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Video system for flight test facilities

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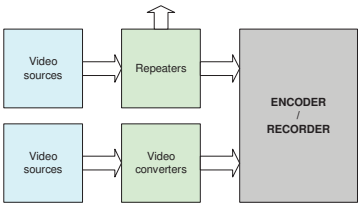
Abstract:
This presentation is a guidance to achieve your video flight test system: All questions you need to answer before beginning.

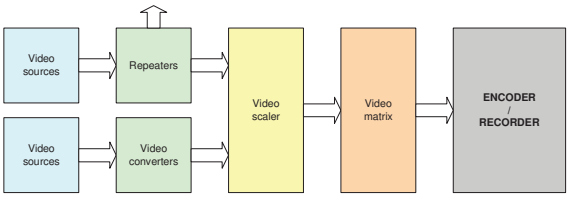
Key words: encoder, recorder, embedded, ARINC818, H264.

From where does the video come?



In your aircraft, you have different video sources with different timing, electrical standard and ~~different~~ resolution. Unfortunately, there is lot of chance that your recorder does not support all these different video sources. So the first step is to add one or more video converters between sources and video recorder. The best approach is to choose standards which are present in public or broadcast products. But you have to think about the distance between all the products, the type of used cable, what you want to do with and finally think about environmental conditions. I want to talk about 3 standards commonly used.
The most common is DVI/HDMI interface because it is simple to use, it support all type of resolution, data are transmit on a RGB 444 format, but it is not easy to carry: 5 meter max in standard, 4 twisted pair, 5 for HDMI, a connector not designed for embedded system and environmental requirements.
SMPTE or HD/SD SDI standards have the advantage to be carried over 100/200meters on one wire and could use copper or optical fibber. But this standard is limited to TV resolution, timings are quite intolerant and the protocol is not very robust because it doesn't use a 8b/10b encoder.
A new standard emerging is ARINC 818 or Avionics Digital Video Bus (ADVB). It has only advantages: robustness, support all resolution you need, long distance because it is carried over optical fibber. But, like emerging standard there is not lot of products and resolution are not standardized. You have to write a document to explain how your data are implemented to ensure cross compatibility between the different users. FO could be a problem too.
One word about criticity, as you know, some of the video present in your aircraft couldn't be cut because the criticity of this video is too important or the company which develops the product doesn't allow the video to be cut. If the calculator which generates this video hasn't any redundancy output, you have a big problem. The only solution is to develop a repeater with a same or higher criticity level and pray for the company which provides the signal agree to be transported threw the repeater and cut the link.

Do I need to switch those video?

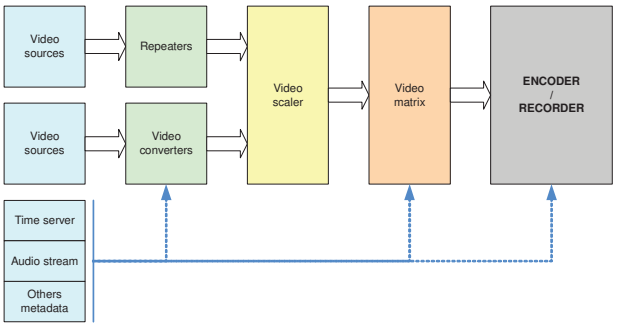


How many sources I have in my aircraft? Do I need to record it all? The most often, the answer is no. To minimize the recorder size and the installation time, you can use a video matrix. It simplifies the wiring which will be done one time. But what's happened when you switch a video by another during the test? How does your recorder react? Unfortunately, I can't answer to this question. It depends of your recorder capability. But, if you do nothing before your recorder, 2 problems could occur. The first one is that video is disconnected during a switch and your encoder/recorder needs to be restarted. So you are going to loose the video during few seconds, time between the stop and restart of your encoder/recorder. It could be acceptable in most of

cases, but in some cases, not. For the latter cases, you will need to synchronize sources with each others to prevent gap or other problems during switching. The second one is: does your encoder detect automatically the new resolution and adapt encoding parameters to this new source? If the answer is yes, there is no problem but if the answer is no you have 2 possibilities:

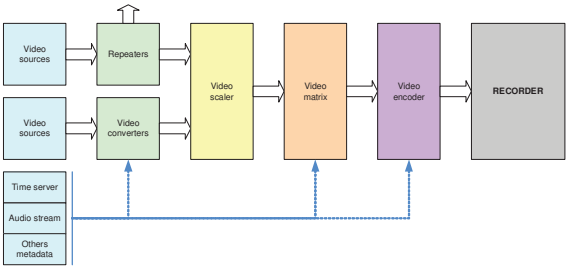
There is an operator who can change parameters but it takes a long time or you have to change the resolution of your video source by a scaler. Scaler is not a synonymous of resizer. Be careful with video resizing, you can distort easily your video content and a **one** could be change in a **seven**. To prevent any problem, Cropping or adding black stripes is a good way to treat avionics video like graphical symbol.

Do I need to enhance those video?



The third step consists in integrating useful information in your recorded video. Time stamping and closed caption are the most popular, but others like audio or information coming from FADEC or others could be important for your application. This information could be transmitted directly to the recorder but, another method is to embed this information in video sources. You can embed data from your video converter or from the video matrix if option is available. Some video protocols like SMPTE or ARINC 818 permit to embed ancillary data. To manage the time in you different system, you can use IRIG-B system but in a network system, I prefer to use NTP or PTP server. Like this, time stamping information is centralised in the encoder and could be dispatched to your different systems. Some of video sources could embed directly the time and other ancillary data as an option. I think it is the best way to time stamp video. Like this you don't add the different products' latency.

How long do I need to record?



Number of video to be record associated with the data stream bitrates is the next challenge. It depends principally on your CPU card characteristics and buses available. Today space and speed are not really a big problem. There are plenty of products and buses available and they are rapid enough for any video system. Be sure however to choose products with the necessary bandwidth. To illustrate this point, the encoder we developed for Airbus' use a compact PCI system and we can encode 48 data stream for a total of 200Mb/s. More recently, TDM had developed a recorder which reach, in writing, 800Mbytes/sec on a 3T Bytes; RAID 5; SSD system.

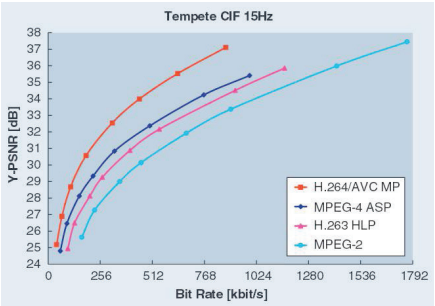
Which quality do I need?

What I want to do with this encoded video? Do I want to survey something in real time or not? Do I only want to record data to see condition if a problem occurs?

In all cases, quality has to be your main requirement. Because quality is associated with 2 parameters: latency and bitrates. Global bitrates is directly associated with the number of video stream, your network and your recording capability. So this parameter is globally fixed by your system.

So you have to choose the good encoding protocol to reach your ratio quality / latency need. I want to add a third item, but I will explain it in other paragraph, it is the standard of the recorded files and the reader capability.

So, if latency is not a problem only the type of encoder and the bitrates will define quality. One more time, be careful with disk capacity and with the network which carries encoded data. MPEG2 and H264 are very common because all the reader decode easily this type of video. But the latency of these 2 encoders is globally high because they use more than one picture to encode data. Only base profile H264 or MOTION JPEG can encode inside a same picture. In those cases, latency is very low but to have a good quality you need to have a high



bitrates.

As you can see on those graphics, if you want to reach the same quality for a CIF video at 15Hz between H264 main profile and MPEG-2 you save approximately 65% of bit rate with H264. ??

I don't find any comparison between H264 multi pictures encoding protocol and MOTION JPEG intra pictures encoding protocol using the same bitrates but you have to believe me, if I say that the ratio is around 3.

In conclusion, the choice is not quite simple and will be pondered. Quality associated with latency is a good approach to determine the standard to use. But don't forget to globalize your integration:

- What is the maximum global data rate I can reach or I don't want to go over?
- What is the latency I need to have? Is video exploited in real time?
- What is the number of output streams by input and the number of inputs?
- What will be the portability of streams?

Do I need to timestamp files?

One of the most popular metadata used is the time stamping. This data permit to synchronise streams during exploitation. You can use different method to enhance video content:

- On Screen Display: this is the most commonly method but not the most easily to exploit in a network or a ground video station.
- TS/RTP protocols are commonly used to transport time stamp but can be lost depending on files type used.
- NAL SEI: this the better way if you use H264 because video and information are in the same structure. Unfortunately, this method is not the most spread and the most easily to implement.
- Other method could be realized in file system and files encapsulation but this method needs a very important computation capacity.

One more thing to note is that most of the common readers like VLC or MPLAYER use only the first image to extract the video time stamp and count the number of image to determine the date. So if your frame rate derives or your file is very long (e.g. more than 10 hours), the time read by your player on your video will be quite inaccurate.

How I can prevent electrical problems?

Embedded systems have others requirements and not the least: environmental requirements.

Temperatures, shock, vibration, EMC are always difficult but, thank you to automotive, industrial temperature component or process are now more easy to find.

One requirement could stay hard to reach if it is not considered early: it is the power supply consideration. This is the list of requirements you have to achieve in avionic embedded system extract from DO160:

- Power input (DO160 –section 16)
- Voltage spike (DO160 –section 17)
- Lightning Induced Transient Susceptibility (DO160 –section 22)
- Lightning Direct Effects (DO160 –section 23)
- Electrostatic discharge (DO160 –section 25)

I haven't got a lot of place, so, I only want to talk about the first one which could be easily managed if it is considered early in the project. The best way is to work directly on the system power supply and integrate, for example, an inverter. If it is not possible you have to work on the recorder power supply and inform your recorder that you are going to loose the power supply to close correctly the files and system files. Files and system files are very important. In few words, the minimum is to choose a journalized file system. Like this, if there is a problem with the current allocation table, you can use a previous one to recover files. If you use SSD or flash device, look at garbage collector and wear levelling specification if you want to ensure writing performances and optimize life time.

Do I need to transmit to ground station or to share video in real time?

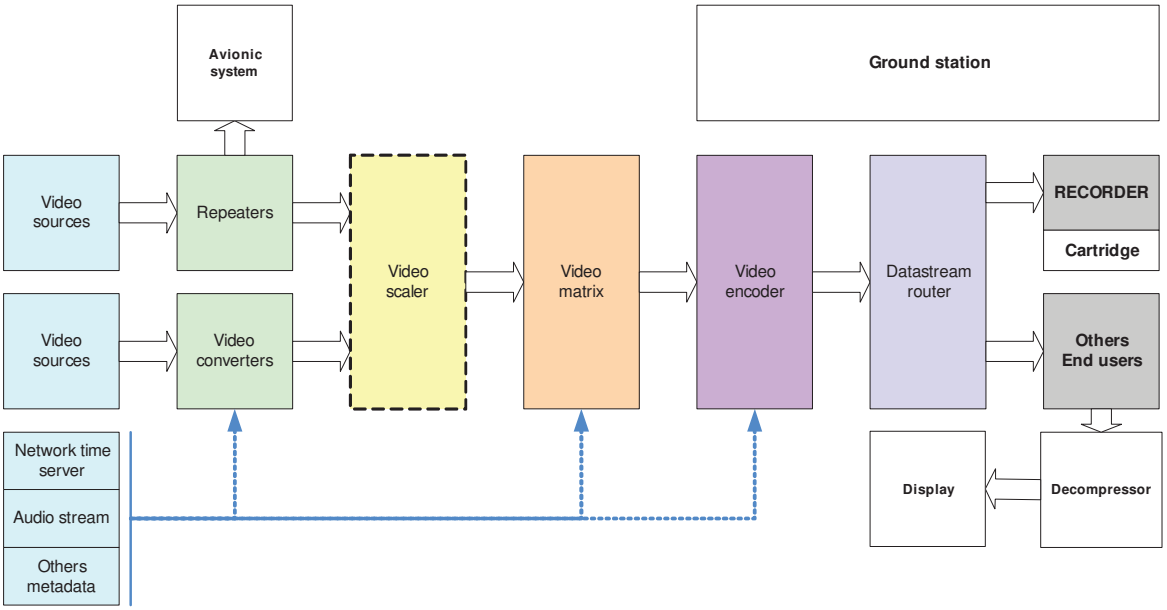
If you want to share this video in real time, either to a ground station or to your flight operator inside the aircraft, data rate of each stream is very important as latency. So the compression method and standard is very important. Make your choice before simplify the routing because it could be done with a simple manageable switch. I want to add an important thing. Stream generated to be recorded haven't be done to be decompressed in real time. By the way, stream packet to be recorded are not cadenced and the player, which decompress the video, does not cadence it anymore. So, in this case, you can see a choppy video. If it is a problem, you have to anticipate this problem and cadenced stream during encoding.

How I can minimize files exploitation time/cost?

The last point is not the simplest one: data exploitation. For example, you record 10 video streams with a data rate of 10Mbit/s during 6 hours. If you make a rapid calculation you obtain 263Gbytes of data. So you can forget the USB stick and if you absolutely want to use an USB2.0 interface to discharge the streams, the mean speed will be 20Mbytes/s and the copy time to your ground station will be 3h45min, more than half time of your test.

An other way is to use cartridge or more powerful links like USB3.0, PCI Express or ESATA.

To minimize the treatment on your ground station files types have importance too. In fact, all operation you will make on each file will takes a lot of time. So, if you have something to retain, maximize the treatment inside the aircraft if you want to minimize exploitation time.



Conclusion

This application is a very heavy installation. I do this to make you aware of the difficulties you can reach if you don't ask yourself all the good questions.
All aircrafts, all practices, all needs, all policies are different and for each of them you may have a different solution.