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**SBIR PHASE I: COMPUTER-BASED TRAINING (CBT)
FOR CORROSION CONTROL**

**Final Technical Report
Comprehensive Report of 26 May - 23 November 1994**

Prepared under Contract Number N00019-94-C-0144

for

**Naval Air Systems Command
Naval Aviation Training Systems Division (PMA-205-2L)
Department of the Navy**

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ABSTRACT

This Research and Development (R&D) study was conducted in the use of advanced instructional technology to introduce Interactive Courseware (ICW) into naval aviation maintenance classroom training. The goal was to design an innovative computer-based instructional system in the area of corrosion control for naval aircraft. Technautics was tasked to evaluate existing interactive authoring systems and naval aviation corrosion control training courses. The research described in this report defines a better approach to using multimedia in ICW. It presents integrated media and planning techniques for providing effective multimedia in a computer-based training system that is uniquely focused on corrosion control training.

Evaluation of existing naval aviation training revealed that even though corrosion is having a tremendous impact on the service life of aircraft and the corrosion control curriculum evaluated in Phase I is one of four mandated by OPNAVINST 4790.2E, Naval Aviation Maintenance Program, the training approach is unchanged from the 1960's. Without an effective implementation of this critical training, naval aircraft will soon become inoperative and unable to perform their vital missions. Our goal is to support and increase the effectiveness of maintenance training tasks in corrosion control. The numerous courses taught by NAMTRAGRUDETs/FRAMP, NAESU, NAVAVDEPOT, and FREST (Fleet Replacement Enlisted Skills Training) are repetitive in basic corrosion control knowledge but they contain very little "hands-on" or interactive training. With this in mind, Technautics Phase II CBT development efforts will focus on the entire Naval Aviation Training community, from basic "A" school, through "C" school (i.e., NAMTRAGRUDET/FRAMP and NAVAVDEPOT training), introducing innovative ICW CBT technology to corrosion control training.

This report includes a detailed presentation of the Phase I R&D effort, including the need for multimedia interfaces in maintenance training, an outline of current state-of-the-art ICW technology and authoring systems, and future Computer-Based Training (CBT) design, development, and implementation strategies. For example, the underlying strategy behind the authoring software is the development of a training system that requires minimal programming, operates under Microsoft Windows, and has the ability of integrating mixed media (i.e., text, animation, sound, still pictures, graphs, and video) into a simple presentation by moving icons with a mouse, keyboard, or touchscreen.

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INTRODUCTION

Technautics Computer-Based Training (CBT) development and implementation efforts will be primarily focused on the basic concepts of corrosion control including Avionics Corrosion Control, Paint and Finish Concepts and Procedures, "Khaki" (senior enlisted/officer) Corrosion Awareness, and Support Equipment Corrosion Control. The CBT system will not be aircraft specific, yet to increase student retention it will utilize pictures and video clips of various naval aircraft for identification of corrosion-prone areas, corrective actions and preventive maintenance procedures. Ultimately, the CBT system will track each student and squadron, their progress, their scores, and their participation. It will be designed to begin at the basic level taught in "A" school and gradually progress to advanced rating levels of training (i.e., NAVAVDEPOT and NAESU).

The research and development approach used by Technautics consisted of performing on-site evaluations of existing corrosion control training at a Naval Aviation Base in Norfolk, Virginia. Technautics interviewed instructors and students concerning classroom and "hands-on" training in corrosion control as instructed by NAMTRAGRUDET, NAVAVDEPOT, and NAESU. We also interacted extensively with the functional airwing personnel involved in tracking and teaching the maintenance Training Improvement Program (MTIP). Issues discussed included adequacy of materials, relationship between CBT and instructors or "hands-on" work, courses best suited for CBT, and the need for realism in the course material. In addition, an insight of current CBT development efforts was obtained by physical examination of the 'E-Z pilot and Naval Flight Officer CBT system developed for aircraft/cockpit/radar simulation training. Issues discussed and evaluated included touch screen display units (pros and cons); design and development requirements; and problems encountered, such as dual screens, authoring languages, and communication/network support requirements (i.e., stand-alone vice network-driven).

The results were extremely useful in identifying the adequacy of existing corrosion control training and assisted in determining how CBT can cost-effectively and efficiently be implemented. Currently, the training available to all maintenance personnel overlaps in theory, but lacks a method to develop practical hands-on skills through interactive training. The surveys performed regarding training effectiveness indicated the need for students to experience interactive corrosion detection and treatment during formal training. Most of the current instruction proceeds from text book work in a classroom to correcting corrosion problems on an aircraft with potentially little On-the-Job Training (OJT) in between these events. The student certainly needs the theory of corrosion, but they will not retain this critical information unless it is made interesting. More importantly they must understand the practical aspects of corrosion control on naval aircraft. A CBT course can visually display corrosion, even "growing" it as they watch. It can place types of corrosion in the appropriate places on naval aircraft to enhance their ability to identify the corrosion properly on their aircraft. With innovative audio and video integration, the CBT can

even illustrate the actual procedures required to prevent or correct the corrosion discrepancy. By creating this corrosion control training in a building block approach, the curriculum can be tailored to any level of expertise needed, from the theory and consequences of corrosion required by most naval aviation personnel to specific prevention and control procedures required by the select corrosion control team members.

This report will introduce numerous other innovative CBT technologies that can greatly increase the effectiveness of current corrosion control training. The CBT system should be developed to directly replace the instructor in teaching the corrosion theory portion of the classroom training. On the other hand, it is recommended that the system be used as an instructor's training aid to supplement existing hands-on training procedures. The CBT course can be used as a presentation system to replace static training aids that do not allow hands-on training and also be used as a tool for the instructor to freeplay enhanced course material dynamically on a classroom large screen. Surveys indicate that interactive, self-paced theory work with CBT supplement of instructional hands-on training not only accelerates student comprehension and increase training efficiency, it even improves instructor effectiveness.

Authoring System Evaluation

Introduction. Research and analysis performed in Phase I focused on the features and functionality of Computer-Based Training Interactive Courseware (CBT ICW) tools from existing Commercial-Off-The-Shelf (COTS) software packages. Packages such as ICONAuthor, Toolbook, Authorware, Quest, and Tencore were evaluated against the requirements of MIL-STD-1379D Military Training Program, MIL-HDBK-284-1 Interactive Courseware (ICW) for Military Training, and traditional Instructional System Designs (ISD). The criteria used in evaluation of the authoring systems included flexibility, adaptability, availability, affordability, and productivity. The criteria were developed into the following easily understood evaluation factors:

- Standard Commercial Off-the-Shelf Software Packages (Windows-based);
- User Friendly Interactive Functions;
- ICON-Based Authoring Systems;
- Mouse, Touch Screen, Keyboard Inputs;
- Ease of Use and Maintenance;
- High Resolution Graphics;
- Low Up-Front Development Costs; and
- Easy Expansion to Interactive Multimedia.

In conclusion, the authoring package selected would meet the military requirement, while providing the developer with a powerful tool to implement challenging training and simulation scenarios and permitting the user the familiarity and ease of a PC-Windows environment.

Authoring Software Evaluation. A detailed evaluation was performed of various COTS authoring software and the results are summarized in Table 1. While presentation software works well for slide show-type production, and some of this software even adds button interactivity, or sound/video playback, more complex multimedia authoring packages let you bypass presenter limitations with script languages. In order to properly evaluate the software products available, the metaphor should be defined first. Basically, there are four types of metaphors: card-based,

iconic authoring, script-based, and time-based. These metaphors are used to differentiate authoring software packages, depending on their application. The result of this evaluation and product descriptions are listed in Table 1.

Table 1. Multimedia Products Comparison

Products	Metaphor	Description	Application
HyperCard ToolBook	Card-Based	Content comes first - presentation like a slide show; create stacks of cards or a book of pages that share a similar architecture, each presenting a single display of text and graphics. Sound, video & animation can be attached to those cards, and cards can be linked to others in the stack with buttons.	Simple, noninteractive presentation. Not flexible to organize; requires some script language
ICONAuthor Authorware	Iconic Authoring	Event-driven programming development: structure design first, Icon-based authoring systems allow flow-chart building with content and diagrams that show how media elements will work together. Works by placing standard icons onto a blank diagram, then adding content to the structure by specifying parameters for the icons.	CBT ICW; flexible and comprehensive; does not require programming skills
Quest	Script-Based	Exclusively depends on scripting line by line; some package applies script event list.	Requires more experienced script skill
TenCORE	Script-Based	Powerful scripting language	Requires more experienced script skill
Director QuickTime	Time-Based	Truly precise and synchronized sound, video and images that will run properly across a range of delivery machines; provides a graphic timeline with marks for the starting and ending points of each media element's appearance sometimes illustrated with detailed media clips.	Lacks multimedia presentation and interactivity

In summary, after a detailed evaluation the discarded products listed in Table 1 contained the following limitations:

<u>Authoring Software</u>	<u>Limitations</u>
• Toolbook	NonInteractive - "A Book of Pages" Not Flexible to Organize Simple Multimedia Application
• Quest	DOS Environment Programming Skills Required Less Flexible
• TenCore	DOS Oriented Less Flexible (Touch Screen Only) Programming and System Integration Skills Required
• Quick Time	Not Specialized for CBT - Lacks Interactive

Authoring Software Selection. In general, AimTech's ICONAuthor and Macromedia's Authorware Professional were the most powerful and user-friendly interactive products currently available for iconic authoring system. The major features of ICONAuthor and Authorware are listed in Table 2. The functional capabilities of both packages were compared and ICONAuthor was selected as the authoring package best suitable for CBT design, development, and implementation. Icon-based authoring software is ideal for CBT design and implementation. After testing and implementing some basic CBT models of various multimedia authoring software, ICONAuthor proved to be the best tool available for the design of an interactive corrosion control course. ICONAuthor provides flexible features to efficiently develop challenging interactive coursewares scenarios; it increases productivity during the development cycle due to its nonprogramming capabilities; it is compatible with all multimedia applications (i.e., audio, video, CD-ROM, etc.); and most importantly, the course can be designed to be either keyboard driven, mouse driven, touch screen sensitive or a combination of all three devices. Selection of touch sensitivity would not only permit ready selection of relevant icons but also make it easy to take the quiz sessions which is essential to the success of the medium.

Table 2. Functional Capabilities of ICONAuthor and Authorware

Product	ICONAuthor V5.11	Authorware V2.01
Company	AmiTech	Macromedia
Platform	Window, OS/2, UNIX, VMS, MAC	Windows, Mac
Authoring Metaphor	Icon	Icon
Media editing & creation	Image, Text, Audio, Video, Animation	Image, Text, Audio, Video, Animation
Text/Spreadsheet	ASCII, RTF, ICONAuthor	Text
Graphic	P C X , B M P , R L E , W M F , D C X , EPS, DIB, PCT, PICT, JPG, TIF, GIF, TGA, WPG	BMP, DIB, EPS, PCT, PIC, PCX, PNT, RLE, TIF, WMF
Database	dBase III+ & IV	Thru XCMDs, DLL
Digital Sound	CD Audio, WAV	SoundEdit, SoundEdit Pro WAV, snd
MIDI Sound	MIDI	Thru XCMDs and DLL
Digital Video	AVI, AVS, Indeo, Fluency, Qtime	AVI, Qtime
Animation	FLI, FLC	PICS, MMM, FLC
Clip Library	No*	No*
Color Depth	24 Bit	24 Bit
Transitions	Yes	Yes
Scripting Language	Support XCMDs on the Mac player	Compiled as XCMDs or DLLs
Debug Tools	Yes	Yes
Interactive Branching	Conditional	Conditional
Create Pull-Down Menu	Yes	Yes
Multimedia Devices Control	Video Disk & CD Player, VCR, MIDI Device	Video Disk & CD Player, VCRs, MIDI Devices
System Support	DLL, OLE, DDE, MCI, VFW, Qtime	PC: MCI, VFW; MAC: Qtime
Create stand-alone application	Yes	Yes
Royalty-free Distribution	Yes	Yes

Product	ICONAuthor V5.11	Authorware V2.01
Other Features	Application content separate from structure; Scrollable workspace	MediaManager complete CMI functionality No-scrolled Workspace w/5 level map icon
Utility	Graphic Editor, Icon Animate, RezSolution, SmartObject Editor Resources Manager	MediaManger (Requires purchase of other products: Director, Action, SoundEdit)
System Requirement	Min: 386/20 w/ 2MB, 16-color VGA, 10MB HD, and a mouse Recommend: 386/33 w/8MB 256-color VGA, 40MB HD, and a mouse	Min: 386/20 w/ 4MB, 16-color VGA, 40MB HD, mouse Recommend: 386/33 w/ 8MB, 256-color VGA, HD, mouse Delivery min: 386/20 w/4MB, 16-color VGA, 20MB HD and a mouse
New Improvement	HotLink, Irregular Graphic Live Object, MCI Command Selector, Object Name Selector, Property Inspector, Sound Object, Movie Object, Program Icon, Print Icon, Enter&Leave Events, Combo boxes	HyperText Link, irregularly shaped Hotspot

* Clip Library is a standard business graphics program; both packages can implement this feature in other ways.

ICONAuthor Features of Interest. Icon-based authoring software is ideal for multimedia nonprogramming design and implementation because it is easy to use and requires little maintenance. The study demonstrated numerous design aids available in ICONAuthor allowed for flexibility in design and ease of multimedia integration. The authoring system Technautics has selected consists of command icons on a flowchart and a set of menus containing commands for various authoring functions. The icon set used for building the sequence of actions are display, animation, pause, video, sound, decision, interaction, calculations, start and stop flags, and organization logic flow. These icons are selected with a mouse and moved onto a logic flow diagram that systematically represents the sequence in which the action is to occur. These logic flow diagrams are easy to reorganize and numerous different interaction types are built in, such as click or touch areas, keyboard presses, time limits, etc. This project-type outline provides an on-line hierarchical design format and will encourage effective planning of large scale CBT development projects. This in turn will encourage the use of appropriate instructional strategies and CBT design. This authoring system also supports an open architecture so that all Windows-based COTS products may be used. This versatility will allow a wide range of compatible software and hardware technologies, including animation, audio, graphics, and video packages. The advantages can be seen in reduced cost, availability, flexibility, and transportability.

Powerful features available in ICONAuthor include:

- Text editor: Capability of creating text in various font sizes and types, with the ability to place the text in author specified screen locations.
- Graphics Editor: Capability of creating, displaying, rotating, and shaping graphics.
- Smart Object Editor: Capability of Linking all multimedia together.
- Audio Editor: Capability of selecting and controlling various audio sequences.
- Video Editor: Capability of selecting and controlling various video sequences.
- Animation Editor: Capability of creating animation to emulate corrosion and other course-specific information.
- Text/Graphics Overlays: Capability of overlays of text or graphics on still or motion video.
- Audio/Video/Graphic Synchronization: author-specified sequence control of audio, video, and graphics overlays.
- Peripheral Input\Output Control: Author-specified control of various input\output devices (i.e., keyboard, mouse, touchscreen, and parallel/serial port) during courseware execution.

ICONAuthor has 53 icons for design and implementation to meet all programming requirements. Some icons such as Program Icon, DDL Icon and DDE Icon are very useful to interface other existing programs and functions; Save Variable Icon, Load Variable Icon, RS-232 Icon and Print Icon can be easily used for I/O processing, such as loading or saving files of records, printing and interfacing; Database Icon can be used to create, retrieve, and manage the records.

In the development cycle, productivity depends on how easy it is to integrate the sub-

application and sub-routine from different team members. ICONAuthor provides the solution from Sub-Application, Sub-routine and Sub-assign Icons. In addition, when a new application is to be developed, it will ask to define the application as a main or a subapplication.

ICONAuthor provides more flexible features to develop Interactive Courseware. Using SmartObject Editor with Click, Enter/Leave and Drag/Drop Event, Object Selector and Property Inspector, all objects such as Text, Graphic, Movie (Video and Animation), and Sound can easily be applied for CBT courseware with different property settings.

ICONAuthor allows an author to design a string of text as selectable and have that selection trigger an event. While in the SmartObject Editor, the author simply selects one or more words within a text object, assigns them as a "HotWord," and sets the text object's "NotifyOnClickHotWord" property to true. HotWords can have special formatting automatically applied. They can also be indexed, allowing the selected set of words to have the same index and the same subsequent action. When this HotWord is selected or touched, a further processing can be driven, such as, an explanation or a graphic display.

An author can use "Irregularly Shaped Graphics" from ICONAuthor to hide an object on the screen. It allows the author to make virtually any graphic a live object while still retaining its natural shape for testing and displaying purposes. This is useful for touch screen and graphics/photo applications.

Finally, ICONAuthor supports extensive graphic file type, device drivers and utilities. capability. ICONAuthor provides RezSolution to capture a full screen, an active window or a region of screen and current color palette, which ensures an exact copy of the colors from the original screen. ICONAuthor also provides List, Combo & Menu Objects for Widows-look application.

Upon final comparison of available ICW with the military training requirements, Technautics began actual design and development of a sample working model of an interactive CBT system created with ICONAuthor. This task included image scanning, database development, object-oriented programming, and application testing of various multimedia features. The Technautics team has established standard CBT Planning, Design, Development, and Implementation Guidelines that are to be used to generate the CBT corrosion control prototype. These guidelines present a systematic approach to proper CBT implementation and are based solely on training requirements and learning objectives.

MIL-STD-1379D Technical Requirements. The hardware/software requirement for the NAVAIR project is based on MIL-STD-1379D. ICONAuthor is an Object Oriented Fourth Generation Language (4GL) Development Tool working on MS Windows. Windows works within MS-DOS Operating System, which is standard in personal computer industry and

adheres to the Navy's requirement. Therefore, the application of ICONAuthor will meet all the requirements for MS-DOS. Table 3 states ICONAuthor's applicability to MIL-STD-1379D.

Table 3. MIL-STD-1379 Technical Requirements Check List

MIL-STD-1379 TASKS & WORK DESCRIPTION	REQUIREMENT	SOLUTION	SUPPORT	EXPLANATION
40.1.5	One or more XY-input Device	Micro Touch's TS & Mouse	YES	Touch Screen & Mouse's Driver simultaneously
40.1.6	One or more Videodisc Player	ICONAuthor Setup can add them	YES	Video Diskplayer, Video Tapeplayer & Digital Video Board; Multisyncro monitor & Overlay* card
40.1.7	Operation System: DOS V2.0 or Higher	MS-DOS/PC-DOS V5.0	YES	DOS Downward compatible and more powerful in new version
40.2	General VDI Management Architecture	MS Window-Virtual Machine	YES	VM is more powerful than VDI & includes VDI's features
40.3	Service Groups & command organization	Windows & ICONAuthor includes	YES	see 70-sy, 80-vm, vd-90 and XY-input-100
40.4	Installation & logical device mapping			see 40.4.1 & 2
40.4.1	Installation methods	Windows Setup utilities	YES	Including system service, service group, logical device mapping
40.4.2	Vendor statement of device mapping	Setup and Install Utilities from Windows/ICONAuthor	YES	Object Selector, Dialog & Content Editor; On-line Help; User Manual and Tech Ref.
40.5	General Interface Implemented by VDI			See 40.5.1-4
40.5.1	ASCII & Binary	DOS-Window	YES	See 40.5.1.1

MIL-STD-1379 TASKS & WORK DESCRIPTION	REQUIREMENT	SOLUTION	SUPPORT	EXPLANATION
40.5.1.1	ASCII	ICONAuthor with Windows	YES	Selector and Dialog/Content Editor with Windows thru driver using DOS I/O and ASCII strings. Also see S-50
40.5.1.2	Binary	ICONAuthor with Windows	Not applicable	4GL OOP & GUI automatically provides the same functionality. Also see S-60
40.5.2	Parameters & values	ICONAuthor with Windows	YES	Also see 40.5.2.1-2
40.5.2.1	ASCII Interface	ICONAuthor with Windows/DOS	YES	Meets the requirement
40.5.2.2	Binary Interface	ICONAuthor with Windows/DOS	Not Applicable	4GL OOP & GUI automatically do it.
40.5.3	Coexistence of interface	Windows	Not applicable	Often use ASCII, but still possible thru DLLs
40.5.4	Vendor statements of interface & memory requirement	ICONAuthor with Windows	YES	ASCII default; statement is easily available
40.6	Error handling	ICONAuthor with Windows	YES	See S-110 (indicated in S-70-100)
40.7	IMA Recommended Practices for Multimedia Portability R1.1	ICONAuthor with Windows	No	MS-Windows Based System is better than MS-DOS Based System
50.1	Command string format	ICONAuthor with Windows	YES	GUI (Icon Content Editor, Object Selector and Dialog Menu) are more friendly as menu options and simple real words; Same format on Tokens, Delimiters, Length, and Multiple Commands

MIL-STD-1379 TASKS & WORK DESCRIPTION	REQUIREMENT	SOLUTION	SUPPORT	EXPLANATION
50.2	Response string format	ICONAuthor with Windows	YES	Same format on Terminator, Delimiters, Case, Content, and Length
50.3	Parameter value format	ICONAuthor with Windows	YES	Same format on Numbers, Bit fields, and Text; For calculation the operator should leave a space to both operand, as A + B, C * D
50.4	Formal string syntax	ICONAuthor with Windows	YES	More friendly as Icon, Icon Content Editor, Dialog Menu, " := " "CR" & "CR/LF" are not necessarily used. Others are same
50.5.1	Compatible to DOS	ICONAuthor with Windows	YES	Microsoft's design
50.5.2	Allocation & initial contents	ICONAuthor with Windows	YES	OOP GUI does it automatically
50.5.3-7	Behavior	ICONAuthor with Windows	YES	OOP GUI does it automatically
50.6	Device driver function & mode options	ICONAuthor with Windows	YES	Windows does it automatically
60.1	Intel 80x86 Register Contents: AX, BX, & ES:DI	Windows	YES	Windows's design and implementation follows them
60.2-8	Software interrupt	ICONAuthor with Windows	YES	Windows/GUI does it automatically
70.2	Command Return Values	ICONAuthor with Windows	Not applicable	OOP support it
70.2.1	ASCII: "OK" or "ERROR n"	ICONAuthor with Windows	YES	Same way as "OK" & "ERROR n"

MIL-STD-1379 TASKS & WORK DESCRIPTION	REQUIREMENT	SOLUTION	SUPPORT	EXPLANATION
70.2.2	Binary: "AX=0" or "AX=error number"	ICONAuthor with Windows	Not applicable	GUI does not support
80	Visual-Management (vm) Service Group	ICONAuthor with Windows	YES	Meets the requirement with drivers and GUI
90	Video (vd) Service Group	ICONAuthor with Windows	YES	Meets the requirement with driver, GUI, Utilities and DLLs
100	XY-Input (xy) Service Group	TS & Mouse with ICONAuthor & Windows	YES	Windows GUI & 4GL OOP meets requirements
110	Error Handling (255 messages)	ICONAuthor with Windows and X-Y Input Devices	Yes	Window GUI & 4GL OOP meet requirements either same way or automatically

* Overlay card lets you display video on the computer monitor.

Naval Aviation Corrosion Control Training Requirement

Evaluation of existing naval aviation training revealed that even though corrosion is having a tremendous impact on the service life of aircraft and the corrosion control courses evaluated in Phase I are one of four mandated curriculum the training approach is unchanged from the 1960's. Our goal is to support and increase the effectiveness of maintenance training tasks in corrosion control. The numerous courses taught by NAMTRAGRUDETS/FRAMP, NAESU, NAVAVDEPOT, and FREST (Fleet Replacement Enlisted Skills Training) are repetitive in basic corrosion control but they contain with very little "hands-on" or interactive training. With this in mind, Technautics Phase II CBT development efforts will focus on the entire Naval Aviation Training community, from basic "A" school, through "C" school (i.e., NAMTRAGRUDET/FRAMP and NAVAVDEPOT training), introducing innovative ICW CBT technology. These requirements are illustrated in Figure 1.

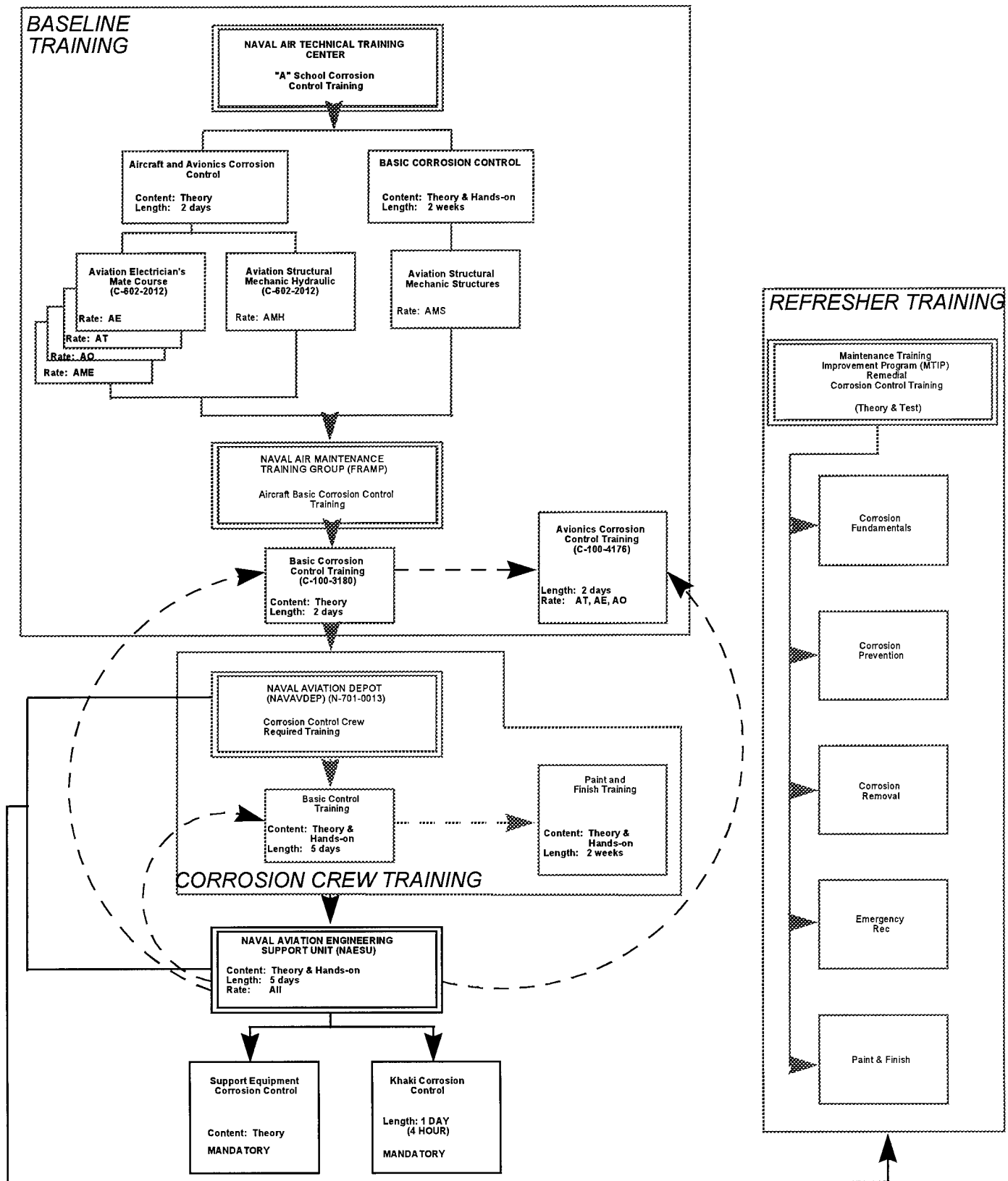
CBT implementation will be primarily focused on the basic concepts of corrosion control including Avionics Corrosion Control, Paint & Finish Concepts and Procedures, "Khaki" (Senior Enlisted/Officer) Corrosion Awareness, and Support Equipment Corrosion Control. The CBT system will not be aircraft specific, yet to increase student retention it will utilize pictures and video clips of various naval aircraft for identification of corrosion prone areas, corrective actions and preventive procedures. Ultimately, the CBT system will track each student and squadron, their progress, their scores, and their participation. It will be designed to begin at the basic level taught as "A" school and NAMTRAGRUDET/FRAMP and gradually progress to advanced rating levels of training, i.e., NAVAVDEPOT and NAESU.

Examination of the training course materials and extensive interviews with students and instructors allowed the Technautics team to develop the Naval Aviation Corrosion Training chart displayed in Figure 1. The baseline training inside the blue box is required for all hands and most personnel receive the same training at the NAMTRAGRU level as they did back in "A" school. Although this is valuable repetition, without the availability of self paced CBT for the review, this step alone is an extremely expensive training cycle. For the AMS's (and some AMH's) training tracks, this is even more wasteful since it is a 2 day review of the previous 2 week course. The Avionics corrosion control course is included because it is taught at this level but notice that it is set inside as an (optional) course and, at many facilities, overflow students are taught by NAESU. The initial portion of this course is a duplicate of the basic corrosion theory taught in "A" school.

The Green outlined corrosion control training courses are the advanced level required only by those personnel actively involved in corrosion control. The paint and finish course is set aside as an (optional) course and is reserved for limited personnel with specific qualification. Although normally taught by NAVAVDEPOT, the basic corrosion control courses can be taught by NAESU. The basic corrosion control and paint and finish courses require extensive hands-on

training which is not properly supported with supplemental interactive classroom work. Furthermore, both courses require extended one-on-one instructor student work which creates deadtime for the rest of the class. Self paced CBT implementation can substitute instructor training during these deadtimes. The two courses taught by NAESU are specialized but both review corrosion theory first before covering their particular topics. Since the instructors are qualified to teach multiple other courses, these two course tend to have the most innovative displays and corrosion samples. This same kind of cross-pollenization of visual effects would be available with a standardized CBT. The last area is the most receptive to CBT. The Maintenance Training Improvement Program (MTIP) begins on cruise away from formal classroom training. It starts with a test, and instruction is only given in those areas where personnel score below 70%. An entire staff must distribute tests, collect and grade tests, notify personnel of needed remedial training, schedule personnel needing training with instructors and classrooms, monitor personnel progress, monitor squadron wide progress, and notify controlling authority of completion. Basically, this is the description of a CBT system.

NAVAL AVIATION CORROSION CONTROL TRAINING



CBT Implementation, Planning, and Development Guidelines

Computer-based training is a term commonly used to refer to any training that relies, in part or whole, on computer technology to manage, develop, deliver, and evaluate student learning activities. Various CBT technologies are being used more and more widely commercially, in the Naval Aviation community, and other parts of the Department of Defense to provide personnel with essential job knowledge and skills. Although CBT is a powerful training tool, it must not be haphazardly integrated into the teaching process. There are certain tasks that will always require hands-on experience and that is particularly true in corrosion control. The CBT development team must ensure that it properly identifies all such areas, develops a smooth flow of interactive courses around these requirements, and then ensures that CBT supplements these requirements but never substitutes for them. Technautics' CBT development team has developed guidelines to assist in the proper planning, selection, and implementation of CBT. These guidelines were based solely on training requirements and learning objectives. Specifically, they lead the developer through the various decisions which must be made in order to determine if CBT is appropriate, to select the right system for their needs, and to plan for proper CBT implementation. These guidelines, illustrated in Figure 2, were used by the Technautics development team to perform the following:

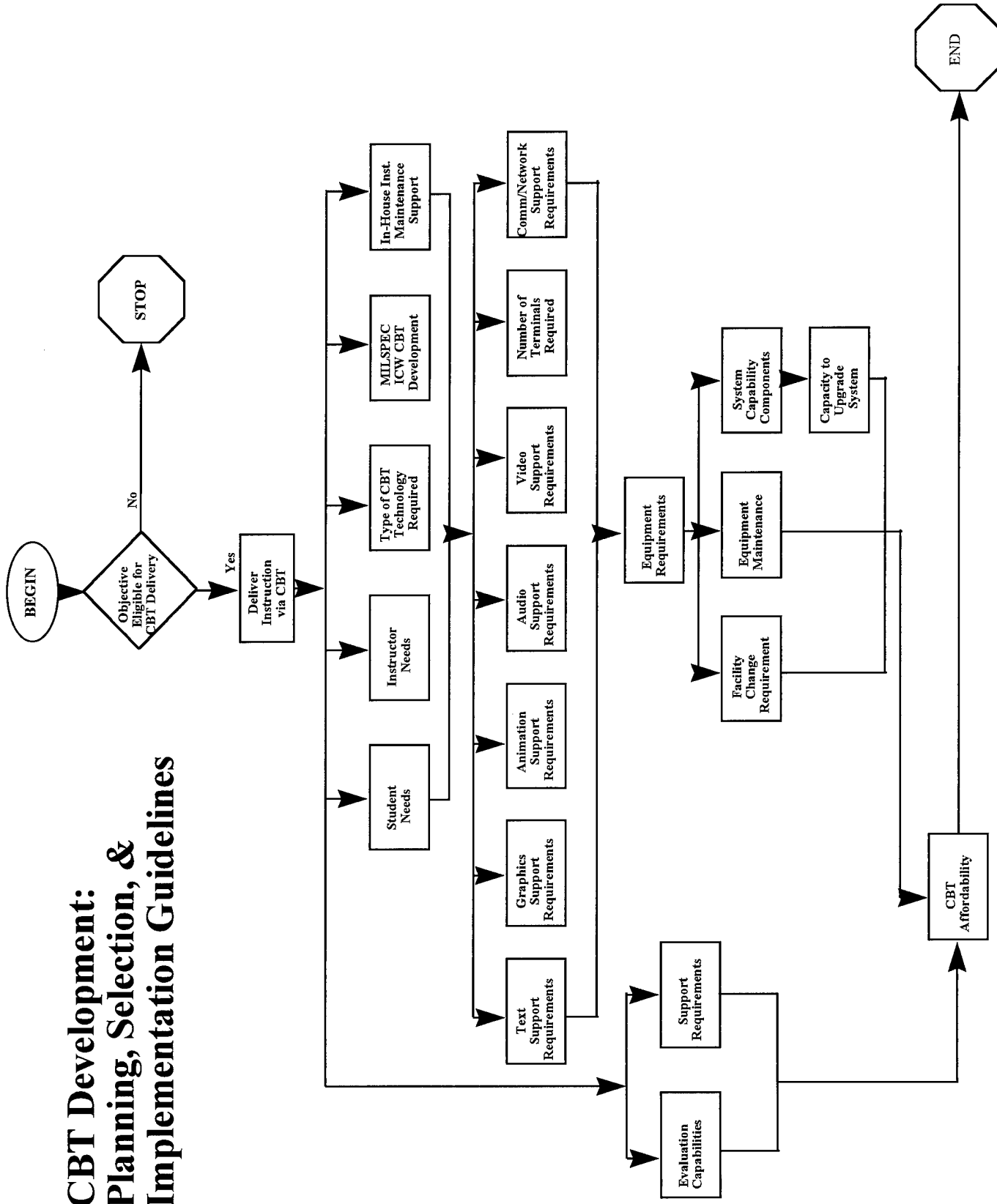
- 1) Determine if CBT could be used as a training medium. If CBT is found to be an acceptable medium for naval aviation corrosion control training;
- 2) Match the appropriate CBT technology(ies) with the learning objectives;
- 3) Assess the impact that CBT technology may have on the organization, including facilities, personnel, organizational structure, and operations; and
- 4) Estimate the affordability of CBT technology in terms of time, personnel, and cost.

Once these guidelines were completed, Technautics compiled the information needed to properly plan for CBT and then selected the CBT system that best suited the Navy's requirements. Technautics can now implement the CBT system with minimal problems and disruption to existing training programs.

Using the Phase I prototype as an example in following these guidelines, the Technautics CBT development staff performed the following:

1. Established the type of CBT technology required: The CBT system will integrate a mixture of video, sound, text, graphics, and animation incorporating the full spectrum of multimedia applications.

CBT Development: Planning, Selection, & Implementation Guidelines



2. Developed the CBT system in-house: Technautics had all software and hardware support equipment to generate the CBT prototype, in addition to developing skills in ICW manipulation including data compression/decompression and multimedia integration.
3. Developed In-House Instructional Analysis Ability: Technautics analyzed correct corrosion control courses throughout the curriculum, determined learning objectives, sorted those not conclusive to CBT, designed augmentation concepts for the remaining, and selected the multimedia approach most appropriate to objective retention.
4. Established In-House Maintenance Support: Although Technautics can not ensure that their CBT courseware maintenance staff is available after the development effort is over, we can develop a specification for the acquisition of equipment (either computers, monitors, printers, or other devices) and software (either networking, authoring systems, or other software).
5. Establish Facility Change Requirement: Technautics evaluated facility support requirements, identified issues to the Government, and determined if available equipment would support the CBT system. Government response confirms that existing facilities are capable of handling the new and/or additional equipment.

Corrosion Control Training Course Outline

The R&D performed in Phase I allowed for Technautics to identify specific corrosion control training areas. These areas were presented in detail in the Preliminary Training Course Control Outline submitted in compliance with the requirements set forth in the contract. In summary, the document presents a series of lesson topics grouped in units of instruction. Its purpose was to identify terminal, enabling objectives, and approximate course durations. Table 4 provides the training course outline of instruction summary. This outline was derived from an in-depth study of field data and current corrosion control documentation. The course objectives should provide all aviation maintenance personnel with sufficient knowledge and theory of corrosion, including types, identification, characteristics, preventive maintenance, corrective procedures, paint and finishes, emergency procedures, preservation, and proper hazardous material disposal procedures. Basically, the student should demonstrate a knowledge of the Aircraft and Avionics Corrosion Control associated with the applicable publications, including the NA 16-1-540 (Avionic Cleaning and Corrosion Prevention/Control Manual), NA 01-1A-509 (Aircraft Weapons Cleaning and Corrosion Control Manual), and NA 15-01-500 (Preservation of Naval Aircraft for Organizational, Intermediate and Depot Maintenance Levels Manual).

Table 4: Training Course Outline of Instruction

Lesson Topic	Title	Classroom Periods (Estm. Hours)	CBT Periods
<u>UNIT 1: BASIC CORROSION CONTROL</u>			
1.1	Corrosion Theory, Detection, and Identification	1.0	0.5
1.2	Preventive Maintenance	2.0	1.0
1.3	Inspection of Corrosion Prone Areas	1.0	0.5
1.4	Aircraft Sealants	1.0	0.5

Lesson Topic	Title	Classroom Periods (Estm. Hours)	CBT Periods
<u>UNIT 2: AVIONICS CORROSION CONTROL</u>			
2.1	Avionics Corrosion Descriptions	1.0	0.5
2.2	Treatment of Specific Avionic Equipment	2.0	1.0
2.3	Corrosion Effects of Electrical Bonding/Grounding, Electromagnetic Interface Shielding and Electrostatic Discharge Sensitivity (ESD)	2.0	1.0
<u>UNIT 3: PAINT AND FINISH</u>			
3.1	Introduction to Paint Systems	1.0	0.5
3.2	Paint Finishes, Paint Removal, and Touch Up Procedures	2.0	1.0
<u>UNIT 4: CORROSION REMOVAL AND SURFACE TREATMENT</u>			
4.1	Corrosion Removal and Surface Treatment	3.0	1.5
<u>UNIT 5: EMERGENCY PROCEDURES</u>			
5.1	Emergency Reclamation	1.0	0.5
5.2	Emergency Cleaning Procedures	1.0	0.5
5.3	Common Areas of Preparation	1.0	0.5
<u>UNIT 6: PRESERVATION OF NAVAL AIRCRAFT</u>			
6.1	Aircraft Preservation	3.0	1.5
6.2	Avionics Cleaning and Preservation	2.0	1.0
<u>UNIT 7: HAZARDOUS MATERIALS</u>			
7.1	HAZMAT Identification and Safety Precautions	None	0.5
7.2	HAZMAT Removal and Disposal Procedures	None	0.5

Sample Phase I Prototype Features

(REFER TO APPENDIX A)

1. **LOGIN SCREEN:** Students can login using their Social Security Number (SSN), Name, and Rate. Once the student registers, his name will be added to the CBT progress evaluation database. A sample of the login screen is illustrated in Appendix A.

2. **MENU DRIVEN:** Technautics chose a menu driven program to allow for a hierarchical arrangement of topics that would enable the student to select specific information based upon their needs or interest and in turn, allow for self-paced instruction. During the initial instruction, however, the student will be restricted to completing each course in the proper sequence. The student may proceed at their own pace and even review past material but they will not be permitted to "jump ahead." The main menu displays the major selections. Each menu option provides a submenu with additional topics. These options can be selected by clicking, touching, or typing the underlined letter of the icon. Appendix B through D shows the sequence of the menu structure. These menu options follow the training course outline illustrated in Table 4. The main menu, Appendix B, has a tracking progress status bar that allows the student to keep track of how much of the course he has completed.

3. **NOTEBOOK FORMAT:** Appendix E illustrates the notebook format Technautics has chosen for CBT training. This format allows for increased student interaction. One page integrates text, graphics, animation, sound, and video. The turning pages allow for ready reference to the previous lessons while encouraging a self paced transition to the next level.

4. **ICW FEATURES/OPTIONS:** The CBT system will include the following interactive features:

HELP Function. Although the CBT system is inherently easy to use, there are certain commands that will increase the student's effective use of the system. Technautics has developed a built-in HELP function similar to Microsoft Windows help function. Appendix F depicts a sample help screen generated using Visual Help.

Hot Keywords. Throughout the entire system keywords are highlighted in red. These are Hot Keywords that can be further defined by text, graphics, or sound by simply touching or clicking on the outlined word.

Activate/Deactivate Sound/Video. The system has an icon that can be used to activate or deactivate audio/video presentations. Not only can the sound/video be replayed multiple times to increase comprehension, the sound or video can be completely deactivated if desired during subsequent logins to enhance a "review only" learning objective.

Touch Screen Option. The system design includes touch screen sensitive areas for installation on PCs with touch screen capabilities. Note: The system can be run without this hardware option and is fully accessible using the mouse or the keyboard.

5. INTERACTIVE TEST STRATEGIES: The system will generate highly interactive test sessions. Tests will be used at critical points to ensure mastery of the material. The trainees performance will determine whether they progress to the next level, repeat the sequence, review or study additional material, or receive an explanation for their incorrect answers. These sessions will consist of a combination of Multiple Choice, True and False, Fill-in-the-blank, Matching, Graphical Identification, and Sequencing Questions. Refer to Appendix G through L for sample formats. The system will incorporate features, such as immediate feedback, that will tell the user why an answer is wrong.

Randomly changes order upon login. The system will be designed to randomly reorder all test questions upon subsequent login. This option will ensure subsequent challenging refresher training.

6. CBT EVALUATION DATABASE: The CBT evaluation database will automatically be updated upon subsequent login.

Password Protected Access. This database has been developed in Microsoft Access and will be password protected for supervisor/instructor access only.

Searches by Name, SSN, or Rates. The instructor will be able to retrieve student records by searching by SSN, name, or rates. The database identifies scores, number of logins, last login date, and areas of weakness. (Refer to Appendix M-O)

Highlights of Innovative CBT Design

State-of-the-Art Compression and Decompression (CODEC)

Motion Video/Audio/Graphics/Pictures

- Software-based video
- Hardware-assisted video (AVI, DVI, MPEG)
- PhotoMotion (Integrating motion video and audio)

Mixed Multimedia Integration:

- Text, Graphics, Animation, Audio, and Video Support
- Object Linking and Embedding (OLE)

Images and Graphics:

- Graphical User Interfaces (GUIs): Graphics, Motion Video, Pictures, etc.

Data Storage and Information Handling:

Innovative CBT ICW Technology. Technautics incorporated state-of-the-art ICW technology, including Compression and Decompression (CODEC), mixed multimedia integration, Graphical User Interfaces, Data Storage and Information technology. Our team focused on functional simplicity; features that make the system easy to use and enable the system operator to implement new applications or modify existing ones. Easy-to-use means that the system requires no formal training. Such a system is self-documenting to the extent that once the user has logged on, the system automatically provides all the necessary instruction. For this reason, Technautics has chosen a menu-based approach to access the CBT system.

CODEC. CODEC represents a new technology that has grown out of the audio and video integrating technology. Compression can decrease the size of video files to the point they require less storage space than uncompressed audio and still images. Research and in Motion Video Technology was performed and Technautics will continue to monitor future developments in the following compression schemes:

AVI (Audio Video Interleaved) is the file format for digital video under Windows. The term interleaved refers to the manner of storing video and audio data alternately in a video file. This

file format is designed for cross-platform compatibility which allows content on Windows-based systems to play on other operating systems as well. The Technautics development team is proficient in the application of AVI, the video compression used in the preliminary design applied the use of AVI format.

DVI (Digital Video Technology) currently appears as the most promising method of rendering hardware-based full-motion video on the PC. Technautics has begun examining numerous DVI technology including:

- Real-Time Video capability that allows for low-cost in-house development of multimedia applications;
- The compression techniques supported by DVI technology that will be available for future generations, allowing Technautics to plan and predict the evolution of their applications over time;
- Convenient content portability on small digital media (i.e., CD-ROMS); and
- The ability to network DVI content.

MPEG (Motion Picture Experts Groups) this compression scheme for full-motion video is still under development. This new technology will be evaluated as information becomes available during the Phase II effort.

Displaying motion video on the PC presented a new challenge for our preliminary demonstration. CD-ROM presents an ideal medium for the distribution of software using multimedia because of its large capacity and its read only nature. Compression's essential function entails reducing significantly the amount of digital information required for full motion video for economical storage and playback through standard PC storage devices like CD-ROM, hard disk, or LANs.

Mixed Multimedia Integration. The ability to integrate different technologies is manifested in the hardware and software selected by Technautics. Combining text, graphics, audio, and video on the PC is the most common implementation. The Technautics prototype integrates all multimedia applications. We used Object Linking and Embedding (OLE) to integrate information created in different applications. The advantage of OLE is that users can create text, graphics, or video documents and integrate them into any program that supports OLE, such as word processors, databases, graphics packages, etc. The goal was to provide the foundation for combining several types of information in the same document.

Images and Graphics. GUIs increasingly supplemented text on the screen. Technautics used

similar elements, such as icons, scroll bars, and dialogue boxes to provide a common denominator for different application software. Our GUI application simulates how a person normally studies and how a typical textbook appears (except few textbooks talk or show movies).

Data Storage and Information Handling. An important feature is the ability to store and quickly retrieve large quantities of information. Computers supporting enhanced applications do very little actual data processing. Photographic-quality imagery and interactive video are usually stored on CDs.

CBT Media Selection. One of the first requirements for running multimedia involves the basic equipment or type of hardware (platform) needed to play the programs. Technautics has defined the following minimum standard requirements:

Recommended Hardware Equipment

486DX2 66 MHz, 16 MB RAM
EISA and/or VESA local bus (32 bit bus)
1 GB SCSI hard drive
Video Card 1 MB Memory (1280 X 1024 Resolution)
17"-24" Touch Screens

Audio Support:
Speakers (Headphones Recommended)
Sound Blaster Card

CBT Authoring System

Aim Tech ICONAuthor V 5.11

Software

Microsoft Windows for Workgroups 3.11 (32 bit access versus 16 bit in Windows 3.1)
Microsoft DOS 6.2 (operating system)

Optional Phase II Considerations

Pentium 66MHz PCI architecture (64 bit bus)
Double Speed CD-ROM (multi-session photoCD)

Minimum Hardware Equipment

486SX 33MHz, 8 MB RAM
EISA and/or VESA Local bus
540 MB, IDE Hard Drive
14"-17" Screens (Touch Screens -
Optional)

In conclusion, the CBT system for corrosion control will meet all training objectives through text, color, audio, graphics, picture quality images, and video implementation. Past and recent research has indicated that various types of equipment have been used without significant reliability problems occurring. The CBT system will require very little maintenance and can operate continuously. Phase II simply involves application of established developmental guidelines.

Summary

PHASE I ACCOMPLISHMENTS

- Reviewed the Requirements of MIL-STD-1379D, Military Training Programs and MIL-HDBK-284-1, Interactive Courseware (ICW) for Military Training.
- Performed Trade-Off Analysis, Selection (Rank Ordered), and Testing of Authoring Systems including ICONAuthor, ToolBook, Authorware, Quest, and Tencore.
- Evaluated and Selected Potential CBT Prototype Multi-Media Applications.
- Front-End Analysis of current Naval Aviation CBT Concepts with regards to Course Effectiveness and CBT Applicability.
- Completed Training Requirements Analysis of Corrosion Control Training Courses.
- Established Learning Objectives and CBT Course Design Concepts.
- Developed Corrosion Control Training Course Outline.
- Began Actual In-house Design, Development, and Testing of CBT Prototype Corrosion Control Training System.
- Evaluated and Implemented Innovative ICW CBT Technology.
- Established Hardware/Software Support Requirement, Equipment Maintenance, CBT System Capability Requirements, Communication

Recommendations and Future Developments

With a carefully detailed plan and properly motivated/talented personnel, there were no significant difficulties encountered in developing the Phase I prototype system. The Phase II full-scale functional prototype will be more time consuming due to photographing and videotaping requirements. Although this task is a one time effort, periodically updating of images and CBT system may be required yet will be much less laborious.

The Phase II SBIR CBT development effort will be to deliver a low-cost, functional innovative interactive training system that will provide Naval Aviation with effective corrosion control training regarding corrosion theory, its origin, its appearance and its damaging effects. The CBT system will provide Naval Aviation with opportunities to more effectively manage the significant corrosion control training process that up until this point has been addressed in a purely qualitative or case-specific manner. Without a positive corrosion control program, Naval Aircraft will soon become inoperative and be unable to perform their vital missions.

To meet these objectives, Technautics will progress through four stages of the training design cycle: Concept Exploration and Application; Interactive Instructional Design; Corrosion Control Training Prototype Development; and CBT Implementation and Proof of Concept Testing. These stages are described in detail in the Phase II proposal Work Plan.

APPENDICES