A SOFTWARE APPROACH TO MARS-II DIGITALLY RECORDED TELEMETRY

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The MARS-II digital recorder is one of the new technologies that will eventually replace the labor intensive and hardware dependent methods associated with traditional analog-based telemetry ground systems. The Standardized MARS-II Analysis and Reduction Tool (SMART) is one of the first software systems developed to take advantage of this new digital recording capability. It processes pulse code modulated (PCM) encoded data and MIL-STD-1553B message traffic, outputting time-tagged PCM frames or 1553 messages to file.

The goal of this software is to provide a portable application that utilizes state-of-the-art, general purpose hardware for rapid telemetry data processing to meet the needs of operational users, telemetry engineers, and data analysts. To satisfy these goals, the software was developed using the C language with VMS and OSF operating systems as the initially targeted platforms. In addition, an X Window System/Motif graphical user interface supporting three tiers of user interaction (operator, telemetry engineer, and telemetry analyst) was layered onto the decommutator functions.

KEY WORDS

MARS-II, SMART, PCM, MIL-STD-1553B, decommutator, C, X Window System, Motif.

INTRODUCTION

MARS-II is an acquisition and recording system developed by DATATAPE Incorporated, Pasadena, California. This system is capable of recording MIL-STD-1553 and PCM encoded data sources. The data is captured to digital media allowing either data playback in a native analog format or digital reduction using computer software applications. This paper shall describe one system of computer software developed by the Air Force Development Test Center (AFDTC), 96th Communications-Computer Systems Group, Eglin AFB, Florida to support post-mission reduction and analysis of data collected by MARS-II instrumented aircraft. This software is called the Standardized MARS-II Analysis and Reduction Tool (SMART).

DEVELOPMENT APPROACH

The near-term goals of this software engineering effort were two-fold. First, to develop a decommutator application program to support the initial verification and validation of data collected by the MARS-II recording system. Second, to provide an operational capability for generating instrumentation data analysis products.

Longer term goals for this software system were to provide for data compression and quality assessment of data products extracted from MARS-II recordings and to develop a graphical user interface for creating, selecting, viewing and editing telemetry setup files, executing decom functions in either interactive or background mode, viewing and signaling execution status, and troubleshooting instrumentation or data problems.

MARS-II DATA FORMAT OVERVIEW

The fundamental data unit for MARS-II recordings is a 16 kilobyte logical data block or “superblock” (using DATATAPE terminology). There are multiple superblocks per physical tape record. All decommutation activities operate at the superblock level. A single superblock contains an information area or superblock header that describes the recorded data. This information includes a binary coded decimal (BCD) timetag for the beginning of each superblock, an analog time and voice segment, and a variable number of PCM and 1553 data segments. The number of data segments, also referred to as channels or blocks, depends upon the number of data streams, the type of data to be recorded, and the respective rates of each data stream as determined at the time of MARS-II recorder setup.

DECOMMUTATOR FUNCTIONS

The initial processing step is to decode the superblock header contents to determine the number, type, and order of user data channels. Having determined the physical data structure, each superblock can be separated by channel and assigned to a unique buffer. Once individually buffered, the data for a specific channel is extracted based on whether it is PCM encoded or MIL-STD-1553.

PCM DATA

The initial step in processing PCM data collected by the MARS-II is to recognize that it is recorded using a 32 bit word structure. However, since it is actually a continuous bit stream without any word boundary alignment characteristics, it requires any software decom function to perform both bit reversal and byte reversal to restore the original bit order. All remaining processing steps revolve around a basic unit of PCM data referred to as a frame.

A frame is considered to be a fixed count of bits beginning with a recognizable bit sequence known as the frame synchronization pattern and includes all bits up to the next occurrence of that same recognizable pattern. The description of a frame is determined by the user and can equate to a major frame or minor frame. This depends on how the frame length in bits, sync pattern, sync pattern length, and sync pattern mask are provided to the decom function. The sync pattern mask is an optional feature that allows the user to ignore unwanted bits. Both the frame sync pattern and sync pattern mask can be up to 32 bits in length.

Having performed the initial step of restoring the original bit order, the stream is evaluated in a manner analogous to traditional bit sync hardware—by shifting the stream 1 bit at a time through a data register. Any necessary bit masking operations are performed and the resulting bit pattern is compared against the frame sync pattern. This constitutes the Search Phase of PCM data processing.

Once the frame sync pattern is located in the stream, the processing transitions to the Lock Phase. This is the phase from which useable, time-tagged data is obtained. The timetag associated with a specific frame is the BCD time extracted from the superblock header plus a calculated bit time offset as determined by the stream bit rate. The decom function remains in the Lock Phase as long as the sync pattern immediately following the current frame is found at the expected location. Failure to find the pattern terminates Lock Phase processing, and the decommutator function reverts to the Search Phase picking up at the first bit following the last recognized sync pattern.

MIL-STD-1553B DATA

1553 data is composed of a sequence of 20 bit data words packed into 32 bit MARS-II words. In other words, every fifth 32 bit MARS-II word will be word boundary aligned with the embedded 20 bit 1553 data words. Unlike PCM data, no bit or byte reversals are required to restore the original bit order. This means the initial step to decom the 1553 data words proceeds rapidly with the majority of the processing centered around the interpretation of message context.

1553 messages are composed of up to 3 types of words: command, data, and status or response. The MARS-II recording format provides for the 1553 data word plus a code that is used to evaluate each word in context, identifying its 1553 word type as command, data, or response. Proper recognition of message word type is required for MIL-STD-1553 data; therefore, sophisticated error detection, reporting, and recovery schemes are essential parts of the 1553 decom function.

Time is associated with each 1553 message by using the BCD time provided in the superblock header plus 20 microseconds for every 1553 word up to the command word. The BCD time and the microsecond offset to the start of the message are combined to timetag the message. When 20 microseconds elapse without receiving a 1553 word, a null or "No Data" word is inserted by the MARS-II system to ensure correct time correlation.

The 1553 decom function allows the selective output of messages by command word or any combination of command word fields and provides for the nth sampling of any or all messages.

GRAPHICAL USER INTERFACE

While SMART can be executed from a dumb terminal, the availability of X Window System capable terminals and workstations led to the development of a Motif graphical user interface. At program startup the user is presented with the window shown in figure 1. The intended audience for this interface to the SMART decom functions is divided into three categories: operational users, telemetry engineers, and telemetry/data analysts. Each category of user has unique data processing requirements which this software tries to address.

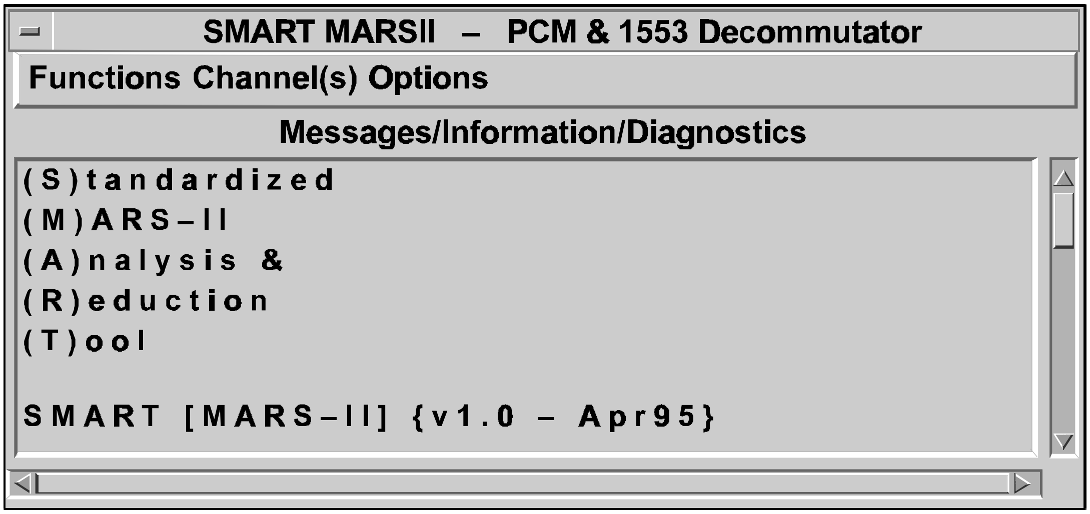

Figure 1. SMART Startup Window

Operational users or telemetry technicians are those individuals responsible for the day-to-day production efforts associated with telemetry data reduction and processing. They are familiar with traditional analog telemetry processing methods but the advent of digital telemetry recording technologies will require changes in how they do their jobs. To assist with this transition, SMART provides the technician with a straight-forward interface as illustrated in figure 2. The technician invokes the Operations Window by menu selection, selects the device to read MARS-II data from, selects the telemetry engineering setup, verifies the displayed setup details, updates the filename(s) directing output, and clicks over the Execute button to launch a background or batch process. Telemetry engineers perform most of their work at the beginning of a test project when new PCM or 1553 data requirements are levied. To accommodate their needs, SMART gives them the Engineering Window illustrated in figure 3. Here the engineer can develop and test the setup details necessary to ensure proper data processing by technicians. Some data fields are relevant to both PCM and 1553 processing such as stream identification (which is similar to analog tape labeling), data type, channel assignment, bit rate, and decom output filename. There are also fields that apply strictly to PCM, including sync pattern and sync mask, sync pattern length, words per frame, and word length. For 1553 there is an option to specify a list of 1553 command words, command word subfields, and/or nth sampling by command word. If data is available, the engineer can invoke the Operations Window to test created or modified setups.

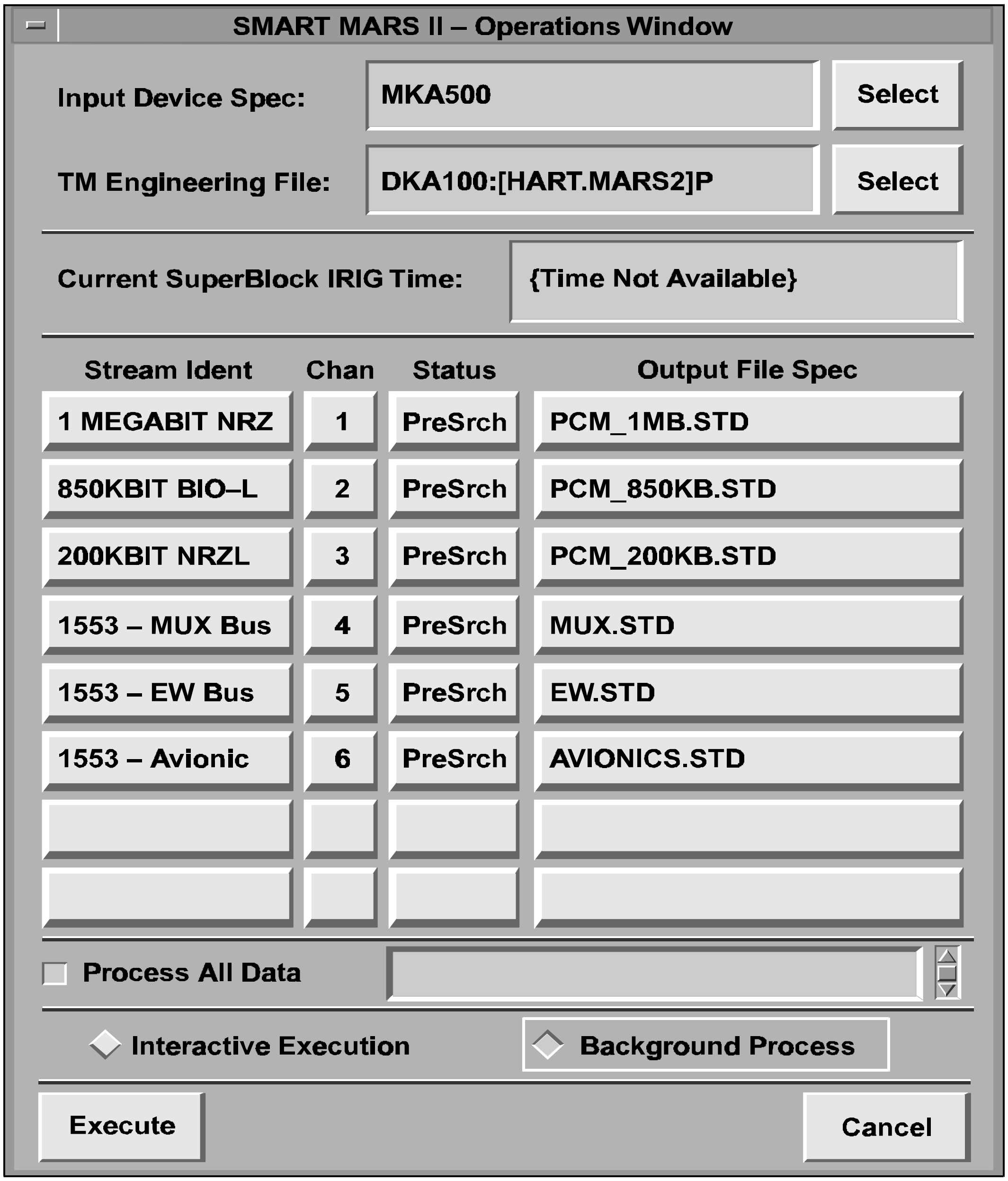

Figure 2. Operations Window

Finally, telemetry analysts become involved when problems occur either in production decom execution or—as AFDTC has done—to assist in the verification and validation of the MARS-II recording system. The Analysis Window (figure 4) allows the user to go directly to a specific superblock or time of interest and vary the level of scrutiny of the superblock contents by looking at either the raw superblock exactly as it was written or to select a specific channel of interest for either frame-by-frame or message-by-message evaluation. When diagnosing 1553 problems, the analyst can select messages by command word or command word fields. Also, this window can be used to verify telemetry engineer setups.

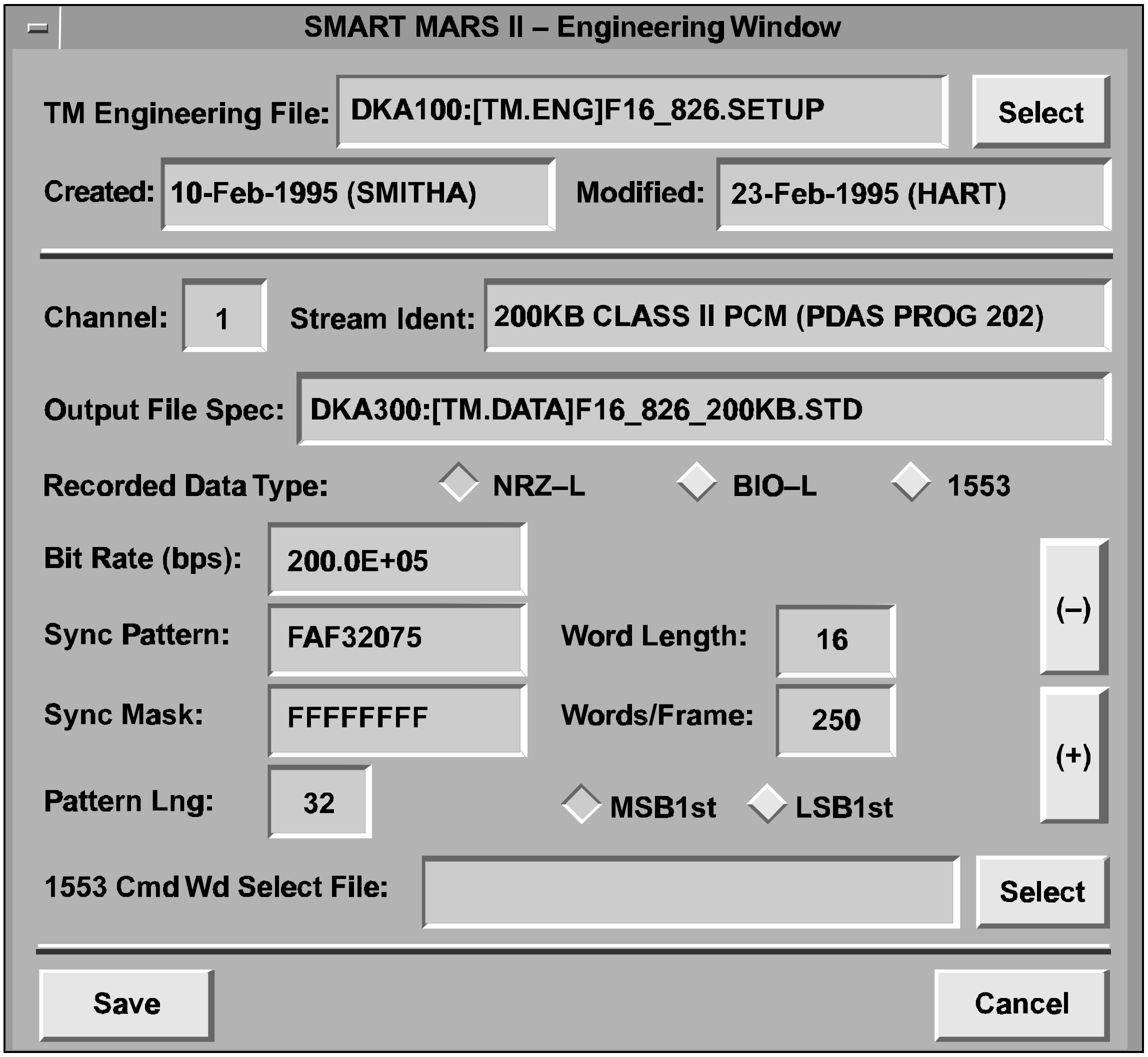

Figure 3. Engineering Window

CONCLUSION

Digital recording technologies similar to MARS-II are beginning to replace traditional analog systems. The Air Force Development Test Center has recognized this fact and is pursuing what will be more cost-effective, upgradeable, and reliable telemetry recording and data processing systems. Plans for SMART include porting the decom functions to Windows and Windows NT and coupling it with the Common Airborne Processing System (CAPS) which performs egineering unit conversion of PCM and 1553 data. The goal is to provide a standardized telemetry to engineering units to analysis solution.

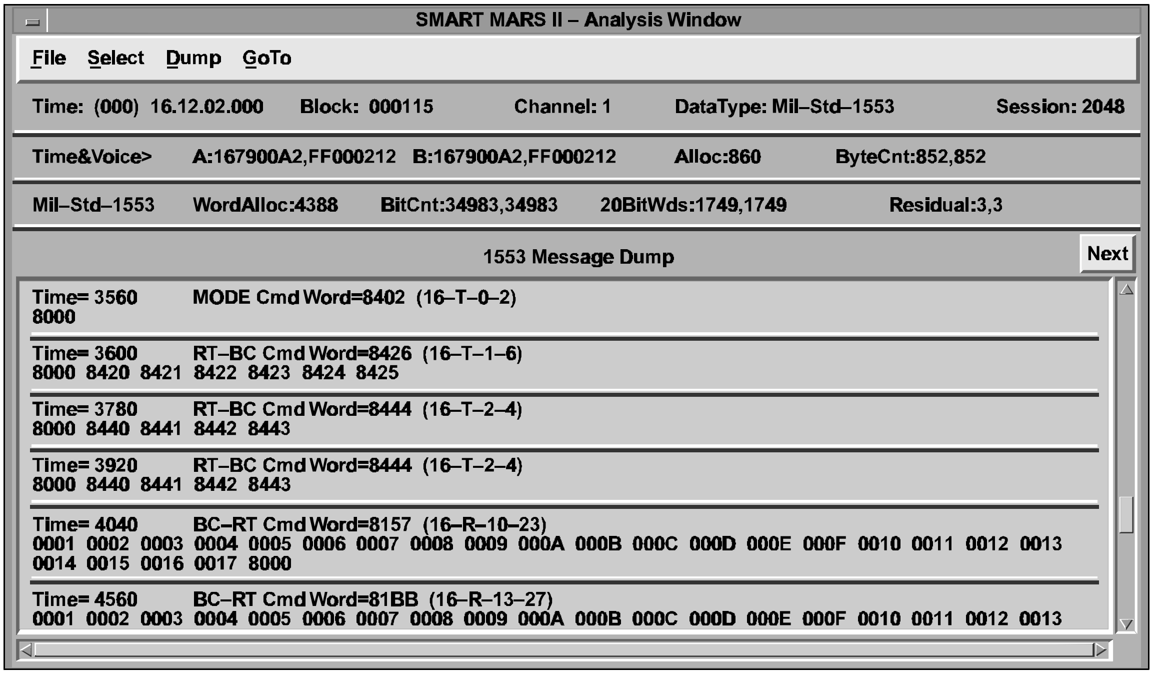

Figure 4. Analysis Window

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REFERENCES

Department of Defense, Military Standard Aircraft Internal Time Division Command/Response Multiplex Data Bus (MIL-STD-1553B), Washington D.C., USA, 21 September 1978.