Digital Audio Recorders

Life Savers, Educators, and Vindicators

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Introduction:

"Those who do not remember the past are condemned to repeat it" (*George Santayana*). What better records of the past are there than those made by recording devices such as the U.S. Navy's recently developed RD-674A/UNH and RD-681/UNH digital audio recorders?

The use of recorders has increased dramatically as the value of recording devices for training and accident investigation and prevention has come to be recognized by both the government and the private sector. The transition from mechanical-based recorders to Personal Computer (PC) based recorders has greatly increased the flexibility and utility of today's modern recorder. The simple, single-channel audio signal recorders of the past have been superceded by today's complex multi-channel, analog and digital data recorders, which provide multi-channel simultaneous playback

**RD-681/UNH
Recorder-Reproducer**

and recording of both digital and analog data. In addition to the ability to store massive amounts of data, this state-of-the-art technology has allowed the Navy's recorders to evolve from simple documentors of "what was said" to instrumental life-saving tools, educators, simulators, vindicators in the courtroom, and documentors.

Recorders Save Lives. The need to have a reliable state-of-the-art recorder is apparent from today's headlines: *Four deaths have Coast Guard pressing for new equipment*[1] and *Clamboat Sinkings Claim 8 Lives.*[2] The advent of computer-controlled recording technology greatly enhances the capabilities of today's recorders. Current generation recorders now permit a watchman monitoring distress channels to instantly play back a distress call without interrupting the recording process, even as additional voice or data signals are received. Weak, unintelligible signals can be enhanced and amplified by signal processing. This allows search and rescue workers to save lives that might otherwise be lost. Tapeless, magneto-optical drive systems provide immediate playback of data when there is uncertainty concerning the exact message that was received or transmitted. This not only saves precious time that would be lost during tape rewinding, but also allows the operator to obtain information that would otherwise have been lost. All of these features are critical and essential when lives are at stake and time is of the essence.

Enhancing Education and Simulation with Recorders. The Navy uses recording devices as training tools to improve air traffic control operations for both ship and shore-based facilities. Operators are given the opportunity to hear themselves and see the consequences of their actions in replicated scenarios. This enhances readiness by allowing total system simulation, and by providing both individual and team training. Managers and commanders can better measure readiness, identify whether proper operational procedures are being used, and evaluate the

outcome of using those procedures. Recorders offer the opportunity for students to safely learn from their mistakes in an unbiased, objective mode.

DOCUMENTORS AND VINDICATORS – RECORDERS PROVIDE CONCLUSIVE, IRREFUTABLE EVIDENCE. **COMPETENT PERSONNEL LOVE THEM, WHILE INCOMPETENT PERSONNEL LOATHE THEM. WHAT BETTER DOCUMENTATION FOR MANAGEMENT TO HAVE IN AN INCIDENT THAN AN EXACT RECORD OF ACTIONS THAT WERE (OR WERE NOT) TAKEN. MULTI-TIERED SECURITY SYSTEMS IMBEDDED IN THE DESIGN OF TODAY'S NAVAL RECORDERS PREVENT UNAUTHORIZED ACCESS TO THE RECORDED INFORM-ATION, THUS PRESERVING THE INTEGRITY OF THE DATA FOR USE IN ACCIDENT INVESTIGATIONS OR ANALYSES. ADDITIONAL FEATURES PREVENT THE OVERWRITING OF DATA PREVIOUSLY RECORDED ON ANOTHER MACHINE. MODERN RECORDERS CAN ALSO BE SYNCHRONIZED TO A UNIVERSAL TIME STANDARD SUCH AS GLOBAL POSITIONING SYSTEM (E.G., HAVEQUICK TIME). THIS ALLOWS PLATFORM-UNIQUE DATA TO BE RECORDED AND PLAYED BACK IN SYNCHRONIZATION WITH RECORDING SYSTEMS IN OTHER LOCATIONS, THEREBY IMPROVING TIME-SENSITIVE ACCIDENT INVESTIGATIONS. RECENT HEADLINES ("*NAVY DESTROYER HEAVILY DAMAGED IN COLLISION WITH CONTAINER SHIP*"[3]) HIGHLIGHT THE NECESSITY FOR ACCELERATING THE INSTALLATION OF RECORDERS ON ALL NAVY SHIPS AND THOSE IN THE MERCHANT MARINE AS WELL.**

USS *Radf*

A Successful Recording System Merges Technology Integration with Human Factor Requirements. Today's explosion in technology poses new challenges to the system integrator of recording devices. It is not only prudent but also absolutely necessary for the system integrator to take into consideration the variety of technologies in conjunction with the intended application and associated human factors. For example, consider the recording media available today. They range from magnetic tape, to flash memory, to magneto-optical disks and beyond.

The selection of the recording medium will impact the operational and maintenance characteristics of the equipment. Selecting magnetic tape increases the time required to access data. If access to data is time critical, magnetic tape is probably not the proper media selection. Magnetic tape's impact on maintenance can be significant as well, with tape alignment, head wear, and capstan degaussing being all too common. Magnetic tape is also susceptible to temperature and humidity and generally requires storage in an environmentally controlled space. However, magnetic tape offers vast amounts of data storage at a moderate cost. Typical digital cassette tapes can archive 50 gigabytes of data. If your application is archiving data, magnetic tape may be a useful medium.

The magneto optical (MO) medium offers immediate access to data with a reasonably high storage capacity (5.2Gbtyes). MO has the added advantage of low maintenance: there are no

heads to wear out and it never requires tape alignments or degaussing. And MO is much more durable and less susceptible to environmental conditions as compared to magnetic tape.

Flash Memory stores data in electronic chips and offers instant access to data with no maintenance. There are no moving parts in flash memory. The disadvantage to flash memory is its limited storage capacity. Improvements in flash memory technology will most assuredly increase today's storage capacity. Flash memory may be the preferred device for short-time storage (refer to Table I, below). It has many possible applications, such as in the crash recording system for the trucking industry.

TABLE I. COMPARISON OF RECORD MEDIA

Recording Medium	Capacity *	Advantages
Magnetic Tape	50 Gbytes	Large storage capacity, allows for multi-head synchronized recording.
Magneto Optical	5.2 Gbytes	Environmentally durable, low maintenance, immediate access to data.
Flash Memory	64 Mbytes	No moving parts, no maintenance, instant access to data.

Subject to change with improvements to technology.

The variety of recording media available today presents unique technical challenges. Earlier recorders incorporated multiple channels into their recorders by employing multi-head systems that were basically several recorders in one. To play back multiple data channels in synchronization (with respect to time) merely involved replaying the tape. Today's typical multi-channel recorders only employ one record-reproduce head. This makes synchronization critical and technically challenging. For example, how do you play back multiple data channels with only one record-reproduce head and make it appear there are multiple heads? One hearing study[4] showed the temporal order identification thresholds (TOT) for the human ear to be on the order of 10 msec. This TOT threshold means that with practice or repeated playbacks, humans can detect a shift in time between two audio events. If the listener has to make an interpretation of the audio events, this threshold may be even longer, but how much longer? We may be able to derive the answer from the Federal Aviation Administration (FAA) specifications that allow a 250ms delay[5] from the time the operator keys a microphone to the time the signal is radiated to the plane. This could be considered an acceptable TOT upper limit. Since operators will not always be discerning audio events that require interpretation (e.g., two people talking) from those that don't (e.g., an alarm), playing back different audio events within 10 msec or less should be the targeted threshold, to avoid a misinterpretation of any audio event. This audio relationship is compounded as the number of channels played back increases. Other challenges include synchronizing recorded digital computer information with audio channels.

Human factors play a significant role in integrating technology available today, from both an operational and technical perspective. Operationally, ease of use is important to those monitoring distress channels that require repetitive playbacks. Simplicity, with the fewest number of keystroke to retrieve data, is paramount. Yesterday's systems had that simplicity - "stop, rewind, and play" - but lacked the enhancements required of today's recording devices.

For example, to enhance weak, unintelligible transmissions requires timely signal processing. Tangential issues now surface, such as whether a recording device should filter the signal prior to presentation to the operator or play it back for the operator as the operator heard it and then filter the signal to be replayed again. The method of integration affects not only response time, but operational procedures also, and may well affect its admission in a court of law. It would be unfair to admit "processed audio" into an incident investigation when an air traffic controller or any operator had made judgements based on unprocessed transmissions.

Magneto Optical - Data Storage for the 21st Century. Today's smart recording systems offer greatly increased storage capacity over tape systems of the past. The reel-to-reel recorder of yesterday ran continuously, 24 hours a day. They recorded even when no audio was present. Now, smart recorders, such as the U.S. Navy's RD-674A/UNH and RD-681/UNH, record only when audio is present. These recorders can discern between noise and audio and so only record when audio is present. All audio is time tagged, and "dead time" is not recorded. Thus the recording media (magneto optical disks on these recorders) are capable of storing up to ten days worth of information on a single disk. Some of the other benefits of using MO drives and disks for recording are: no environmentally controlled storage requirements, limited mechanical parts, and an absence of read-write heads contacting the media. MO drives and disks are also capable of thousands of read-write cycles and provide immediate access to recorded data since there is no need to rewind tapes.

Better Products and More Capability for Less Money. The Navy's RD-674A/UNH and RD-681/UNH recorder-reproducers are more reliable and require less maintenance and training than their obsolete, mechanical, reel-to-reel predecessor. As this new family of recorders was designed on nearly 100% incorporation of commercial-off-the-shelf (COTS) equipment, they are relatively inexpensive to acquire and are much easier and less costly to support and maintain throughout their extended lifecycle. To ensure the recorders would be rugged enough to withstand shipboard (Marine) and wartime conditions, they were shipboard shock and vibration qualified. They are PC-based systems with a Windows 95 operating system, are user-friendly with touch screen functionality, and require no special off-site classroom training. A computer-based training (CBT) module on CD-ROM is provided with the system. As with most PC-based systems they are extremely reliable, require minimal maintenance and can be easily upgraded to take advantage of the latest technology or to adapt to changing requirements. The Navy's RD-674A/UNH and RD-681/UNH Recorders have other failsafe features, such as alarms to indicate that media capacity is about to be exceeded or power has been lost, automatic switching to a back up power source, and the ability to search for a particular voice recording by time or channel.

Recorders - An Ounce of Prevention. Data recorders have evolved from simple data logging devices to sophisticated, versatile and essential tools capable of saving lives, training personnel, and aiding in accident investigation and prevention. The technology explosion has made available numerous options that require careful scrutiny before their integration and implementation into recording devices of today. Careful consideration needs to be given to the technology, to human factors, and to the application for which the recorder will be used. Since the current information revolution requires quantum increases in technology and in the speed at

which information is processed, there is only one thing we know for sure –recorders of tomorrow are sure to bring new uses, provide new challenges and require even more advanced technology.

Acknowledgments:

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Biography:

Mr. Matthew Durkin, NAWCAD (4.5.8.3). Mr. Durkin received a BSEE from the University of Maryland in 1982. He has over 13 years experience as a Government engineer for projects involving the test and evaluation of both cooperative and non-cooperative Identification, Friend or Foe (IFF) systems and for shipboard and shore-based air traffic control display, antenna and recording systems. He is currently a Senior Project Engineer with the Naval Air Warfare Center Aircraft Division and manages projects to transition technological advances into the Navy's shipboard Command, Control, Communications, Computers and Intelligence (C^4I) systems.