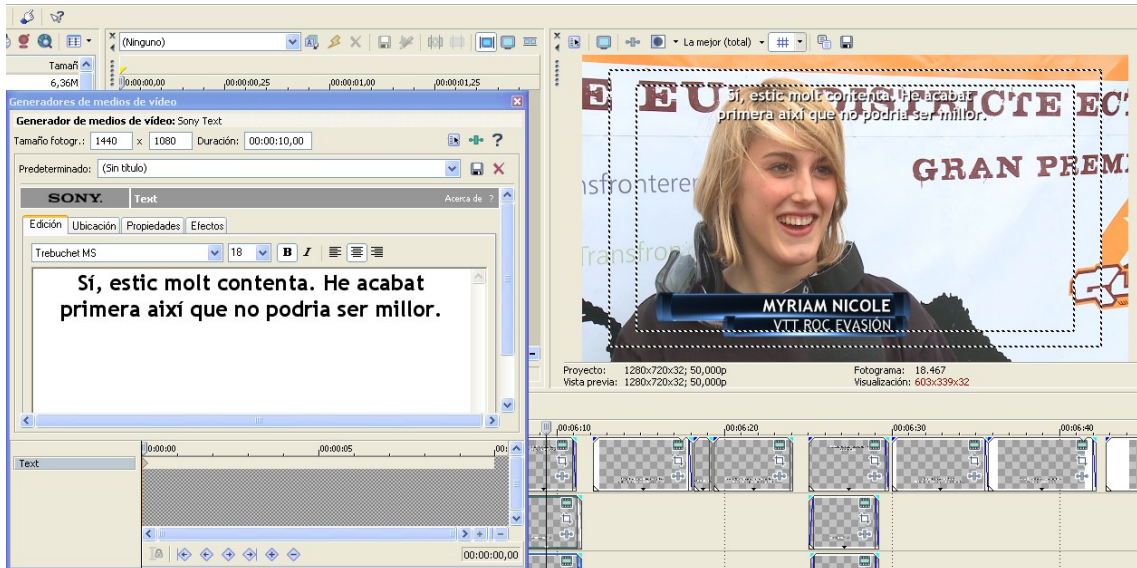


Figure 4.22: Sony Vegas text editor for subtitling

Regarding subtitles, they are also done in the Sony Vegas text editor. There are two basic things to take into account when adding subtitles to a video. First, the letter must be easily readable. We have chosen one of the industry standards type *Trebuchet MS*, widely used for subtitling. Second, it is important to activate the safe area lines and put the text inside them, otherwise the text can be cutted by the overscan effect of some displays.

## 4.5 Audio editing

### 4.5.1 Mixing audio layers

When it comes to audio editing we rely on the audio tools of Sony Vegas editor. In fact, Sony Vegas began being an audio only application and then it progressively added video functionalities. Therefore, its audio capabilities are very powerful. The aim of audio editing is to basically adjust the audio levels of speech, music and effects so that they have a consistent level across the entire video. For example, the level of the music must be lowered when someone speaks and raised again when he or she finishes. This is accomplished by using audio rubberbandings and keyframes. The main challenge here is that music typically has much more level and presence than speeches and lowering the music is not enough. The solution is to apply soft dynamic compression

to the speech tracks in order to raise its volume but avoiding overclipping. The **graphics compression tool** under the non-real time audio effects tab is the right tool to achieve this purpose.

## 4.5.2 Soft dynamic compression

In the editing stage we monitor the audio using the Yamaha MSP-5 near-field studio powered loudspeakers. They are two-way bi-amplified bassreflex speakers that deliver outstanding monitoring precision for digital or analog production in stereo. They have a flat response and therefore, we hear audio as it is.

But we have to bear in mind that not always the final video will be played through a couple of high-quality loudspeakers. In fact, the viewer will probably play it through the TV speakers or cheap headphones. That means that what we thought it sounded great on our editing room would probably play awfully in the viewer's speakers. All the broadcasters know that and they apply heavy audio compression to the delivered audio signal.

Dynamic range compression is a process that reduces the dynamic range of an audio signal, that is, narrows the difference between high and low audio levels or volumes. The use of compressors can make videos sound musically better by controlling maximum levels and maintaining higher average loudness. All we hear on radio or television is always compressed, polished and buffed so even when played on tiny speakers, it is fully listenable and accessible.

Apart from applying compression to the speech track it is a very common practice to apply compression to the final audio bus. We use the *iZotope* specialized audio plugin for Sony Vegas that enables us to apply soft compression to the master audio track. It can be seen in Figure 4.23 how the output levels are boosted without overclipping the signal.





Figure 4.23: Sony Vegas' plugin for audio dynamics compression

## 4.6 Final word on editing and post-processing

As a wrap up for this section it is important to point out that the editing of a video of this type is a time consuming process. There are several steps that must be done one after the other.

It all begins with the transfer of the footage to the editing software. Then it comes the transcoding step in order to edit the images faster and with higher quality. The editors have to select, trim and edit the footage producing a final video which will be enhanced later on with superimposed graphics or computer-generated animations and effects. It is also very important the color correction job, which is usually done at the end of the editing process. Finally, audio postproduction is crucial because in an artistic production, audio is as important as video so we must ensure that the delivered clip has consistent audio tracks.

We must stress the fact that shooting tapeless (as opposed to use cameras which record on tape) has great advantages when it comes the editing process. The transfer of all the footage is much faster, with improved metadata and very flexible. But that comes with some drawbacks such as the need to transcode some of the footage to less compressed formats that are more editing friendly or the need to establish a solid tapeless workflow so that every people, from the cameraman to the editor, knows and uses. Until now, we have proven that the proposed workflow works in real-world situations. Of course, it can be improved and we are on that direction as it can be seen in section 7.2 Which procedures can be improved.

## Chapter 5. Delivery

This chapter describes the final stage of the whole production process. Once the video has been edited it must be rendered for different purposes. All of the different target outputs require specific compression schemes, whether it is a high-quality version for TV broadcast or just a small clip for the web.

### 5.1 Technical requirements

There are specific software tools for compressing the final video to various delivery formats, some of them even require dedicated hardware for improving the encoding performance. But we have found that Sony Vegas NLE has all the necessary functions to render high-quality video in a lot of different output formats. Sony Vegas relies its advanced encoding capabilities to the well-known *Mainconcept*<sup>29</sup> codecs. Vegas is also very quick in the rendering process provided you have a fast computer (quad-core is desirable) although it would be very difficult to achieve better than real time encoding speeds. Specific render parameters for each type of video output will be further discussed in the following sections.

Basically, we must produce these output formats:

- 6 min Rough Cut
- Broadcast-quality final edited video
- Edited video for customer
- Webclip for youtube/vimeo

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<sup>29</sup> **MainConcept** is a worldwide leading provider of high-quality codec technology supporting industry standards such as H.264/AVC or MPEG-2 among others.

<http://www.mainconcept.com/>

## 5.2 After-the-event highlights delivery

When the competition is finished, typically on Sunday at 17h, we hurry up to sort out all the audiovisual clips and text documents so that in 3h maximum the following files are uploaded to a public FTP and available for download for the accredited media.

- **6 min Rough Cut:** it is a short clip (also known as "rushes") with neither music nor graphics which includes the opener sequence<sup>30</sup>, beauty shots<sup>31</sup> of the place where the event is held, Vox Pops<sup>32</sup> of several riders and highlights from the trials, the race and the award ceremony. This clip is an MPEG-2 standard definition file which is intended to be the most compatible possible file format so that everyone is able to play it, edit it and generate its own report of the event.

<b>Format:</b>	Standard definition at 576/50i
<b>Codec:</b>	MPEG-2 Program Stream
<b>Resolution:</b>	720x576 pixels
<b>Aspect ratio:</b>	16:9
<b>Field order</b>	Upper Field First
<b>Total bitrate:</b>	CBR at 12 Mbps (broadcast standard for SD MPEG-2)
<b>Audio:</b>	MPEG-1 layer 2 at 384 kbps, stereo
<b>File container:</b>	MPG

*Table 5.1: Technical details of the standard delivery format for rough cuts:*

- **Shotlist PDF:** it is a short text that describes the shots which appear in the roughcut clip along with its timecode. It is useful for the journalists to find quickly what they are looking for.
- **Press release PDF:** text report about the event which includes a general description of the competition, the results (timings) of the winning riders of

30 The **opener sequence** is typically a quick animation or graphics composition with the title of the competition.

31 **Beauty Shots** are generally general shots of the place where the event is held. The city environment, the track, general shots of the riders, the event atmosphere.

32 The term "**vox pop**" means "voice of the people". In the broadcast television context, vox pops are used to provide a snapshot of the rider's opinion. They are asked to give their views on a particular topic and their responses are presented to the viewer as a reflection of popular opinion.

each category and some event figures such as the number of participants, visitors, exhibitors, brands, or contact details for further information. This text, or an adapted version of it, is what the media (electronic newspapers, web portals, TV channels...) use for researching about the event.

### 5.2.1 Virtual disk and FTP

We use the *steekR*<sup>33</sup> online virtual drive to store all the previous files for each race so that any media with the required user and password can download the files and use them freely. The subscription service of *steekR* has a 10GB limit storage which is enough for our purpose.

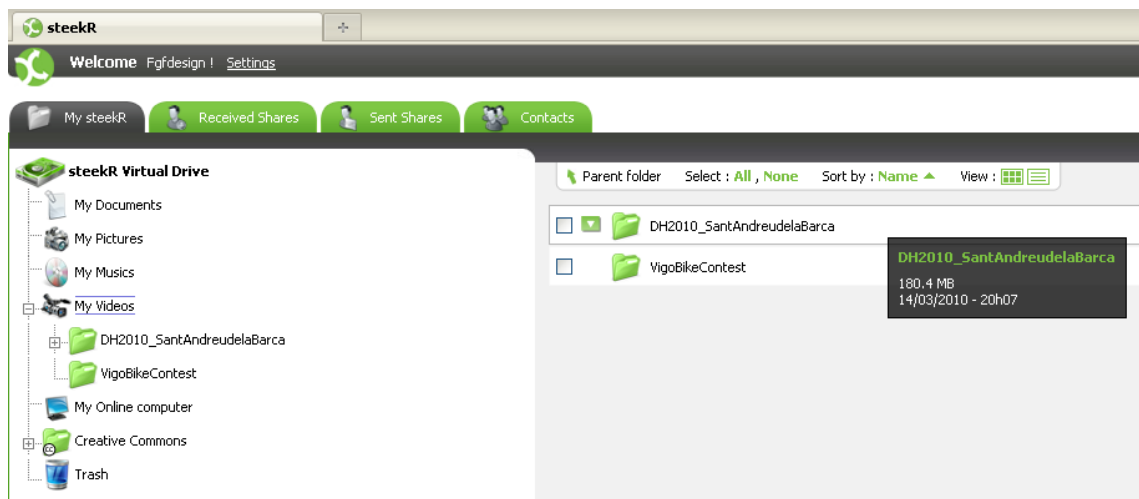


Figure 5.1: SteekR Virtual Drive

Some broadcasters like TVC (Televisió de Catalunya) prefer us to upload those files to their own FTP<sup>34</sup> for a faster access. They typically use the rough clips to edit a piece of news for the 3/24 channel<sup>35</sup>.

<sup>33</sup> [SteekR virtual drive](#)

<sup>34</sup> TVC news FTP: <ftp://informatius.tv3.cat>

<sup>35</sup> [3/24 TV channel](#): 24h news channel

## 5.3 Files to be delivered in 4 days

### 5.3.1 Broadcast Quality Final Edited video

Once the video is edited the final master version is generated by rendering the whole timeline to the MXF format. This is the best way to export the final edited version of the video because the render output is exactly the same format as the video input. That means that only the parts of the timeline that have effects will be actually processed while the other parts will be left as is thus maintaining its original picture quality. It is important to point out that in every processed part of the timeline, for example a transition, a fade out effect, a superimposed graphic or color corrected clip will imply the NLE software to decode the video, perform the processing and encode the video again. This by itself produces a little loss of picture quality because of the decompression-compression process. NLE are optimized softwares and only process the chunks of the timeline that are needed. So, rendering to a file format that is the same as the original format is undoubtedly the best possible way to keep the maximum video quality. Figure 5.2 shows the MXF render parameters of the Sony Vegas editor.

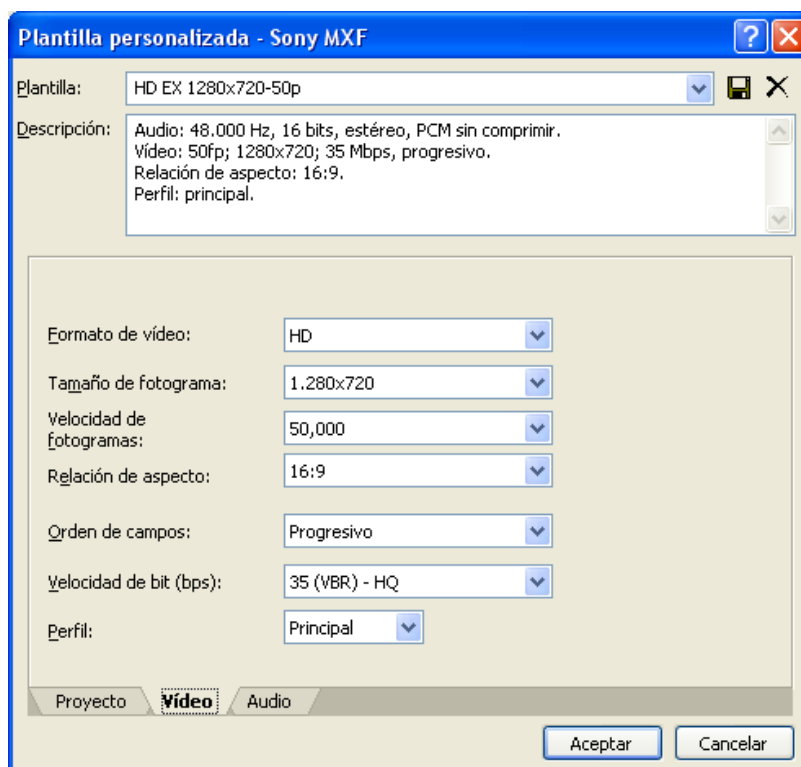


Figure 5.2: High-quality archiving file compression parameters

<b>Format:</b>	XDCAM EX 420
<b>Codec:</b>	MPEG-2 4:2:0 MP@HL
<b>Resolution:</b>	1280x720 pixels
<b>Aspect ratio:</b>	16:9
<b>Field order</b>	Progressive
<b>Total bitrate:</b>	VBR 35 Mbps
<b>Audio:</b>	PCM uncompressed 16 bits, 48kHz.  Ch.#01 -> Full Programme Mix - including voiceover (stereo left) Ch.#02 -> Full Programme Mix - including voiceover (stereo right) Ch.#03 -> International Sound <sup>36</sup> + interviews (no voiceover, no music) (stereo left) Ch.#04 -> International Sound + interviews (no voiceover, no music) (stereo right)
<b>File container:</b>	MXF

Table 5.2: Technical details of the standard delivery format for final video

### 5.3.2 Edited video for customer

The problem of the MXF format is that it is not a delivery format. It is not very common that the consumer players actually play the MXF format. Even though it is the format that retains the best quality, it is not the best file to give to the customer. We have decided to render a high quality MPEG-4 video file at a high bitrate which is almost indistinguishable from the original MXF but it is a delivery format fully compatible with all the computer players<sup>37</sup>.

<sup>36</sup> **International Sound:** also called Ambient sound or Atmo; no Music, no Voice Over, CLEAN

<sup>37</sup> **Computer player:** software used to play video files. Windows Media Player or VLC are the most common players and both of them are fully compatible with MPEG-4 H.264 format.



<b>Format:</b>	High definition at 720/50p
<b>Codec:</b>	MPEG-4 H.264 (Mainconcept codec)
<b>Resolution:</b>	1280x720 pixels
<b>Aspect ratio:</b>	16:9
<b>Field order</b>	Progressive
<b>Total bitrate:</b>	VBR (25 Mbps maximum; 20 Mbps average)
<b>Audio:</b>	MPEG-1 layer 3 at 320 kbps, stereo
<b>File container:</b>	MP4

Table 5.3: Technical details of the standard delivery format for final video

### 5.3.3 Webclip for youtube/vimeo

Apart from generating a high-quality video we also render a lower quality version of it to showcase in Youtube or Vimeo sites. We have created a Vimeo channel<sup>38</sup> called *Copa Catalana de Descens 2010* which is used to showcase the videos of all the races.

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38 FGFdesign vimeo channel: <http://vimeo.com/channels/copacatalanadh2010>



Figure 5.3: Vimeo customized channel appearance

The render parameters of the videos uploaded in Vimeo are very similar to those of the final video but at a much lower bitrate. In fact, we decrease the bitrate of both the video and the audio in order to keep reasonably file sizes of the resulting files. The exact parameters are shown in Table 5.4 and Figure 5.4.

<b>Format:</b>	High definition at 720/25p
<b>Codec:</b>	MPEG-4 H.264 (Mainconcept codec)
<b>Resolution:</b>	1280x720 pixels
<b>Aspect ratio:</b>	16:9
<b>Field order</b>	Progressive
<b>Total bitrate:</b>	VBR (5,5 Mbps maximum; 4,5 Mbps average)
<b>Audio:</b>	MPEG-1 layer 3 at 192 kbps, stereo
<b>File container:</b>	MP4

Table 5.4: Technical details of the standard delivery format for the webclip

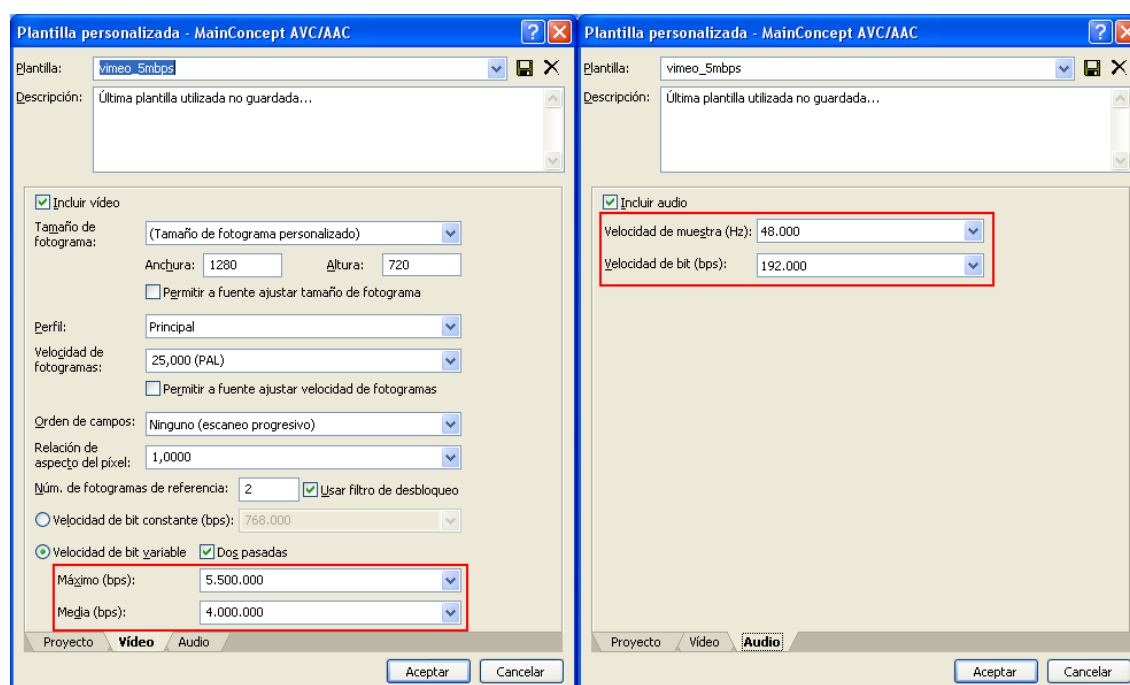


Figure 5.4: Webclip render compression parameters from Sony Vegas

The choose of the bitrate is not arbitrary. We follow the compression guidelines<sup>39</sup> of the vimeo and youtube sites. For example, Vimeo recommends to upload the HD videos at 5000 Kbps in the MPEG-4 H.264 codec with the MP4 file container. So, the rendered video has a variable bitrate which can go up to 5,5 Mbps for the fast motion parts and 4Mbps of bandwidth is used for low-mid motion sequences of the video. This provides the best trade-off between file size and picture quality.

<sup>39</sup> Vimeo compression guidelines: <http://www.vimeo.com/help/compression>

### 5.3.4 Video hosting sites comparison

There are two main video hosting sites: Youtube and Vimeo. They are a good place to showcase the videos we produce.

Actually both Vimeo and Youtube do recompress all the uploaded files to their own format for displaying purposes. They apply their own compression techniques and the resulting bitrate of the video is, in fact, much lower. For example, the following is the actual codecs and bitrates that Vimeo uses which result from analysing one of the transcoded videos:

<b>Video codec:</b>	MPEG-4 H.264
<b>Video bitrate.</b>	2000Kbps (HD), 800Kbps (SD) . 2-pass VBR
<b>Audio codec:</b>	AAC
<b>Audio bitrate:</b>	128Kbps

Table 5.5: Vimeo video and audio codecs

Although Vimeo and Youtube offer basically the same, there are differences between them. The next two tables show the pros and cons of each one taking into consideration our needs as a content providers.

VIMEO	
Pros	Cons
Good quality encoding (crisp pictures)	Small, but select community.
2GB per file. No limit in video lenght.	Paid hosting video service. Although there is a free version with limited features
Faster encoding (only vimeo + paid subscription)	Not the smoothest playback experience. Jittery video playback.
Sleek embeddable design	
Great viewer loyalty.	
Keeps original uploaded file and let you download it if needed.	

Table 5.6: Vimeo pros and cons

YOUTUBE	
Pros	Cons
Free	10 minute per video limit (hard restriction)
Large community (more potential exposure)	Easy "lose" visitors. This means that visitors do not tend to check out your channel for updates. Bad viewer loyalty.
Smooth playback experience	Rather dull embeddable design
	Not as crisp, detailed pictures.

Table 5.7: Youtube pros and cons

### **Our video hosting choice:**

We have chosen Vimeo as the main showcase platform for our videos because its much more professional approach when it comes to uploading and managing videos. Its user interface is nicer and the administration tools are more powerful than the ones from Youtube from our point of view. Regarding picture quality, it seems like YouTube favors smoother motion playback whereas Vimeo favors detailed crisp pictures. But the differences here are subtle and each hosting service is improving its compression schemes and gradually increasing bitrates so that this is not a deciding factor. What is more, when doing commercial videos like we do, there is really no point in evaluating one of the two. It is a good idea to upload the videos on both and get the best of both worlds.

### **5.3.5 Vimeo's video mobile version**

We do produce a compatible mobile version of each video so portable multimedia devices such as iPhone and iPod Touch can play it. Other phones must have to be Android<sup>40</sup> based to view videos on Vimeo's mobile site.

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40 [Android](#): Android is Google's operating system for mobile devices. It is a competitor to Apple's iOS for the iPhone.



Figure 5.5: Vimeo's mobile video version settings page

### 5.3.6 Vimeo detailed statistics

Vimeo offers in-depth statistics about its hosted videos. There is plenty of information about how many plays each video has, how many people actually reached the end of the video or detailed information about where each video has been embedded.

All these data is very useful both for the customer and for the producer because it helps to create a viewer profile and get to know the user preferences by reading their comments and likes about the hosted videos. Apart from that, we also have full control of which webpages are embedding our videos and we can also restrict the domains we want to allow each video to appear on.

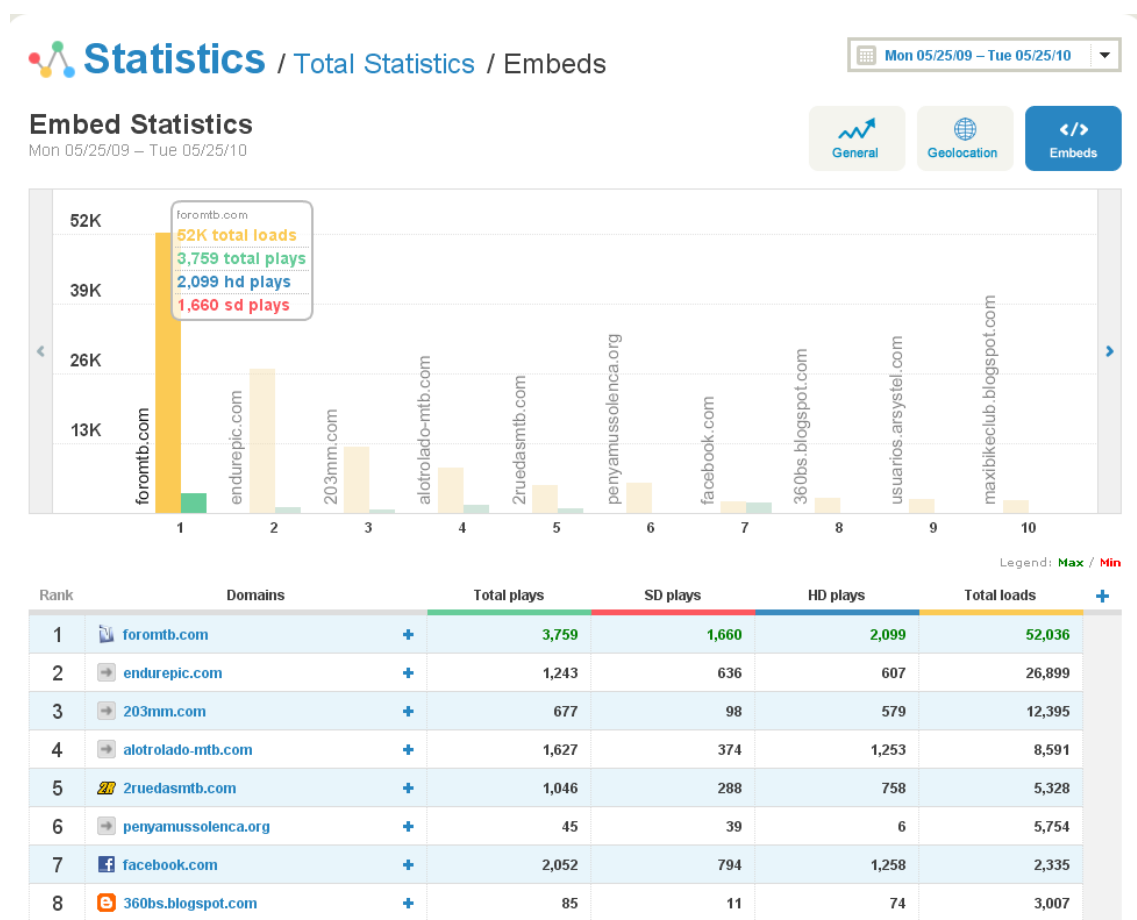


Figure 5.7: Embeds statistics

## 5.4 DVD authoring production

The deliver of the final video to the customer on DVD is still the most common way. This ensures that almost everyone can play the video either on a standard DVD player or in a PC. Blu-ray is also an option but the truth is that very little customers have a Blu-ray player. Most of the times the customer wants the final video on several DVD's in order to give them to the companies that sponsored the mountain bike competition event or just for promoting the event or to attract new sponsors. So, compatibility is our priority.

Creating a DVD is not as straightforward as simply burning a DVD. The DVD must be a compliant DVD-video with its menu for navigating through the contents and that requires creating a special folders structure so that the DVD players recognize the disc as a DVD-video. This is accomplished by using a DVD authoring software.



### Our DVD authoring software choice:

We have chosen *Adobe Encore DVD CS4* as our authoring software for producing compliant DVD discs because it is one of the most complete tools nowadays.

#### 5.4.1 Steps to produce a navigable DVD-video

The first step is to import the videos into the Adobe Encore and create a menu splash screen. This menu is best done in Adobe Photoshop and then import the resultant .psd file into the Adobe Encore as well.



Figure 5.8: DVD menu creation in Photoshop

The previous figure shows how to create a menu with Photoshop. It is basically composed by several layers. The one at the bottom is the background layer and then each button (which will be the buttons the user will use to navigate with) is represented by a folder (e.g. Scenes 6-10). Each button has two programmable states, that is, the appearance that has the button when it is selected and the one that has when it is unselected. Both must be designed and configured and this is set by writing the special characters (=1) and (=2). The (=1) layer is how the button will look like when the user puts the cursor on it and the (=2) is how the button will look like when the user actually hits "ok" in his remote control.

Once the menu is done, it is necessary to import it to Adobe Encore and to program the navigation. This is done by assigning each button to each desired video. This is represented by the following flow diagram:

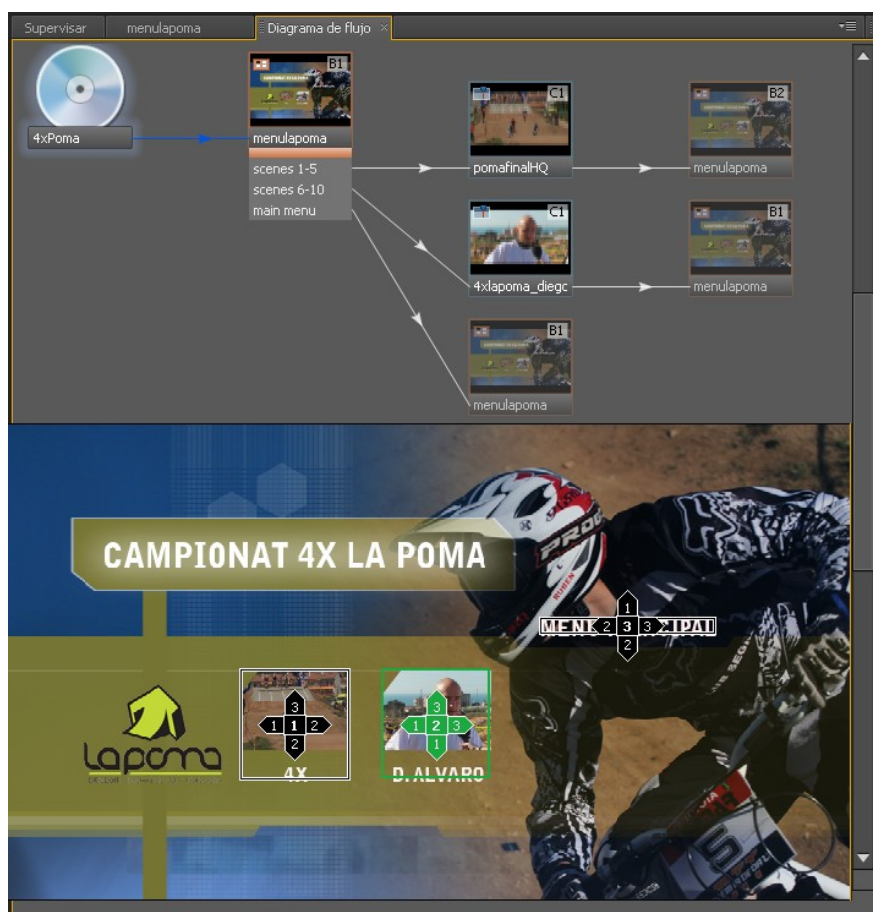


Figure 5.9: Flow diagram of the DVD menu navigation

It is important to configure what is known as the *end play*, which is at which point of the DVD menu structure will jump the DVD when the video is finished. The previous diagram can be read this way: When the user introduces the DVD it will jump to the menu screen. If the user selects the first button it will jump to the source video **pomafinalHQ** and when this video finishes it will jump to the previous menu but automatically pointing the cursor to the next button (B2). Below is represented the way the navigation with the remote control arrows is configured. In this case it is quite simple because there are only two videos but with more videos and submenus the navigation structure can become very complex.

Finally, it is necessary to downconvert the high definition videos to standard definition MPEG-2 DVD-Video compliant format.

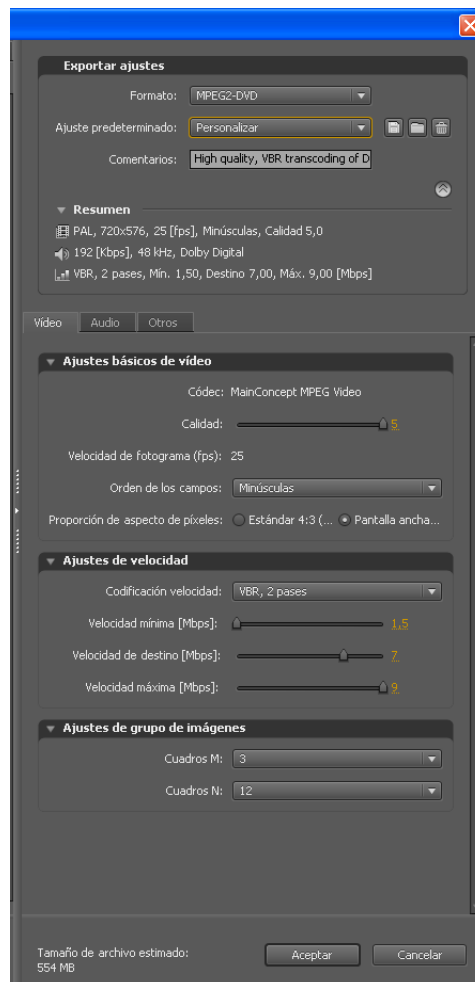


Figure 5.10: DVD-Video MPEG-2 parameters

The DVD-Video standard allows for a maximum bitrate of 11,08 Mbps, that includes a 1 Mbps overhead, so the raw bitrate is actually 10,08 Mbps. Within these

10,08Mbps, up to 3,36Mbps can be used for subtitles and a maximum of 9,80 Mbps can be split amongst video and audio.

Typically, movie DVD's have an average bitrate of 4-5 Mbps but we can allow ourselves to use a higher bitrate because our videos are short in length so there is not a capacity problem. But it is not recommended to surpass the 7-8 average bitrate in order to ensure compatibility among DVD players and help to prevent buffer underruns in the case of scratched discs. Variable bitrate coded in 2-passes is used in order to better optimize the compression.

Once the video has been transcoded it is needed to create the special folders DVD-Video structure and finally burn the data onto the DVD raw disc. Video, audio and subtitles (if any) are multiplex and stored on a DVD-Video in the VOB container format. VOB is basically a MPEG program stream format.

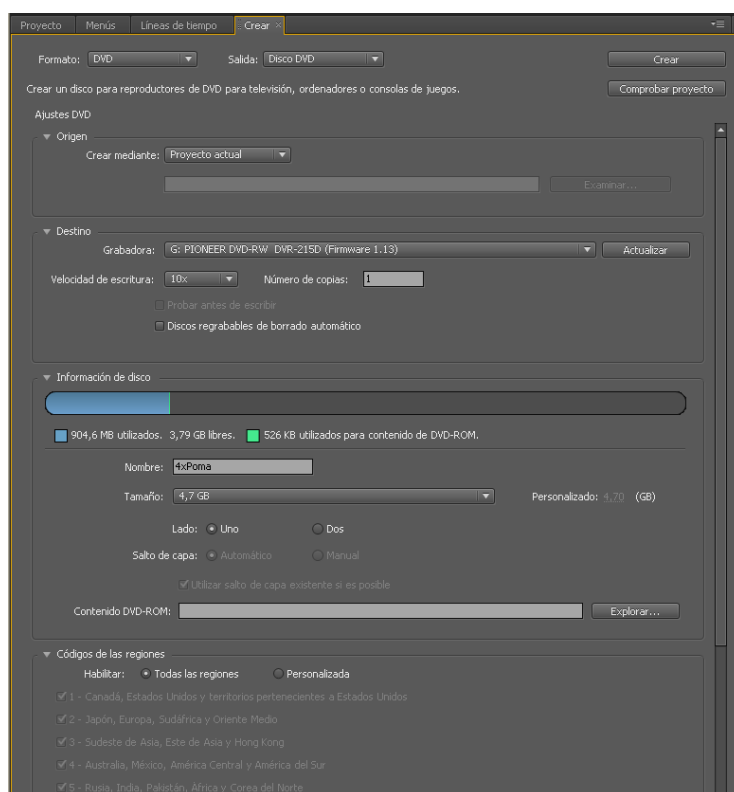


Figure 5.11: DVD-Video VOB creation and burning

We make our DVD region free so that it can be played in any player without restrictions. It could be possible to add a copy protection system like the Macrovision but that requires to pay a fee. We use professional raw *Verbatim* printable DVD-R discs and we print on it with a special inkjet printer so the result is a professional looking DVD disc.

## Chapter 6. Results

### 6.1 Results

The procedures explained in this project have been applied in real-world situations. Since the beginning of the year, we have audiovisually covered these mountain bike competitions:

- Eurodistrict ECT. Gran Premi Guak (Maçanet de Cabrenys, Alt Empordà)
- Gran Premi Marzocchi. Gran Premi Diputació de Barcelona. (Sant Andreu de la Barca, Barcelona).
- 4X La Poma Bikepark (Premià de Dalt, Barcelona)
- European Vigo Bike Contest (Coruxo, Vigo)

The previous are real competitions which let us apply the production workflow described in this project. This is very important because the proposed workflow is not only a theoretical approach to the problem but also it has been demonstrated to work in real competitions with real customers.

Another fulfilled achievement is writing a document reporting the coverage of a mountain bike race. The FCC (Federació Catalana de Ciclisme) and Comissió de Descens de Catalunya has asked us to write a document explaining the steps to organize the TV production crew in order to cover the three different types of races. This document is very similar to this project but leaving out all the technical discussion and focusing more on the logistical and organizational issues. This document was delivered on the first of July.

Our images have been broadcasted in *3/24 channel*<sup>41</sup> of *Televisió de Catalunya* in a small news clip form. They have also appeared in some other small local televisions

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41 **3/24 channel**: 24h news channel from Catalonia

such as *Sant Andreu Televisió*<sup>42</sup> and *Tramuntana TV*<sup>43</sup> and one of our video reports of the races has been broadcasted in the programme called *XS-Esports*<sup>44</sup> from la *Xarxa de Televisions Locals de Catalunya (XTVL)*.

Our videos also appeared in electronic newspapers like *El Mundo Deportivo*<sup>45</sup> and some other specialized and also very popular mountain bike web portals like *alotrolado-mtb*<sup>46</sup>, *203mm*<sup>47</sup> or *MTB-news*<sup>48</sup>. Our highlight videos hosted on *Vimeo* enjoy an excellent reputation with more than 17.000 plays in total (See Figure 6.1), 42 comments and hundreds embeds<sup>49</sup> from the users, especially in forums like *foromtb*<sup>50</sup>.



Rank	Title	Plays	Loads	Likes	Comments	Embeds	Downloads
1	Copa Catalana de 4X	5,173	26.3K	16	15	20.3K	0
2	Copa Catalana de DH Sant Andreu de la Barca [video oficial]	4,219	26.7K	15	4	24.5K	0
3	Vigo Bike Contest [video oficial]	4,173	26.3K	12	15	10.3K	0
4	Copa Catalana de DH Maçanet de Cabrenys [video oficial]	3,749	16.9K	22	8	12.2K	0

Figure 6.1: Vimeo statistics for the mountain bike competitions

The following are some screenshots of media appearances of our videos and reports of the mountain bike races.

42 **Sant Andreu TV**: <http://santandreutv.com/>

43 **Tramuntana TV**: local TV of Alt Empordà and Figueras. <http://www.tramuntanatv.com/>

44 **XS-Sports**: Sports programme of XTVL. <http://www.xtvl.tv/programes/xsesports/>

45 **El Mundo Deportivo**: electronic sports newspaper. <http://www.elmundodeportivo.es/>

46 **Alotrolado-mtb**: extreme sports web portal. <http://www.alotrolado-mtb.com>

47 **203mm**: extreme sports web portal. <http://www.203mm.com/>

48 **MTB-news**: most important MTB web portal from Deutschland. <http://www.mtb-news.de/>

49 **Video embeds**: Vimeo player code can be embedded in a website so that the video plays directly from that site. Users that like our videos can freely embed them in their websites, blogs or forums. Vimeo keeps track of the embedded videos and it is a good way to know the popularity of a video.

50 **foromtb**: most important Spanish MTB forum. <http://www.foromtb.com/>

**MUNDO DEPORTIVO.ES**  
Martes 16 de Marzo de 2010

INICIO | FÚTBOL | MOTOR | POLIDEPORTIVO | BALONCESTO | SERVICIOS | HEM

Atletismo | Balonmano | Ciclismo | Golf | H. Patines | Olimpismo | Tenis | Caballos | Waterpolo | Vaya Mundo | Rugby | Más dep

Renovación Guardiola |

**MÁS DEPORTES**

## Bernat Guàrdia, gana el GP Marzocchi-DH de Sant Andreu

Redacción - 16/03/2010 19:45

Bernat Guàrdia (Massi) ha sido el claro dominador de la XI GP Marzocchi-DH de Sant Andreu, siendo el claro dominador de las dos mangas. Guàrdia ha estado acompañado en el podio de Fabien Barel (Subaru Mondraker), segundo, y de Arnau Sugrañés (XMS Devinci), tercero.

El ambiente en el XI del GP Marzocchi-DH de Sant Andreu-Gran Premi Diputació de Barcelona ha sido el de las grandes ocasiones, con cerca de 400 participantes y la presencia de muchos aficionados, que no han querido perderse la cita descender con más tradición del calendario nacional. Las nuevas secciones abiertas en el trazado, como la rock garden o zona de piedras, y la remodelación final han sido del agrado de pilotos y público

PUBLICIDAD. ¿Has pensado en Mazda? Descubre todos sus modelos.

Compartir Noticia: [Facebook] [Twitter] [Google+] [LinkedIn] [YouTube] [RSS]

**MEDIA CENTER**

### Resumen del GP Marzocchi-DH de Sant Andreu

00:00 / 01:59

REPRODUCIR | correo | url | código | MENÚ

Figure 6.2: Electronic Newspaper show our footage in its website along with the press release text

The electronic newspaper EL MUNDO DEPORTIVO has used our rough cut footage and the press release text to publish the event in the sports section.





Figure 6.3: 3/24 screenshot of the Sant Andreu de la Barca downhill race

Catalan news channel 3/24 has broadcasted a small clip of the event at the night news.



Figure 6.4: Screenshot of the TV programme XS-Esports (XTVL) where the presenter introduces our video of the race

The XTVL programme XS-Sports has dedicated an entire section to show our video coverage of a Mountain Bike competition.

## Chapter 7. Conclusions

### 7.1 Conclusions

At this point we have to analyze whether the initial objectives stated in 1.1 Summary have been accomplished. Planning how to cover sports event from scratch, these were our contributions:

- Wisely select the audiovisual equipment to achieve the required customer quality standards and within budget.
- Plan optimum technical coverage for each type of race (downhill, four cross and downtown).
- Provide solutions to challenging technical situations like transmitting video wirelessly or shooting an event with several cameras and synchronizing them all.
- Provide a reliable tapeless workflow from acquisition to delivering. Opposed to traditional tape based procedures.
- Mix the various recording formats producing a high-quality professional output video of the event. This implies transcoding the footage to the best codec for each purpose, mixing video and audio tracks, do multicamera edits, do color correction to the clips, add effects, titles, etc.
- Establish a proven workflow in order to deliver pictures of the race to the media as soon as the competition finishes. This required an in-depth timing planning in order to determine bottlenecks wether they occur when transferring the footage or transcoding or rendering.

- Adapt the final video to several delivery targets which implies generating different versions of each video to satisfy the destination requirements. This includes the rough cuts for the media, the customer version, the webclip, the DVD version for the sponsors, etc.

For our customers the need of delivering images straight after the event was a really a must, and for us, a technical challenge to overcome. Establishing a good workflow was essential and it depends on three factors: good planning, strict discipline and specialized equipment. An engineer I used to work with has a saying: *Plan your work, and work your plan*. This is where discipline comes in, to carry out the plan you have thought up. But having the right video and audio equipment is crucial as well. Fortunately, tapeless cameras have become affordable enough to be used in small budget projects and enabled us to establish a good tapeless workflow which has proved to be faster and more efficient than the traditional tape-based shooting and editing techniques. In fact, all the major broadcasters are transitioning to tapeless video acquisition, especially when time matters and the deadlines are tight, for example in the television news department.

We strongly believe that all the initial objectives have been fulfilled and from our customer feedback we have even exceeded the customer expectations with our coverages of the events. Some of them are already interested in our availability for the next season events which is something that proves that.

Indeed, planning our work and make these videos is also a way to make money. It is a business which gives work to 4 employees at part-time. It is a matter of time to keep growing and dealing with larger projects, but what it is important is that all the technical procedures we have thought up actually work in real jobs.

## 7.2 Which procedures can be improved

In television production there is always room for improvement. Producing a high-quality television coverage is a combination of working with skilful people and having the utmost technical resources. But these does not come cheap and given a budget there is always a trade-off between resources (human and technical) and quality of the final video.

Improving the coverage of the event is not only a matter of increasing picture quality or spreading the number of cameras, in fact, the customer will appreciate more a faster deliver of the video. So we should think of ways for further optimize the proposed audiovisual workflow and the weakest part of it is the editing stage. This is clearly the bottleneck because it is very time-consuming. In order to speed up the edition and post-production of the raw footage more people working on the same project is required. But the problem is that the media is only accessible for one edit

workstation at the same time. Therefore, the only way to enable more than one workstation to access the footage is to share the media across the different edit stations. Some manufacturers offer solutions for this issue with dedicated RAID storage systems and specialized software. One of the most powerful systems is the industry-standard Avid Unity<sup>51</sup> for news. But it comes with a high price tag and it is targeted to large companies like TV broadcast stations. For small companies, Apple offers a technical solution which is much more affordable and yet very interesting.

Apple has given us the possibility to test one of their flagship product, the Apple Final Cut Server<sup>52</sup> plus the XSAN<sup>53</sup> storage system. This system enables us to share our assets and efficiently divide tasks using version management tools. This means that multiple persons can work on different sections of the video production simultaneously. For example, one editor could be working in the first part of the final video, another trimming the rough cuts and another one focusing on the graphics and lower thirds of the podium ceremony of the competition. Each one would work in a different project but sharing the same referenced media, with no need for additional copies or storage. Once the different parts are finished, all the projects can be assembled into a single master project for delivery. Version management makes it possible to revert to a previous version for each defined section and always keep track of who edited which part. Furthermore, having all the media in a RAID system like Apple XSAN is much more reliable in case of harddisk failure because all the data is redundant.

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51 **Avid Unity:** Avid Unity is a professional media storage system developed for use in highly demanding and time sensitive video postproduction, like the television news department. <http://www.avid.es/es/products/unityisis/index.asp>

52 **Apple Final Cut Server:** Final Cut Server is an Apple editing software for managing Final Cut Pro files and workflow automation when doing collaborative editing. Final Cut Server can catalogue any file type and allows for the addition of custom metadata to make those files searchable. Final Cut Server runs on Apple hardware but the server is accessed through a Java client that runs on PCs and Macs. In addition to Java, Final Cut Server makes heavy use of the QuickTime framework. <http://www.apple.com/finalcutserver/>

53 **Apple XSAN:** Xsan is a SAN (Storage Attached Network) system made by Apple. Xsan enables multiple Mac desktop and Xserve systems to access shared block storage over a Fibre Channel network. With the Xsan file system installed, these computers can read and write to the same storage volume at the same time. Xsan is a complete SAN solution which includes the metadata controller software, the file system client software, and integrated setup, management and monitoring tools. Xsan has all the normal features to be expected in an enterprise shared disk file system, which includes support for large files and file systems, multiple mounted file systems, meta data controller failover for fault tolerance, support for multiple operating systems. <http://www.apple.com/xsan/>



*Figure 7.1: Apple Final Cut Server collaborative editing system with XSAN raid disk storage*

This system implies changing our NLE to date, which has been Sony Vegas Pro, to Apple Final Cut Pro<sup>54</sup>. The downside is that it will be necessary to buy new computers and learn a new non-linear editing software, but NLE's are just tools and all of them are very similar so we expect the learning curve not to be very steep. But, after having done some tests with this collaborative editing workflow, we honestly think that Apple Final Cut Server can truly speed up the delivery of the final video to the customer and that would be a huge step forward in our production.

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54 **Apple Final Cut Pro:** Apple's non-linear editing software.  
<http://www.apple.com/es/finalcutstudio/finalcutpro/>

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## Anexo A. BBC framerates guidelines

The following chart is what BBC thinks is the best format/framerate to use according to the type of programme being shot.

Production type	super16	25p	50i	Reason
Drama with cinema release	Very likely	Possibly 24p	No	Compatibility with 35mm
Television drama	Possibly	25p	If you want a video look	If shot progressive it could be used for large screen release / compatibility with 35mm
Soap opera / Continuing Drama	Unlikely	Possibly	Likely	More likely to want the 'immediacy' of i
Sitcom	Not common	Possibly	Likely especially if mixed studio and location	Depend on broadcaster / look of the programme
Live Sport	Never	Very unlikely	Always	Fast movement requires smooth motion.
Documentaries / Current Affairs	Possibly	Possibly	Possibly	Dependent on the style of the documentary, and what look you're trying to achieve.
Live events - concerts etc	Practically impossible	Optional	More likely	Live events suit interlace images, which gives the audience a feeling of being at the event. But it is a choice of style.
Natural history / wildlife	Often	Often	Sometimes	Progressive shot at high frame rates produces good slow motion. Compatibility with 16mm archive material.
News	Never	Very unlikely	Always	Interlace delivery appropriate for news footage. Also matches in better with interlace archive material on varied formats

Table 7.1: BBC's guidelines for video formats and framerates

**Anexo B. RedBull guidelines for  
moving images contribution.  
Technical requirements.**

# Guidelines for Moving Images Contribution

**Technical requirements v1.1**  
**27th of July 2009**

A technical guideline about moving images production and contribution for the Red Bull Content Pool.



# Introduction

## About this specification

Red Bull aims to maintain the highest technical standards possible. This document sets out the standards required to deliver material to the Red Bull Media House and Red Bull Content Pool. It covers the technical requirements for moving images produced and delivered in high definition (HD) or standard definition (SD).

## Delivery factsheet

Each delivery must include the 'Red Bull Content Pool Delivery Factsheet', which has to be completed in full.

**A delivery can only be accepted if the 'Red Bull Content Pool Delivery Factsheet' is completely filled-in and if the delivered content fulfils the Red Bull Content Pool requirements.**

# Contents

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# 1. Video production specification

The following specifications are minimal requirements of cameras used for Red Bull Media House contributions.

This chapter does not define the specifications for the delivery of content but the requirements for the actual production of the moving images.

## a. High definition

We only accept high definition native video formats, which fulfil the following criteria:

- A frame size of at least 1920 x 1080 pixels
- A bitrate of at least 35 Mbit/s
- A framerate of at least 23.97 frames/s progressive or 50 fields/s interlaced
- RGB luma and gamut limits have to fulfil the recommendation of EBU R103-2000

or

- A frame size of at least 1280 x 720 pixels
- A bitrate of at least 35 Mbit/s
- A framerate of at least 50 frames/s progressive
- RGB luma and gamut limits have to fulfil the recommendation of EBU R103-2000

A maximum of 10% of the programme - with no sequence being more than 1 minute long - may be below the named requirements.

We recommend using one of the following production formats:

- **XDCAM HD 422 - Sony**
- **XDCAM EX - Sony**
- **HDCAM (SR) - Sony**
- **AVC-Intra - Panasonic**

## **b. Standard definition**

We only accept standard native video formats, which fulfil the following criteria:

- An image size of 720x576 or 720x486 pixels
- A bitrate of at least 30 Mbit/s
- A field rate of at least 50 fields/s
- RGB luma and gamut limits have to fulfil the recommendation of EBU R103-2000



## 2. Delivery video format

We only accept one of the following formats:

### a. High definition

<b>Format</b>	XDCAM HD 422
<b>Codec</b>	MPEG2 4:2:2 Profile (422P) @ High Level (HL)
<b>Bitrate</b>	50 Mbps Constant Bit Rate (CBR)
<b>Display aspect ratio</b>	16:9

The following standards are possible:

	<b>Frame size</b>	<b>Frame rate</b>	<b>Field rate</b>	<b>Scan type</b>
<b>1080i/25</b>	1920 x 1080	25	50	Interlaced
<b>1080i/29.97</b>	1920 x 1080	29.97	59.94	Interlaced
<b>1080p/23.98</b>	1920 x 1080	23.98	23.98	Progressive
<b>1080p/24</b>	1920 x 1080	24	24	Progressive
<b>1080p/25</b>	1920 x 1080	25	25	Progressive
<b>1080p/29.97</b>	1920 x 1080	29.97	29.97	Progressive
<b>720p/50</b>	1280 x 720	50	50	Progressive
<b>720p/59.94</b>	1280 x 720	59.94	59.94	Progressive

For editing purposes we accept Apple ProRes format (MOV Container).

For those who are technically not able to export to XDCAM HD 422 or Apple ProRes, please contact the

#### **Red Bull Content Pool Support**

- support@redbullcontentpool.com
- +43 662 2240 28666

## b. Standard definition

<b>Format</b>	MPEG IMX D10
<b>Codec</b>	MPEG2 (Intra-Frame-Coding) 4:2:2 Profile (422P) @ Main Level (ML)
<b>Bitrate</b>	50 Mbps Constant Bit Rate (CBR)
<b>Display aspect ratio</b>	16:9 (no Letterbox, no Pillarbox)

The following standards are possible

	<b>Frame size</b>	<b>Image size</b>	<b>Frame rate</b>	<b>Field rate</b>	<b>Scan type</b>
<b>PAL</b>	720 x 608	720 x 576	25	50	Interlaced (Top/First/Odd field first)
<b>NTSC</b>	720 x 512	720 x 486	29,97	59,94	Interlaced (Bottom/Last/Even field first)

### 3. Delivery audio specification

<b>Codec</b>	PCM
<b>Sample Rate</b>	48.000 Hz
<b>Bits / Sample</b>	16 Bit or 24 Bit
<b>Channels</b>	4 / 8
<b>Audio limited to</b>	- 9 dB

All channels must be delivered as **discrete channels**.

No Dolby Digital or Dolby E is accepted.

Any other audio channels (e.g. auxiliary data) have to be agreed beforehand.

For file-based delivery in MXF container use the 8 channel specification, for tape delivery the 4 channel version.

#### 8 Channels

#01	Full Programme Mix	stereo left
#02	Full Programme Mix	stereo right
#03	International Sound	stereo left
#04	International Sound	stereo right
#05	Music & Effects	stereo left
#06	Music & Effects	stereo right
#07	Voice Over	mono
#08	Interviews	mono

#### 4 Channels

#01	Full Programme Mix (incl. Voice Over)	stereo left
#02	Full Programme Mix (incl. Voice Over)	stereo right
#03	International Sound + Interviews (no Voice Over, no Music)	stereo left
#04	International Sound + Interviews (no Voice Over, no Music)	stereo right

#### Rough Cuts, News Cuts and Selects

#01	International Sound	stereo left
#02	International Sound	stereo right

### **Surround**

#01	Full Programme Mix	stereo left
#02	Full Programme Mix	stereo right
#03	L	
#04	R	
#05	C	
#06	LFE	
#07	LS	
#08	RS	

### **Glossar**

#### **International Sound**

also called Ambient sound or Atmo; no Music, no Voice Over, CLEAN

#### **Interviews**

Extra recorded interviews (with an additional microphone)

#### **Effects**

Sound added in postproduction (e.g. explosions etc.) and not recorded on location, no music.

#### **Music**

Music added in postproduction.

#### **Voice Over**

Additional voice, which is recorded in postproduction.

#### **Full Programme Mix**

A mix, which includes everything incl. voice over.

#### **Ambient Sound**

is International sound; no Music, no Voice Over, CLEAN

#### **Atmo**

is International sound; no Music, no Voice Over, CLEAN

## 4. Delivery

### a. File-Based

All video files, which fulfil the specifications described above, have to be delivered in an MXF container (MXF Standard OP1a: SMPTE 378M).

The files have to respect the following naming convention:

{VIN}\_{Title of Asset}.mxf

The data medium has to contain a directory named ,ContentPool' in the root-directory. All relevant files have to be placed in there.

### b. Tape-Based

Videos which fulfil the specifications in 1a have to be delivered on HDCam; for the specifications in 1b you have to use DigiBeta or IMX tapes.

#### ● Timecode

A tape has to be delivered with the following title strip and final title strip.

Timecode	Type	Length	Image	Audio
09:58:30:00	Calibration	60 sec	Colour bars (75%)	Tone 1kHz @ -9 dB
09:59:30:00		10 sec	Black level	No
09:59:40:00	Identification	10 sec	Slate	No
09:59:50:00		10 sec	Black level	No
10:00:00:00	PROGRAMME			
	Final title strip	10 sec	Black level	No

● **Slate**

A slate has to contain at least the following information

- Name of production partner
- Production date
- Asset VIN and title
- Audio tracks mapping (Channel 1 - 4/8)

Red Bull North America  
March 23, 2009  
Program Title: Red Bull Big Tune National Finals  
Textless Version  
Episode: N/A  
Producers: Scott Bradfield, Karma Gardner, Jonathan Moore  
TRT: 20:55  
Segment 1: 01:00:00:00 – 01:10:24;28  
Segment 2: 01:10:34;28 – 01:14:56;18  
Segment 3: 01:15:06;20 – 01:20:55;09  
Ch 1. Dialog  
Ch 2. SOT  
Ch 3. Music Stereo L  
Ch 4. Music Stereo R

## 5. Fast delivery of content for newsroom

If due to limited bandwidth a fast delivery of the high quality file is not possible and a fast distribution is necessary, you have to provide a file with one of the following specifications.

**Nevertheless, THE HIGH QUALITY FILE (which fulfills the Video and Audio specifications in 2) HAS TO BE DELIVERED WITHIN 14 DAYS.**

### a. High Definition

Video

<b>Container</b>	MPEG-4
<b>Codec</b>	H.264
<b>Bitrate</b>	13 Mbps (max 15 Mbps, min 10 Mbps) Variable bit rate (VBR)
<b>Display aspect ratio</b>	16:9

One of the following sub types is required:

	<b>Frame size</b>	<b>Frame rate</b>	<b>Field rate</b>	<b>Scan type</b>
<b>1080p/25</b>	1920 x 1080	25	25	Progressive
<b>1080p/29.97</b>	1920 x 1080	29.97	29.97	Progressive
<b>1080p/23.98</b>	1920 x 1080	23.98	23.98	Progressive
<b>1080p/24</b>	1920 x 1080	24	24	Progressive
<b>720p/25</b>	1280 x 720	25	25	Progressive
<b>720p/29.97</b>	1280 x 720	29.97	29.97	Progressive
<b>720p/50</b>	1280 x 720	50	50	Progressive
<b>720p/59.94</b>	1280 x 720	59.94	59.94	Progressive

Audio

<b>Codec</b>	AAC
<b>Sample rate</b>	48.000 kHz
<b>Audio channels</b>	2 (Full Programme Mix - stereo left and right)
<b>Bits / Sample</b>	16 Bit
<b>Limited to</b>	-9 dB



## b. Standard Definition

### Video

<b>Container</b>	MPEG-2
<b>Codec</b>	MPEG-2 Program Stream (PS)
<b>Bitrate</b>	10 Mbps (max 12 Mbps, min 8 Mbps) Variable bit rate (VBR)
<b>Display aspect ratio</b>	16:9 (no Letterbox, no Pillarbox)

One of the following sub types is required:

	<b>Frame size</b>	<b>Frame rate</b>	<b>Field rate</b>	<b>Scan type</b>
<b>PAL</b>	720 x 576	25	25	Progressive
<b>NTSC</b>	720 x 480	29.97	29.97	Progressive

### Audio

<b>Codec</b>	MPEG-2
<b>Sample rate</b>	48.000 kHz
<b>Audio channels</b>	2 (Full Programme Mix - stereo left and right)
<b>Bits / Sample</b>	16 Bit
<b>Limited to</b>	-9 dB

## 6. Additional information

### a. Labelling

All tapes, hard drives, etc. have to be labelled with

- Production company
- Date of production
- Title of production
- VINs of included assets

### b. Shipping

All tapes and hard drives need to be sent to the following address

**Red Bull Media House GmbH**  
**Moving Images Portfolio**  
**Oberst-Lepperdinger-Strasse 11-15**  
**5071 Wals**  
**Austria / Europe**

For shippings from the U.S. or Canada you can also ship it to

**Red Bull North America**  
**Moving Images Department**  
**1740 Stewart Street**  
**Santa Monica, CA 90404**  
**United States of America**

#### **d. Versions**

Productions delivered to the Red Bull Content Pool have to include two versions (also see 3 - Delivery Audio Specifications)

- clean (w/o graphics)
- dirty (with graphics)

#### **e. Raw Material**

All raw material shall be delivered on original source or lossless dubs including raw material overview sheet.

#### **c. Additional requirements**

- Pump Audio music cue sheet
- Final production must be logged with a shot list
- If specified a transcript/interview log may be required
- All the graphics should be delivered digitally
- Final Cut Project File and all related media

# Anexo C. Sensor artifacts

## explained

Traditionally, camcorders used 3 CCD sensors but now many new camcorders (both consumer and professional) are using CMOS sensors. While both CCD and CMOS sensors have unique characteristics that make each one suitable for one application or another, there are some properties to each that need to be known in order to determine whether a CMOS or a CCD camcorder is more appropriate for the kind of shooting necessary for the job.

### C.1 CCD vs CMOS

Traditionally, CCD cameras were better than CMOS cameras, the latter usually associated with webcams or consumer gear. It has been claimed that the CCD technology is better, but now, it has reached its maximum point of efficiency while CMOS technology is in the preliminary stages and there is a lot of room for improvement which is why all the manufacturers are now switching to the CMOS technology.

Both sensor technologies basically do the same job, which is gather light and turning it into electric signals. But they do that in different ways. Describing the differences between these two technologies is beyond the purpose of this chapter. Instead, the attention will be focused on the different artifacts that each sensor produces because they actually have an impact on the type of footage the camera gathers. So it will provide more information when deciding which camera choose depending on which sensor has.

## C.2 Rolling shutter

The "rolling shutter" effect or the "jello" effect occurs when the user quickly pans or tilts the camera and produces a skewing effect. This is caused by the way the CMOS sensors are read.

CCDs do not suffer from this undesired effect because they use a "global shutter" while CMOS can use either "rolling" or "global" .

- A **GLOBAL SHUTTER** exposes the entire image simultaneously. The entire frame is exposed and begins gathering light until the predetermined "shutter speed" has elapsed. For example at 1/50 sec. Then, the sensor stops gathering light and turns its current exposure into an electronic image. There is no physical "shutter" that covers and uncovers the sensor. It is all done with timing.
- A **ROLLING SHUTTER** is very different. The rolling shutter actually exposes different portions of the frame at different points in time, "rolling" through the frame. Again, this is not an actual physical moving shutter as opposed to a film camera, which actually has a moving physical shutter. Instead, the sensor is telling different portions to become light-sensitive at different instants in time until the entire frame is exposed. That is why quick pans result in skew pictures because the first lines of the CMOS have been exposed prior to the last ones.

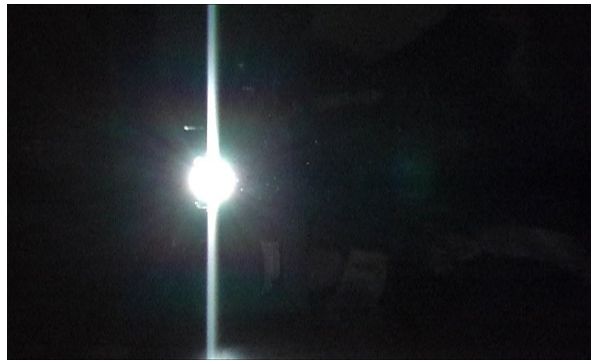
With a global shutter, any motion during the frame does not imply skew but blurring. The amount of blurring depends on the shutter speed (SS). If the SS is so slow that the object actually moves during one shutter cycle the blur becomes noticeable. But with a high shutter speed any motion will be frozen in time resulting in clear, crisp blur-less pictures. Note that the skew or rolling shutter effect is not affected by the shutter speed, it is only affected by the frame rate. The faster the framerate, the less skew will appear. That is, shooting at 50fps in 720p will cut down on the skew effect while shooting at 25fps in 1080p mode will increase the undesired effect.

The Sony EX1 has 3-CMOS sensors that exhibit rolling shutter effect when a rapid pan or tilt is done, but the manufacturer has optimized the camera electronics so that the effect is minimized. The HD SLR Canon EOS 7D uses 1 CMOS sensor and exhibits a more noticeable skew problems, especially when shooting handheld in 1080p modes. The Sony Z1 camcorder has 3-CCD so it does not suffer from rolling shutter issues at all.

### C.3 Smear

Smear happens when a very bright portion of a picture (such as streetlights or car lights) causes an entire column of pixels to overload and bloom to white creating a vertical white line in the resulting image.

To avoid smear it is necessary to lower the exposure enough so that the bright lights do not bloom and trigger a column of smearing. Stopping down the iris of the camera in order to bring down the brightness of the bright lights can eliminate the smear entirely, but also may cause the overall picture to be too dark. CMOS sensors do not exhibit smear effect because of the way they read the pixels.



*Figure 7.2: Example of vertical smear effect*

### C.4 Wooble

The wooble effect is related to skew and it is caused by the same cause. Whereas skew represents a leaning of vertical lines, the wooble is a stretchy look that affects the entire image. The visible effect is like the image liquidizes itself. Wooble is more noticeable when shooting handheld footage or in situations where the camera is subject to vibration or sudden motion. For example, if the camera is moved downwards the picture becomes stretched out and, in the same manner, if moved upwards the image gets scrunched down and the same thing if it is moved side to side. The resulting effect is that the whole image becomes "wobbly".

To avoid this effect it is necessary to shot always on a tripod as direct linear motion (such as a tripod pan) does not produce wooble. If handheld is necessary it must be done slowly and steadily.



Figure 7.3: Example of the wobble effect

There is an example of the wobbling effect in the Figure 7.3 where the image gets distorted when the camera is suddenly shaken.

Slower frame rates seem to accentuate the wobble while faster frame rates seem to minimize it. Higher shutter speeds make it more distinct, and slower shutter speeds mask the wobble under motion blur, but the wobbling effect is equivalent regardless of the shutter speed.

## C.5 Partial exposure

Partial exposure happens when there is a flash of light that significantly alters the exposure such as a camera flash or a bolt of lightning. Here is how it looks like:



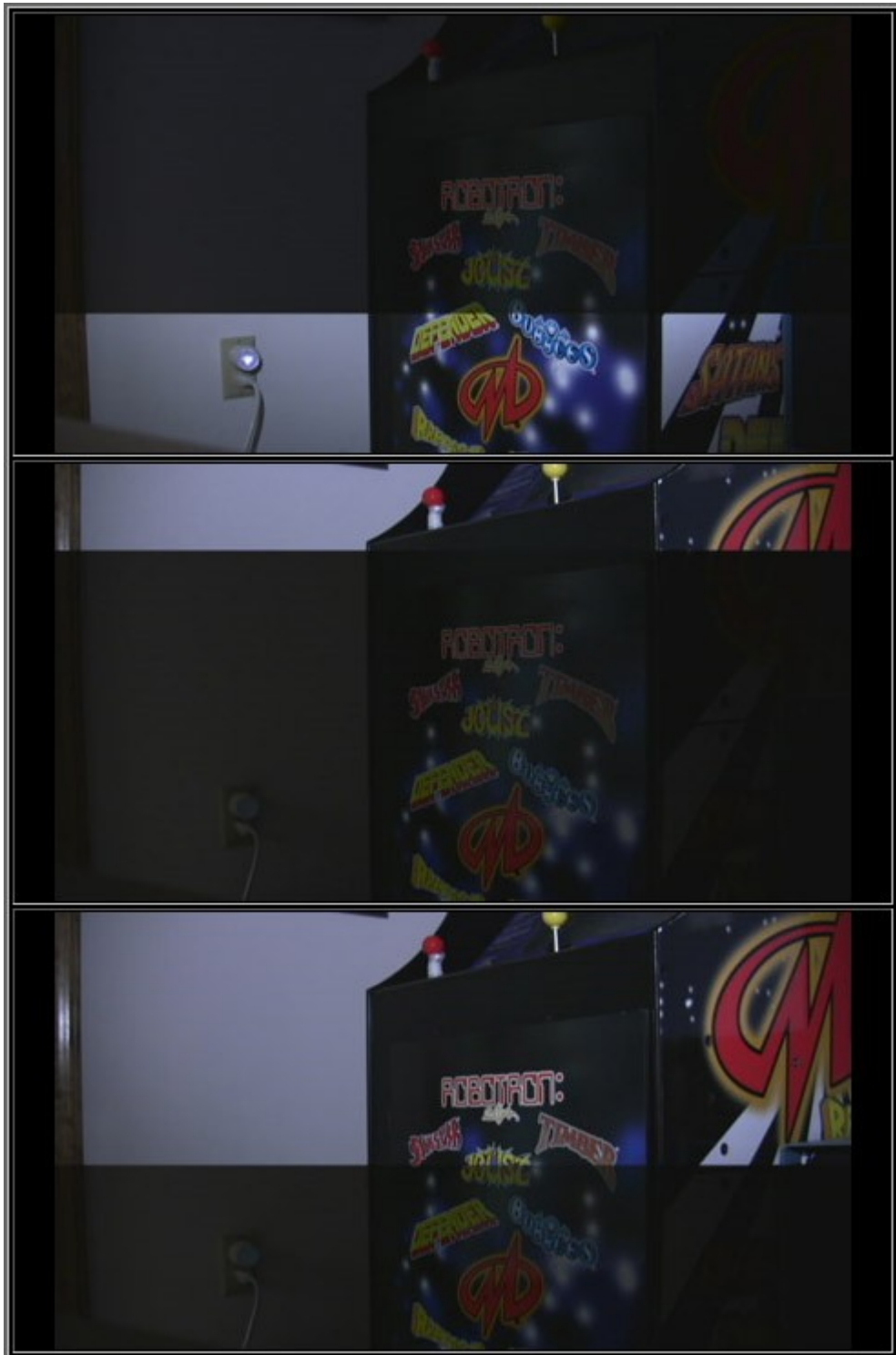


Figure 7.4: Example of the partial exposure effect

In these cases, the resulting effect can be understood by looking at how the rolling shutter system works. As the shutter "rolls" through the frame, part of the image is dark and the rest of the image is bright when a sudden light is captured. The shutter exposes portions of the frame at the prevailing light conditions, and then when the "flash" occurs, the current portion of the frame that the shutter is exposing becomes brightly lit. The result is that when a camera is using a CMOS in a scenario where flash photography is taking place (such as a wedding or a press conference) it is possible to encounter black or dark bands, or even bright bands in the video.

Keep in mind that all these effects are not possible to correct in post.

## C.6 Sensor artifacts summarizing chart

technology ►	CCD	CMOS
<b>Sensor artifacts ▼</b>		
Rolling shutter (skew effect)	inexistent	noticeable
Smear	noticeable	inexistent
Partial exposure	inexistent	noticeable
Wooble	inexistent	noticeable

# **Anexo D. Manual d'estil per la Producció televisiva de les carreres de Descens en Mountain Bike.**

La **Federació Catalana de Ciclisme** asked us to document all the steps needed to technically organize the TV production crew in a sports event. The following is a document we edited for them for that purpose.

## **D.1 Consideracions tècnics segons tipus de circuits**

### **D.1.1 Carreres de descens**

Les carreres de descens és una disciplina del mountain bike on els corredors baixen per un circuit natural enmig del bosc. Típicament són pistes abruptes, amb desnivell i amb varis obstacles naturals com pedres, arrels, etc. Les velocitats que s'assoleixen solen ser més altes que en altres modalitats com ara el cross-country. El format de les carreres és tal que cada corredor baixa individualment a intervals de 30 segons i el corredor que arriba a meta amb el menor temps és el guanyador de la prova. La bicicleta que s'utilitza per aquestes modalitats té certes característiques molt

diferenciades d'altres modalitats. És més robusta, més pesada, amb suspensions de major recorregut i frens de disc més grans i potents.

Un exemple d'un circuit de descens de la Copa Catalana és el circuit de Sant Andreu de la Barca (Veure Figura 7.5).

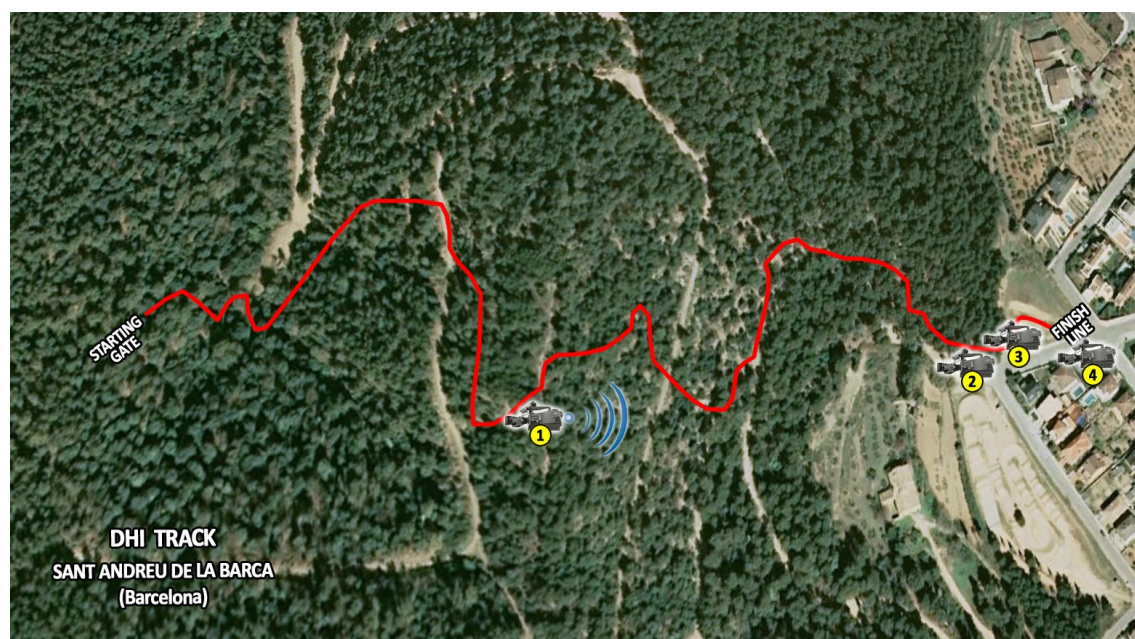


Figura 7.5: Circuit de descens de St. Andreu de la Barca

Aquest circuit és representatiu de com són els circuits de descens de la Copa Catalana. Té una distància total de 1.100 metres i un desnivell acumulat entre la sortida i l'arribada de 140m. El millor dels corredors triga 1 minut i 48 segons en completar-lo.

Cal destacar que els circuits de descens de la Copa del Món de Descens són més exigents física i tècnicament. Són més llargs (fins a 2Km), amb més pendent i amb obstacles més difícils com ara salts, arrels, etc.

Per a cobrir televisivament aquests tipus de circuits cal tenir en compte varies consideracions. Primer de tot, cobrir el 100% del recorregut amb càmeres és tècnicament molt complicat ja que són circuits enmig del bosc on el camp de visió és reduït i caldria situar moltes càmeres al llarg del circuit. Per tant no es sol cobrir la totalitat del circuit sinó les parts més importants com la sortida, punts intermitjos i sobretot l'arribada.

En la Figura 7.5 es pot veure la distribució de càmeres al circuit quan es fa un cobriment en fals directe. Es pot comprovar que hi ha una càmera a un punt d'interès al mig del circuit i la resta de càmeres es concentren a l'arribada que és on hi ha el



major grau d'interès (públic, meta, podis...). La càmera del punt intermig s'utilitza per a transmetre en directe la senyal del corredor i mostrar-la en una pantalla de leds situada a la meta per al públic assistent. Aquesta càmera utilitza un radioenllaç per a transmetre el vídeo i àudio de forma inalámbrica ja que és la forma més adequada per a transmetre la senyal degut a les característiques del terreny i la gran distància entre la càmera i la pantalla, fet que fa impossible utilitzar cablejat.

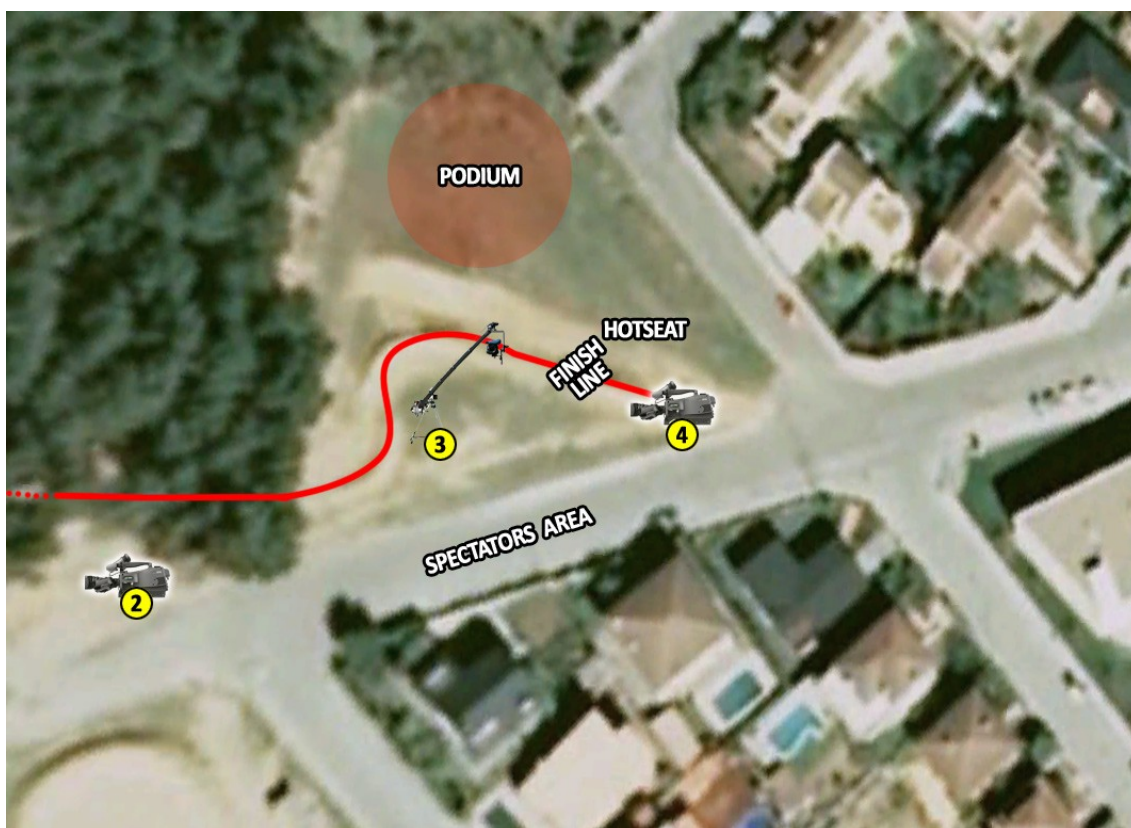


Figura 7.6: Zona de meta del circuit de St. Andreu de la Barca

En la Figura 7.6 es pot veure un detall de la configuració de càmeres utilitzada a la meta. La càmera número 2 cobreix la recta final, la número 3, les dues últimes curves i la 4 l'entrada a meta dels corredors. La càmera 3 va montada en una grua i operada remotament. Aquesta càmera també s'utilitza per a gravar recursos del públic i ambient en general. La càmera número 4 també s'utilitza per a captar els corredors que estan al hot seat. Finalment, aquesta configuració permet que durant que es pugui cobrir també els podis i entrega de premis sense canviar substancialment la posició de les càmeres. És a dir, quan es fa la cerimònia final, només les càmeres 2 i 3 s'han de moure acostant-se a la zona de podis, mentre que la càmera 3, més difícil de maniobrar, manté la seva posició.

Amb aquesta configuració, o molt similars a aquesta, es pot cobrir una carrera amb únicament 4 càmeres. Sempre i quant, en la fase d'edició es munti adequadament, simulant una realització en directe.

## **D.1.2 Carreres de Four Cross**

Les carreres de four cross o 4X són una modalitat de competició de mountain bike relativament nova. Consisteix en quatre corredors que surten simultàniament competint entre ells en un circuit preparat tipus BMX. Sol tenir més nivell i amb terreny més irregular que un circuit de BMX, que és bastant llis. Hi ha salts, peraltes, dobles i obstacles artificials com pedres o troncs, però sense ser tant complicat tècnicament com un circuit de descens pur.

Els circuits de 4X solen ser bastant curts, sobre 1Km de llarg aproximadament. A la Figura 7.7 hi ha representat el circuit de 4X del bikepark de La Poma a Premià de Dalt (Barcelona). Té una distància total de 500m i el corredor més ràpid el completa en uns 36 segons.

A nivell de cobriment televisiu de baix pressupost, les carreres de 4X és la única modalitat que pot ser coberta en la totalitat del seu recorregut. A l'exemple hi ha representat com es podria retransmetre utilitzant 4 cameres. Cadascuna d'elles cobreix una part del circuit.



Figura 7.7: Posició de les càmeres en un circuit de 4X



- **Camera 1:** *Sony EX1 a tríode.* Aquesta càmera capta un enquadrament frontal de la sortida amb l'arc de l'sponsor al darrera. Un enquadrament frontal és necessari per tal de sobreimpressionar el rètol amb els noms dels corredors abans que comenci la carrera tal i com es pot veure a la Figura 7.9.
- **Camera 2:** *Sony Z1 en grua.* És una bona pràctica situar aquesta càmera a la part interior d'una curva del circuit. En aquest cas es va situar en el primer peraltes del recorregut. La grua es mou des d'una posició baixa fins a una alta mentre fa una panoràmica cap a la dreta seguint els corredors. Ofereix una de les imatges més espectaculars del circuit com mostra la Figura 7.10.
- **Camera 3:** *Sony EX1 en tríode.* Aquesta càmera està situada en una plataforma elevada (anomenat practicable mòbil) i cobreix gran part del circuit. S'usa principalment per a fer un enquadrament de seguiment amb un pla general. Està muntada en un tríode amb ròtula fluida per tal d'aconseguir moviments suaus.
- **Camera 4:** *Canon EOS 7D en tríode.* Aquesta càmera està situada a la línia d'arribada i capta un pla frontal del corredor que guanya.



Figura 7.8: Fotografia de la càmera 1 en el circuit de La Poma Bikepark





Figura 7.9: Fotografia de la càmera frontal en el circuit de la Copa del Món de 4X a Houffalize (Bèlgica) retransmès per Eurosport



Figura 7.10: Fotografia de la càmera núm.2 muntada en una grua



Figura 7.11: Fotograma de la càmera 3



Figura 7.12: Fotograma de la càmera 4 a la línia d'arribada

### Consideracions sobre el problema de salt d'eix

És molt important sempre situar les càmeres al mateix costat del circuit per tal de que no es produeixin salts d'eixos. Un salt d'eix es produeix quan dos plans consecutius en el temps mostren els corredors movent-se en direccions oposades. L'efecte per l'espectador és desagradable ja que sembla que l'acció no passi simultàniament ja que es passa a veure els corredors d'esquerra a dreta de la pantalla i llavors en el pròxim pla es veu com passen de dreta a esquerra per exemple. Això passa quan la situació de les càmeres en el circuit no ha estat ben planificada. Cal doncs tenir

molt en compte això i no situar càmeres en costats oposats del circuit sinó totes al mateix costat.

### **Senyal de televisió en directe pels espectadors.**

Una de les càmeres del circuit ha d'alimentar una pantalla de leds situada a l'arribada per tal que el públic pugui seguir el desenvolupament de la carrera als punts on no es pugui veure. Si la distància a cobrir entre la càmera i la pantalla és petita (100m màxim) es pot utilitzar cable de vídeo compost. Si la distància és major cal utilitzar un radioenllaç.

### **Cubrimient del podi**

Just després de la carrera té lloc la cerimònia de podi i entrega de premis. Hi ha per tant molt poc temps per moure les càmeres de lloc i situar-les en una posició òptima per a gravar el podi. Típicament la grua es situa de tal forma que no s'hagi de moure considerablement entre la carrera i la zona de podi. La resta de càmeres és més fàcil moure-les, sempre i quan s'habilitin zones especials i reservades amb antel·lació. En la Figura 7.13 es mostra una foto de la gravació de la cerimònia de podis. La càmera muntada a la grua està equipada amb un objectiu gran angular i dóna plans generals. Les altres càmeres estan muntades en trípodes i capten primers plans dels corredors al podi.



*Figura 7.13: Photo of the crane rig in the podium ceremony*



### D.1.3 Descensos Urbans

El descensos urbans són un cas especial de les carreres de descens que tenen lloc dins de les ciutats en comptes de transcórrer en circuits a la muntanya. És una forma d'acostar l'esport del descens en mountain bike a la gent i fer un espectacle.

Les competicions de descensos urbans tenen moltes similituds amb les de descens pur i les de 4x. Les distàncies a cubrir són molt més curtes que en els circuits de descens, però per altra banda no sol haver-hi tanta visibilitat com a les carreres de 4X. És en aquests circuits on és més important posar una pantalla pel públic a l'arribada. Els requeriments tècnics per a cubrir aquest tipus de carreres són els mateixos que per a cubrir les carreres de descens.



Figura 7.14: Picture of a downtown race

digitalRoot

## D.2 Requeriments tècnics mínims de qualitat

La producció televisiva ha de complir uns certs mínims de qualitat pel que fa tant a la captació de les imatges i del so com a l'entrega de l'arxiu de vídeo final. A continuació es fan un seguit de recomanacions del que es considera acceptable i/o recomanable per a assolir uns estàndards mínims de qualitat.

- **Dispositius d'enregistrament (càmeres de vídeo):**
- Es consideren càmeres adequades les que disposin de sensors iguals o superiors a 1/2".
- Es consideren insuficients les càmeres domèstiques amb sensors de 1/4" o menors.
- **Formats d'adquisició:**
- Es considera insuficient qualsevol format en definició estàndard (miniDV, Betacam SP, etc.) o bé formats massa comprimits (AVCHD) sigui el bitrate que sigui.
- Es considera formats d'adquisició de qualitat mitjana i/o acceptable el format HDV o formats tipus MPEG-2 amb bitrates fins a 35Mbps.
- Es considera formats d'adquisició de qualitat bona i recomanables el següents
  - DVCPRO HD
  - XDCAM EX
  - XDCAM HD 422
  - AVC-Intra
  - HDCAM

## D.3 Entrega dels videos finals

Una vegada acabat la carrera s'entregaran els següents arxius:

- **Selecció de bruts de càmera.** Es tracta d'un compactat de curta duració (10 minuts) que es genera 4 hores després que acabi la carrera. Ha d'incloure imatges dels entrenaments, entrevistes als corredors, imatges de la carrera, podis i declaracions dels guanyadors. Aquestes imatges seran pujades a un

servidor i posades a disposició dels mitjans de comunicació que les demanin per tal que puguin elaborar el seu propi reportatge de l'event. Pel que fa al format de vídeo ha de ser en definició estàndard i el màxim compatible possible. Es recomanen aquests paràmetres a l'hora de generar l'arxiu de vídeo:

<b>Format:</b>	Definició estàndard a 576/50i
<b>Codec:</b>	MPEG-2 Program Stream
<b>Ressolució:</b>	720x576 píxels
<b>Rel. Aspecte:</b>	16:9
<b>Ordre Camps:</b>	Camp Superior Primer
<b>Bitrate total:</b>	CBR a 12 Mbps (Estàndard per SD MPEG-2)
<b>Àudio:</b>	MPEG-1 layer 2 a 384 kbps, stereo
<b>Contenedor:</b>	MPG

*Taula 7.2: Detalls tècnics per l'entrega dels compactats de càmera*

- **Llista de plans.** Document curt en format PDF on hi ha una columna amb el codi de temps (timecode) i al costat una descripció de les imatges, entrevistes, etc. Pot incloure la transcripció de les entrevistes. Serveix per que el mitjà que es descarregui els bruts de càmera pugui localitzar les imatges que li interessin de forma ràpida.
- **Nota de premsa.** Reportatge escrit de la cursa (1 pàgina màxim) que inclou una descripció genèrica del tipus de competició, els resultats, temps, classificacions de cada categoria, i altres dades d'interès de la competició per tal d'informar objectivament i facilitar la redacció de notícies dels mitjans de comunicació.
- **Vídeo final amb qualitat broadcast.** Versió màster en màxima qualitat del vídeo final. Ha d'incloure les imatges, músiques, rètols gràfics, etc. Es prefereix que el format d'entrega sigui MXF amb les següents especificacions:

<b>Format:</b>	XDCAM EX 420
<b>Codec:</b>	MPEG-2 4:2:0 MP@HL
<b>Ressolució:</b>	1280x720 pixels
<b>Rel. Aspecte:</b>	16:9
<b>Ordre Camps:</b>	Progressiu
<b>Bitrate total:</b>	VBR 35 Mbps
<b>Audio:</b>	PCM sense comprimir 16 bits, 48kHz.  Ch.#01 -> Mescla final programa - incloent veu en off (stereo esquerra) Ch.#02 -> Mescla final programa - incloent veu en off (stereo dret) Ch.#03 -> So internacional <sup>55</sup> + entrevistes (no off, no música) (stereo esquerra) Ch.#04 -> So internacional + entrevistes (no off, no música) (stereo dret)
<b>Contenedor:</b>	MXF

Taula 7.3: Detalls tècnics de la versió en alta qualitat

- **Versió del vídeo final per youtube/vimeo.** A més a ñes de generar el vídeo d'alta qualitat s'ha de generar una versió més comprimida apta per a pujar-la a un servidor de vídeos com youtube o vimeo. Els paràmetres òptims per aquesta versió reduïda en tamany i qualitat es recomana que siguin els següents:

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<sup>55</sup> **So internacional:** també anomenat àudio d'ambient; sense música, sense veu en off, àudio net.



<b>Format:</b>	Alta definició a 720/25p
<b>Codec:</b>	MPEG-4 H.264 (codec Mainconcept)
<b>Ressolució:</b>	1280x720 pixels
<b>Rel. Aspecte:</b>	16:9
<b>Ordre Camps:</b>	Progressiu
<b>Bitrate total:</b>	VBR (5,5 Mbps màxim; 4,5 Mbps mitjana)
<b>Àudio:</b>	MPEG-1 layer 3 a 192 kbps, stereo
<b>Contenidor:</b>	MP4

*Taula 7.4: Detalls tècnics del fitxer de vídeo per a web*