So You Think Tape is Dead

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ABSTRACT

The times that we live in offers the most advanced pace of technology development ever known to the world, and it is getting faster. A large part of commercial computer technology development is based on increased size and decreased cost of memory devices, from which the instrumentation community can derive great benefit through the development of solid state systems. The procurement cost of new solid state systems utilizing increased memory capability makes the temptation to move to this technology unavoidable. There are, however, some issues that need to be discussed which go beyond procurement costs and involve operational and life cycle considerations.

KEYWORDS

Digital Recorders, Instrumentation Recorders, Solid State Recorders

INTRODUCTION

Tape systems have been the primary, and in most cases, only means of capturing various forms of data for over 30 years. Through the years, capturing of parameters has been accomplished with analog longitudinal systems, which developed over time to the extent possible given the limitations of physics. Digital recorders then came along to meet requirements for ever increasing data rates and capacity requirements. These increasing data rate requirements have been generated by current and future avionics and test

systems, whether they are ground, air, space, or other applications, and are expected to continue to grow. The next logical evolution of recording technology is in the area of memory-based recording, or solid state, systems. Solid state systems are projected to offer increased performance at a lower acquisition cost as compared to traditional tape based systems. Solid state systems can provide benefits for both data and video collection and, at a minimum, will no doubt allow recording of high-speed burst data at a lower cost than is available now. They will also challenge the operational community to consider the effects of the employment of such systems. People responsible for collecting data are and should be joyful of these developments. People in the data processing end of the business need to be careful that they are not overwhelmed by the amount of work that may be generated with solid state recorders. People responsible for both data collection and reproduction need to be careful and make sure that systems being used in their organization make sense for their applications from a technical, financial, and operational viewpoint. All engineers and technicians in government and commercial sectors like new technology and implementation of that technology for useful products. At the same time, there has not been a community who has been more long-suffering for new technology as the instrumentation recording community, but these feelings do not always mean that the best solution for the requirement is the newest solution for the requirement. The remaining portions of this paper will explore considerations relating to the implementation of solid state recorders.

BODY

The decision process to use solid state based systems as opposed to tape based systems must consider the following technical questions:

What is the recurring cost to archive the data?

How many storage modules or tapes will be required over the life of the system?

What is useful life of the system and how long will it be supported?

What commercial standards are the systems based upon?

How does the system record many data sources?

Will the test environment allow the system to function?

What is the risk of tape failure as compared to solid state unit failure?

What is the acquisition costs for the target recording systems?

What is the acquisition cost for the target playback/reproduce systems?

The answers to the above will provide necessary data needed by decision makers to answer the three broad based questions which the final decision (for any program or project) should always be based on:

Of the options that meet the basic system requirements:

What is the life cycle costs for each of the systems?

What is the risk of non-performance for each of the systems?

Do higher priced systems offer additional features that justify the additional cost?

A major consideration of larger programs is the recurring costs for operation over the life of a system. A program such as the F/A-18 at China Lake requires a significant amount of flight test activity. This to both support new software development as well as integration and testing of new and improved weapon systems. The F/A-18 A/B and C/D generates a nominal file size of 3.4 Gbytes per flight test event. The F/A-18 E/F, which is a benchmark for future data collection requirements in the flight test community, generates file sizes of 9.3 Gbytes of data for avionics data alone per flight test event, not including weapons system and radar data. The F/A-18 program at China Lake generates an average of 100 flight tests a month. The data generated from these flights needs to be archived for two or three years. When considering solid state recorders for an application such as the F/A-18 program at China Lake, recurring costs for transferring data from solid state memory modules to mass storage devices must be considered. This process does not have to be considered when using tape-based systems, as the tape itself becomes the mass storage media. With solid state recording, an additional recurring cost will be incurred in the form of labor to transfer data to a mass storage device and to provide for mass storage media. An additional acquisition cost will be incurred to provide for additional mass storage systems that will not be required if tape is used. Though these costs may be minimal on a per flight basis, over the life of a system they may be significant. In the case of F/A-18 at China Lake, additional storage requirements (if solid state recorders were used) will start at 800 Gbytes a month and end up at over 1,200 Gbytes per month. The increase is due to the percentage of E/F flights increasing and the percentage of C/D flights decreasing over time. The design to criteria for the minimum total capacity of the mass storage system will be at least 43 Terabytes. There is an obvious tradeoff to benefits of a solid state data collection system when compared to cost and effort required to transfer and store data on a mass storage system. Solid state systems will no doubt be a great advance and benefit to the data collection community but these benefits may be at the expense of increased post data collection costs incurred by the data processing community.

Another issue is one of the number of storage modules that will have to be purchased as compared to the number of tapes that will have to be purchased over the life of the program. The number of tapes is a trivial figure to determine as it is simply based on the number of test events that will occur. The number of storage modules that will be required is more complex. The number of storage modules will be based on the number of test events that will occur within a certain time frame, how long before the test event is the module required to be in place, and how the module will be used once the test event is completed. Obviously, it will not be required to have a module installed in every recorder at all times as it will only have to be installed prior to the test activity. The number of modules is also dependent on the amount of time required to perform whatever processing is necessary after the test event. The most expeditious approach will be to dump the memory module onto disk and distribute the raw data as required. Other options will be to keep the module and give it to the analysts as required with some cutoff time for clearing and recirculation. It will be inconceivable to use the modules themselves as a mass storage device due to storage cost per Mbyte of storage. It is likely that there will always be more efficient means of mass storage than memory modules. In addition to the above, costs for replacements must also be considered.

The development of memory has gone at such a pace that parts for solid state systems that are two-three years old may be difficult to obtain. There will already be a sunk cost in solid state acquisition as well as unit installation, so new memory modules will have to be purchased if an inoperable one cannot be repaired. These units will be available from the original supplier and that supplier is aware of the law of supply and demand, so memory module costs will no doubt be based somewhat on the replacement cost for the entire system. Memory modules for a specific solid state system will no doubt only be available from the original supplier as they will have patent rights on the interface between the solid state recorder and memory module. This issue is not meant to be negative, but to acknowledge the forces of capitalism, which exist in our society. So the issue is not only how many memory modules will be required with the initial acquisition, but also how long will those modules last and how many additional modules will have to be purchased over the life of the system.

Another issue is what is useful life of the system and how long will it be supported? Memory development is and will continue to advance at an almost overwhelming pace. Memory development has proceeded and will continue to proceed at a very fast pace. There are many companies involved in developing this new technology and they may offer very low cost solutions. Will these companies be in business in two or three years? If they are acquired by other companies will parts and support be available for the installed base? Though this can be said for any company, there are only a limited number of tape technologies that are in use at this time, which represent the culmination of the technology.

A previous example of the point is the beginnings of the mass storage industry. Many companies had their own technology and were eager to sell it. In fact, there were many companies offering many solutions. Over time, several technologies emerged as market preferences based on product acquisition cost, recurring cost, cost per Mbyte of storage, and backwards compatibility. The same will no doubt happen in the solid state recorder business but that will take time.

Additionally, related to the issue of the useful life of the recorders, are the issues of installation and checkout costs related to replacing recording systems and integrating them into aircraft and other test beds. Given the decreased cost of technology in general, it is now often the case that the installation and checkout costs involved in recorder replacement and integration often exceed the acquisition price of the procured system. This is a cost that is often overlooked when considering new systems, but as budgets decrease and requirements increase, the cost of replacing and integrating a recording system into the target test vehicle must be considered in the overall decision making process.

Another issue is one of how different signal paths will be recorded on a recorder. Solid state recorders to date do not allow more than one or two signal paths to the recorder. The technology to record several or many will need to be developed as part of the unit or a multiplexer will have to be used. As most tape recorders come with a multiplexer a solid state recorder that is being used for space advantages may not provide the required solution if a separate multiplexer needs to be included. Additionally, the added cost of a multiplexer will make solid state recording less attractive. In fact, a multiplexer without a recorder often is not much less than an integrated recorder/mux.

Concerning recorder failures, it is a fair assessment to say that the tape technology has matured as much as it is going to given physics and the basics of the technology being used. This technology has evolved to the point where failures are very rare and these systems have proven themselves in the flight test environment. Though solid state systems do not have any moving parts that are the risk in tape systems, the technology is new and does not have a history of operation in a test environment. Therefore, it is premature to say that solid state recorders will have increased reliability at this point. They are unproved at this time but it is probable that they will be at least as reliable, if not more so, than the tape systems in use today given time and development.

Solid state recorders have been successfully used for applications which have low bit rates, low capacity requirements, and/or which are used for special purposes for which a tape based system would not be feasible. Examples of these are in the systems that are used to collect a limited amount of data from aircraft used for operation testing and the

differential GPS systems, known as the Advanced Range Data System (ARDS) which is used by various ranges within the United States.

One way which solid state recording technology is and can continue to have an effect on tape systems is through buffers that are used on most digital recorders. There could be great benefit derived from hybrid systems, which use solid state technology to record data and then use tape to store data on the test platform during or soon after the test. This prospect is an interesting one, which will allow basic development of memory based technology at a pace and in an environment that will ensure operability and reliability. There are several contracts that have been issued for development of solid state technology. Data from United States Government Small Business Innovative Research (SBIR) contracts are available to industry for further research and integration possibilities of memory technology into tape systems. The hybrid approach may allow for development of solid state technology to be built upon the maturity of tape technology. The two technologies, in concert, will no doubt eventually provide for a solution, which may eventually cause the use of tape to disappear, but only after solutions for operational constraints that currently exist for some programs have been eliminated.

After all of the technical issues have been addressed and the requirements defined, the only remaining question is the acquisition costs for the recording and playback/reproduce systems. There are many solutions at various costs for every requirement, but at least the issue needs to be addressed in the initial stages to ensure that the systems being considered can be procured given budget allocations. After all of the issues have been addressed, due consideration can be given to all of the options and the appropriate choice can be made for that application.

CONCLUSION

The issues addressed in this paper are not meant to imply that solid state recorders do not have a future or that they cannot meet test requirement. Solid state recorders do and will have a place in the future of testing, whether it be ground, flight, or for space applications. These issues are meant to bring to the forefront items that need to be addressed when deciding which technology to use. These decisions are based on the fact that the instrumentation community has something it has never had when it comes to a recording medium, a true choice.