NAVAL HEALTH RESEARCH CENTER

A COMPUTER PROGRAM FOR ESTIMATING MEDICAL INFORMATION STORAGE REQUIREMENTS

P. J. Konoske

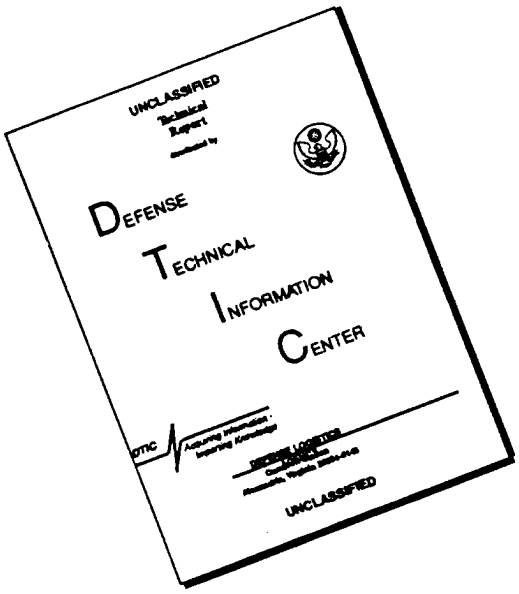
R. W. Dobbins

Technical Document 96-6F

NAVAL HEALTH RESEARCH CENTER
P. O. BOX 85122
SAN DIEGO, CALIFORNIA 92186 – 5122

NAVAL MEDICAL RESEARCH AND DEVELOPMENT COMMAND
BETHESDA, MARYLAND

DISCLAIMER NOTICE



THIS DOCUMENT IS BEST QUALITY AVAILABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

A Computer Program

for

Estimating Medical Information Storage Requirements

Paula J. Konoske[1]

Roy W. Dobbins[2]

[1]Medical Information Systems and Operations Research Department
Naval Health Research Center
P.O. Box 85122
San Diego, California 92186-5122

[2]Ogden Government Services
7480 Mission Valley Rd., Suite 101
San Diego, California 92108-4406

Document No. 96-6F supported by the Navy Medical Research and Development Command, Bethesda, MD, Department of the Navy, under Work Unit No. 63706N M0095.005-6508. The views expressed in this article are those of the authors and do not reflect the official policy or position of the Department of the Navy, Department of Defense, or the U.S. Government. Approved for public release, distribution unlimited.

Table of Contents

List of Tables

List of Figures

Summary

Problem. During combat, documentation of medical treatment information is critical for maintaining continuity of patient care. However, knowledge of the prior status and treatment of patients is limited to the information noted on a paper field medical card. The Multi-technology Automated Reader Card (MARC) has been identified as a potential storage mechanism for casualty medical information. The data capture and storage technology on the MARC consists of an integrated circuit computer chip. Since the available space on the computer chip is limited, the space required for medical documentation needs to be determined.

Objective. Currently, the MEDTAG, an electronic hand-held field medical documentation device, is designed to write the individual's medical data to the MARC where it is stored. The MARC's capacity is limited, and various requirements are competing for the available space. For example, MARC may be used to store an individual's food service, pay, or personnel data. Therefore, accurate estimates of the space needed to store medical information collected in the field are required. The development of a computer model that can be used to estimate storage space for medical care documentation on the MARC is the focus of this effort.

Approach. MARC ES, a Windows™ program for estimating storage requirements for the MARC, was designed and developed by the Naval Health Research Center (NHRC). The program calculates storage requirements for a variety of scenarios using medical documentation requirements, casualty rates, and casualty flows. Input parameters to the model include patient condition, upload site, theater, chip size, and echelon. Using these factors, together with historical data about field medical documentation requirements and patient stream, the model projects the storage requirements for a deployable field medical device.

Results. The program estimates the amount of space required to store medical care documentation at forward echelons for a variety of patient conditions. The percentage of casualties whose medical data can be recorded and stored also can be calculated. A variety of reporting formats are available for producing hard-copy results and tables

generated by the MARC ES model. A sample scenario was developed to illustrate the capability of the program.

Discussion. This model provides a tool that allows the user to determine the total amount of space required to store medical data at each echelon of care for selected operational theaters. This information can be used to specify storage space required to retain medical information on the MARC or to identify the point at which the data must be uploaded from the MARC if size constraints are imposed. In addition, this model can be readily extended to other systems that store or transmit medical data.

Introduction

During combat the handling of medical information is a critical aspect of the continuity of casualty care. Medical personnel, however, generally have limited knowledge of the prior status of their patients other than what may have been noted on a paper field medical card, which has many deficiencies (Wilcox & Pugh, 1990). In addition, transcribing the information at Battalion Aid Stations (BASs), Surgical Support Companies, and other medical treatment facilities (MTFs), can introduce errors. Historically, the Field Medical Card (FMC, DD1380) has been used to provide the clinical record that moves with the casualty during evacuation. Recently, a hand-held, portable, electronic device, called MEDTAG, has been shown to be a feasible method for documenting the required information at the forward echelons of care. It takes less time and provides more accurate data than the current manual method (Galarneau & Wilcox, 1993a; Galarneau & Wilcox, 1993b; Wilcox, Galarneau, & Fitzgerald, 1993).

In view of the potential of the MEDTAG prototype, the Office of the Secretary of Defense (Health Affairs) has integrated it into the Theater Medical Information System (TMIS; SRA Corporation, 1995). An essential part of the MEDTAG concept is that every military person carries his or her own medical data on electronic media. Currently, the MEDTAG is designed to use the Multi-technology Automated Reader Card (MARC) to store the individual's medical data. TMIS is exploring the use of an individually carried media for medical data. The MARC is one of many that are being examined as a field data carrier to communicate medical information between MTFs. The MARC and the MEDTAG have the capability of recording specified treatment information, such as the type of injury, treatments, and the type and time of administered medications, in battlefield situations. Further, the MEDTAG software is capable of documenting a very high percentage of all relevant information needed at the forward echelons of care (Wilcox, Emens, & Fitzgerald, 1994).

The MARC is a "smart card" that incorporates five different data storage media: printed, embossed, bar code, magnetic strip, and an integrated circuit (IC) chip. The printing, embossing, and bar coding on the card are static media -- once they are imprinted, they may not be changed without reissuing a new card. By contrast, the

magnetic strip and IC chip on the MARC are revisable media whose primary function is to store data that may change frequently.

The MARC's IC chip serves as a medical data carrier, making the MARC a portable patient record. The information on the chip is divided into two separate files: a demographic record and a medical record. All of the demographic information can be pre-encoded on the MARC. The medical record section of the MARC can include treatment, medication administered, and injury description. The medical record holds casualty data encoded by Navy Hospital corpsmen, Army medics, and other medical professionals.

MARC, used with the MEDTAG, offers improvements in speed, documentation quality, and user satisfaction. Although these improvements in data collection are significant, the greatest benefits of automating field medical documentation accrue to users retrieving data, not entering them. Medical data stored electronically are easier to read, copy, aggregate, sort, analyze, and transmit than are data on paper records. As a result, electronic data can facilitate the delivery of timely, accurate information to all who need it. Finally, as an automated data carrier, MARC offers many benefits that the FMC does not. The MARC eliminates redundant data entry, improves documentation speed, facilitates data transferability, and is more durable. Furthermore, medical personnel responded favorably to the MARC and would rather use it than the paper version in the field (R&DSD, 1994).

Problem

The storage capacity of the IC chip on the MARC is limited, and there are competing requirements for the available space. For example, MARC has been used for manifesting during deployments, for Composite Health Care System (CHCS) patient reception, and for accountability information, such as personnel location and status tracking. It also can be used to store an individual's food service, pay, physical readiness test, personnel, or legal data. Information on the chip may be shared by more than one application or function. For example, demographic information may be useful for medical, personnel, and manifesting, yet only need be recorded once on the chip, thus eliminating redundant data entry. The MARC's security also does not allow one

functional area to access another's data; medical personnel will only be able to access medical data.

Since the MEDTAG and the MARC have shown potential to provide faster, more accurate field medical data, it becomes important to know the storage requirements for the full range of medical problems, treatments, and patient conditions that could be encountered on the battlefield. Currently, allocation for medical data is only 200 bytes of the 2 KB chip. Therefore, an accurate estimate of the space needed to store medical information collected in the field is required.

Objective

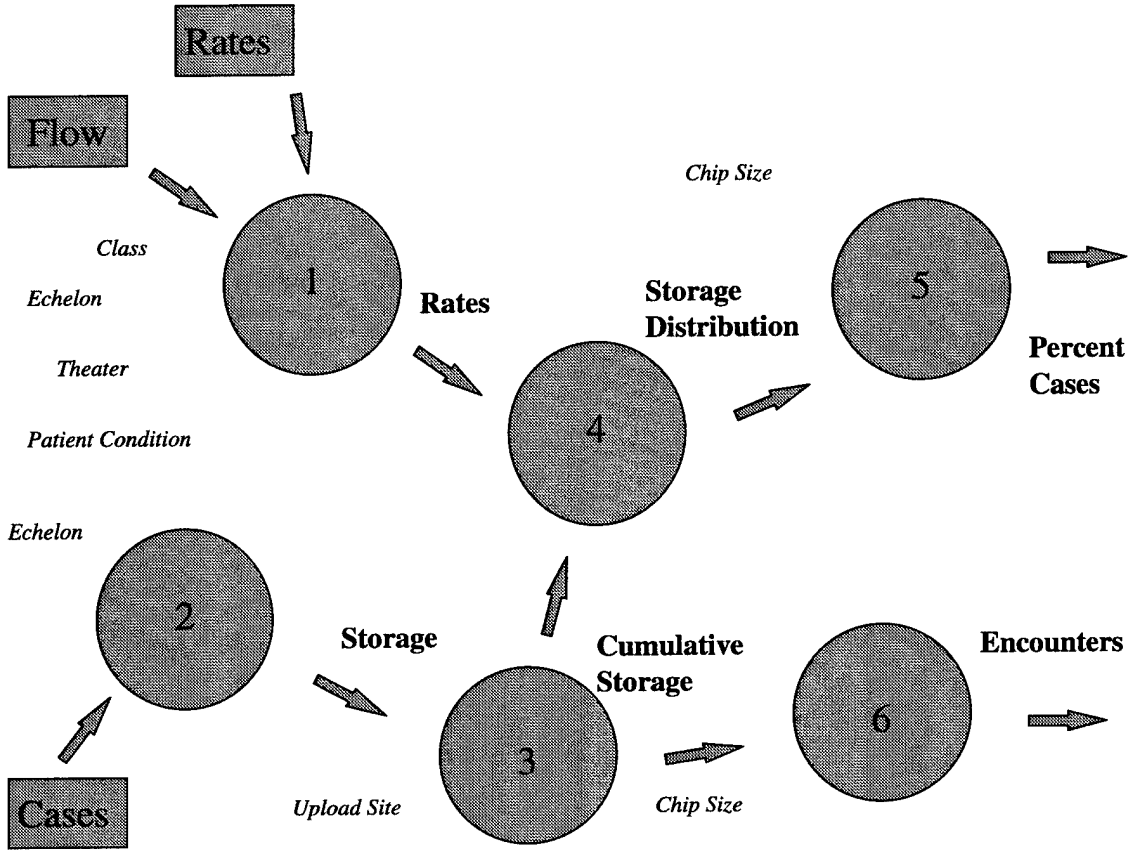
If the MARC is to be dedicated only partially to the storage of medical data, more study is needed to determine the full extent of medical data storage requirements. The development of a computer model that can be used to estimate storage space for medical care documentation on the MARC is the focus of this effort. This report describes the model and computer program that can be used to estimate MARC medical documentation storage requirements. The program estimates the size chip needed at forward echelons to record and store medical care documentation. The percentage of casualties whose medical data can be recorded and stored for any size chip is also calculated.

Approach

About the Model

MARC ES is a computer model designed to estimate MARC storage requirements for a variety of scenarios. Figure 1 presents a top-level description of the MARC storage model. This diagram shows the major data of the program. The input parameters, in italics, represent factors the user can manipulate. The data files, shown in rectangular boxes, contain historical information the program uses. Finally, the circles represent the major tasks the program performs. The model works on and generates reports from scenarios developed by the user.

Figure 1. MARC Storage Model



1. Determine injury rates
2. Estimate storage per echelon
3. Calculate cumulative storage
4. Generate rate vs. storage distribution
5. Estimate percent cases accommodated
6. Estimate number of encounters

User Parameters. Parameters allow the MARC ES program to compute multiple solutions based on the input factors selected. The parameters are described as follows.

Class. Class refers to the following five categories: wounded in action (WIA), non-battle injury (NBI), disease (D), battle fatigue (BF), and female specific (FS). Each patient condition is classified according to these categories. These classes are not unique, hence patient conditions may be classified into several classes.

Echelon. Echelon refers to the medical care and treatment echelons for which documentation requirements are determined. In this study, Echelons 1A (battlefield), 1B (Battalion Aid Station) and 2 (Surgical Support Company) are the primary focus. However, capability is built in to address Echelons 3 through 5 as well.

Theater. This refers to the theater of operations for which data are provided. The program currently covers Major Regional Conflict East (MRCE) and Major Regional Conflict West (MRCW). Additional theaters may be added.

Patient Condition. Using the Deployable Medical System (DEPMEDS) database, we identified 350 distinct patient conditions considered representative of disorders expected in an operational theater (Defense Medical Standardization Board, 1994).

Upload Site. The upload site is the echelon where patient data are uploaded from their MARC device to higher-order storage systems such as CHCS. Since the MARC has limited capacity, uploading can free the card for continued use at the emergency treatment facility. Medical data uploading sites are at the end of care at Echelons 1A, 1B, and 2.

Chip Size. The MARC chip may be manufactured with different storage capacities. Chip size refers to the overall storage capacity available for carrying patient demographics, special conditions, and medical history. Size is specified in bytes. The user can select or add any size chip according to the types of chips available on the market and how much storage is allocated on the chips for medical history.

Data Files. The following data files are used in the calculations by the model. The tables are all dBASE compatible, which makes them readily accessible to many commonly available PC tools, such as database desktops, spreadsheets, and report generators.

Rates. This table lists the rates of occurrence of injuries per patient condition for all theaters and injury classes. The rates are for all patients who arrive for treatment by a corpsman (Echelon 1A). Units are number per thousand troops per day. The data files contain the patient condition rates for two theaters: MRCE and MRCW.

Flow. This table lists the arrival and departure rates per patient condition by echelon. The patient flow covers the five echelons of care. This data file also contains return to duty (RTD) rates for each patient condition and for all levels of care. If personnel return to duty, their medical data do not remain on the card.

Cases. This table lists the documentation requirements per patient condition, by echelon. Subject matter experts developed medical documentation requirements for the

350 patient conditions at Echelons 1A, 1B, and 2. Medical documentation for each patient condition consisted of assessment, treatment, patient conditions, and disposition appropriate for that level of care. Each medical item recorded in the patient's medical file consisted of the coded numbers currently employed in the MEDTAG and MEDTAB devices. The MEDTAB was developed by the Naval Health Research Center to record treatment rendered at the Battalion Aid Station and the Surgical Support Company.

Results Tables. The user may select from the following list of tasks. The program produces a table that displays the result for the selected task. Appendix A contains descriptions of the data tables.

Rate by Theater. This table lists the rates of occurrence for each patient condition, by theater, echelon, and injury class. The original source table, *Rates*, is filtered by selecting records matching the user-specified theater, class, and echelon parameters. The rates are combined with arrival rates from the *Flow* table to get the effective rates for each echelon.

Storage by Echelon. This table lists the storage requirements in bytes per patient condition for each echelon. The number of documentation elements for each patient condition, multiplied by the data element size, combined with the overhead required to store an encounter, gives the total number of bytes of storage. The storage requirements are for the documentation of one medical treatment encounter and do not include space needed for demographic or special condition information. However, the storage requirements do include the date/time stamp. Further, for Echelon 1A the space required includes the "activation sequence" used by the MEDTAG. The activation sequence consists of prompted menus designed to elicit the most critical facts needed in the field in the most timely manner possible. The activation sequence has a fixed storage requirement of 20 bytes.

Cumulative Storage. This table lists the cumulative storage requirements in bytes per patient condition by echelon and upload site. The cumulative storage is the sum of the storage required for one encounter at each echelon, up to and including the echelon at which data are uploaded, plus an additional per-card overhead. The overhead required for the demographics and special conditions may be configured in the setup dialog. The

storage requirements include the space needed for demographic and special condition information. The amount of data that must be stored varies according to the point where the data are uploaded from the individually carried device into the patient's permanent medical record.

Storage Distribution. This table lists the frequency of occurrence versus storage distribution (bin size) by theater, injury class, echelon, and upload site. The data from the *Storage* and *Rates* tables are combined for all patient conditions and echelons selected by the user. The patient conditions are sorted into "bins" according to their storage sizes. The rates for all patient conditions in each bin size are summed to give the final result. For example, the rates of all those patient conditions that can be adequately documented using 200 bytes of storage or less are added together. Next, the rates of patient conditions that can be documented using 200 to 250 bytes are summed, followed by the next larger bin size, and so on.

Encounters. This table lists the number of encounters accommodated per chip size by patient condition, echelon, and upload site. The total number of encounters depends on the initial overhead plus the number of medical data elements needed to document each additional encounter. The initial overhead, counted only once, includes demographic and special condition information.

Percent Cases. This table lists the percentage of patient conditions that can be documented per chip size by theater, injury class, echelon, and upload site.

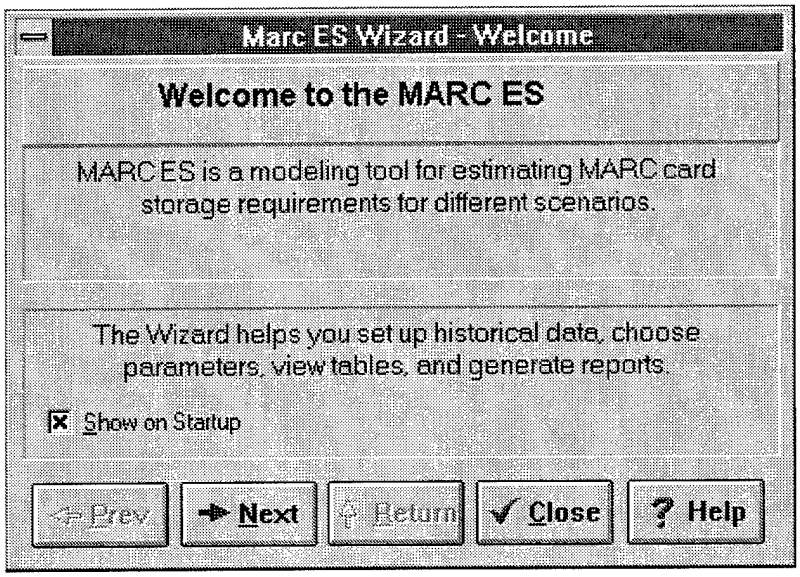
Using the Program

Installation. The MARC ES program is written in Borland Delphi, which is a visual application development system for Windows. The essentials required to install, backup, and compile the MARC ES software are covered in Appendix B.

Wizard. The MARC ES program handles a large amount of data consisting of many tables and forms. Dealing with this amount of data and ensuring consistent results can be confusing. The Wizard is an application expert running in an independent window on top of the MARC ES window. Figure 2 shows the introductory Wizard screen. By clicking on the <Next> button, the Wizard guides the user through an orderly

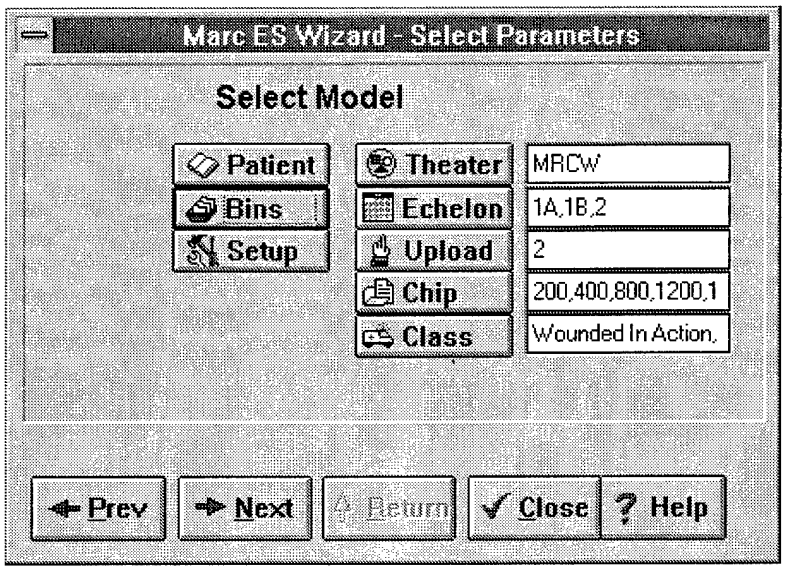
sequence of tasks to set up historical data, choose input parameters, view tables, and generate reports. At each step, the Wizard provides a brief synopsis of the current tasks, opens the necessary windows on the MARC ES screen, and provides a <Help> button for further information about the current topic. The Wizard will automatically run the first time the MARC ES program is started after installation. A checkbox on the Wizard screen explicitly enables or disables the Wizard screen on startup. The Wizard is still available any time from the Help menu.

Figure 2. Introductory Wizard Screen



Select Parameters. Figure 3 shows the Select Parameters screen using Wizard.

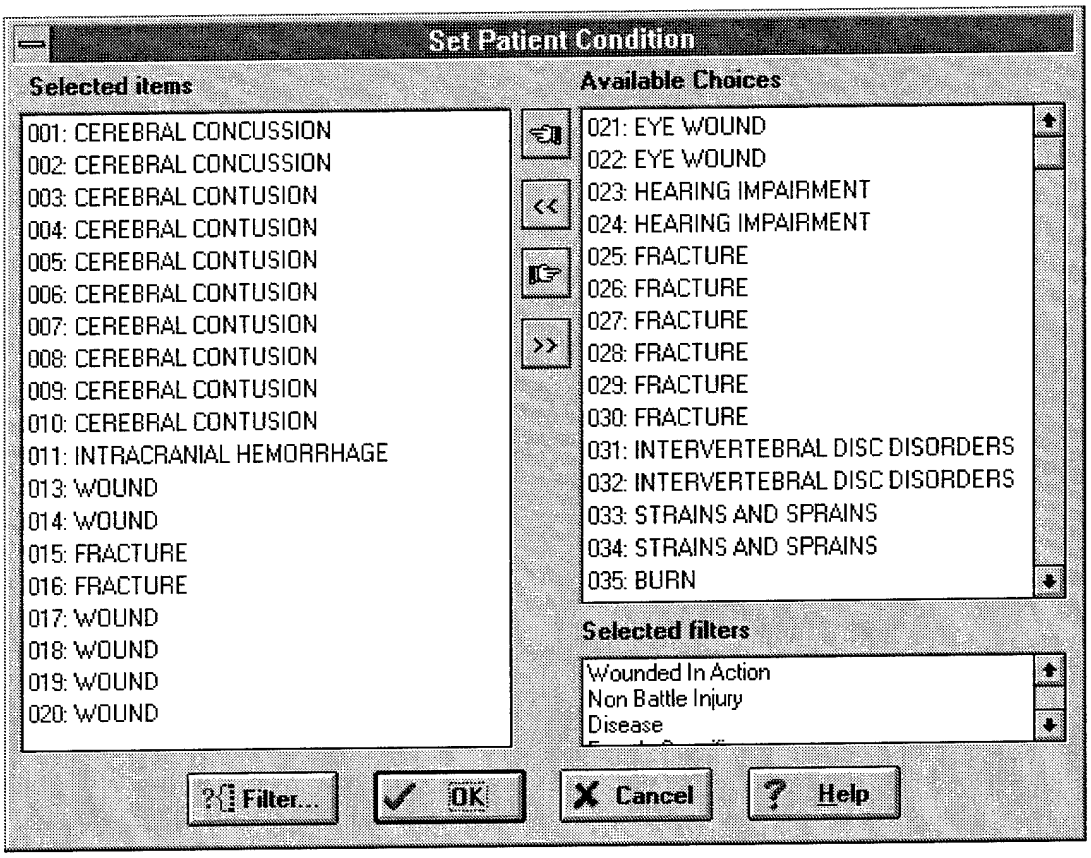
Figure 3. Wizard Screen Used to Select Model Parameters



The Select menu provides commands to select input parameters for the MARC ES model. The Select menu consists of the following parameters: echelon, theater, patient condition, upload site, class, and chip size. The user also can identify the patient conditions, bin size, and the other setup configurations from this same screen.

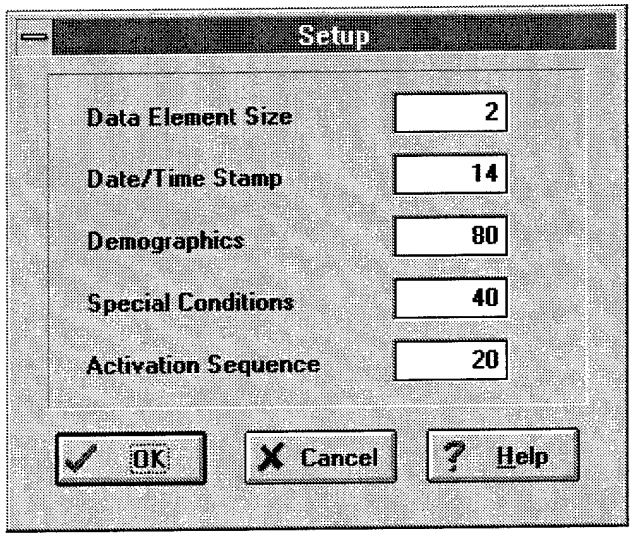
The Select Patient Condition dialog, shown in Figure 4, provides a means to select a set of injury class parameters from the MARC ES model. This determines the set of patient conditions that will be selected and viewed in tables. This filter allows the user to select injuries from the five classes: WIA, NBI, D, BF, and FS. Patient conditions are selected by highlighting them in the available choice box and then clicking on the hand pointing left in the direction of the selected items' box. Selections can be changed using the arrows at any time. Clicking on the double arrows (>> or <<) allows the user to select all 350 patient conditions at one time.

Figure 4. Set Patient Condition Dialog Box



The Select Parameters menu also allows the user to set up or configure the documentation size in bytes for the data elements. This screen is shown in Figure 5.

Figure 5. The Setup Screen Used to Configure Size of the Data Elements



The following data elements can be configured from the Setup menu:

Data Element Size: The size of a medical data element is the number of bytes required per medical action item.

Date/Time Stamp Size: A date/time stamp is included in the patient record. The date/time stamp size is the number of bytes required per medical encounter to record the date and the time.

Demographics Size: The demographics size is the number of bytes required per MARC to record the patient demographic information. Demographic information includes name, social security number, rank, branch, and religion.

Special Conditions Size: The special conditions size is the number of bytes required per MARC for recording the patient special conditions. The special condition section is free text and can be read but not changed. Information in this section includes blood type, allergies, and other special conditions.

Activation Sequence Size: The activation sequence size is the number of bytes required per medical encounter (currently Echelon 1A only) for recording basic patient condition and injury information (Wilcox et al., 1993).

If the user changes the setup configuration, the affected tables are automatically marked for recalculation so that the new values are incorporated. This applies to the *Storage by Echelon* and *Cumulative Storage* tables.

The Select Bins dialog allows the user to select a set of storage size bin parameters from the MARC ES model. This is a technique of dividing a frequency distribution into discrete ranges to facilitate analysis and visualization. Data are placed into one of the defined bins if the values fall within the lowest and highest ranges of the bin. This allows a distribution chart to be tailored to a manageable set of ranges, instead of a potentially large number of values.

Select Tasks. Tasks or Results Tables can be selected using the toolbar or the drop-down task menu. When a task command is selected, a data window is displayed. Most tables obtain data from one or more other tables and display a computed relation of their input elements and parameters. Changing a parameter forces the table to recalculate.

Tables. A variety of reporting formats are available for producing hard-copy results and tables generated by the MARC ES model. All changes to the table are saved whenever the user moves from the current record. Most tables have a <Find> button on the toolbar. Clicking on the <Find> button brings up a floating Find dialog, which allows the user to search on any field of the table. Typically, this works best for patient conditions since there are so many of those, but any field can be selected from the drop-down list.

Refresh Option. A subset of the available parameters can be changed from the Select menu. Refresh recalculates the data from one or more tables and displays a computed relation of their input elements and parameters. Any table is automatically recalculated when any of the data or parameters on which it depends have changed.

Charting. Tables can be charted automatically. Chart displays the table in the form of a 3D bar chart. The Chart Options dialog displays one or more parameters the user can select to filter the chart display. The chart allows the user to set many different options. The popup menu allows various chart tools, including palette bar, pattern bar, and data editor, to be selected. In this application extensive use of these options are not used, but they are included. The user can click with the right mouse button on a data point to display a popup bubble showing the actual data value. The legend displays color and text information for the chart.

Printing. The tables generated by the program can be printed using Quick Reports or ReportSmith. The user can generate a report by clicking the File|Print menu for the individual table. This opens a preview form showing the table to be printed. The <Print> button on the preview form sends the table to the printer.

Results

This section describes one example scenario selected to depict the tables and charts generated when using the MARC ES program. The Setup Configuration, shown in Table 1, is used for the following example.

Table 1
Setup Configuration for the MARC ES Program

Element	Size in Bytes
Data Element	2
Date/Time Stamp	14
Demographics	80
Special Conditions	40
Activation Sequence	20

The size of the space required for an individual medical data element is 2 bytes, the date/time stamp requires 14 bytes, demographics uses 80 bytes, and special conditions needs 40 bytes. The activation sequence used only for Echelon 1A uses 20 bytes.

The Parameters chosen for the example are shown in Table 2.

Table 2
User Parameters Chosen for MARC ES Program

Parameter	Selection
Patient Conditions	350
Bin Sizes	100, 150, 200, 250, 300, 350, 400, 450, 500
Theater	MRCW
Class	WIA, NBI, D, BF, FS
Echelon	1A, 1B, 2
Upload Site	2
Chip Size (in bytes)	200, 400, 800, 1200, 1600

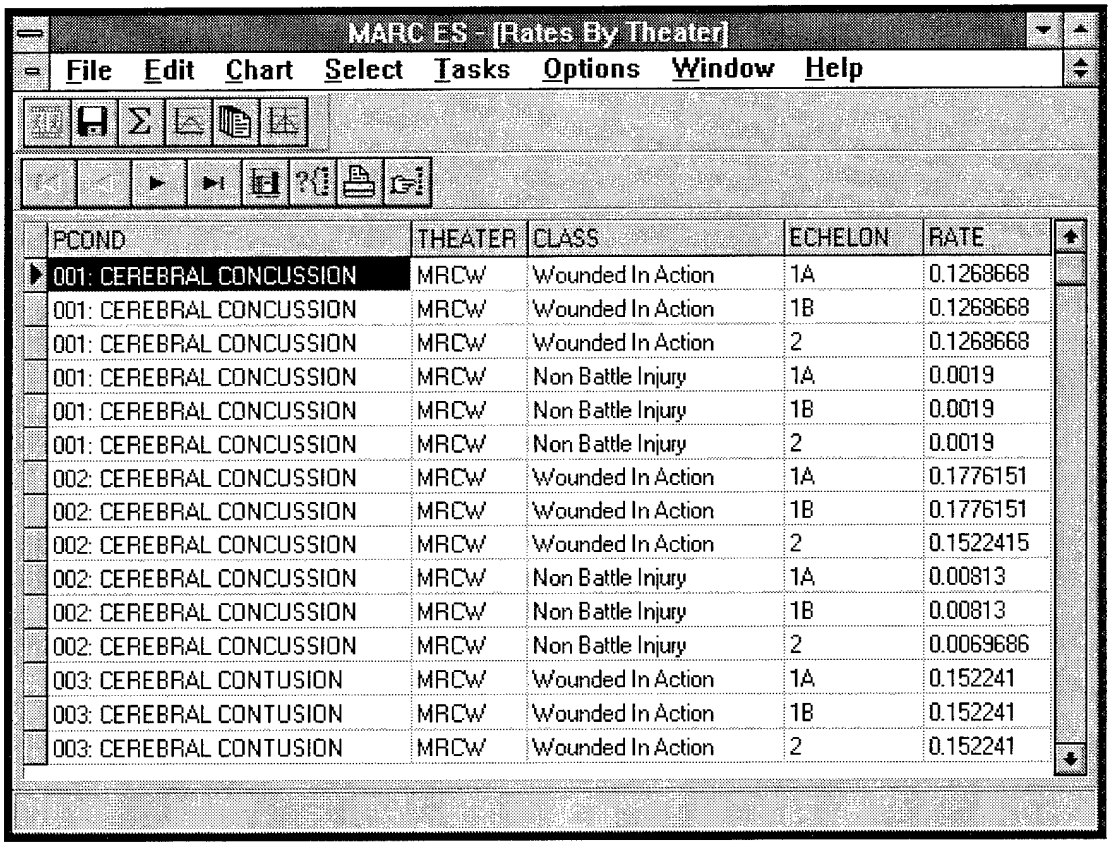
In this example, MRCW is selected as the theater, the echelons of interest selected are 1A, 1B, and 2, the upload site chosen is Echelon 2, five different chip sizes in bytes (200, 400, 800, 1200, 1600), and all 350 patient conditions are also selected. These parameters also can be selected from the Select menu of the main program. When a parameter is selected, a common dialog box that accompanies the selection of each parameter is displayed.

A variety of scenarios can be created by varying the parameters selected. For example, storage requirements for patient conditions classified as disease can be estimated for both MRCW and MRCE. Or, patient conditions classified as multiple injury wounds (MIWs) can be used to estimate the storage required for documentation.

The MIW would be expected to require the most treatment and therefore require the most documentation space. The setup configuration also can be altered to reflect any coding scheme by changing the size in bytes of the data elements. The demographics and special conditions storage areas also can be made larger or smaller by changing their size during setup.

After the input parameters are identified, several tasks may be chosen. Figure 6 shows the results produced when the *Rates by Theater* task is selected. This table provides the rate of occurrence for each of the selected patient conditions in the MRCW theater arriving at each echelon.

Figure 6. Rates by Theater Task

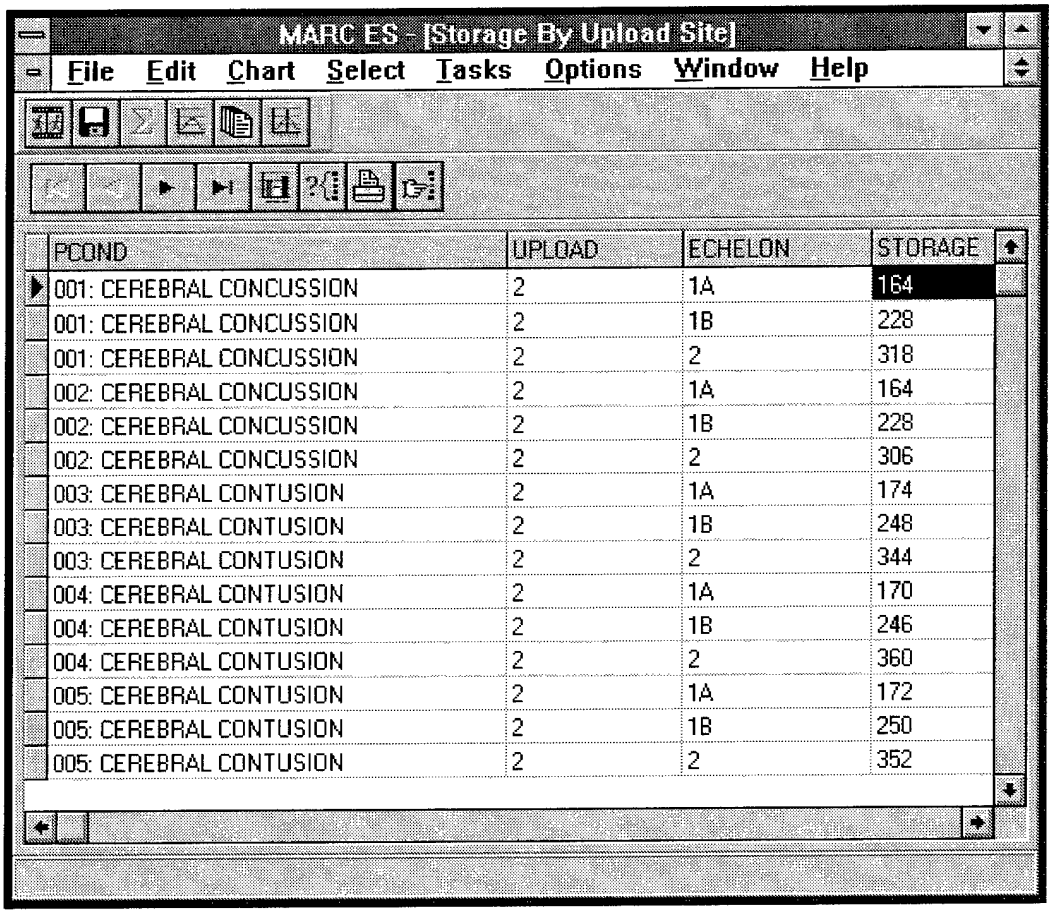


PCOND	THEATER	CLASS	ECHELON	RATE
001: CEREBRAL CONCUSSION	MRCW	Wounded In Action	1A	0.1268668
001: CEREBRAL CONCUSSION	MRCW	Wounded In Action	1B	0.1268668
001: CEREBRAL CONCUSSION	MRCW	Wounded In Action	2	0.1268668
001: CEREBRAL CONCUSSION	MRCW	Non Battle Injury	1A	0.0019
001: CEREBRAL CONCUSSION	MRCW	Non Battle Injury	1B	0.0019
001: CEREBRAL CONCUSSION	MRCW	Non Battle Injury	2	0.0019
002: CEREBRAL CONCUSSION	MRCW	Wounded In Action	1A	0.1776151
002: CEREBRAL CONCUSSION	MRCW	Wounded In Action	1B	0.1776151
002: CEREBRAL CONCUSSION	MRCW	Wounded In Action	2	0.1522415
002: CEREBRAL CONCUSSION	MRCW	Non Battle Injury	1A	0.00813
002: CEREBRAL CONCUSSION	MRCW	Non Battle Injury	1B	0.00813
002: CEREBRAL CONCUSSION	MRCW	Non Battle Injury	2	0.0069686
003: CEREBRAL CONTUSION	MRCW	Wounded In Action	1A	0.152241
003: CEREBRAL CONTUSION	MRCW	Wounded In Action	1B	0.152241
003: CEREBRAL CONTUSION	MRCW	Wounded In Action	2	0.152241

For example, Patient Condition 001, a cerebral concussion classified as WIA, has the rate of occurrence of .01268668 at Echelons 1A, 1B, and 2 for MRCW theater. Patient Condition 002, a cerebral concussion resulting from NBI, has a rate of occurrence of .00813 at Echelons 1A and 1B and of .0069686 at Echelon 2. The model uses this information to estimate the percentage of patient conditions that can be documented while chip size, theater, echelon, and upload site vary. The user can print the table or display the table as a chart.

Figure 7 shows the results generated by the *Cumulative Storage* task. The cumulative number of bytes needed for documentation for the selected patient conditions at each echelon is calculated. For example, Patient Condition 001 requires 164 bytes for medical documentation at Echelon 1A, 228 bytes at Echelon 1B, and 318 bytes at Echelon 2.

Figure 7. Cumulative Storage Task

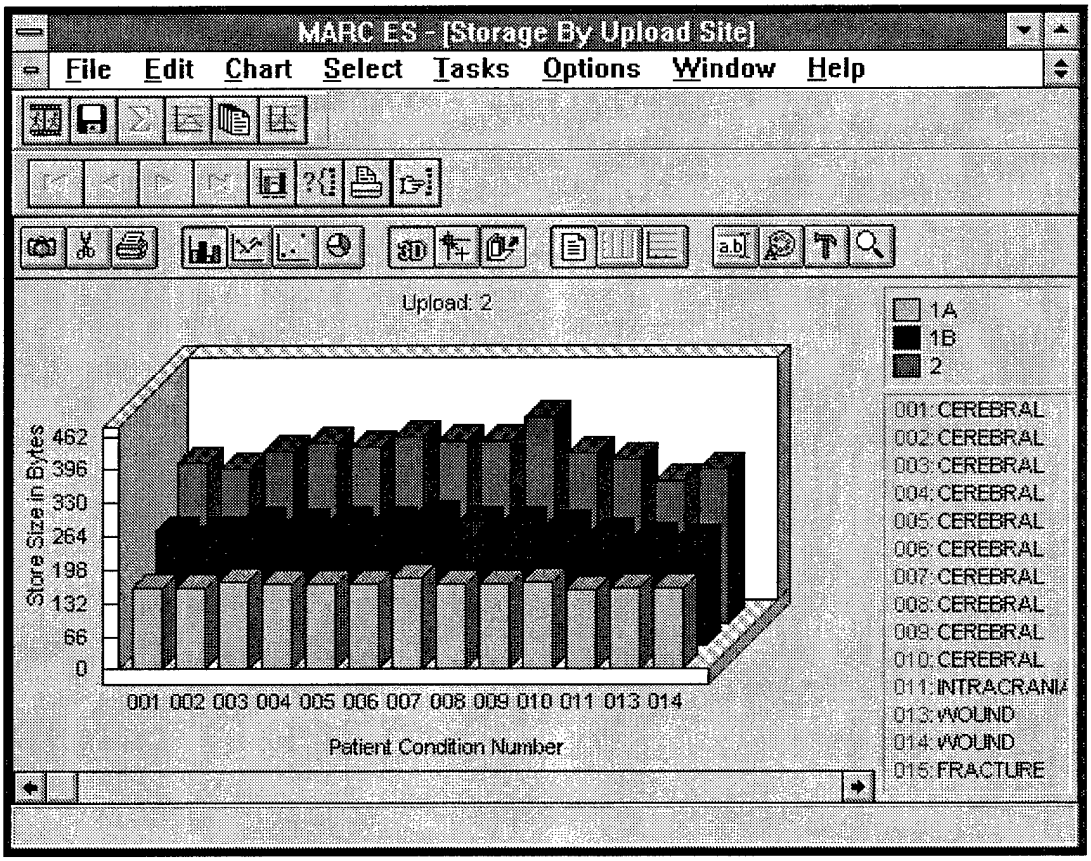


PCOND	UPLOAD	ECHELON	STORAGE
001: CEREBRAL CONCUSSION	2	1A	164
001: CEREBRAL CONCUSSION	2	1B	228
001: CEREBRAL CONCUSSION	2	2	318
002: CEREBRAL CONCUSSION	2	1A	164
002: CEREBRAL CONCUSSION	2	1B	228
002: CEREBRAL CONCUSSION	2	2	306
003: CEREBRAL CONTUSION	2	1A	174
003: CEREBRAL CONTUSION	2	1B	248
003: CEREBRAL CONTUSION	2	2	344
004: CEREBRAL CONTUSION	2	1A	170
004: CEREBRAL CONTUSION	2	1B	246
004: CEREBRAL CONTUSION	2	2	360
005: CEREBRAL CONTUSION	2	1A	172
005: CEREBRAL CONTUSION	2	1B	250
005: CEREBRAL CONTUSION	2	2	352

The 164 bytes required for documentation at Echelon 1A includes 44 bytes for medical information and date/time stamp and 120 bytes for demographics and special condition information. At Echelon 1B, 228 bytes are estimated, the 164 bytes from Echelon 1A plus 64 for additional medical information, while at Echelon 2, 90 bytes are estimated for additional medical information plus the 228 from the two previous echelons. Storage by individual echelon can be calculated and displayed by choosing the *Storage by Echelon* selection from the Task menu.

The *Cumulative Storage* table also can be displayed as a chart (see Figure 8). The patient conditions are displayed along the x-axis and are labeled in the legend. The storage size in bytes is shown on the y-axis. The user can click on the right mouse button on a data point to display a popup bubble showing the actual data value. From the chart window the user can edit titles and legends, change fonts and font sizes, and modify scale ranges.

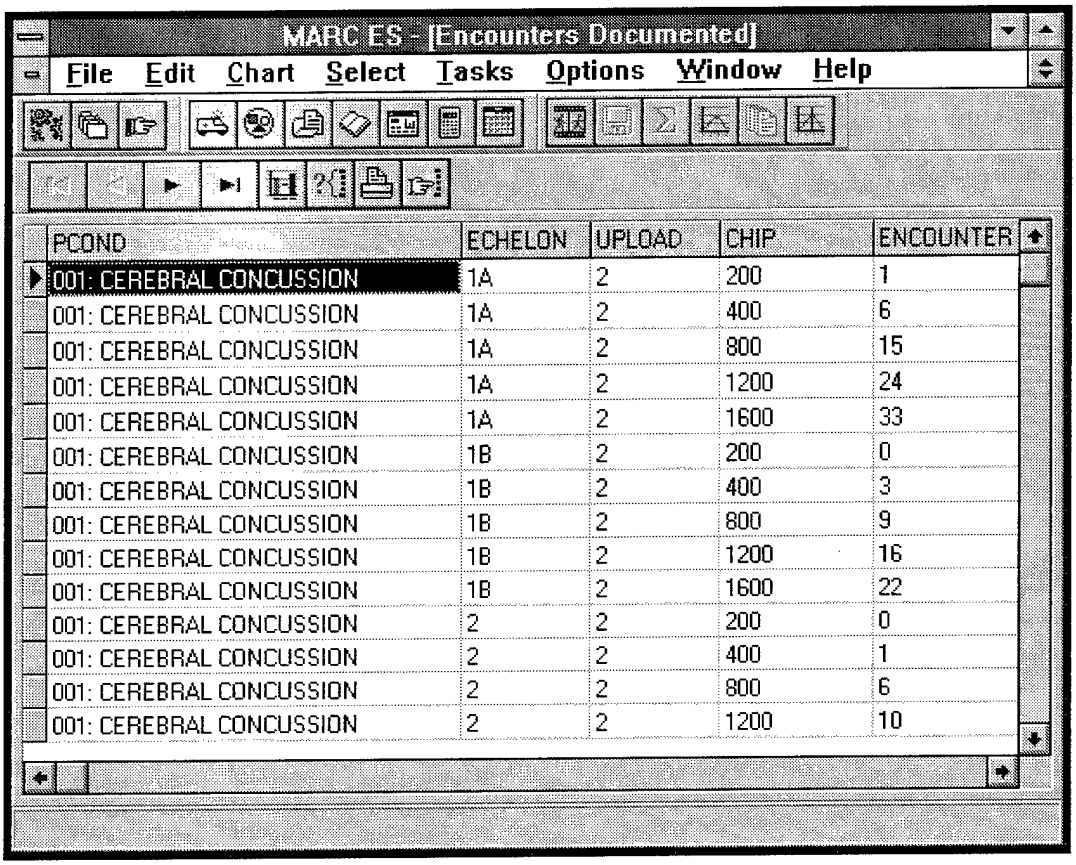
Figure 8. Cumulative Storage Requirements



The number of encounters that various chip sizes can accommodate for each patient condition at Echelons 1A, 1B, and 2 are shown in Figure 9. The total number of encounters is estimated by calculating the initial overhead plus the number of data elements needed to document each additional encounter. For example, for Patient

Condition 001 (Cerebral Concussion) a 400-byte allocation can hold 6 different medical encounters at Echelon 1A, 3 encounters at Echelon 1B, and 1 encounter at Echelon 2.

Figure 9. Number of Encounters Documented for Each Patient Condition

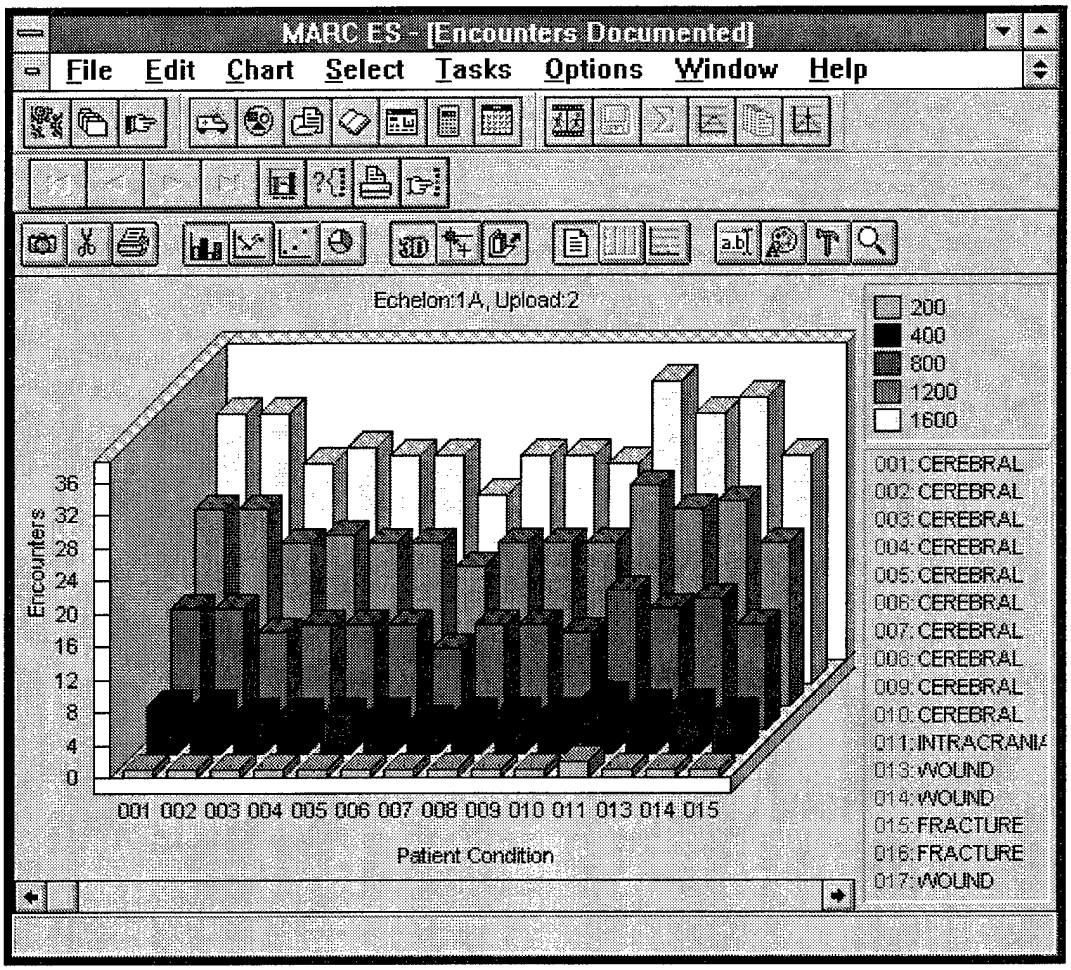


PCOND	ECHELON	UPLOAD	CHIP	ENCOUNTER
001: CEREBRAL CONCUSSION	1A	2	200	1
001: CEREBRAL CONCUSSION	1A	2	400	6
001: CEREBRAL CONCUSSION	1A	2	800	15
001: CEREBRAL CONCUSSION	1A	2	1200	24
001: CEREBRAL CONCUSSION	1A	2	1600	33
001: CEREBRAL CONCUSSION	1B	2	200	0
001: CEREBRAL CONCUSSION	1B	2	400	3
001: CEREBRAL CONCUSSION	1B	2	800	9
001: CEREBRAL CONCUSSION	1B	2	1200	16
001: CEREBRAL CONCUSSION	1B	2	1600	22
001: CEREBRAL CONCUSSION	2	2	200	0
001: CEREBRAL CONCUSSION	2	2	400	1
001: CEREBRAL CONCUSSION	2	2	800	6
001: CEREBRAL CONCUSSION	2	2	1200	10

Figure 9 also shows that, at Echelon 1A, a 200-byte allocation can store only one medical encounter, while at Echelons 1B and 2 a 200-byte allocation cannot hold even one. It can be expected that while at Echelons 1B or 2 the patient is likely to be assessed and treated more than once.

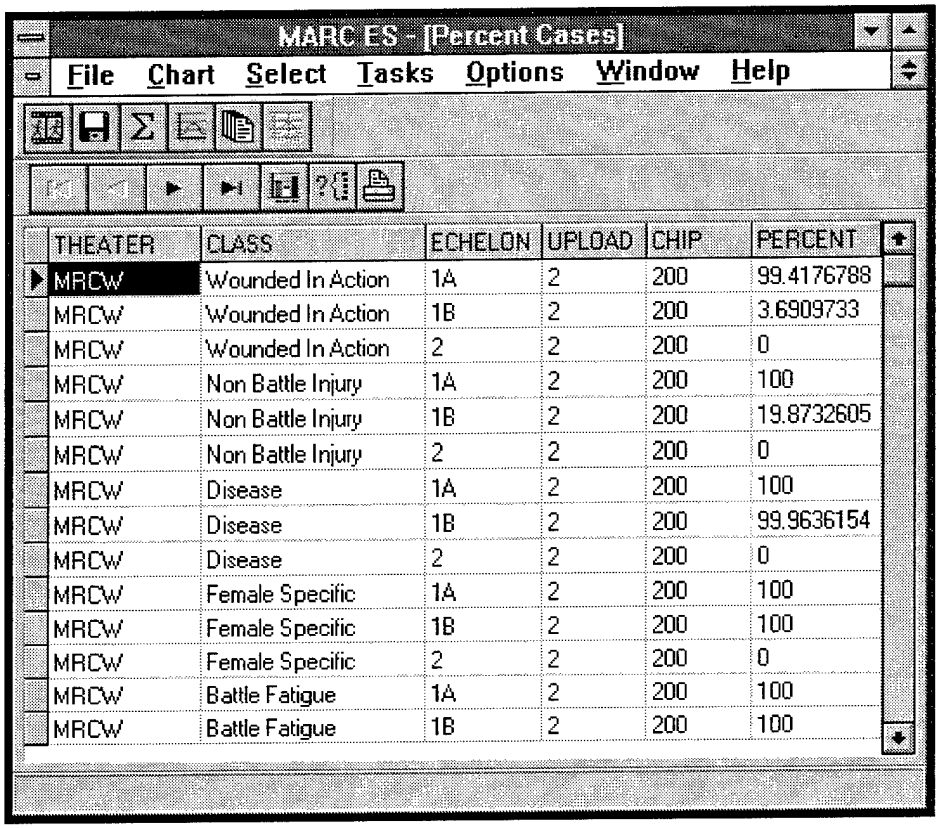
Figure 10 displays the number of encounters that the various amounts of storage space allocated can handle at Echelon 1A. The user can select chart options to identify the echelon of interest. The number of encounters for Echelons 1B and 2 also can be displayed using the chart options.

Figure 10. Number of Encounters Documented by Amount of Storage Space Allocated



The *Percent Cases* result is shown in Figure 11. This table displays the percentage of the patient conditions that can be documented *once* for various amounts of storage space. This distribution allows one to determine the percentage of cases that different capacity chips can accommodate. For example, for those patient conditions classified as WIA, 200-bytes of storage can accommodate 99.41% at Echelon 1A, 3.69% at Echelon 1B, and none at Echelon 2. This table indicates that for WIA, NBI, D, BF, and FS patient conditions 100% of all cases at Echelons 1A, 1B, and 2 can be stored within an 800-byte space. However, in this example, only one medical encounter is documented at each echelon.

Figure 11. Pecentage of Cases Documented by Amount of Storage Space Allocated



THEATER	CLASS	ECHELON	UPLOAD	CHIP	PERCENT
MRCW	Wounded In Action	1A	2	200	99.4176788
MRCW	Wounded In Action	1B	2	200	3.6909733
MRCW	Wounded In Action	2	2	200	0
MRCW	Non Battle Injury	1A	2	200	100
MRCW	Non Battle Injury	1B	2	200	19.8732605
MRCW	Non Battle Injury	2	2	200	0
MRCW	Disease	1A	2	200	100
MRCW	Disease	1B	2	200	99.9636154
MRCW	Disease	2	2	200	0
MRCW	Female Specific	1A	2	200	100
MRCW	Female Specific	1B	2	200	100
MRCW	Female Specific	2	2	200	0
MRCW	Battle Fatigue	1A	2	200	100
MRCW	Battle Fatigue	1B	2	200	100

Discussion and Conclusions

This model provides a tool that allows the user to estimate the total amount of space required to store medical data at each echelon of care for selected operational theaters. This information can be used to specify the amount of storage space required to retain medical information on the MARC. By selecting various parameters and modifying the setup, a variety of casualty scenarios can be created. In the example presented here all 350 patient conditions were selected, the region of interest was MRCW, and the chip sizes chosen included 200, 400, 800, 1200, and 1600 bytes. The results indicated that 800 bytes could accomodate all of the demographic data, special condition information, and medical documentation for one encounter at Echelons 1A, 1B, and 2.

The MARC ES program, however, allows the user to select any combination of input variables. The setup configuration can be modified to allocate storage space for demographic information or to evaluate the impact of coding special condition information rather than storing it in a free-text format. In addition, the program can be used to identify the point at which data must be uploaded from the MARC if size constraints are imposed.

The MARC ES program has several features that contribute to its flexibility. For example, data tables can be imported easily and new information can be added to the program at any time. The Cases data file, which documents the medical treatment provided at each of the echelons, can be modified at any time using the Import feature. Changes or updates in the injury rates also can be made. Additional theaters, patient conditions, echelons of care, chip sizes, and upload sites can all be appended to reflect the latest information.

Currently, this model is specific to the storage of medical data on the MARC because the Cases file assumes that the MARC/MEDTAG coding scheme is used. However, by selecting setup sizes and bins, the user can reconfigure the data element sizes and approximate the storage requirements of any documentation coding scheme.

Further, this model can be readily extended to other systems that store or transmit medical data in one of two ways. First, a factor representing the relative efficiency of the MARC/MEDTAG storage system and the alternative system could be estimated. The model results then could be multiplied by this factor. Second, a new Cases file could be developed that reflects the coding used in the alternative system.

References

Defense Medical Standardization Board. (1994). *DEPMEDS policies/guidelines, treatment briefs.* Fort Detrick, MD.

Galarneau, M., & Wilcox, W. (1993a). *Design and refinement of an automated method of documenting combat casualty care* (Tech. Rep. No. 93-21). San Diego, CA: Naval Health Research Center.

Galarneau, M., & Wilcox, W. (1993b). *Field evaluation of an electronic battlefield combat casualty medical data collection device (MEDTAG)* (Tech Rep. No. 93-31). San Diego, CA: Naval Health Research Center.

Readiness and Deployable System Division (R&DSD). Office of Medical Functional Integration Management (MFIM). (1994) *MARC, Multi-technology Automated Reader Card, field medical operational evaluation, mass casualty exercise* (Final Draft).

SRA Corporation. (1995, September). *Corps level Theater Medical Information System (TMIS) functional and architectural analysis report.*

Wilcox, W., Emens, K., & Fitzgerald, R. (1994). *Evaluation of the documentation capabilities of the Navy's field medical data collection prototype device (MEDTAG)* (Tech. Rep. No. 94-33). San Diego, CA: Naval Health Research Center.

Wilcox, W., Galarneau, M., & Fitzgerald, R. (1993). *Factors related to accuracy and completeness of field medical documentation.* (Tech. Rep. No. 93-19). San Diego, CA: Naval Health Research Center.

Wilcox, W., & Pugh, W. (1990). *Evaluation of revised field medical card for Navy and Marine Corps.* (Tech. Rep. No. 90-12). San Diego, CA: Naval Health Research Center.

Glossary: Terms and Abbreviations

1. **Action Item.** Medical action items recorded in patient medical files consist of coded numbers as currently employed in the MEDTAG and MEDTAB devices.

2. **Bin.** This is a technique of dividing a frequency distribution into discrete ranges to facilitate analysis and visualization. Data are placed into one of the defined bins if the values fall within the lowest or highest ranges of the bin. This allows a distribution chart to be tailored to a manageable set of ranges, instead of a potentially large number of values. Bin sizes may be identified by the user.

3. **Chip.** The electronic device in which each person carries his or her own medical data to fulfill the function of the field medical card. The prototype device is the MARC, a smart card containing a computer chip that can store treatment, medicines administered, and injury information.

4. **Chip Size.** This refers to the overall storage capacity available for carrying patient demographics, special conditions, and medical history. Size is specified in bytes, and it determines the number of medical action items that the chip can accommodate.

5. **Class.** This refers to the following five categories: WIA, NBI, D, BF, and FS. Each patient condition is classified according to these categories. These classes are not unique, hence patient conditions may be classified in more than one class.

6. **Echelon.** This refers to the medical care and treatment echelons for which documentation requirements are determined. In this study, Echelons 1A (battlefield), 1B (Battalion Aid Station) and 2 (Surgical Support Company) are the primary focus. However, capability is built in to address Echelons 1 through 5.

7. **Patient Condition.** Using the DEPMEDS database, 350 patient conditions were identified.

8. **Rates.** The rates of occurrence of injuries and patient conditions are provided. Rates are specified in terms of the number of occurrences per 1,000 troops per day.

9. **Theater.** This refers to the theater of operations for which data are provided. The program currently covers MRCE and MRCW. Additional theaters may be added.

10. **Upload Site.** The upload site is the echelon in which patient data are uploaded from their MARC device to higher levels of care. Since the MARC has limited capacity, uploading can free the card for continued use at the emergency treatment facility. Medical data uploading sites are at the end of care at Echelons 1A, 1B, and 2.

Appendix A

Data Tables and Lookup Tables

The primary data structures used are encompassed in the following tables.

TABLE NAME: ECHELON
DESCRIPTION: Echelons - This table lists the (6) echelons, and a descriptive name for each echelon. Each echelon is assigned a unique "ECHELON" code (1A,1B,2,3,4,5) for reference purposes.

FIELD NAME	TYPE	SIZE	DEC
ECHELON	C	5	
NAME	C	50	

TABLE NAME: PATCOND
DESCRIPTION: Patient conditions - This table lists the (350) patient conditions, a descriptive name, and the category into which each condition falls. Each patient condition is assigned a unique "PCOND" code (1..350) for reference purposes. The "category" field is used to access the "category" table directly.

FIELD NAME	TYPE	SIZE	DEC
PCOND	C	5	
NAME	C	50	
CATEGORY	C	5	

TABLE NAME: THEATER
DESCRIPTION: Theaters - This table lists the (3) theaters, a descriptive name, and an abbreviation for each theater. Each theater is assigned a unique "THEATER" code (1..3) for reference purposes.

FIELD NAME	TYPE	SIZE	DEC
THEATER	C	5	
NAME	C	50	
ABBREV	C	5	

TABLE NAME: CLASS
DESCRIPTION: Injury classes - This table lists the (5) classes defined for patient conditions and a descriptive name for each class (Wounded in Action, Non Battle Injury, Disease, Female Specific, Battle Fatigue). Each class is assigned a unique "CLASS" code (1..5) for reference purposes.

FIELD NAME	TYPE	SIZE	DEC
CLASS	C	5	
NAME	C	50	

TABLE NAME: CHIPSIZE
DESCRIPTION: Computer chips - This table lists the available computer chips and the size of available space in bytes for each chip.

FIELD NAME	TYPE	SIZE	DEC
CHIP	C	5	
NAME	C	50	
SIZE	N	10	

TABLE NAME: CATEGORY
DESCRIPTION: Categories - This table lists the (27) categories defined for patient conditions and a descriptive name for each category. Each category is assigned a unique "CATEGORY" code (1..27) for reference purposes.

FIELD NAME	TYPE	SIZE	DEC
CATEGORY	C	5	
NAME	C	50	

TABLE NAME: ACTION
DESCRIPTION: MEDTAG action codes - This table lists the medical data elements and menu elements as used in the current MEDTAG and MEDTAB systems. This table can be used to determine or simulate menu selections used in MEDTAB to document a patient condition. "NAME" is a shortened name for a data element, as used in menus in MEDTAB. "DESCRIPTION" is a complete name for a data element, as used in reports or external documentation. "ATTR" is a code describing the attributes of a data element, as used in MEDTAB to document a patient condition. The "ATTR" field can be used to determine what additional documentation may be required, such as location, body area, or quantity of medication. Each data element is assigned a unique "CODE" action code (1..32000) for reference purposes.

FIELD NAME	TYPE	SIZE	DEC
CODE	C		
TAG	C		
ATTR	C	10	
PROPS	C	5	
NAME	C	25	
DESCRIPTION	C	50	

TABLE NAME: RATES
DESCRIPTION: Rates of occurrence - This table lists the rates of occurrence per 1,000 troops per day. The table is triple-indexed on "PCOND" (patient condition), "THEATER", and "CLASS" (injury class).

FIELD NAME	TYPE	SIZE	DEC	
PCOND		C	5	
THEATER	C	5		
CLASS	C	5		
RATE	N	13	7	

TABLE NAME: FLOW
DESCRIPTION: Arrival departure flow - This table lists the arrival and departure rates at each echelon, for each patient condition. The table is double-indexed on "PCOND" (patient condition) and "ECHELON".

FIELD NAME	TYPE	SIZE	DEC	
PCOND		C	5	
ECHELON	C	5		
ARRIVE		N	10	0
RTD	N	10	0	
DIE	N	10	0	

TABLE NAME: CASES
DESCRIPTION: Documentation requirements for cases - This table lists the documentation requirements for each echelon, for each patient condition. The table is double-indexed on "PCOND" (patient condition) and "ECHELON". The table is a one-to-many relationship between patient condition and data element code. "CODE" is a code referencing a MEDTAB data element.

FIELD NAME	TYPE	SIZE	DEC
PCOND		C	5
ECHELON	C	5	
CODE	C	5	

TABLE NAME: ERATES
DESCRIPTION: Rates by theater - This table lists the rates of occurrence per 1,000 troops per day. The table is triple indexed on "PCOND" (patient condition), "THEATER", and "CLASS" (injury class).

FIELD NAME	TYPE	SIZE	DEC
PCOND		C	5
THEATER	C	5	
CLASS	C	5	
ECHELON	C	5	
RATE	N	13	7

TABLE NAME: STORAGE
DESCRIPTION: Storage requirements - This table lists the storage requirements in bytes for each patient condition at each echelon.

FIELD NAME	TYPE	SIZE	DEC
PCOND		C	5
ECHELON	C	5	
SIZE	N	10	0

TABLE NAME: ASTORAGE
DESCRIPTION: Cumulative storage requirements - This table lists the cumulative storage requirements in bytes for each patient condition at each echelon, per upload site.

FIELD NAME	TYPE	SIZE	DEC
PCOND		C	5
ECHELON	C	5	
UPLOAD		C	5
SIZE	N	10	0

TABLE NAME: DSPACE
DESCRIPTION: Storage distribution - This table lists the frequency versus storage distribution per theater, class, echelon, and upload site.

FIELD NAME	TYPE	SIZE	DEC
THEATER	C	5	
CLASS	C	5	
ECHELON	C	5	
UPLOAD		C	5
RATE	N	13	7
SPACE	N	10	0

TABLE NAME: PCASES

DESCRIPTION: Percent cases documented - This table lists the percent cases documented versus chip size, per theater, class, echelon, and upload site.

FIELD NAME	TYPE	SIZE	DEC
THEATER	C	5	
CLASS	C	5	
ECHELON	C	5	
UPLOAD	C	5	
CHIP	C	5	
PERCENT	N	13	7

TABLE NAME: ENCOUNT

DESCRIPTION: Number of encounters - This table lists the number of encounters accommodated versus chip size, per patient condition, echelon, and upload site.

FIELD NAME	TYPE	SIZE	DEC
PCOND	C	5	
ECHELON	C	5	
UPLOAD	C	5	
CHIP	C	5	
ENCOUNTER	N	10	0

Appendix B
MARC ES Version 1.1 for Windows
Installation Instructions

INTRODUCTION. MARC ES is a Windows program for estimating medical storage requirements for the MARC. This file contains details about the contents of the package, installation instructions, and help on getting started and using the package.

SYSTEM REQUIREMENTS. The following hardware and software are required to install and run the MARC ES package on your computer:

Windows 3.1 or later. The MARC ES has been tested under Windows 3.1 and Windows NT. It has not been fully tested under Windows '95 but it should run as well as it does under Windows NT.

4.0 MB minimum of free disk space is required to install the MARC ES software and basic set of database tables. More space is required to allow for expansion of databases and other applications.

386DX/33 MHZ or better processor, 486DX/66 MHZ or better is recommended. A 386 should be equipped with math co-processor.

4 MB of memory, 8 MB to 16 MB recommended, particularly if running under Windows NT or '95. The amount of memory will greatly affect the performance of the program. If you have too little memory, it will spend much of its time swapping to disk. Sufficient memory space should be made available for disk caching to improve performance.

VGA color display, Super VGA recommended.

Contents of the Package. The MARC ES package consists of three components, distributed on several diskettes:

DISKETTE	DESCRIPTION
1-2	MARC ES software
3-4	Borland Database Engine (BDE)
5-9	ReportSmith reporting engine

Contents of MARC ES Disk 1. The following MARC ES files are on the distribution diskette. Most files are compressed and will be decompressed onto your hard drive during the install process. Some files are used only during setup and will not be copied to your hard drive:

ACTION.DB_	ENCOUNT.MD_	RATES.DB_
ACTION.MD_	ENCOUNT.RP_	README.TXT

ASTORAGE.DB_
ASTORAGE.MD_
BIVBX11.DL_
CASES.DB_
CASES.MD_
CATEGORY.DB_
CATEGORY.MD_
CHART2FX.VB_
CHIPSIZE.DB_
CLASS.MD_
CTL3D.DLL
DSPACE.DB_
DSPACE.MD_
ECHELON.DB_
ECHELON.MD_
ENCOUNT.DB_
ERATES.DB_
ERATES.MD_
LOW.DB_
FLOW.MD_
INSTALDR.EXE
INSTALL.INF
MARC.EX_
MARC.IN_
ARCES.HL_
PATCOND.DB_
PATCOND.MD_
PCASES.DB_
CASES.MD_
CLASS.MD_
CLASS.DB_
COND.DB_
SETBIN.DB_
SETCAT.DB_
SETCHIP.DB_
SETCLASS.DB_
SETECH.DB_
SETPC.DB_
SETSUM.IN_
SETTHE.DB_
SETUP.DB_
SETUP.EXE
SETUPL.DB_
STORAGE.DB_
STORAGE.MD_
THEATER.DB
THEATER.MD_

Contents of MARC ES Disk 2.

1A.EX_
1B.EX_
ASTORAGE.RP_
DSPACE.RP_
CH22.DB_
NCOUNT.RP_
ERATES.RP
PCASES.RP_
STORAGE.RP
UNPAKSMP.BAT

Contents of Disks 3-4. These diskettes contain the Borland Database Engine (BDE) component. The BDE package is distributed as part of the MARC ES software, in terms of the Borland Redistributable License Agreement. The BDE may be used only for the purposes of running the MARC ES program.

Contents of Disks 5-9. These diskettes contain the ReportSmith Runtime component. ReportSmith is distributed as part of the MARC ES software, in terms of the Borland Redistributable License Agreement. ReportSmith may be used only for the purposes of running the MARC ES program.

Installing MARC ES. A full installation of MARC ES requires three steps:

1. Install the MARC ES software
2. Install the BDE
3. Install the ReportSmith Runtime (OPTIONAL)

Install the MARC ES Software. To install MARC ES, run the Setup program from the MARC ES diskette under Windows. Setup copies the files to your hard disk and creates a program group under Windows, with a MARC ES icon. In most cases that's all there is to setting up MARC ES. If you experience problems in installing or running the software refer to the Troubleshooting section at the end of this document.

Upgrading From a Previous Version. If you are upgrading MARC ES from a previous version, follow the same basic procedures as the normal installation. During Setup you

will be presented with some options for the components to be installed. *If you wish to preserve your data files,* ensure that the Databases option is set to No, otherwise the data files will be overwritten from the setup disk. Any changes you've made will be lost. The necessary files to perform the upgrade will automatically be copied to the hard drive. Newer files will replace older files.

Install the BDE. Install the BDE by running Setup from the BDE DISK 1 under Windows. Follow instructions to complete the installation.

********** NOTE **********

Installing the BDE will alter some of your Windows setups! Please exercise caution, especially if you are running either dBASE or PARADOX on your system. Since both those packages also use the BDE, it is possible that some files may be replaced with an incompatible version from the BDE supplied here. The best procedure is to make backups of all PARADOX/dBASE drivers and dynamic link libraries first before installing MARC ES. If in doubt, please consult your system administrator, or contact the supplier.

****

Install the ReportSmith (OPTIONAL). To install ReportSmith, run the Install program from the first ReportSmith diskette under Windows. You will be prompted to insert each of the 5 diskettes required to install the ReportSmith Runtime support. ReportSmith is a very flexible and powerful tool for generating and printing reports. It can be used to modify reports, or even to produce completely new reports. Existing reports are viewed and printed with the ReportSmith Runtime, which is shipped with MARC ES. If you wish to modify or extend the reports, the full release of ReportSmith is required.

********** NOTE: REPORTSMITH IS OPTIONAL **********

ReportSmith is needed only if you wish to print reports. Otherwise it will not be required. The ReportSmith window is activated from the Print menu or <Print> button in several data windows. If you click on a Print icon, and ReportSmith is not installed, you will receive an error notification message. The ReportSmith Runtime can print any of the preconfigured reports shipped with MARC ES. If you wish to design your own reports, or modify any of the existing reports, the full version of ReportSmith, or another application, capable of producing compatible report formats, will be required.

****

Help on Using MARC ES. To run the MARC ES program, go to Windows Program Manager, open the MARC ES group, and click on the MARC icon. Or Run MARC.EXE from the ProgMan File|Run menu. You must first install the BDE before you can run MARC ES! Once the program is running, click on the Help menu for more information. You can also open the Help file independently of the program. You should find this file as C:\MARC\DOC\MARCES.HLP. To open the file, use Windows File Manager and double click on the MARCES.HLP file.

Troubleshooting. If you experience problems installing or running MARC ES or any of its components, here are some hints that may help you get the software up and running correctly.

Check the BDE configuration. The BDE does not have to be configured in order to run MARC ES, but in some circumstances, if you are experiencing problems starting up MARC ES or accessing the tables, a solution might be to configure the BDE:

Ensure the BDE is correctly configured to access the databases. Run the BDECFG program under Windows to set up the BDE. You should find this file as C:\IDAPI\BDECFG.EXE. The configuration it expects to edit will be the file C:\IDAPI\IDAPI.CFG.

The BDECFG is easy to use and comes with on-line help. The key aspects of the configuration are:

Drivers:	Ensure that the dBASE driver is configured.
Aliases:	There should be an alias defined as follows:
Alias Name:	marc (must be all lowercase)
Type:	STANDARD
Path:	C:\MARC\DATA

Check the MARC.INI File. MARC.INI is created in the MARC directory. The default location will be C:\MARC\MARC.INI. The simplest way to look at this file is to open the File Manager or Explorer and double click on the MARC.INI file. This should open Notepad under Windows.

***** NOTE: EXERCISE EXTREME CAUTION WHEN EDITING MARC.INI *****

This is an important configuration file. If it is incorrectly edited you may not be able to run MARC ES. We suggest you make a backup copy of this file in case it is damaged. Sometimes MARC ES may not be able to find tables if the pathnames are incorrect. Review the pathnames for data, reports, and help files. This is particularly important if you have multiple disk drives on your machine, or if you are using networked drives. If this is the case then you should ensure that the MARC ES program and data are all installed on the same drive. When the program starts up it assumes that the data, report, help, and other directories are on the same drive. Do not add drivenames to the paths in MARC.INI.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATE COVERED
	June 1996	Interim 9/95-6/96

4. TITLE AND SUBTITLE
A Computer Program for Estimating Medical Information Storage Requirements

5. FUNDING NUMBERS
Program Element: 63706N
Work Unit Number:
M0095.005-6508

6. AUTHOR(S)
Paula J. Konoske and Roy W. Dobbins

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Naval Health Research Center
P. O. Box 85122
San Diego, CA 92186-5122

8. PERFORMING ORGANIZATION
Technical Document 96-6F

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Naval Medical Research and Development Command
National Naval Medical Center
Building 1, Tower 2
Bethesda, MD 20889-5044

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

During combat, documentation of medical treatment information is critical for maintaining continuity of patient care. However, knowledge of prior status and treatment of patients is limited to the information noted on a paper field medical card. The Multi-technology Automated Reader Card (MARC), a smart card, has beed identified as a potential storage mechanism for casualty medical information. The data capture and storage technology on the MARC was the focus of this effort. MARC ES, a Windows program, was developed for estimating storage requirements for the MARC. The program calculates storage requirements for a variety of scenarios using medical documentation requirements, casualty rates, and casualty flows. This model provides a tool that allows the user to estimate the total amount of space required to store medical data at each echelon of care for selected operational theaters. The program can also be used to identify the point at which data must be uploaded from the MARC if size constraints are imposed. Further, this model can be readily extended to other systems that store or transmit medical information.

14. SUBJECT TERMS	15. NUMBER OF PAGES
MEDTAG, MARC, combat casualty care, medical information systems	36
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited