THE AIR FORCE JUNIOR ROTC DIGITAL VIDEO DISK INITIATIVE

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Abstract. The U.S. Air Force Junior Reserve Officer Training Corp (JROTC) staff is upgrading its training program to better leverage the advantages provided by today's emerging technologies. The present system in place at over 600 training sites throughout the country relies on the coordination of several media (i.e., print, videotape, film, and videodisc) elements in the delivery of instruction. The recent emergence of Digital Video Disk (DVD) technology provides the potential to consolidate the various media into a single delivery platform. Of particular significance to the Air Force is standardization of delivery and the portability afforded by this technology.

The development approach capitalizes on the availability of Commercial-off-the Shelf (COTS) hardware and software, and instructional content provided by the Air Force in producing a prototype lesson incorporating the latest advances in bar coding and DVD technology. The prototype system contains a graphic user interface that allows the instructor to display and control the content and flow of instruction, and to record relevant personal notations in support of the instructional content. Updates to the Instructor Guide stored on the system hard drive, will be achieved by delivering changes and updates via the Air Force JROTC "Cyber-Campus" network.

This paper describes the DVD-ROM prototype development effort, identifies DVD-ROM hardware and software requirements, and describes significant technological challenges encountered during development and the methods developed to resolve them.

Biographies. Ms D. Jule Zumwalt, GM-13, is the Educational Advisor for AFJROTC. She has 38 years in the field of education (18 years at the high school and college level), and served as both a Regional Director of Aerospace Education and National Director of Aerospace Education for the Air Force.

Major Steven Soller, USAF, is Chief of the Programs Branch and former Chief of the AFJROTC Junior Curriculum, and is the creator, and administrator of the AFJROTC "Cyber-Campus" Intranet. His development and implementation of the "Cyber-Campus" earned him recognition as one of *Federal Computer Week'* prestigious **FEDERAL 100**, a selection of the 100 Information Technology executives that had the greatest impact on government information technology for 1997.

Dr. Richard Smith is AmerInd's DVD Prototype Project Manager/Instructional Designer. He received his doctoral degree (Ed.D.) in adult education from Nova Southeastern University. He coordinates the activities of the team members and ensures the design philosophy for the DVD-ROM program incorporates sound, educational strategies and methodologies for the delivery of instruction.

Mr. Gerard Foret is AmerInd's lead graphic artist and graphic user interface designer. He has extensive experience coordinating and designing static, animated, and 3-D graphic and video materials for application across a wide range of content areas.

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CURRENT STATE OF TRAINING

Delivery Modes

The Air Force Junior Reserve Officer Training Corps (AFJROTC) currently uses textbooks with accompanying workbooks for students and an instructor guide. Prior to the AFJROTC expansion period (up to 1993) this was an acceptable classroom teaching process. From 1993 to 1996, AFJROTC went through a congressionally mandated expansion from 320 to 609 units. Since the expansion, our audience has changed dramatically due to the introduction of our program into a larger proportion of inner-city and at-risk high schools. At-risk schools are those with high drop-out, community violent crime, and subsidized lunch rates. Much of the difficulty we have experienced is due to the sociological changes in our cadet population (which has nearly doubled) and the fact many cadets are not reading at grade level. In fact, some are reading at the elementary grade level. This has caused tremendous frustrations for our instructors who are attempting to teach both accelerated/gifted students, and students with special needs such as low reading levels. The instructors' methods of delivery have required significant changes to keep pace. To assist them, we have started to provide additional videos to supplement the texts, which require extra lesson planning time to integrate, for instructors who are already spread thin.

The new block scheduling formats (there are several) further complicate traditional lesson delivery methods. Normal lessons have to be expanded or chopped-up due to block scheduling conflicts.

The use of an interactive Digital Video Disk Read Only Memory (DVD-ROM) program allows our instructors to use our current texts and supplemental workbooks. These texts are approved by the various school districts. DVD-ROM also gives them enhanced learning effects to present the curriculum lessons in an new and exciting way.

Through the DVD-ROM program, our instructors are readily able to present the lesson in an organized instructional format and quickly able to continue the lesson where they stopped during the previous class. Enhancing the students' attention span and comprehension level when dealing with some very difficult materials ensures that effective teaching and learning take place.

Instructors

There are over 1400 instructors at 609 units in 49 states and 8 foreign countries in the AFJROTC program. These instructors are all Air Force Officers and Non-Commissioned Officers (NCOs), who have retired from the military with from 15 years to over 30 years of service.

Each AFJROTC unit is required to have at least one retired officer as the Senior Aerospace Science Instructor (SASI), and one retired NCO as the Aerospace Science Instructor (ASI). Larger units have additional instructors as needed.

Currently most of our instructors use the platform method of instruction they experienced while on active duty. In addition to their active duty experience, some instructors have regular secondary special subject teaching credentials.

Existing Media

AFJROTC needed to have teaching materials that facilitated the delivery of course content to a very challenging and diverse audience. Many of our instructors are still augmenting training using a mixture of slides and 16mm films, along with videotape. This method of delivery is ineffective with students who have grown up with computers and video games.

Prototype

Initial investigation of potential solutions to enhancement of course delivery centered on two options: Laser Disk or CD-ROM.

Laser Disk was used successfully by the Naval Junior ROTC program, delivering content similar to that required in the AFJROTC program. Laser Disk allowed a large amount of electronic information, including large-scale video sequences, on a single media. The cost to implement (purchase of both hardware and media), as well as future compatibility issues made this solution problematic at best.

Several CD-ROM products (Microsoft Flight Simulator, and Space Simulator) had already been purchased for the AFJROTC program, with good results. A CD-ROM hardware infrastructure was already in place, with new computers being purchased for the program with CD-ROM drives already installed. But, CD-ROM did not have the necessary storage capacity to allow for the amount of material needed for electronic delivery of support materials for even one course. Multiple CD-ROMs would be required.

Fortunately, a third option arrived on the scene during these discussions. DVD-ROM became commercially available. With a higher storage capacity than Laser Disk, and the ease of use, hardware support, and compatibility with existing CD-ROM programs, DVD appeared to be the answer to our AFJROTC course delivery problem.

Another question, that of keeping course material up-to-date, was solved through a second AFJROTC initiative: The “Cyber-Campus”.

Cyber-Campus

With the advent of our Cyber-Campus Intranet, for the first time, the AFJROTC program had a means to disseminate information quickly, easily, and cheaply.

As a secure sub-area within Military City Online, an area within America Online, the Cyber-Campus is divided into four functional areas: The School Office, Library, Conference Center, and Teacher Lounge. These areas allow messages to be left for review by Headquarters and units, on-line discussions and classes to be held, and files to be available for download and use throughout the program. The Cyber-Campus provides all units with e-mail capability and Internet access.

Since AFJROTC is an educational program, the Cyber-Campus provides the key to long term success in delivering our main product, the Aerospace Science and Leadership Education course materials.

Written materials can be properly formatted for electronic media, and are uploaded into file libraries for units to download and use. But simply supplying the same information, in a different delivery vehicle (i.e. electronic versus print), is only part of the solution. The Cyber-Campus opens the way to easily deliver electronic curriculum products (audio, video, still photos, graphics, and animations). It is the means whereby future AFJROTC curriculum initiatives, such as the Air Force Junior ROTC DVD-ROM program, can continue to be kept up-to-date economically, without having to frequently distribute to each unit changes and updates to digital videodisc course material.

Updates can be distributed electronically by the Cyber-Campus to ensure our courses contain the most current information. These updates are delivered electronically to each unit and stored on the computer hard drive. This functionality is built into the AFJROTC DVD system. Instructors will be able to access all types of electronic materials such as lesson plans, graphics, articles, publications, and World Wide Web (WWW) links for reference in their classroom.

By using our curriculum materials and the proposed DVD-ROM program, with bar code reader support, rapid retrieval of material for immediate reinforcement of learning is possible. This form of learning is very exciting to the cadets and will keep their attention focused.

Selection of Prototype Content

The AFJROTC textbook, *AEROSPACE SCIENCE: The Exploration of Space* was selected for prototype development for two primary reasons, time and money. We used a previously developed Interactive Videodisc (IVD) program on Astronomy developed for the Navy's JROTC program to ensure completion of an AFJROTC prototype in less than 90 days. Use of the Navy's title reduced research and development costs.

WHY DVD?

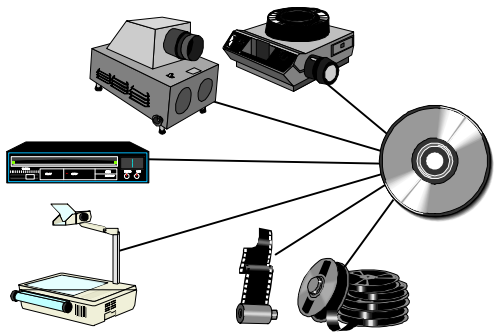
DVD-ROM increases storage capacity, unifies media, provides ease of use, increases interactivity, and heightens visual impact.

Storage Capacity

Legacy-based CD-ROM and Interactive Videodisc (IVD) programs provide the capability to deliver visual support media but have limited storage capacity. A CD-ROM has a capacity of 650 MB while a single-sided dual-layer DVD-ROM has an 8 GB capacity. A Constant Angular Velocity (CAV) IVD can store 30 minutes of linear motion per side while a single-sided dual-layer DVD-ROM (utilizing MPEG-2 compression) can store over 7 hours of linear motion.

Unified Media

Currently, AFJROTC instructors use multiple media resources, as described previously, to present their instructional programs. The media may include segments on videotape, slides, transparencies, maps and charts, and print-based handouts over the period of an individual class, course, or year-long program. DVD-ROM integrates all media into a standard MPEG-2 dataset. In fact, it is possible to place the AFJROTC's four-year curriculum on a single dual-sided, dual-layer DVD-ROM.



Ease of Use

Trainers who are competent using a PC as an instructional and administrative tool will be able to transition to DVD-ROM with a minimal learning curve. Navigation through course content can be implemented using the Windows standard point, click, and drag metaphor or using bar code scanning technology.

Increases Interactivity

With all course material readily accessible, the ability to easily transition between related subjects allows the instructor more options when teaching relationships between topics. Interactive gaming, such as content related "Jeopardy", allows trainers to conduct subject reviews in an exciting, attention grabbing, and competitive manner.

In addition to developing chapter 1-1 from the *AEROSPACE SCIENCE: The Exploration of Space* textbook for the prototype effort, we created an interactive lesson review, quiz, and timed game. The lesson review covers materials taught by the instructor in the classroom. This review can function at the classroom level or be made available to individual students for self-study. The multiple-choice quiz is used to measure student retention. The timed game allows up to four teams or individuals to compete by testing their knowledge of lesson content.

Visual Impact

The ability to present high-quality, full-screen, full-motion imagery in support of an instructional concept has a great impact on retention and comprehension. The MPEG-2 compression algorithm (the same compression used by Direct Satellite Systems (DSS)) provides the ability to store, retrieve, and manipulate this imagery for delivery through the computer screen and/or a television or video projector.

DVD TECHNOLOGY REQUIREMENTS

With moderately priced high performance Windows/Intel (WINTEL) based computer platforms being made available to classroom instructors on an ever increasing scale, most tools and skills necessary to implement DVD media supported instruction are already in place. Many major manufacturers are delivering DVD equipped Personal Computers (PCs) in lieu of

CD-ROM based systems. All that is needed to complete the DVD classroom scenario is the availability of instructional titles designed to exploit the capabilities of this robust new media.

The following paragraphs describe the hardware and software requirements necessary to implement a DVD-ROM supported instructional program. Also included are hardware requirements for selecting bar coded non-linear media.

Hardware

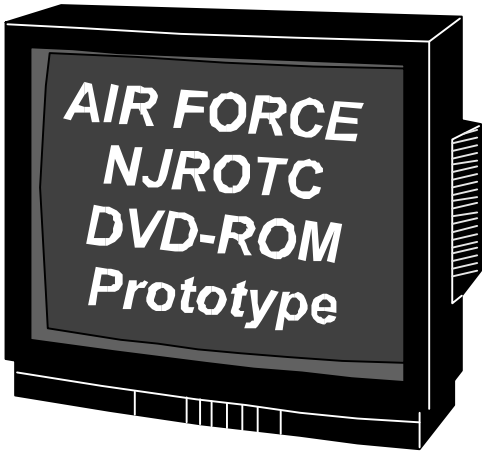
For DVD-ROM, a DVD equipped personal computer running an operating system (OS) that is compatible with the OS specified by the developer is used (e.g., WIN/TEL (95/NT/3.11) or Apple/MacIntosh). The minimum recommended hardware requirements for delivering DVD-ROM through a Windows 95 platform are:

133 MHz Pentium Processor
32 MB Ram
DVD Drive
MPEG-2 Decoder Card
Speakers (for audio output)
5 MB of free hard drive space

Currently available DVD-ROM upgrade kits provide the drive, decoder card, and all cabling. Most kits also provide the ability to send the output directly to a television as well as to the computer's monitor.

The following is recommended for classroom delivery:

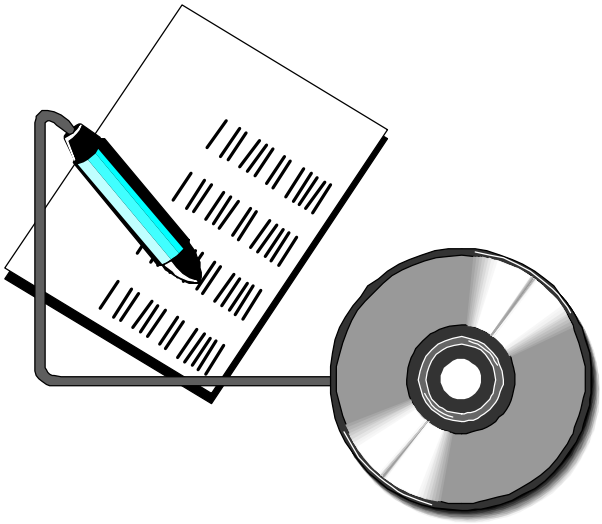
32" television with audio/video inputs (s-video optional)
RCA to RCA video cable



The DVD prototype uses bar code technology for media navigation and selection and requires the following additional hardware:

Bar Code Scanner with Wedge

The bar code scanner connects to the computer via the keyboard and facilitates rapid retrieval of visual media by way of scanning bar codes found in the instructor guide and/or bar code manual.



Software

The DVD-ROM upgrade kits or computers shipped with DVD players include all necessary drivers and utilities. Any additional functionality is embedded in software provided by the title/content developer. For example, in this prototype, the software driver required for bar code operation is included.

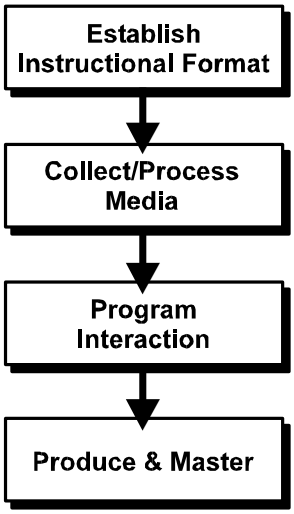
Media (content)

In addressing classroom instructional support needs, one of the most useful features of DVD-ROM is the consolidation of assorted presentation materials (transparencies, slides, photographs, articles, video, etc.) into a standard uniform media. The end-user works closely with the content developer converting existing materials as well as defining and developing new materials. The end result is a DVD-ROM containing a dataset of all instructional support media needed. The ability to retrieve, deliver, and manage this dataset is governed by the functionality of the content title. The manipulative abilities built into the title can be as simple as clicking the mouse button to advance to the next visual, or as

complex as a database driven, CMI enabled CBT course. Thus, the DVD-ROM title is not only responsible for storage of visual support data, but also provides the interaction and management functions needed to make DVD-ROM a complete solution for classroom media delivery.

DVD PROTOTYPE

When developing content for instructional DVD-ROM delivery, new methods and processes must be implemented. While some current CD-ROM development tools can be used, certain capital expenditures cannot be avoided due to the authoring, encoding, and mastering requirements for DVD-ROM production. Where differences exist, they will be described.



Establishing Instructional Format

An instructor does not have to change the way he or she administers instructional content to use DVD-ROM. To take advantage of the bar coding capabilities built into the prototype a new instructor guide is produced. A bar code, referencing a particular media clip, is added to the traditional instructor guide. Also, an ancillary bar code manual is produced that consolidates all the bar codes into an easy to use reference.

Because all support media resides on a single disc, the traditional linear sequence of instruction can be broken. For example, impromptu reviews of covered topics can be achieved by simply scanning a bar code rather than retrieving and loading a previously viewed video tape sequence. The time required to retrieve and return various media resources to a central repository can now be used for instruction. This is just one example of how DVD-ROM can be tailored to supplement and enhance existing instructional programs.

Lessons learned: Existing interactive instructional development models can successfully be used in developing the instructional format for DVD-ROM training titles.

Collection/Processing Media

The consolidation of the existing media resources into the unified DVD-ROM title presents several hurdles and requires an understanding of the MPEG-2 encoding process. MPEG-2 encoded data provides the ability to deliver high quality imagery through a complex compression/ decompression (CODEC) system. This compression is usually accomplished by utilizing dedicated hardware. However, MPEG-2 compression can be achieved via software compressors with the compromise being additional time and computer resources required.

Nowhere is the adage “garbage in, garbage out” more appropriate than in the encoding of MPEG-2 content which provides the unification of the dataset. The ability of MPEG-2 to deliver full-screen full-motion video sequences is the result of a compression algorithm utilizing consecutive frame delta information. In other words, when compressing sequential frames in a video stream, the first frame is analyzed, and compressed based on the total pixel information contained within the frame. The next frame is analyzed, and any pixel change from the previous frame is compressed and stored. This pixel change from frame to frame is referred to as delta and is the basis for the achieving such high compression rates. The drawback of such an algorithm is that any pixel changes between consecutive frames is perceived as delta information. The more change between frames, the more data that needs to be compressed and stored. While MPEG-2 compression can generate high quality output, it is considered a “lossy” (data is altered or removed) compression scheme. The most obvious tradeoff in MPEG-2 encoding is that artifacts are generated and included in the final output as a result of excessive delta. These artifacts appear as blotchy areas in the output.

This presents a problem when incorporating archival video material into a DVD title. Any abnormalities in the source footage (i.e., video noise, weak signal, dropouts, tears, etc.) are

interpreted as delta information and subsequently encoded and stored. Care must be taken to obtain and preserve the highest degree of quality when utilizing archival footage.

Still images and computer generated animation sequences do not present problems with delta-based artifacts. Still images do not generate delta, and computer generated animations are encoded directly from their digital source files, bypassing the noise issues associated with analog video systems.

Line art, still graphics, maps, charts, photographs, etc., are easily cleaned, scaled, and/or reproduced in a resolution and level of quality sufficient for DVD-ROM delivery.

Audio information is easily digitized using COTS hardware and software and encoded into the AC-3 format.

Lessons Learned: Quality of source material is vital to the successful conversion to the MPEG-2 format. The developer must 1) obtain original or first-generation video sources and 2) when high quality footage is not available scale the video to a size that masks flaws and composite footage onto appropriate sized background thus reducing artifacts.

Programming

Due to the standard file format (ISO 9660), most methods and techniques used in the development of computer-based training (CBT) can be adapted to DVD-ROM.

***Authoring* –** There are many COTS authoring systems on the market today that may be used to develop a DVD-ROM program. The authoring system provides links and a relationship between assorted source files (stills, animations, and video). It also defines the functionality of the user interface.

Bar Coding – Again, there are COTS bar code software programs that may be used to develop the bar codes. The bar codes provide a means to retrieve specific audiovisual content. The functionality of the bar code input/output is managed by the authoring system.

Lesson Learned: Not all COTS authoring tools provide DVD-ROM support. Of those that do support DVD-ROM, each only provide partial support and additional programming savvy is required to circumvent this obstacle. Investigate COTS authoring tools carefully before selecting, and ensure DVD-ROM support prior to commitment.

Production and Mastering

Producing the DVD-ROM involves constructing the user interface and authoring the title using COTS authoring system. Any additional media requirements are addressed and produced by the graphics art department. Graphic clips are MPEG-2 encoded and added to the media list. The links providing the relationship between media clips and the interface are constructed. In the case of a bar-code scanner equipped title, the programming for scanner control is performed. The title is then tested for proper operation and any issues regarding interface functions and content flow are addressed and corrected.

Until the material is ready for mastering, it resides on the development systems (developer's PCs or Local Area Network (LAN)) as a set of digital files interconnected with links provided by the authoring system. For DVD-ROM based mastering, there exists organizations that will take your computer data, usually stored in an ISO 9660 file format, and create DVD-ROM titles directly from this source. There is also software that will create the Digital Linear Tape (DLT) format used for final replication as well as COTS DVD recorders that will allow the in-house production of an actual DVD-ROM checkdisk.

Lessons Learned: The facilities which provide mastering and replication services are evolving, and the current interim formats used to deliver source data to mastering and replication facilities change regularly. The most stable method of delivering content source data for checkdisk mastering and final program replication is via the Digital Linear Tape (DLT) format.

EVALUATION RESULTS

Instructor Comments

Recent survey results of needs, obtained from our instructors at re-certification workshops indicate we have a reading deficiency problem in our cadet population. Trainers must spend considerable time in obtaining materials and preparing instruction to accommodate this deficiency. The DVD-ROM program will greatly

reduce wasted man-hours and enable the instructor to focus on content rather than delivery methods.

Student Comments

We anticipate the students will be excited about this new form of delivery. Because the DVD-ROM program is interactive, the students will see this as fun and will not realize how much they are learning.

Future Plans

In the near future, the Commander, AFROTC will be reviewing the progress of the AFJROTC DVD initiative, and we expect the final go-ahead to proceed with field-testing.

Field-testing is projected for the August through October timeframe. It will include a number of AFJROTC units, with the SASI, ASI, and cadets taking part. Comments and suggestions from these units will be consolidated, and changes made based on this feedback.

After these changes are incorporated, a final version will be produced and plans will proceed for general implementation of the DVD-ROM media for course delivery throughout the program.

SUMMARY

Conclusions

The technology is now available. The current trends in new computer sales show that CD-ROM equipped PCs are being replaced by systems containing DVD-ROM components. Additionally, after-market sales of DVD-ROM upgrade kits continue to grow. With this market growth, the ability to provide thought provoking, student stimulating, interactive instructional content dramatically increases.

DVD-ROM, with bar code support, is a dynamic instructional tool that can be used in the classroom today. A DVD-ROM title can 1) unify media to reduce instructor preparation time, 2) facilitate non-linear instructional methods, 3) provide near instantaneous access to DVD-ROM based source materials, and 4) stimulate learning by delivering high-impact, full-screen, full-motion imagery.

Recommendations

Economical replacement of traditional media is now possible by using DVD-ROM titles. Training departments should begin developing contingency plans focused on conversion of current instructional support materials to a unified format, such as MPEG-2. The migration of training to a totally electronic classroom has already begun, and a unified dataset provides the basis for an instructional network enabling global utilization of training support materials.