COMPUTER MANAGED TRAINING: CONCEPT AND IMPLEMENTATION

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In 1970, some innovative U. S. Navy personnel involved with the F-14 Program established a Navy/contractor team under COMFAIRMIRAMAR at NAS Miramar, California. The specific purpose of this team was to establish an integrated state-of-the-art training system to implement the aircrew and maintenance personnel training mission of the F-14 Readiness Squadron. This on-site team concept provided a continual transfusion of Navy fleet operational experience and contractor training/technical expertise. As such, the underlying precepts of Instructional System Development (ISD) technology were focused upon the unique training situation of the F-14 Readiness Squadron. This situation was unique in the involvement of a new, highly sophisticated weapon system with training requirements ranging from complex tactics to very basic maintenance procedures. This application of ISD technology was conceptually oriented toward a training system components model such as depicted in Figure 1.

As the team efforts progressed from the basic definitions of specific tasks relevant to successful job performance (specific behavioral objectives) through translation of task definitions into training objectives and identification of the software/hardware implementation of the objectives, the magnitude of the "Management and Evaluation" element of the components model became increasingly apparent. The efficient utilization of training resources ranging in complexity from the Air Combat Maneuvering Range to self-study carrels, overlaid with a greatly enhanced potential for meaningful performance evaluation and an overall individualized instruction orientation, presented an additional challenge to the developing training system. The inappropriateness of forcing these functions upon the traditionally overloaded squadron cadre and instructor staff, without providing an efficient system to support them, was immediately transparent.

As a direct result of this situation the feasibility of providing a computer-based training management system was evaluated during the Spring and Summer of 1971 and the system development effort started in September 1971 under contract with Hughes Aircraft Company. The result of this Navy/Hughes effort— the Computer Managed Training (CMT) system— has been operational since October 1972 and is currently undergoing system refinement and evolutionary enhancement.

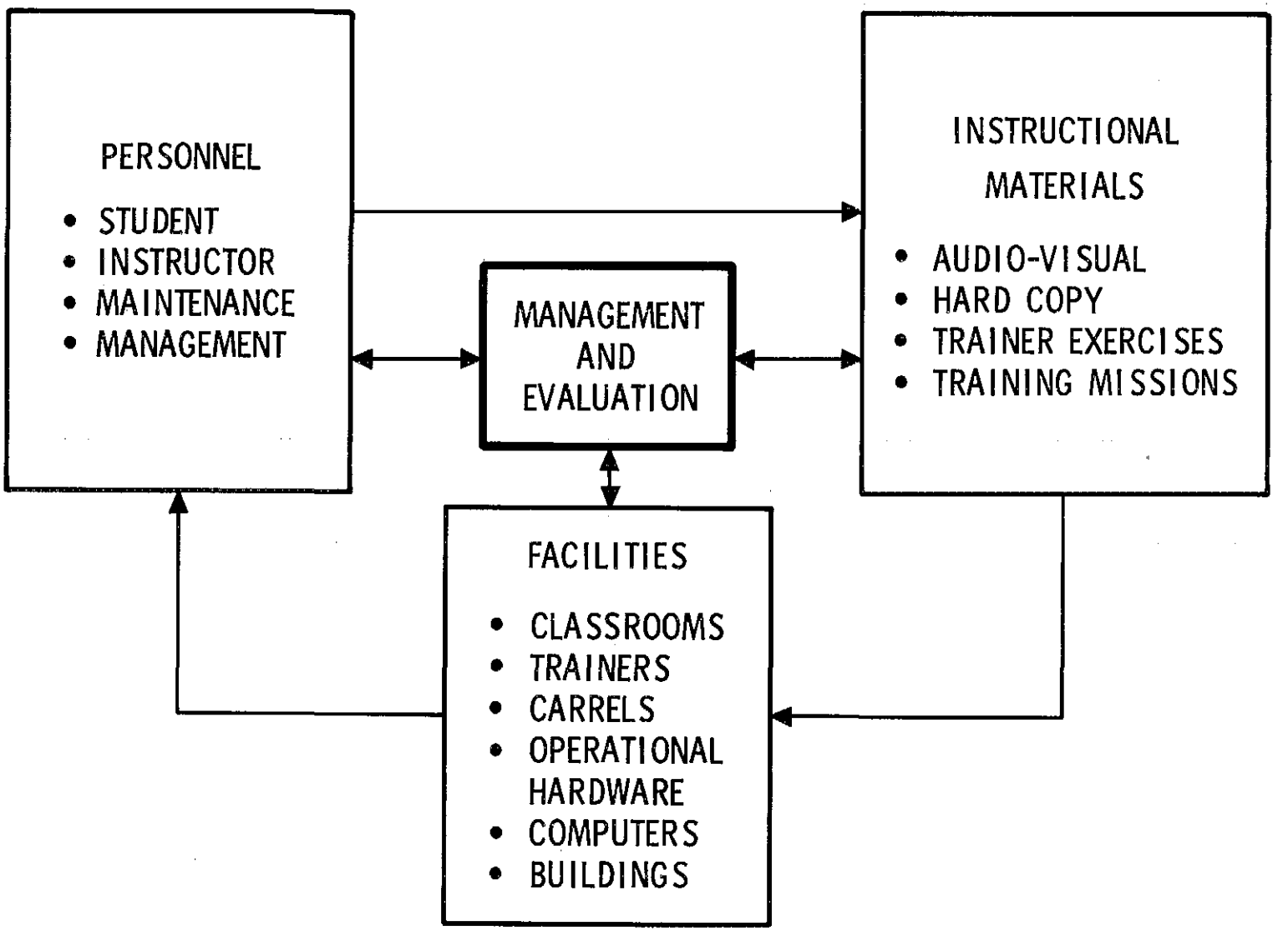

Figure 1. Training System Components Model

1.0 SYSTEM CAPABILITIES

The Computer Managed Training (CMT) system is conceptualized as having three functional components as depicted in Figure 2. Although other computer applications have had some success in implementing specific parts of these functional components (e. g., the USAF flying training scheduling system), the CMT system is unique in marrying all three components into a training management support system.

The "Record Keeping" component is closely related to the more traditional business applications of computers. That is, this component provides an integrated data base containing all the data elements required to manage the F-14 Readiness Squadron - from complete curriculum definition to individual personnel records. In addition, Record Keeping accommodates the full range of sort, merge and data base manipulation functions required to support the other two system components.

The "Resource Management" component represents a higher order of sophistication in computer applications. For the purposes of the CMT system, the term "resource" is defined in its broadest possible sense. All things available to the squadron to accomplish the training mission are subsumed under this definition. The resulting management processes address the efficient application of these resources toward maintaining student progression through the program against an optimized training day time-line. As such, the system is designed to maximize the use of student/instructor time (individualized scheduling) and the use of available training "tools" (asset scheduling). This maximization is further enhanced through the ability to match student priorities against training assets and to accommodate real-time perturbations to planned activities (be they daily schedules or quarterly forecasts).

The third component— "Performance Evaluation"— represents the highest degree of sophistication and the one which, traditionally, has fallen into the "too-hard-to-do" category. This component comprises the biggest challenge to the evolving CMT system— both from a conceptual and from an implementation viewpoint. However, there are two aspects of the F-14 Training System which tend to offer encouragement. One aspect is the rigorous foundation of the Training System upon specific identifications of operationally relevant job tasks. This provides a significant step toward the most difficult part of performance evaluation— that of establishing meaningful criteria. The other encouraging aspect is the fact of having a sophisticated tool available to support the undertaking in the form of the CMT system. The Performance Evaluation component, therefore, is functionally directed toward evaluation and prediction of student performance, instructor performance and Training System performance. Integral to this concept is an initial reliance upon operational fleet experience as a point of departure and a total commitment to establishing a realistic evaluative feedback loop from the fleet environment to the F-14 Readiness Squadron.

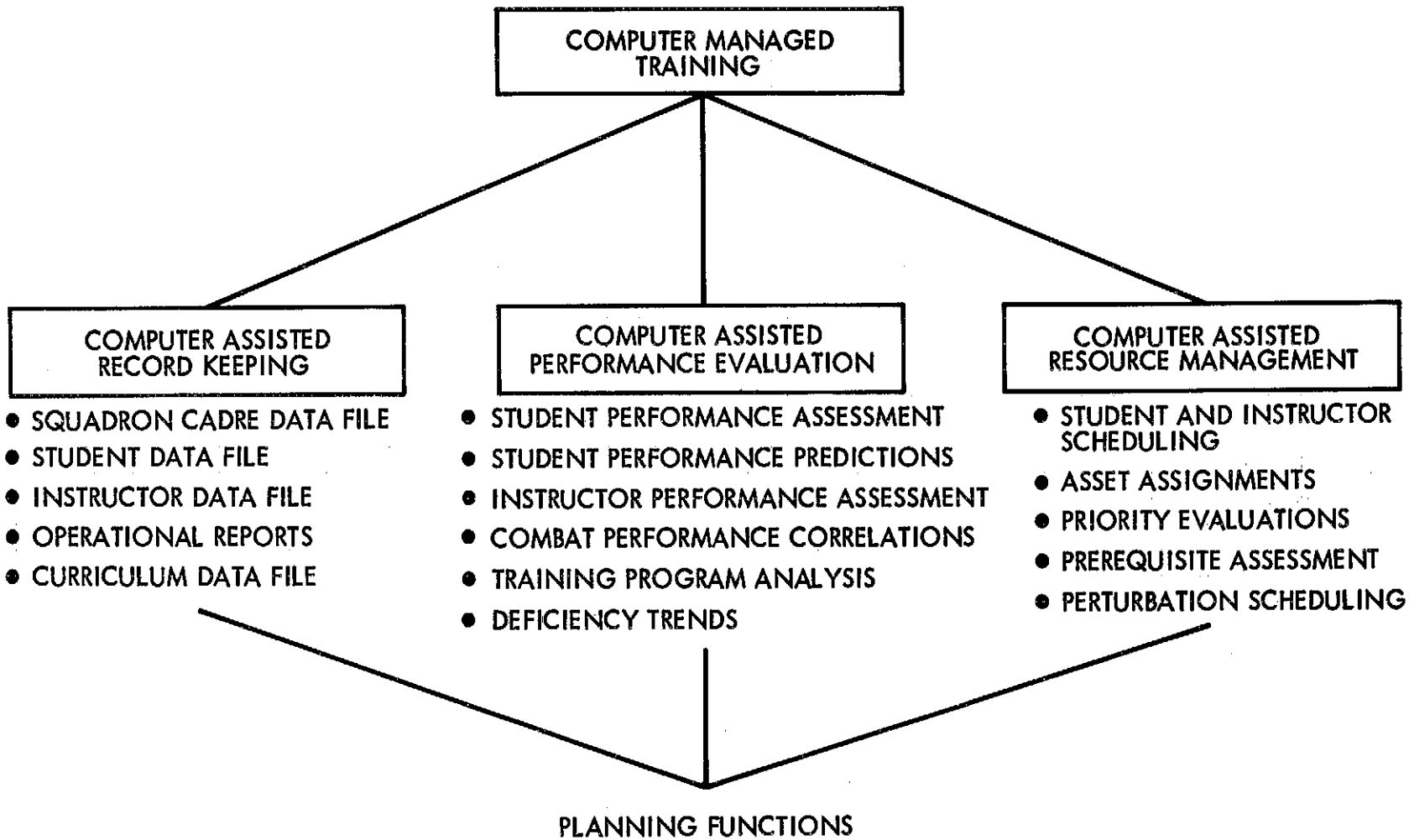

Figure 2. CMT Functional Components

1.1 System User Procedures

The CMT system is specifically oriented toward the interactive use of CRT terminals located at key positions throughout the squadron area and a resultant minimization of paperwork. Although the majority of user interactions occur through "fill-in-the-blanks" types of formatted displays, the system provides for free-form inputs in appropriate cases (e.g., entering "Remarks" amplifying a student's performance during a particular airborne training session). User orientation to the system procedures and capabilities is accomplished by a brief verbal presentation (averaging 15-25 minutes for a totally naive individual) and a User Handbook which provides complete data element definitions and step-by-step procedural instructions. The following material describing the basic system and user procedures is abstracted from Section 2.0 of the Handbook with minimal editing (primarily deletion of Figure references not included in this paper).

"General

"CMT users will communicate with the system through the Hazeltine cathode ray tube (CRT) terminals. The typewriter-like keyboard and television-display make the Hazeltine terminal easy to use. However, there are some procedural steps each user must learn to make the terminal accept or produce information as desired.

"Information is grouped into files by subject and a Function Index display is provided. Each item in the index is associated with a three-digit number which is used at the terminal keyboard for "call-up". For example, all the information about personnel is in the 100 series. It is apparent that some files represent primary data that must be entered by the user, such as service record information, while other files, such as rosters, are derived by the system.

"Note on the Function Index that ECI&D are shown to the right of the function. "E" stands for data entry into the system. For instance, if you select the personnel function and want to enter data into the system, the function call-up would be 101. System command "ENTER" would be checked automatically. "C" stands for change or a correction to data contained within the system. Once the personnel record page one is completed, the other pages are considered updates or changes. "I" stands for INQUIRE into the information contained within the data base. To inquire within the system, the function and key are typed in and the requested data is displayed. "D" stands for DELETE, which removes data from the active file and places the information in historical files. Only those control messages shown on the option list are available.

"Date Base

"In order to more readily understand the capabilities and the limitations of CMT, it is helpful to view the data base as a storage area full of information. The lowest order thing the system can "track" is a data item. You may also see it referred to as a data element since the Navy recently changed the standard terminology. A collection of data items related to the same thing make up a record just as a single folder in an office file unites all the items about a subject into a record. A collection of similar records constitutes a file which also parallels an office file.

"It is a simple hierarchy— item, record, file. The CMT index is a list of the files available and relates each to a three-digit number you can use to "call up" that file. The records within a file are called up by name—a person's name if it is a personnel file, a syllabus number if it is a syllabus file, etc. The CMT design concept assumes that users will not only quickly learn the details of the files, but will assist in improving the design by recommending modifications.

"Access

"To ensure accuracy and validity of information in the CMT data base, the ability to change data is controlled by limiting access to those with appropriate authority. Access keys are added to files and functions as specified by the Navy.

"Terminal Description

"The face of the CRT looks very much like a television display. It displays characters (letters, numbers and a few special characters) in 74 rows and 27 lines for a total of 1988 per display. A cursor, which looks like an underscore, shows where the next character will appear when you depress a key and is controlled by a set of five keys at the right end of the keyboard. Control messages to the computer are usually typed in the upper left-hand corner of the screen. That upper left-hand corner of the screen is home cursor position and the center cursor control key (labelled "home") will return the cursor to that position. Characters appear on the screen at one of two intensity levels. Terminal inputs and variable data are bright - foreground. Computer messages to the terminals (aside from variable data) are dimmer-background. Overall intensity is adjustable at the bottom of the screen.

"The terminal subsystem uses the top two lines of the screen for system functions. Thus, system control functions entered on the top line of the terminal result in displayed control options such as: "ENTER", "DELETE", "CHANGE", "NEXT PAGE". The

second line contains the file or record name. The bottom two lines are reserved for system messages to the operator, such as "TRANSACTION ACCEPTED", "TRANSACTION REJECTED" and corresponding data.

"Terminal Operations

"To commence operations, each terminal must be "logged in". This is done by homing the cursor, typing "LI" and then depressing SHIFT and XMIT simultaneously. The system will respond with "LOGGED IN AT TIME" on the bottom line. Now clear the screen by depressing the SHIFT/CLR simultaneously, type "IN", SHIFT/XMIT. That will cause the index to be displayed.

NOTE: The above can be combined by typing "LIIN" and the system will log in the terminal and display the index in one operation.

"Starting with a three-digit number from the index, records can be called up for display or manipulation by typing as follows (starting from the home position):

"NNN/PPAAA RRRRRRRRRRRRRRRRRRRRRRRRR ■

Where	Equals
NNN	Three digit subject code.
/	Diagonal must separate file and page.
PP	Page of record (or file if single record file) must be two digits.
AAA	Access code (if required).
RRR-----RRR	Record name.
■	The transmit order symbol, generated by placing the cursor beyond the last character to be transmitted, then depressing SHIFT/XMIT.

"The above message is a user request for a record display. The response will be the display selected."

As a result of the system becoming more interactive as enhancements are incorporated, system guidance in response to erroneous user inputs is relied upon more extensively. For example, syntactical and lexical analysis of the user input may cause display of a corrective message on the bottom three lines of the inputting terminal (e.g., "YOU HAVE ENTERED INSUFFICIENT NUMBERS FOR THE SSN, PLEASE CORRECT AND RE-TRANSMIT").

This display and resulting correction must occur before the data base will be updated. This and similar techniques are used to hold inaccuracy of the source data to an absolute minimum.

1.2 Initial Operational Capability (IOC)

The initial capability of the CMT system became operational in October 1972. This capability specifically addressed the needs of the F-14 Readiness Squadron (RS) at that point in time and, therefore, placed great emphasis upon the Record Keeping function and the teleprocessing aspects of the system. More specifically, IOC provided user capability to access and interact with the remotely located main frame computer (see Section 2.0) through his CRT terminal at NAS Miramar.

During this time, the F-14 community was undergoing an extensive personnel build-up in preparation for the start of training activities, both in the F-14 RS and the first two operational squadrons (VF-1 and VF-2). Since one of the basic CMT concepts is the minimization of paperwork within the squadrons, IOC provided the capability to establish records for all F-14 personnel within the integrated data base and obviated reliance upon file cabinet storage and access. This capability provided for record creation through five standard format entry displays, referred to as "pages". These five pages were derived on the basis of a worst case analysis (i.e., rated officer personnel) of the personnel record data required in the F-14 training community. As such, the pages range from very basic personal data (e.g., rank/rate, SSN, date of birth, residence address, etc.) to flight record summary data (e.g., carrier approaches/landings, number of flights on a monthly/yearly basis, etc.). The personnel data contained in the CMT data base does not represent a one-for-one transcription of each individual's personnel folder. Rather, only those data elements relevant to operation/management of the F-14 RS are extracted and entered. The resulting CMT data base creation was handled almost entirely by F-14 RS Administrative personnel through their interactive terminals, after a minimal amount of training.

In addition to the basic Personnel Data function, IOC provided a number of displays extracted from the basic data (e.g., officer/enlisted lists, officer/enlisted rosters, emergency recall bill, etc.). Although these types of extracted file displays are almost trivial from a data processing sense, the squadron manpower effort saving they represent is considerable. For example, preparation of the squadron rosters alone traditionally has required 3-5 manweeks of effort per month. This manpower is now applied to more productive tasks.

Beyond the emphasis on Administrative/Personnel activities, a limited amount of support was provided to the Fleet Replacement Aviation Maintenance Personnel (FRAMP) training effort at IOC. This support was specifically directed toward the then-current efforts to define the FRAMP syllabus. It provided the ability to build/edit the entire syllabus and to create an extracted gradebook for each FRAMP student.

1.3 Current Capabilities and Planned Enhancements

As the CMT system has evolved, the specific capabilities available to system users have become categorized in accordance with the three major organizational elements of the F-14 RS— Personnel/Administration, Aircrew and FRAMP. Since these capabilities tend to create an overlay matrix with the system functional components discussed at the beginning of this section, the following description adopts the organizational element orientation. These descriptions should be interpreted as being in addition to the on-going efforts to enhance the efficiency of system software operations to provide an even more rapid response time to user interactions. Furthermore, to allow this paper to maintain a reasonable page length, these capabilities are presented in a condensed, summarized format with the amplifying details omitted.

1.3.1 Personnel/Administration Functions

The current CMT capabilities which support the F-14 RS Personnel/Administration function are:

- Entry, retrieval and update of individual personnel files.
- Extracted list generation for rosters, mailing labels, personnel lists, etc.
- Control of required reports — including due dates, ticklers and action requirements.
- A file of current, appropriate directives.
- Source data listings for manpower accounting.
- Promotional requirements tracking system — including the capability to both track and produce exception (potentially delinquent) reports.

The planned enhancements for this area of RS operations are:

- A generalized data base sort, formatting and retrieval capability; the ability to scan personnel files against a user-defined criteria and provide a summary display; for example, the ability to produce a displayed list of all personnel who have had more than 1800 hours experience in the F-8.
- Modification of the data base file structure to permit chaining additional "pages" of information to an individual's record.

1.3.2 Aircrew Functions

Current CMT capabilities which support the Aircrew functions are:

- A generalized structure to support syllabus creation/ modification, individualized syllabus tailoring for both incoming and currently on-board students, optimized association of training events, and specific identification of resultant reference/ training materials requirements.
- Ability to generate planning requirements in terms of number of sorties, carrel utilization, etc.
- Historical files on all students.

Planned enhancements for Aircrew functions are:

- Training event scheduling capability.
- Student and instructor performance evaluation.
- Long range performance prediction.
- Identification of training mission capability of a system as a function of configuration and status.
- Source data entry for Individual Flight Accountability Record System (IFARS).

1.3.3 FRAMP Functions

The current CMT capabilities which are responsive to FRAMP activities are:

- Single point entry; i.e., grade books and class lists generated automatically upon establishment of student personnel records.
- Class or individual level grade entry — accommodates numerical and BQS completion entry.
- Class grade averaging and class standing generation for individual students.
- Real-time exception reporting; e.g., the postion of each class and individual with regard to a min-max-optimum training day time-line.
- Class status reports — identification of all current classes, projected completion dates, number of students, etc.

- Maintenance of a historical file for each student with the ability to update as OJT is completed.
- Generation of all out-of-squadron reports.
- A scheduling system which sub-optimizes practical training through shift assignments, handles impact/constraint analyses and provides compatibility checking. It is used both to generate daily schedules and to develop fiscal year plans.

The planned enhancements to these capabilities are:

- Student/instructor performance evaluation.
- Refinements to the existing scheduling system.
- Maintenance of a fleet-level F-14 skills data bank.

2.0 HARDWARE IMPLEMENTATION

The CMT hardware implementation (Figure 3) is interactive terminal oriented and involves the application of a general-purpose digital computer "main frame" and a mini-computer "front end" teleprocessing network. The main frame system is located remotely from NAS Miramar and employs a Burroughs B-3500 third-generation digital computer with a 240 kilo-byte memory and associated peripherals. Two independently addressable fixed-head disc units provide 60 megabytes of rapid access storage. Bulk storage and input, including disaster recovery, is accommodated by two nine-channel magnetic tape units. Although a card reader and a high-speed line printer are included in the main frame system, their functions are dedicated to software development and checkout rather than on-line system operation. In addition, two CRT terminals, identical to those in the front end system, are used to support system design and evolution.

Communications between the main frame and front end systems operate at a 4,800 BAUD rate across a leased telephone data line (C-2 conditioned). The front end system is located entirely on-site at NAS Miramar and consists of a mini-computer, 1200 BAUD modems transmitting across voice-grade telephone lines, a medium-speed line printer unit and the interactive CRT terminals. The mini-computer is currently being used in a data concentrator role rather than as a true computer. However, near-term plans are to upgrade the role of the mini-computer to off-load as much as possible from the main frame to the front end with resultant decreased data transmission requirements.

User interface with the CMT system is implemented through Hazeltine 2000 CRT/keyboard terminals with an auxiliary low-speed (30 cps) printer unit. Each terminal has a 12-inch CRT capable of displaying 27 lines of 74 characters per line for a total capacity of 1998 characters. Keyboard

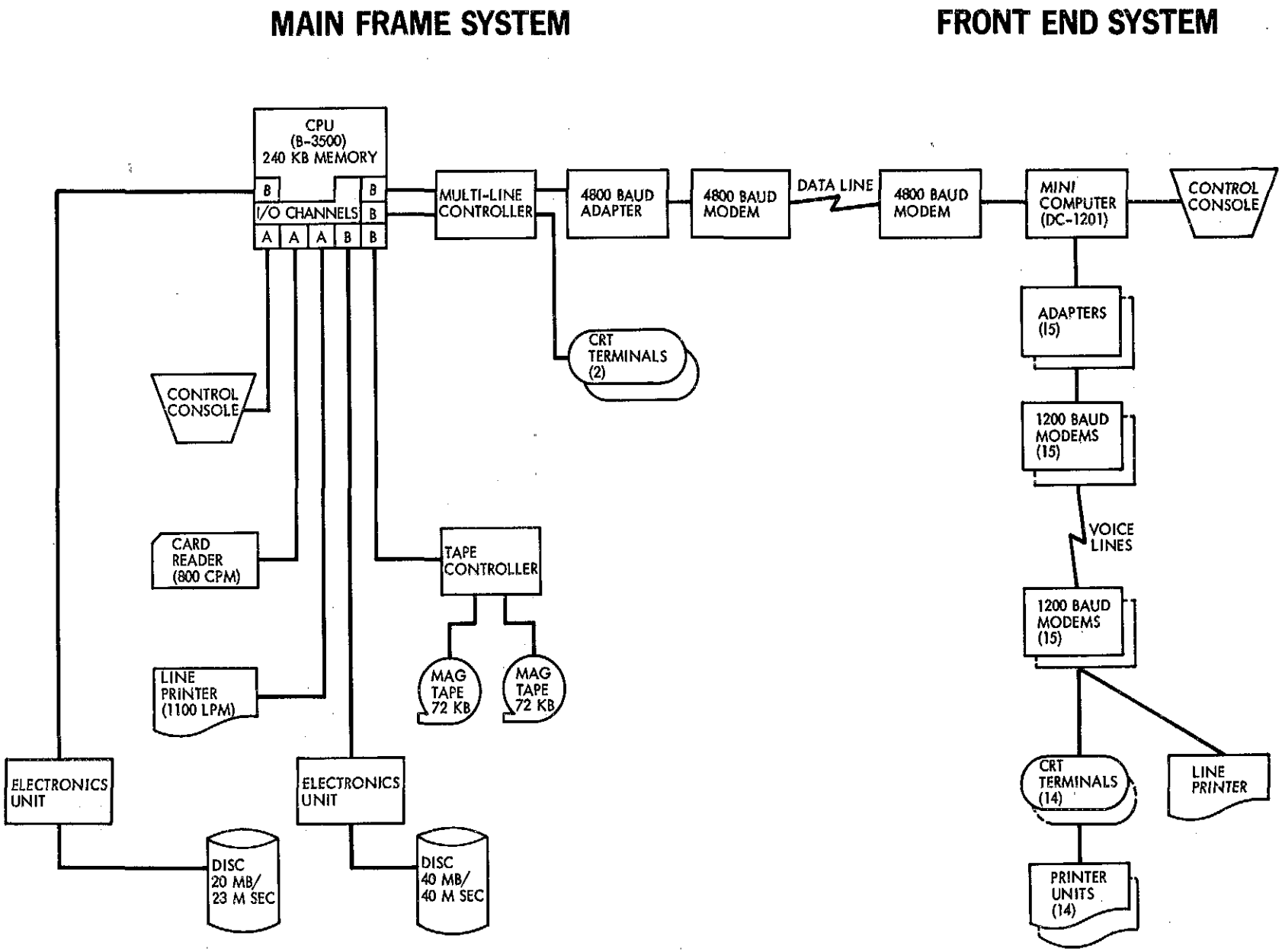

Figure 3. CMT Hardware Implementation

controls provide a full range of alpha-numeric data input as well as extensive character/line editing capabilities. In addition, a foreground/background scheme is provided using two levels of illumination intensity. The background (lower intensity) indicates computer-generated data which may not be altered by the user, the foreground identifies user-posted data which is completely under his control. This foreground/background scheme allows implementation of those CMT functions (e.g., Record Keeping) which provide a computer-generated display format and have the user fill in the blanks, as appropriate.

3.0 SOFTWARE IMPLEMENTATION

The system software (Figure 4) consists of a core resident operating system containing the data base manager, the data communications interface, and the standard Burroughs operating system. The core resident routines provide for a rapid response to the operator for the bulk of the transactions which consist of data entry, display and updates. The system goal is to keep the response time under five seconds for routine transactions. Applications programs are called in and sequenced by the scheduler for the slower response, less frequently used, applications which involve the manipulation of data. A positive disaster recovery system which logs every transaction to tape is utilized for protection of the data base and gathering statistical data on system usage that can be utilized for design enhancements.

For security purposes, single and double keys are utilized to prevent unauthorized personnel from gaining access to or altering designated files and data. The access levels can be assigned by terminal or by file, and codes changed while the system is on-line in the event the keys are compromised. All records that are deleted are retained on magnetic tape for a period of time before they are purged to preclude the possibility of deliberate destruction.

The data base management system in use was developed for the Burroughs B-3500 by the Air Force with Navy participation through HAC and embodies the current CODASYL concepts. Version II is in production at present with Version III scheduled for implementation in the late Fall. Version III will contain a powerful retrieval system which will permit the individual users to retrieve and manipulate those data elements they require without the necessity of requesting programming services.

In conjunction with the basic philosophy of developing a software package structured to meet the requirements of the user, a generalized system has been developed which will allow the user to enter, change, delete, and combine files to suit his purposes. From a user perspective, this appears as a sequence of pages displayed on the CRT that are controlled and placed in a network structure according to user key assignments. For example, the requirement to enter and update reference material for a particular training event can be viewed as a text editing requirement which is handled directly on the CRT through single entry.

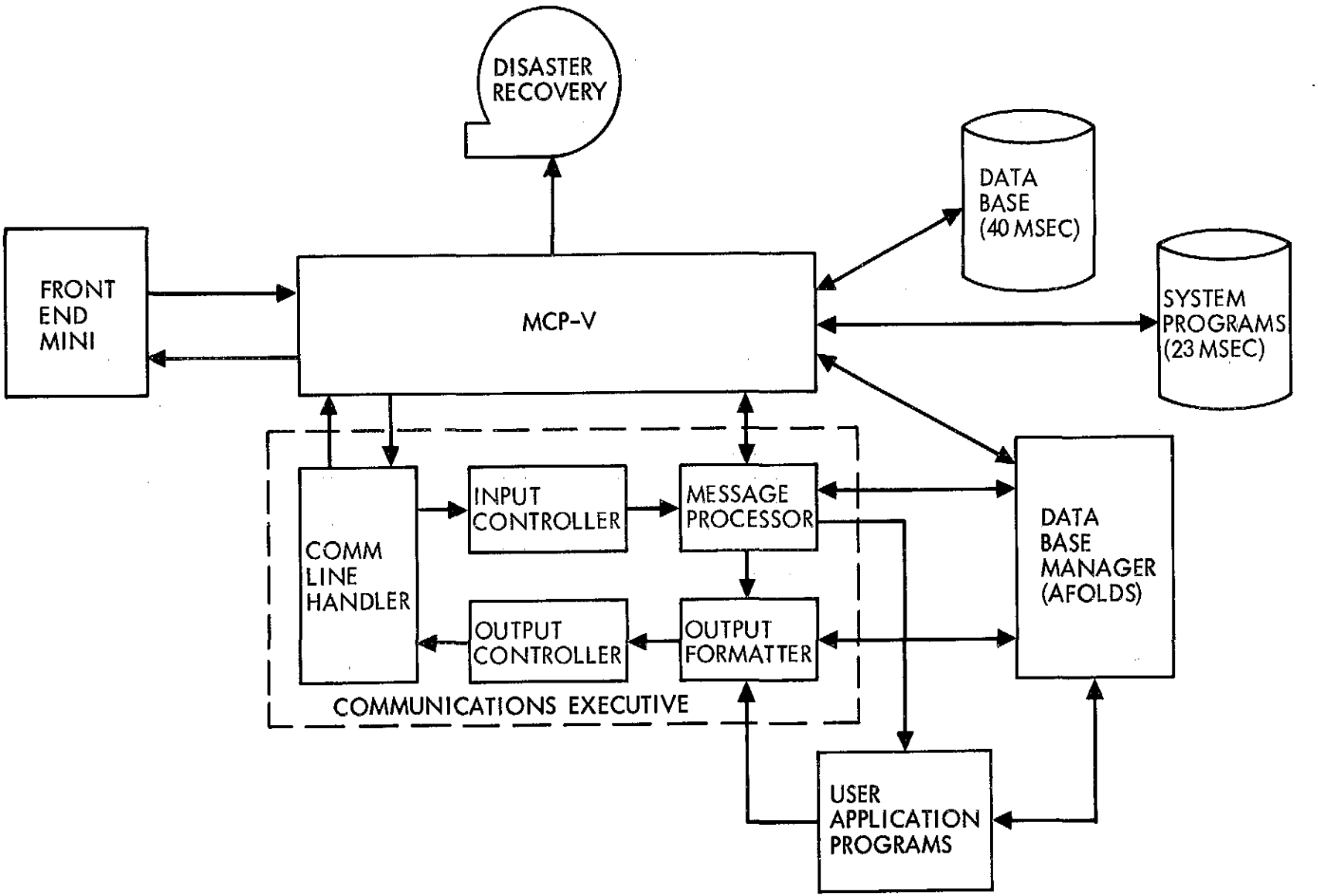

Figure 4. CMT Software Structure

The software has also been structured to fully utilize the capabilities of the CRT. Unlike many installations which operate in a teletype mode, the system software uses large block transmissions in foreground and background with a user capability of entering either foreground or background information in selected files. For other files, the background is protected and all data entry is through foreground keying to protect the structure and simplify data entry.

For further system development and testing, a generalized automated testing system has been developed. This provides a means of controllable time-sequence stepping through each function. Although it has not been used for anything other than system testing at present, this functional capability provides a means of automatically stepping through a time-sequenced order of pages or CRT displays which could be used for demonstration or training as well as system testing.

A data item dictionary is automatically generated when additional data elements or edits are altered. This dictionary contains a complete listing of all files, data elements, descriptions, allowable values, and edits. It was developed primarily as a system maintenance tool, but has had widespread usage among the line managers to answer questions as to what data is available within the system for additional applications.

4.0 SUMMARY

There are several salient characteristics woven through the discussions presented in this paper which serve to identify the underlying philosophy, conceptual orientation and implementation approach of the Navy/Hughes CMT system. These are briefly reiterated for your consideration in the following:

- User Involvement: An overt dedication to providing a user-oriented system heavily flavored with "real-world" fleet operational experience to specifically negate the primary factor behind the majority of management system failures — lack of attention to the user and his needs. This characteristic, coupled with a system evolution responsive to the existing RS state of development, has contributed significantly to the high degree of system acceptance evident today.

- Interactive, On-Line Terminals: An interactive system employing video terminals for both data entry and display with on-line editing features for rapid response (typically about 5 seconds). Although "scratch-pad" hard copy can be had via the low speed line printers if needed, the use of hard-copy forms/paperwork is minimized.

- Minimal Reliance on Software Support Personnel: Following establishment of a "mature" CMT system, reliance upon software support personnel by squadron management is greatly

reduced by having a system which they can change (barring major modifications/additions) and by placing input/output in the hands of line management (no cards, key punch forms, etc.). In addition, this represents a major step toward resolving the traditional source data accuracy problem.

- An Evolutionary System: Based upon an "open-ended" concept that will accept the predictable perturbations in training facilities/methods and student loads. Furthermore, it constitutes a sophisticated training research "tool" which will support empirical validation of instructional strategies and performance evaluation techniques. One specific area which will evolve is an increase in functions performed by the on-site mini-computer and a decreased reliance on a remote main frame computer.

- Readily Exportable: The bulk of the technology and system software developed under F-14 auspices is directly applicable to other training programs. Additional effort required for such applications rests with the premise of user involvement. That is, the unique requirements of the training program must be identified and folded into the basic CMT system design.

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13. ABSTRACT

A compilation of papers on a variety of technical and training subjects related to training device technology and training methodology. The enclosed papers were presented at the Sixth NAVTRAEQUIPCEN/Industry Conference at the Kahler Plaza Inn, Orlando, Florida, November 13-15, 1973.

The conference theme "Man--The Focus of the Training System" provides a common ground for the examination of the various aspects of the training system which contributes to the effective development of man's capability to carry out the tasks to which he is assigned. The sixth conference is part of a continuing program to promote cooperation between Government and industry in the procurement of training equipment, and to foster an exchange of ideas on new simulation technology.

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