DIGITAL DATA RECORDING: NEW WAYS IN DATA PROCESSING

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ABSTRACT

With the introduction of digital data recorders new ways of data processing have been developed. The three most important improvements are discussed in this paper:

A) By processing PCM Data from a digital recorder by using the SCSI-Interface our ground station has developed software to detect the synchronization pattern of the PCM data and then perform software frame decommutation. Many advantages will be found with this method.

B) New digital recorders already use the CCSDS Standard as the internal recording format. Once this technique is implemented in our ground station's software and becomes part of our software engineering team's general know-how, the switch to CCSDS telemetry in the future will require no quantum leap in effort.

C) Digital recorders offer a very new application: Writing data to a digital tape in the recorder's own format, allows the replay of data using the recorder's interfaces; i.e. writing vibration data from the host system to tape, using the analog format of the digital recorder, allows the analysis of the data either in analog form, using the analog interface of the recorder, or in digital form.

KEY WORDS

Digital recorders, CCSDS, SCSI-Interface, A/D Conversion, Software De-commutation

INTRODUCTION

With the introduction of digital data recorders in the world of flight test more then ten years ago a new dimension of data capacity and transfer speed immediately became available to flight test engineers. But as these tape devices were not developed for flight test purposes only, a wide range of commercial applications made these devices extremely successful on the market: Video storage, standard data backup, long range data storage, etc.

The general philosophy of a digital recorder is to sample data of a certain data source, store it into a packet, give it a time stamp and then write this packet to the tape device. Because the tape device is essentially a simple porter, transferring the data from the onboard data systems to the ground station's data processing devices, it became necessary to create intelligent interfaces to both the onboard recording system and to the ground station's replay system, to make them compatible with more traditional tape devices. With these interfaces all the data-streams commonly used in flight test (PCM, MIL 1553, ARINC 429/629,analog data,....) may be recorded. This had the pleasant consequence that no changes were necessary in both onboard recording techniques and data processing techniques at our ground station, as the same techniques used in processing traditional tape devices were still valid. Furthermore, at the dawning of this new technology the computer systems were still very expensive and of low performance (as compared with today's computer price/power ratio) and only specially dedicated hardware was able to process the high data rates of the digital tape recorders. Because of these reasons, there was no urgent need to develop techniques to process the data directly from the digital tape.

In the succeeding years the environment has changed significantly:

- Digital recording systems have increased their share of the market, and simultaneously increased both storage capacities and transfer speeds while their price has decreased.

- At the same time demands on our ground station were increased. As the requirement of flexible response to varying rates of flying was imposed, it became difficult to process all the recorded data with an economical amount of time and manpower.

- In an era of industrial austerity, the ground station's budget was incrementally reduced over the years, and it became impossible to master the deluge of data simply by buying additional hardware.

- Perhaps most dramatically, the computing power of general-use computers in the terms I/O performance, through-put and their processing capacity has been grown so rapidly, that any limitation in processing flight test data with standard computer systems is no longer to be anticipated.

Considering the background of the situation as described above, new ways of data processing have been developed at the Flight Test Ground Station of DASA, Manching. To understand our approach, it should be mentioned that the DASA Ground Station is required to handle at most three different types of data:

1) PCM Data (IRIG 106 Standard, up to level 2 and non-standard PCM data)
2) Mil 1553 data (recorded with the IRIG 106, Chapter 8 format)
3) Analog Data (high frequency data such as voice and vibrations)

Additionally, we should stress that we have a more then ten year's experience with various UNIX based systems and only weak experience with Windows-based software.

A third important point is our data processing philosophy: We try to process our data in a very straight forward fashion: From the start of data processing, to the last quality and confidence checks at the end of the process, the operator will not be required to change the graphical interface, the storage medium or

even the computer system. To make data from the tape or from the telemetry stream available to our users, our operators must only perform the following tasks: Insert the tape (in case of tape data processing), select the source and the target device, specify the description format and then start the job. No additional manual operation should be necessary.

Three very different ideas to the new technologies, their benefits and their disadvantages, from our point of view, will be discussed in this paper.

Topic 1) Processing PCM Data from a Digital Recorder by using the Standard-SCSI-Interface.

As mentioned above, a digital data recorder typically offers the possibility to read the recorded data directly from the tape using the SCSI interface. This is because that the new generation of digital data recorders are COTS tape drives, packed into a ruggedized chassis with an intelligent data management system; generally if no SCSI interface is offered by the recorder's vendor, a converter from this specific interface to SCSI will be commercially available. The data management system within the recorder writes the data from the different sources in well defined packets to the tape. The idea to directly process the data from the SCSI interface is seductively simple: Decode the data of the different sources from the tape and interpret it. Some of the recorder manufacturers already offering decoding software, but for our use, the vendor software was unsatisfactory. When using a manufacturer's decoding software, we typically encountered the following problems:

1. The software was Windows based in the most cases.

2. The data retrieved by most vendor software typically dumps the packages from the different sources in internal format to disk, ignoring the logical format of the data. In some cases the packets were filled with additional zero-bits, making it more difficult to interpret.

3. The interpretation of the extracted raw data into engineering units, which is the main task of data processing, still wasn't done.

Because of these reasons we developed software (we call it the SCSI-Data Processing SDP) with the functions as described below in our (SGI-) UNIX environment:

- Decode the packets.

- Decommutate the particular format (PCM frames, MILBUS 1553 Messages, analog records)

- Calibrate the data.

- Perform some quality checks.

- Archive the data.

Although this appears to be very simple, many problems had to be solved in the development phase. There were problems with our various computer systems, which did not accept the onboard tape device. We encountered problems in detecting and handling the synchronization pattern of a PCM datastream. Last but not least we had (and maybe we still have) to struggle with the different errors which may have come from the tape. But reading directly from the digital interface of the tape by SDP we identified many advantages:

- **Cost reduction:** Typically a digital flight recorder is based on a commercial tape device like DAT, DLT, or AIT. To process the data from a digital flight recorder via the digital interface, only this standard tape device has to be purchased. This reduction in the costs to our ground station was often more than 90%; another advantage of the commercial device is, that the computer systems sometimes do not recognize the digital flight recorder as a standard device, but there are few problems with a commercial tape drive.

- Data processing now can be done with every general purpose computer instead of expensive ground station equipment.

- **Time reduction:** Processing the data via the SCSI Interface reduces the processing time!

- Our software although allows parallel processing of the different data-streams on the digital tape. This allows unattended over-night data processing.

- **Manpower considerations:** Because the handling of the digital tape via software is much simpler than classical data processing, training an operator on the software is done within a few days instead of some month's with the traditional method.

- **Security improvements:** Hardware errors become reduced, because the processing chain of ground station equipment is dramatically reduced with the software method.

- Errors induced by the operators (like wrong cable patching) become nearly impossible.

We have identified one disadvantage of the use of SDP: Software, once written, is only valid for a particular tape device or manufacturer. This problem will be treated in the next topic:

Topic 2) CCSDS standard technologies used in digital recorders could guarantee a smooth transition from conventional PCM –technologies to CCSCS technology

As pointed out in the first topic, onboard data processing wasn't changed very much by the introduction of digital tape technology. One reason may be found in the long lasting military projects. When reading the IRIG 106/2000/Appendix L I was very happy to find a first attempt of a basic concept of a tape multiplexing standard for small format media (ARMOR); but for the SDP method this document was not very helpful, because it described the hardware configuration of the ARMOR and some information about the data streams, but no standardization about the internal formats. An more appropriate document in describing structures of multiplexed data streams was found in the IRIG 107-98 Standard, which

originated from CCSDS Blue Book 102. Although this book was written for telemetry applications nevertheless it's contents may be used (and is used by at some manufacturers) for data multiplexing on tape. The disadvantage of IRIG 107-98 (from my point of view) is that it only defines the structure of the internal frames and packets, carrying the data, but the contents of the packets is totally in the user's responsibility. A recommendation for storing PCM and Mil 15553 is given in IRIG 106. On the other hand, this specification allows a smooth transfer from PCM to CCSDS technology: By learning to read the CCSDS packets and frames, by learning how to rearrange the tape information to gather the original datastream, confidence and experience to the CCSDS standard will grow at ground stations. After CCSDS structures and processing software have been implemented in many telemetry ground stations, the acceptance of CCSDS data coming from aircraft telemetry will be very high.

The first both topics of this paper may suggest, that hardware interfaces to the digital recorders at the ground stations may be obsolete in the future. The next topic will exemplify an application, which demonstrates the need for hardware interfaces to digital recorders.

Topic 3) Using digital recorder formats as a standard for data exchange

With the change from the old analog tape technology to the new digital recorders a problem arose: The traditional method of writing high frequency data to an FM-track of the tape wasn't possible any more. To solve this problem only two methods were available:

- Either using an analog interface (A/D Converter) of the onboard recorder to write the data to the digital tape. Or:

- Sample the data within an high speed PCM.

Both ways solve the problem of storing the data. At the ground station, the first method provides you with analog data (using the D/A Converter of the replay unit), whereas the second method provides you with high frequency digital data in a format defined by yourself. Nobody expected any problems in dealing with either method of storing the high frequency data. But surprisingly, in one particular case we had the following problem: We recorded the high frequency data in a high speed PCM with a digital recorder, which had no analog interface. This wouldn't have caused any problems, if the engineers analyzing the data could have worked with data in digital format; but we were required by contractual obligation to provide our customer with FM-data. So we made an D/A-conversion of the PCM Data on a FM-Tape. After the data was output to a strip chart writer everything seemed okay. But after some analysis steps in the frequency range we received strange results. This was because the PCM-replay unit of this recorder returned the PCM-signal not in continuous mode, but in burst mode, resulting in a small jitter in the clock signal. To overcome this problem, we "invented" an interestingly unique method: We first wrote the high-speed PCM to disk in a known format. In a second step another program wrote the data to a tape, which could be read by another type of digital recorder. The format in which this program wrote the data to tape, was exactly the recorder-internal analog format. Now we were able to replay the high speed data in analog format, using the D/A converter output card of the recorder. With the use of this admittedly circuitous method, the letter of the contract could be fulfilled and our customer was happy.

Another customer, who preferred the data in digital format, used the SCSI interface of the recorder an decoded the analog packets to create the format that he needed for his FFT-Analysis. With this method we found a way to provide both customers with either analog data (by replaying it with the specific data recorders interface) or digital data (by providing the user with the software to read the data directly from the tape). So we only have to produce one kind of tape to satisfy both groups of users which makes life and work much easier for our operations team.

CONCLUSIONS

Although the possibilities of the new digital recorders may not be used on the onboard recording side by historical or economical reasons, new data processing techniques could be used today in ground stations improving processing speed, processing efficiency, processing security and processing costs dramatically. In the future, when the onboard data systems are able to compress the data (i.e. by transmitting data as tag and data only on change and using additional compression algorithms) the digital recorders will be able to save much of bandwidth by using the CCSDS or related internal frame formats. A common frame standard for multiplexed data frames and packets accepted by all recorder manufacturers would be very helpful to the customers. IRIG 107-98 is already defining a format of the multiplexed data frames and could be an example of this standard. To bring more efficiency into the recording technology a recommendation for writing analog data or tagged data formats into these frames would be helpful.

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