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MULTISPECTRAL IMAGE CAPTURE AND ARCHIVAL SYSTEM (MICAS): SYSTEM DESCRIPTION

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The Coastal Battlefield Reconnaissance Analysis (COBRA) program is developing a coastal reconnaisance system using an airborne multispectral sensor. The low cost sensor being used for this program collects multispectral imagery using an intensified video camera incorporating a spinning filter wheel. The filter wheel contains six relatively narrow band filters. The output of the camera is in the form of standard RS-170 video signals. In order to process the multispectral imagery to automatically detect the presence of minefields, the video imagery must first be digitized and stored in a database for analysis. Under the program, the Environmental Research Institute of Michigan (ERIM) developed a low cost Image Capture and Archival System (MICAS). MICAS is capable of digitizing multiband imagery from live or taped video signals, decoding camera parameter data encoded in each video frame, and archiving the image and camera data into standard Tagged Image File Format (TIFF) files. When digitizing from video tape, the computer controls all functions of the tape drive so long sequences of video

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images can be acquired automatically. The resulting TIFF files contain not only the multispectral imagery, but also all ancillary data required to correctly interpret the data. Thus, no separate files need to be maintained along with the imagery. This report describes the architecture and implementation of the MICAS system.

PREFACE

This document describes the Multispectral Image Capture and Archival System (MICAS) developed for the Coastal Systems Station (CSS), Panama City, Florida, by the Environmental Research Institute of Michigan (ERIM) under Contract DLA900-88-D-0392, Delivery Order 0046. MICAS was developed as part of the Coastal Battlefield Reconnaissance and Analysis (COBRA) program to digitize and archive multispectral imagery. The system is capable of acquiring and archiving any image data recorded on video tapes and, therefore, is generally applicable to many data acquisition applications. The system description provided in this document overviews the system architecture, its implementation and use. Further information is available from Code 10T1, Coastal Systems Station, Panama City, Florida.

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This study was supported by the COBRA Program Office, Code 10T1, of the Research and Technology Department at the Coastal Systems Station. Mr. Ned Witherspoon is the COBRA Program Manager.

The ERIM Principal Researcher and Program Manager for this effort was Dr. James A. Wright. He was assisted in the development of the MICAS system by Mr. Russell Hilton.

CONTENTS

FIGURES

1.0 INTRODUCTION

The Coastal Battlefield Reconnaissance and Analysis (COBRA) program involves the development of a multispectral airborne imaging sensor for acquiring images in coastal areas. The current advanced technology demonstration (ATD) COBRA sensor uses off-the-shelf camera technology incorporating a spinning filter wheel synchronized to an electronically shuttered video camera. The filter wheel contains six different optical filters, each with a different pass band. The camera records multispectral imagery by imaging through a different filter for each video frame so that a single multispectral image is made up of six video images. COBRA video images are recorded on S-VHS video tape which must be digitized for post-mission image processing and analysis.

In order to digitally process COBRA multispectral imagery, the video images must be digitized and properly archived. Since multispectral images are formed from sequences of video images, image acquisition requires digitizing sequences of video images without the loss of any frames. And, because target arrays are often fairly long, a single acquisition can involve a sequence of over 100 video frames. While direct-to-disk video acquisition systems are available, these were judged too expensive for the preliminary COBRA test program. It was decided that a more economical system would use a standard video framegrabber in a Personal Computer, along with a computer controllable video tape player. Thus, the computer can step the video player through sequences of images, digitizing them and archiving them to disk and/or tape. The Multispectral Image Capture and Archival System (MICAS) was developed for this purpose.

Besides the actual sensor image, the COBRA system also encodes camera parameter data (e.g., frame time, filter number, gain, exposure) in each video image. This data must be decoded in order to properly interpret the imagery. It appears as bars of black or white pixels down the left edge of each image and is decoded by digitizing the images, reading out a column of pixels along the left edge, forming bytes of data from the pixel values, and decoding the resulting bytes. The MICAS system performs this operation automatically and records the camera data for each sensor image in the image header, as well as in a database file. The imagery is stored in standard Tagged Image File Format (TIFF) files and the database information is stored in an ASCII file. Using these formats, the data is easily readable by almost any available image analysis and database software.

The design of the MICAS system allows resulting image data to contain all of the ancillary data necessary to interpret the imagery. Image analysts no longer have to search for supporting data but have immediate access to this information as user data in the TIFF header. While an application specific program is required in order to read the user data, in cases where the supporting data is not required, such as when viewing or printing images, standard software capable of reading TIFF images can be used. Likewise, when searching for images corresponding to particular values of a camera parameter, almost any standard database software can be used as long as it can read an ASCII file. This makes data acquired with the MICAS system available to a wide variety of applications.

The remainder of this report describes the specific hardware and software components of MICAS, along with their operation. Consideration is given throughout as to how this system could be used in other related applications.

2.0 HARDWARE DESCRIPTION

Figure 2-1 shows the primary MICAS hardware components. These include an IBM-compatible Personal Computer (PC) with a video framegrabber, a Panasonic computer controllable Video Cassette Recorder (VCR), a Horita Vertical Interval Time Code (VITC) encoder and decoder, and a Sony video monitor. The following subsections describe the purpose and function of each of these components.

2.1 PERSONAL COMPUTER

The MICAS system is intended to be a low-cost video data acquisition system with capabilities available to a broad range of personnel. The PC was chosen as the host system because of its relatively low cost and familiarity with many personnel. The primary functions performed by the PC are operator interface, image data acquisition, data storage, and quick-look processing. Operator interface is achieved using both commercial, off-the-shelf (COTS) Windows-based programs, as well as Windows programs developed by ERIM specifically to control MICAS image data acquisition operations. For data storage, the PC currently includes two 512 megabyte (MB) fixed disk drives, and a 120 MB tape drive. Other storage media, such as removable disks, are planned for the future.

The MICAS PC is also used for quick-look (QL) processing during field data collections. This allows an operator to analyze image data as it is acquired to ensure that it meets data acquisition requirements. To do this, a high end i486DX-66MHz PC was chosen with local bus video and 17" color monitor. This system provides adequate processing and display throughput for QL image analysis functions.

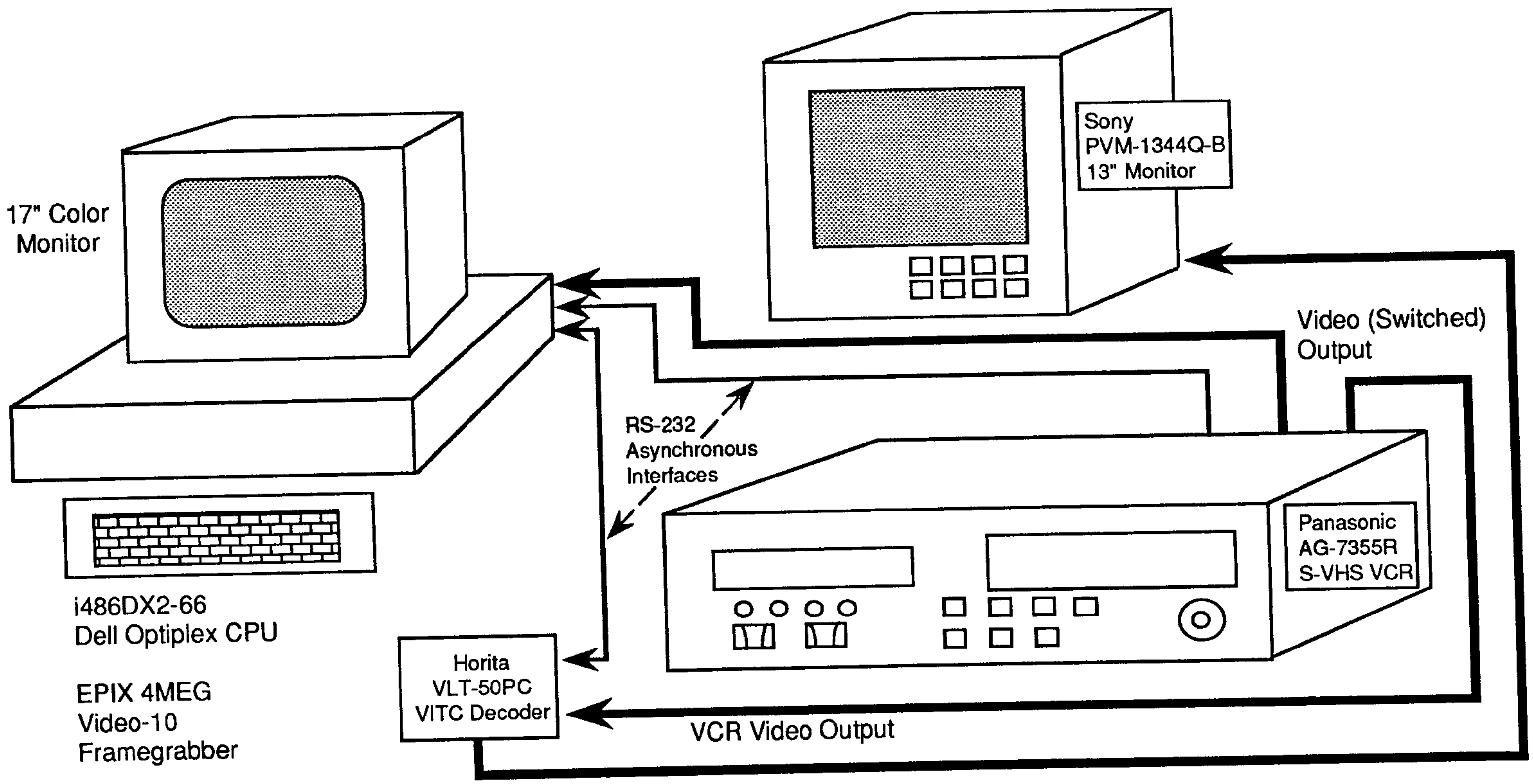

Figure 2-1. MICAS Hardware Components

2.2 VIDEO FRAMEGRABBER

In order for MICAS to acquire and archive video imagery, a video framegrabber was required. This framegrabber must be capable of digitizing S-VHS quality intensity (not color) data from a VCR. The MICAS PC contains an EPIX 4MEG Video-10 framegrabber for this function. This card has four (4) MB of memory which can be configured to hold multiple frames of digitized video with the amount depending on the number of pixels in each digitized image. Using 480 by 740 pixels for each image, the card is capable of acquiring nine (9) live video images before having to transfer them to disk. The capability to acquire nine images ensures that for a single acquisition of live COBRA data, the operator will obtain all six bands of imagery making up a single multispectral image. However, the process of manually digitizing long sequences of images is very tedious since only nine images are acquired at a time. The operator must play the recorder, acquire nine images, store them, rewind the recorder to just before the sequence of images acquired, play the recorder, and trigger the digitizer at just the right time to acquire the next sequence of images. This is a very labor-intensive task which is relatively easily automated.

2.3 VIDEO CASSETTE RECORDER

In order to automate the image acquisition process, the VCR used in MICAS must be controllable from the PC. In addition, for the operator to be able to capture a particular frame of interest paused on the VCR, the VCR must be capable of outputing a full frame image with stable sync while in pause mode. VCRs capable of doing this capture the desired image into their own digital memory and convert the digitized image back to a stable analog signal prior to output. Thus, the MICAS VCR must not only be computer controllable, but must also have digital frame storage capability. The Panasonic AG-7355R S-VHS VCR was chosen based on these requirements.

The AG-7355R can be controlled from a standard RS-232 serial link. Its digital frame storage capability maintains full S-VHS image quality and can be triggered both when playing or when paused. If the VCR is paused when digital storage is selected, the VCR automatically rewinds the tape slightly, plays at regular speed, and captures the desired video frame when reached. Manual operation includes standard jog-and-shuttle controls, which can be used in conjunction with the computer interface, for quick location of desired video data.

An additional feature of the AG-7355R is its ability to encode and decode Linear Time Code (LTC) information. LTC is a standard time reference for video tape recordings and is written onto one of the audio tracks of the video tape when recorded. This timing data can be accessed over the RS-232 serial link during playback, rewind, fast forward and pause modes. While LTC does provide a time reference which can resolve time corresponding to individual frames (1/30th of a second), it is not accurate enough to reliably identify the time of each individual frame. Typically, LTC time is within one to three frames of the desired frame. Since individual frames in COBRA data correspond to separate bands, and because it is desirable to provide image data time referenced back to the original tape recordings, we require that MICAS have an accurate time reference capability down to individual frames.

2.4 VERTICAL INTERVAL TIME CODE ENCODER AND DECODER

The Vertical Interval Time Code (VITC) standard time reference was developed to provide timing accuracy down to the individual frame for video tape recordings. This time code is recorded into the sync portion of video signals during which video is blanked. It has resolution and accuracy down to individual fields of video (1/60th of a second). The MICAS system uses the VITC time reference so that resulting data can be resolved to the original data on video tape, and to ensure that desired video data is accurately acquired.

The original COBRA sensor implementation did not have the capability to record VITC timing signals directly. However, the original video tapes were duplicated prior to use in analysis so that VITC could be added during duplication. To do this, a Horita VITC time encoder is included in MICAS. During tape duplication, the Horita encoder is placed between the VCR playing the original tape, and the VCR recording the duplicate tape. In order to read the VITC data during tape playback, a Horita VITC time decoder is used. The decoder is placed between the VCR output and the video monitor so that it does not degrade the video signal going to the EPIX framegrabber. Also, the decoder can be set to write the VITC time in readable numeric format over the video image on the monitor without interfering with the image acquired by the framegrabber. The decoder includes an RS-232 serial data link allowing the PC access to VITC time at the current tape position. This time is available in all VCR operating modes.

An additional feature of the Horita VITC time encoder is the ability to sync to an LTC signal. This allows the original video recording, which may include an LTC signal in the audio track, to be duplicated with the higher accuracy VITC signal while still maintaining the original LTC time reference. If multiple recordings are desired, multiple VITC encoders can be synced to the same LTC signal so that all recordings possess the exact same time reference. Furthermore, Horita offers an LTC generator which can sync to the Global Positioning System (GPS) time reference allowing multiple recorders at different locations to have identically the same reference around the world. Adding this capability will allow MICAS to record video data transmitted from an airborne platform equipped with an on-board GPS receiver and accurately reference the GPS position data with the resulting video images, even though the position data is not transmitted to the ground at the time of recording.

2.5 VIDEO MONITOR

Imagery acquired by the MICAS system is displayed on a video monitor. In order to allow a single monitor to be used both for viewing video tapes, as well as viewing images captured and processed by the EPIX framegrabber, a monitor was chosen with multiple input capability. In order to view video tapes at full resolution, it was required that the monitor possess an S-VHS input. Furthermore, in order to display pseudocolored images from the framegrabber, it also required an Red-Green-Blue (RGB) input. The Sony PVM-1344Q-B 13" color monitor was selected for MICAS. The operator can easily switch from the VCR video output to the RGB framegrabber output by front-panel buttons.

3.0 SOFTWARE DESCRIPTION

MICAS includes both commercial, off-the-shelf (COTS) software as well as custom software. The COTS software performs standard computer control and operator interface functions, as well as quick-look (QL) image analysis functions. The custom software includes all MICAS application specific functions not handled by available COTS software. The following subsections describe the primary software components of MICAS.

3.1 COTS SOFTWARE

Principal MICAS COTS software falls into two categories: general operating system software and support software required to control the PC and its peripherals, and software controlling framegrabber operations.

3.1.1 Operating System

The MICAS PC uses the DOS operating system and Windows interface. All operation and control software, both commercial and custom, use Windows interface standards for compatibility and ease of use. Control of all PC peripherals is handled through standard Windows functions.

3.1.2 Framegrabber Control

The EPIX framegrabber is manually controlled through the IO Industries EYE Image Calculator software. This software directly interfaces with the EPIX card with a unique capability to handle its reconfigurable image memory. The operator can graphically reconfigure video digitizer memory through the Image Calculator making the memory appear similar to a spreadsheet. Newly acquired images can be assigned to specific "cells" within image memory by dragging and dropping a camera icon on the desired cell. Any cell can be displayed by dragging and dropping a monitor icon on that cell. A sequence of live video images can be captured simply by dragging across the number of cells desired and clicking on a "Go" button. The Image Calculator also includes a variety of image analysis functions including zoom, plotting profiles and projections, computing image statistics, adding and subtracting images, etc. These functions allow the Image Calculator to perform primary quick-look processing operations.

Also included with the EYE Image Calculator software is a Windows Dynamic Link Library (DLL) allowing custom software to call Image Calculator functions. Some of these functions are used in MICAS application specific software.

3.2 CUSTOM SOFTWARE

MICAS custom software controls image acquisition and archival functions. All software was developed in C using Borland C++ and associated design tools. Borland C++ is widely accepted as a standard compiler and provides a fully functional, intuitive environment for advanced software development. All applications have a Graphical User Interface (GUI) consistent with Microsoft Windows. Each has a standard main window, displayed when the application is launched, pull-down user selection menus and pop-up dialog boxes. The main window contains multiple pull down selections addressing the specific requirements of the application. Application specific dialog boxes requiring user confirmation and data input are displayed during the execution and are based on the user's selection from current menu items.

The MICAS application software is divided into three major functions: Image Data Acquisition System (IDAS), Ancillary Data Insertion (ADI), and Database Formation (DBF). The following subsections briefly overview each application.

3.2.1 Image Data Acquisition System

The primary function of the IDAS application is collection, digitization, and storage of video images. This requires that the application have control of all associated video peripherals. The IDAS software interacts with the operator via windows, menus, and dialog boxes to produce formatted digital image files. These files contain all user-entered setup data and decoded camera parameter data accepted during the acquisition, along with the digitized video images. The IDAS application also provides an editing and review capability for the digitized images and their ancillary data. The following paragraphs briefly describe IDAS operation.

3.2.1.1 Collection Setup/Data Input Interface

When the IDAS application is launched from MS Windows, it displays a main window containing the three pull-down menu selections as depicted in Figure 3-1. These provide the operator with all available functions of the application.

SETUP	COLLECT	EDIT/REVIEW
|---- New	|---- Source	|---- Setup Info
|---- Open	|---- Go	
|---- Save As ...		
|---- Close		
|---- Exit		

Figure 3-1. IDAS Application Main Window Menus

The first operation taken by the user is to pull down the SETUP menu, and select the New or Open option. This initializes and/or opens a file containing general data acquisition setup information such as Mission Name, Sensor Type, Acquisition Mode, etc. When the selection is New, the operator is given the opportunity to name the setup file (filename only, the extension is .STP). For the Open selection, a list of available setup files are displayed for selection by the operator. After file selection or naming is completed, a dialog box containing some general setup information is displayed. Figure 3-2 shows the information contained in this dialog box. When Open is selected, the existing file data is displayed and the operator is given an opportunity to modify this information; whereas, when New is selected, most data appears blank and the user is required to enter the necessary fields. This information is later written to the stored image file on disk for identification (discussed further in the Data Output section).

Next, the operator is ready to select the video image source and related information. This information specifies whether images are to be captured from a live video signal, a recorded signal, whether the video capture will involve single images or multiple sequential frames, and other relevant information. Figure 3-3 shows the source information that is displayed. To set these values, the Collect menu is pulled down, and the Source selection is made. A dialog box appears, containing information about the image source. Most user selectable options in this box are implemented with radio buttons (i.e., circular buttons that allow only one selection to be made). Once the information is selected and/or confirmed by the operator, the dialog box is closed.

With the appropriate information entered, the operator selects Go from the Collect menu. When the source of data selected by the operator is VCR Control, the dialog box shown in Figure 3-4 appears containing standard VCR type button controls; i.e., REWIND, STOP, PLAY, FAST FORWARD, PAUSE, FRAME ADVANCE, FRAME RETREAT. An additional group of buttons for SLOW STEP is also available to step frame-by-frame at a user selected speed.

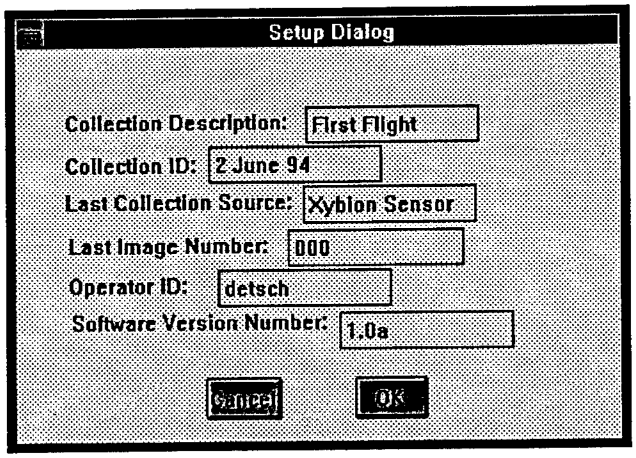

Figure 3-2. IDAS Setup Dialog Box

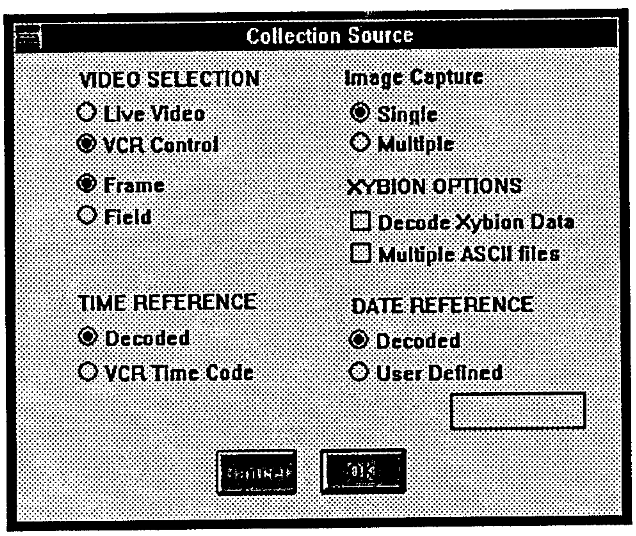

Figure 3-3. Collection Source Dialog Box

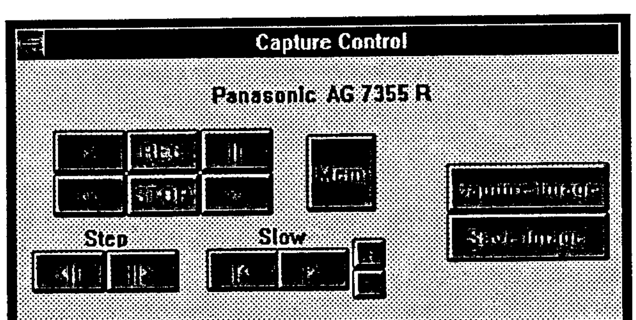

Figure 3-4. VCR Control Dialog Box

3.2.1.2 Capturing Digital Images

Once the collection mode is entered, the user is now able to capture live or recorded images and display them on the auxiliary monitor. These images are captured and stored to disk in accordance with the setup information. In the single capture VCR mode of operation, images are captured when the user selects SAVE IMAGE and the VCR is paused with an image captured into its own digital frame storage memory. In the multiple capture, operator control, mode of operation, the SAVE IMAGE selection initiates a series of automated step, capture, and store operations for the desired number of images. In the multiple capture, time control, mode of operation, SAVE IMAGE will begin the tape search for the selected time (this feature to be implemented). Once found, capture of images will proceed until the end time is reached (currently, within the storage limitations of the PC fixed disk).

One of the selections within the Setup dialog box allows the user to specify whether the video source is Frame or Field. Standard RS-170 video signals contain horizontal lines of video making each frame. These lines are divided up into even and odd sets referred to as fields. The odd field lines are acquired and written out first, followed by the even field lines. Some specialized video sensors acquire a new image for every field (1/60th second) of video rather than for each frame (1/30th of a second). This allows images to be acquired at a faster rate but with lower resolution (half as many horizontal lines). While the MICAS digitizer always digitizes full frames of video, when in Field mode each field is stored as a separate image. In Frame mode, both fields are stored together.

3.2.1.3 Data Output

A primary objective in storage of MICAS digital imagery is to produce data which is as portable as possible across commercial and custom application software. For this reason, MICAS stores image data using the Tagged Image File Format (TIFF). The TIFF format was developed jointly between Aldus and Microsoft, and is currently one of the most preferred and supported formats across many commercial products, including word processors, image analysis packages, illustrators, etc. Its principle advantage over other image file formats is that it was specifically designed to allow custom user data to appear in the image header without interfering with other applications not requiring this data. Fixed file structures, such as the PCX format and many others, do not allow this possibility. This capability is very important to MICAS because of the requirement to store ancillary data (e.g., camera gain and exposure, weather data) in the header of each image. By not requiring a fixed format, the amount and type of this ancillary information can be changed to support new requirements. The TIFF format is discussed completely in Reference (1). For complete details, please refer to this document, produced by Aldus. However, a brief discussion of TIFF follows, with particular attention given to how custom user data is stored in the headers.

The Tagged Image File Format contains three distinct types of data entries. The first, the Image File Header (IFH), contains eight (8) bytes of information necessary to identify the TIFF image. Information included identifies the byte-ordering of the data (different CPUs use different data storage techniques), TIFF version number (although this is actually a static number), and an offset pointer to the first Image File Directory (IFD). The second and third type entries are the IFD, and the Directory Entry (DE). A TIFF file may consist of multiple IFDs, and each IFD contains the DEs. The DE is where TIFF obtains its flexibility. It contains TAG fields which define the raster imagery. The flexibility of TIFF allows application programs to determine relevant image information from these tags, while ignoring "private" fields containing custom user data not required by the application. Within these private fields, up to 32,767 tags may be defined by an application. These fields are officially assigned by the developer of TIFF, Aldus Corporation. ERIM has assigned a private field ID for MICAS and notified Aldus.

All ancillary data including mission data, camera parameters, weather data, etc. are contained within the private data fields within the TIFF header of each image. By placing this data within the TIFF image file, bookkeeping is considerably reduced since an image file does not need any associated files for complete analysis. Applications which do not require the ancillary data can read and process the TIFF images. Applications which need the ancillary data can read it from the private tags within the TIFF header. Reading the ancillary data is specific to the MICAS application so a separate, stand alone routine is supplied with MICAS to read the data from previously stored MICAS images and store it in an ASCII file. This allows any data analyst to have access to the data even if they cannot handle reading private tags from TIFF headers. In addition, MICAS by default creates the ASCII data file containing the ancillary data when storing TIFF image files. This file can be saved or recreated using the stand alone program.

3.2.1.4 Edit/Review Capabilities

Another IDAS function allows viewing of previously acquired images and their associated ancillary data. The user is allowed to edit only the setup information for the data from within the IDAS application. Modifications to the actual image require an additional image processing application, such as the EYE Calculator package included with MICAS. When changes are made to any field within the setup data, the appropriate file is updated on disk by the IDAS application.

3.2.2 Ancillary Data Insertion

The ADI software reads ancillary data not available during image acquisition (e.g., weather, aircraft position) and inserts it into the TIFF header of corresponding images. The time of each image, read by the IDAS application from the camera data in each video frame and stored in the ASCII database file, is used as a reference to synchronize ancillary data to the digitized imagery. The data is placed is the same user tag area in the TIFF header as the camera data. Currently, the ancillary data formats have not been specified for the COBRA program so this application has not been written. It is a stand-alone program so that it can be easily changed for new applications.

3.2.3 Database Formation

The DBF application's primary purpose is to generate an ASCII data file containing the ancillary data stored in the header of each MICAS image file in the current directory. This ASCII file is exactly the same file that is generated by the IDAS application when storing images. The DBF allows this file to be generated for images which have previously been stored but for which the database file has been lost, corrupted or is otherwise not available. The output file, containing all relevant descriptive information on the image, is available for the operator to import to any commercially available database management software.